



LAO PEOPLE'S DEMOCRATIC REPUBLIC

Peace Independence Democracy Unity Prosperity

Ministry of Public Works and Transport

DEPARTMENT OF ROADS



**STANDARD
TECHNICAL
SPECIFICATIONS**

MAINTENANCE ACTIVITY CODES (MAC)

UPDATED

July 2019

PREFACE

◆ Background (Why the MAC was Developed and Revised?)

Maintenance Activity Codes (MAC) is developed for the parties related to rehabilitation and/or maintenance project of road infrastructure (i.e. government staffs, consultants and contractors). Purpose of the development is:-

The parties share common understanding for content of maintenance work identified by the code respectively.

The contractors are also required to propose unit rates in the BOQ under appropriate understanding of the contents when they participate the bidding.

Regarding history of the MAC, the Road Administration Division (RAD) in the Department of Roads (DOR), the Ministry of Public Works and Transport (MPWT) initially developed the MAC to use for national roads under cooperation of the SweRoad in 1998. Subsequently, the MAC was revised by the RAD and the Local Road Division (LRD) in 2002. The codes related to labor based works were added to use particularly for local roads in this edition.

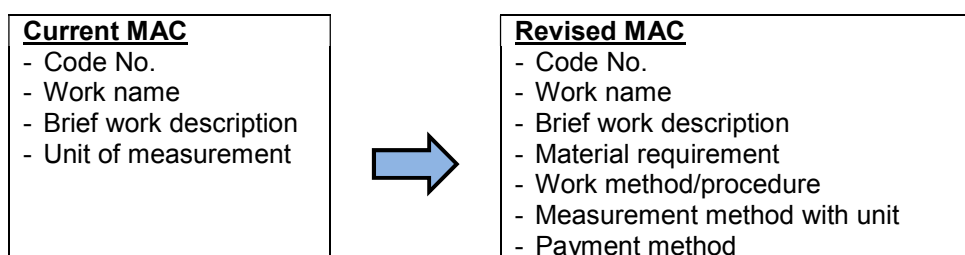
Although the current MAC (2002) has been applied among many road projects, this edition only describes code names and their brief work explanations. Detailed contents such as requirement of material and work methodology/procedure are not stipulated. In such an insufficient indication, it is incapable to fulfill the above purpose.

Given above situation, the Project Management Consultant (PMC) for Road Sector Governance and Maintenance Project (ADB Loan No. 3368-LAO) developed the revision version of the MAC in order to accomplish the purpose.

◆ Contents of the Revision of the MAC

(1) Reconstruction of Contents

The PMC reconstructed the contents in line with the structure of the Standard Technical Specifications (April 2018) which was also revised by the PMC as shown below.



(2) Adding New Codes

The PMC identified that the current MAC is incapable to deal with several defects to be occurred on roads and bridges on the basis of its review work. And therefore, the PMC created additional codes in order to improve of applicability of the MAC.

Additional codes are illustrated by “A” or “AA” on head of their code numbers such as “**A001** SPOT REPLACEMENT” and “**AA002** REPAIR OF DRAIN COVER”.

Note the codes with “A” were added by proposal of the PMC at the draft preparation stage. Furthermore, the PMC implemented the workshop for presentation of the revised MAC (draft) at Public Transportation Training Institute (PTTI) on 27th of April, 2018. The participants are as follows.

Organization	Numbers
PMC	4
Department of Roads/MPWT	10
Department of Waterway/MPWT	1
Department of Legislature/MPWT	1
PTRI	1
PTTI	1
Project Manager & Deputy Project Manager of on-going road maintenance project/MPWT	46
Private Firms	5
Engineering Faculty/NUOL	2
Total	71

During the workshop, the participants were divided into 5 groups for having discussions for the revised MAC (draft). The discussion results were compiled in the discussion memo and utilized for the further revision works. Consequently, the codes with “AA” were added by the discussion results.

(3) Submission of the Revised MAC.

The PMC made necessary revision works in accordance with result of the workshop. And then, the PMC submitted the MAC as “**Standard Technical Specifications, Part-2: Maintenance Activity Codes (MAC) (DRAFT)**” to the DOR/MPWT on **22nd August 2018**.

(4) Additional Works for Revision and Finalization

The RAD reviewed and made comments for the revised MAC (Version: 22/Aug/2018). The comments were sent to the PMC on 1st November 2018. Accordingly, the PMC revised and finalized on the basis of the comments in February 2019.

(5) Updating Work to be “ONE STOP” Specifications

The PMC developed 2 kinds of the Standard Technical Specifications (STS) as follows.

- (i) Standard Technical Specifications (finalized in April 2018)
- (ii) Standard Technical Specifications (MAC) (i.e. this book)

(i) is utilized for large scale construction works such as new construction and/or rehabilitation in principle.

Some codes in (ii) (Version: February 2019) state that the “the work shall comply with the description in (i)”, if the work content is duplicated each other, in term of paper saving.

Corresponding to this measure, the RAD suggested that the description in (ii) should not be abbreviated because the reader without (i) will not be able to confirm the meaning of (ii).

Consequently, related description of (i) is presented without abbreviating in all corresponding codes in (ii) for its independent application (i.e. **ONE STOP** application) in this updated

version (July 2019).

◆ How to Apply the MAC?

It is suggested that the MAC (Updated: August 2019) will constitute a part of bidding/contract document and broadly be applied for future road projects as presented in next page.

Sample Bidding Document (Road Sector Governance and Maintenance Project: ADB Loan No. 3368-LAO)	
PART I: Bidding Procedures	Section 1 - Instructions to Bidders (ITB) Section 2 - Bid Data Sheet (BDS) Section 3 - Evaluation and Qualification Criteria (EQC) Section 4 - Bidding Forms (BDF) Section 5 - Eligible Countries (ELC)
PART II: Requirements	Section 6 – Employer's Requirements (ERQ) * Standard Technical Specifications (April 2018)
* Standard Technical Specifications, Maintenance Activity Codes (MAC) (August 2019)	
	* Particular Specifications * Environmental Safeguard Documents * Social Safeguard Documents * Drawings * Supplemental Information regarding Works to be Procured
PART III: Conditions of Contract and Contract Forms	Section 7 - General Conditions of Contract (GCC) Section 8 - Particular Conditions of Contract (PCC) Section 9 - Contract Forms (COF)

Sample Contract Document (Road Sector Governance and Maintenance Project: ADB Loan No. 3368-LAO)	
	(a) Contract Agreement (b) Letter of Acceptance (c) Letter of Bid (d) Particular Conditions of Contract (e) The List of Eligible Countries that was specified in Section 5 of the bidding document (f) General Conditions of Contract (g) Specifications, (g)-1 Standard Technical Specifications (April 2018)
(g)-2 Standard Technical Specifications, Maintenance Activity Codes (MAC) (August 2019)	
	(g)-3 Particular Specifications (h) Drawings (i) Completed Activity Schedules or Bill of Quantities (j) Any other document listed in the PCC as forming part of the Contract

Developing Road Maintenance Manual

Road Maintenance Manual will be developed in corresponding to completion of the MAC final edition. The manual will explain content of the each code by using photo(s) and/or figure(s) to ease understanding level of the users.

Vientiane, July 2019

ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AR	Asphalt Rubber
ASTM	American Society for Testing and Materials
BOQ	Bill of Quantities
BS	British Standard
CBR	California Bearing Ratio
DOR	Department of Roads
in	Inch
LRD	Local Road Division
MAC	Maintenance Activity Codes
MDD	Maximum Dry Density
MPWT	Ministry of Public Works and Transport
LL	Liquid Limit
LS	Linear Shrinkage
PI	Plasticity Index
PL	Plastic Limit
PMC	Project Management Consultant
PTFE	Polytetrafluorethylene
PTTI	Public Transportation Training Institute
PVC	Polyvinyl Chloride
RAD	Road Administration Division
STS	Standard Technical Specifications
UCS	Unconfined Compressive Strength
VOC	Volatile Organic Compounds

PREFACE
ABBREVIATIONS

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1. ROUTINE MAINTENANCE

1.1 PAVED SURFACE REPAIRS

1.1.1 BITUMINOUS PAVEMENT

CODE 111 FILLING POTHoles WITH BASE MATERIALS

111.01 DESCRIPTION

- (1) This work is to repair the damages occurred on pavement as follows;
1. Mesh cracking
 2. Ruts and depressions
 3. Edge subsidence and rutting
 4. Potholes
 5. Shoving.

111.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials to be used shall comply with the following requirements.

Spraying temperatures for binders

Cutback Grades (US Asphalt Institute)	Whirling Spray Jets		Slots Jets	
	Min	Max	Min	Max
	°C	°C	°C	°C
MC 30	50	60	40	50
RC/MC 70	65	80	55	70
RC/MC 250	95	115	80	90
RC/MC 800	115	135	105	115
RC/MC 3000	135	150	120	130
Penetration Grades				
400/500	160	170	140	150
280/320	165	175	150	160
180/200	170	190	165	175
80/100	180	200	165	175

- (3) Aggregate shall comply with the requirement as follows. (Corresponding to SECTION 302 of the STS.)

1. General

- (a) The coarse and fine aggregates for base shall consist of crushed rock, clean, tough, durable, sharp-angled fragments free of any excess of thin or elongated pieces, and reasonably free of soft, disintegrated or decomposed stone, dirt or other deleterious matter.
- (b) The aggregate shall be obtained by crushing material, which if so directed by the Engineer, has first been screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least two mechanically fractured faces.

2. Grading Requirements

- (a) Material for base course shall be crushed rock and the combined aggregate shall have the following grading. Testing of grading is to be done according to AASHTO T 27:

Grading Requirements of Crushed Aggregate Base Course

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Type A	Type B	Type C
50.0	100	–	–
37.5	90 – 100	100	–
25.0	75 – 95	85 – 100	100
19.0	60 – 90	70 – 90	70 – 100
9.5	40 – 75	50 – 85	50 – 85
2.36	20 – 45	25 – 45	20 – 50
0.425	10 – 26	10 – 25	15 – 30
0.075	4 – 12	5 – 15	5 – 15

3. Other Requirements

- (a) The combined material passing the 19 mm sieve shall have a 4 days soaked CBR not less than 80% (AASHTO T 193) at 95% of Maximum Dry Density (AASHTO T 180).
- (b) Aggregate retained on the 2.36 mm sieve shall have a percentage of wear, by Los Angeles Abrasion test AASHTO T 96, of not more than 40%.
- (c) Coarse aggregate flakiness and elongation indices, determined by BS EN 933-3 (Flakiness index) and BS 812-105.2 (Elongation Index), shall not be greater than 35%. Soundness loss shall not be greater than 12% as determined by AASHTO T 104.
- (d) The fraction passing the 0.425 mm sieve shall have a liquid limit (AASHTO T 89) not greater than 20 and plasticity index (AASHTO T 90) not greater than 6 nor less than 2 and the Plasticity Product (PI x percentage passing the 0.425 mm sieve) shall not exceed 90.
- (e) The aggregate shall have a 10% Fines Value (wet) [AASHTO T 176] of not less than 130 kN and the Wet Dry Variation of the 10% Fines Value shall not exceed 40%.

4. Acceptance of Production Materials

- (a) The aggregate will be accepted immediately following mixing, based on periodic random samples taken from the mixing plant output. Acceptance of the material by the Engineer does not constitute acceptance of the base, only that the material is approved for use in the base.
- (4) Other materials if necessary for work execution.

111.03 WORK PROCEDURES

- (1) Mark out and layout the area to be treated and repaired with chalk by drawing a rectangular alignment around the damage.
- (2) Excavate and remove unsuitable materials on the marked out of the road surface.
- (3) Increase the depth of the hole until firm and found dry and trim the walls of the hole in vertical.
- (4) Trim the bottom of the hole to make it flat horizontally, remove loose materials and compact.
- (5) Apply bitumen as primer on side cuts and fill the hole with base materials.
- (6) Compact the materials in one or more layers of regular thickness depending on the depth involved.
- (7) The last layer, prior to compaction, must have an excess thickness of about 1/5 the depth of the final layer, in order to allow for settlement on compaction.
- (8) Work area shall be resealed by covering with the binder, bitumen emulsion (1.5kg/m²) or cut back bitumen (0.5 – 1.0kg/m²) and compaction is required.
- (9) Make the area clean & tidy.
- (10) After a week of completion, return to the worked area for sweeping and removing loose aggregates on the area to ensure safety.

111.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
111-1	Filling potholes with base materials	Metre Cube

111.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 112 PATCHING POTHoles

112.01 DESCRIPTION

- (1) This work is to maintain the road surface in a condition that provides reasonable safety and adequate riding comfort and quality for the motorists.
- (2) This work is dealing with potholes (less than 5 cm) and subsidence corrugation (less than 3cm), depression (less than 5cm), rutting (less than 3cm) and surface irregularities due to shoving (less than 5cm).

112.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials to be used shall comply with the following requirements.

Spraying temperatures for binders

Cutback Grades (US Asphalt Institute)	Whirling Spray Jets		Slots Jets	
	Min	Max	Min	Max
	°C	°C	°C	°C
MC 30	50	60	40	50
RC/MC 70	65	80	55	70
RC/MC 250	95	115	80	90
RC/MC 800	115	135	105	115
RC/MC 3000	135	150	120	130
PENETRATION GRADES				
400/500	160	170	140	150
280/320	165	175	150	160
180/200	170	190	165	175
80/100	180	200	165	175

- (3) Other materials specifications as follows:
 1. Binder distribution rates;
 - (a) Bitumen emulsion : 1.5 kg/m²
 - (b) Cut back bitumen : 0.5 to 1 kg/m²
 2. Size of aggregates;
 - (a) Coarse sand : 5 mm
 - (b) Chippings : 6 to 10 mm
- (4) Other materials if necessary for work execution.

112.03 WORK PROCEDURES

- (1) Sweep, clean and ensure the dryness on the subject area.
- (2) Mark and layout the subject area with a chalk or paint.
- (3) Deliver the cold mix asphalt from the approved supplier or manufacturer to the site.

- (4) Apply hot mix bitumen to the prepared area using spray lance machine or water can. Do not overheat cut back bitumen; use a thermometer to check the temperature during heating.
- (5) Fill-in the material within the marked outline using a rake and leaving an excess thickness of about one third (1/3) of the depth of the depression for compaction.
- (6) Compact the placed materials thoroughly using small vibrating roller, plate or a rammer until the level is 3mm above the surrounding surface.
- (7) Work area shall be resealed by covering with the binder, bitumen emulsion or cut back bitumen and compaction is required.
- (8) Make the area clean & tidy.
- (9) After a week of completion, return to the worked area for sweeping and removing loose aggregates on the area to ensure safety.

112.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
112-1	Patching potholes	Metre Cube

112.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 113 FILLING ALONG EDGES WITH GRAVEL

113.01 DESCRIPTION

- (1) This work is to repair shoulders that have settled or been eroded by traffic and water.

113.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Aggregate shall comply with the requirement as follows. (Corresponding to SECTION 302 of the STS.) **OR** the material shall be obtained from a quarry or gravel pit that needs approval of the Engineer.

1. General

- (a) The coarse and fine aggregates for base shall consist of crushed rock, clean, tough, durable, sharp-angled fragments free of any excess of thin or elongated pieces, and reasonably free of soft, disintegrated or decomposed stone, dirt or other deleterious matter.
- (b) The aggregate shall be obtained by crushing material, which if so directed by the Engineer, has first been screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least two mechanically fractured faces.

2. Grading Requirements

- (a) Material for base course shall be crushed rock and the combined aggregate shall have the following grading. Testing of grading is to be done according to AASHTO T 27:

Grading Requirements of Crushed Aggregate Base Course

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Type A	Type B	Type C
50.0	100	–	-
37.5	90 – 100	100	-
25.0	75 – 95	85 – 100	100
19.0	60 – 90	70 – 90	70 – 100
9.5	40 – 75	50 – 85	50 – 85
2.36	20 – 45	25 – 45	20 – 50
0.425	10 – 26	10 – 25	15 – 30
0.075	4 – 12	5 – 15	5 – 15

3. Other Requirements

- (a) The combined material passing the 19 mm sieve shall have a 4 days soaked CBR not less than 80% (AASHTO T 193) at 95% of Maximum Dry Density (AASHTO T 180).

- (b) Aggregate retained on the 2.36 mm sieve shall have a percentage of wear, by Los Angeles Abrasion test AASHTO T 96, of not more than 40%.
- (c) Coarse aggregate flakiness and elongation indices, determined by BS EN 933-3 (Flakiness index) and BS 812-105.2 (Elongation Index), shall not be greater than 35%. Soundness loss shall not be greater than 12% as determined by AASHTO T 104.
- (d) The fraction passing the 0.425 mm sieve shall have a liquid limit (AASHTO T 89) not greater than 20 and plasticity index (AASHTO T 90) not greater than 6 nor less than 2 and the Plasticity Product (PI x percentage passing the 0.425 mm sieve) shall not exceed 90.
- (e) The aggregate shall have a 10% Fines Value (wet) [AASHTO T 176] of not less than 130 kN and the Wet Dry Variation of the 10% Fines Value shall not exceed 40%.

4. Acceptance of Production Materials

- (a) The aggregate will be accepted immediately following mixing, based on periodic random samples taken from the mixing plant output. Acceptance of the material by the Engineer does not constitute acceptance of the base, only that the material is approved for use in the base.

- (3) Other materials if necessary for work execution.

113.03 WORK PROCEDURES

- (1) Scarify existing surface of the shoulder with the blade of a motor or towed grader to allow a key for the added materials.
- (2) Off-load or tip new materials onto the shoulder.
- (3) Shape to the final level and ensure correct cross-fall using motor or towed grader blade.
- (4) Care must be taken not to damage the edge of the road pavement with the blade.
- (5) Excess materials should be graded to the embankment side slope.
- (6) In cutting, it should be graded into a windrow for removal by wheelbarrow, tractor and trailer or truck.
- (7) Excess materials should not be deposited on the carriageway or into the drainage ditch.
- (8) If the materials are dry it should be sprinkled with water.
- (9) Compact shoulder surface using a self-propelled, towed or pedestrian roller and should butt smoothly into the road surface. Compaction of each layer should not exceed 100 mm.

(10) Clean and remove all loose materials and debris from the carriageway.

113.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
113-1	Filling along edges with gravel	Metre Cube

113.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 114 EDGE REPAIRS, PATCHING

114.01 DESCRIPTION

- (1) This work is to repair bituminous pavement surface by dressing the pavement areas where damages appeared cause by deformation (corrugation) and surface textile deficiency by streaking and glazing.
- (2) This treatment usually deals with the same as of mechanized method, but it is common used in a remote location and limited areas or when the specialized equipment is too expensive or is not available for surface dressing works.

114.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials to be used shall comply with the following requirements.

Spraying temperatures for binders

Cutback Grades (US Asphalt Institute)	Whirling Spray Jets		Slots Jets	
	Min	Max	Min	Max
	°C	°C	°C	°C
MC 30	50	60	40	50
RC/MC 70	65	80	55	70
RC/MC 250	95	115	80	90
RC/MC 800	115	135	105	115
RC/MC 3000	135	150	120	130
PENETRATION GRADES				
400/500	160	170	140	150
280/320	165	175	150	160
180/200	170	190	165	175
80/100	180	200	165	175

- (3) Aggregate shall comply with the requirement as follows. (Corresponding to SECTION 302 of the STS.)

1. General

- (a) The coarse and fine aggregates for base shall consist of crushed rock, clean, tough, durable, sharp-angled fragments free of any excess of thin or elongated pieces, and reasonably free of soft, disintegrated or decomposed stone, dirt or other deleterious matter.
- (b) The aggregate shall be obtained by crushing material, which if so directed by the Engineer, has first been screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least two mechanically fractured faces.

2. Grading Requirements

- (a) Material for base course shall be crushed rock and the combined aggregate shall have the following grading. Testing of grading is to be done according to AASHTO T 27:

Grading Requirements of Crushed Aggregate Base Course

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Type A	Type B	Type C
50.0	100	–	–
37.5	90 – 100	100	–
25.0	75 – 95	85 – 100	100
19.0	60 – 90	70 – 90	70 – 100
9.5	40 – 75	50 – 85	50 – 85
2.36	20 – 45	25 – 45	20 – 50
0.425	10 – 26	10 – 25	15 – 30
0.075	4 – 12	5 – 15	5 – 15

3. Other Requirements

- (a) The combined material passing the 19 mm sieve shall have a 4 days soaked CBR not less than 80% (AASHTO T 193) at 95% of Maximum Dry Density (AASHTO T 180).
- (b) Aggregate retained on the 2.36 mm sieve shall have a percentage of wear, by Los Angeles Abrasion test AASHTO T 96, of not more than 40%.
- (c) Coarse aggregate flakiness and elongation indices, determined by BS EN 933-3 (Flakiness index) and BS 812-105.2 (Elongation Index), shall not be greater than 35%. Soundness loss shall not be greater than 12% as determined by AASHTO T 104.
- (d) The fraction passing the 0.425 mm sieve shall have a liquid limit (AASHTO T 89) not greater than 20 and plasticity index (AASHTO T 90) not greater than 6 nor less than 2 and the Plasticity Product (PI x percentage passing the 0.425 mm sieve) shall not exceed 90.
- (e) The aggregate shall have a 10% Fines Value (wet) [AASHTO T 176] of not less than 130 kN and the Wet Dry Variation of the 10% Fines Value shall not exceed 40%.

4. Acceptance of Production Materials

- (a) The aggregate will be accepted immediately following mixing, based on periodic random samples taken from the mixing plant output. Acceptance of the material by the Engineer does not constitute acceptance of the base, only that the material is approved for use in the base.
- (4) (Chipping) grading requirements: Min dia./Max dia.: 4/6 - 6/10 - 10/14
- (5) Other materials if necessary for work execution.

114.03 WORK PROCEDURES

- (1) Heating bitumen at a controlled temperature (see table for temperature above) when cut back bitumen is to be used ahead of work starts.
- (2) Sweep and clean the area and ensure dryness on where the binder is to be applied.
- (3) Mark out and layout the area that is subject for surface dressing treatment.
- (4) Binder either cut back bitumen or bitumen emulsion is poured over the marked area as evenly as possible. Squeegees are used to ensure the even distribution.
- (5) Make sure that the spreading of chipping materials covering is completely and evenly to the area.
- (6) Compaction by rolling of tires of the empty truck in many passes to complete the treatment works.
- (7) Fog spray in a very light film on top of the chips road surface to bind together and hold in place the chips particles and sprinkled with sand as sealant.
- (8) Record the area of the completed activities using work record sheet.
- (9) Make the site clean & tidy.
- (10) After a week of completion, return to the worked area for sweeping and removing loose aggregates on the area to ensure safety.

114.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
114-1	Edge repairing, patching	Metre Cube

114.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 115 CRACK SEALING (SLIGHTLY DAMAGED)

115.01 DESCRIPTION

(1) This work is to repair the different crack defects on the pavement road surface under the following appearances:

1. Block cracks (less than 2 mm width)
2. Longitudinal cracks (less than 2 mm width)
3. Slippage (aka Crescent) cracks (less than 2 mm width)
4. Transverse cracks (less than 2 mm width)

115.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials to be used shall comply with the following requirements.

Spraying temperatures for binders

Cutback Grades (US Asphalt Institute)	Whirling Spray Jets		Slots Jets	
	Min	Max	Min	Max
	°C	°C	°C	°C
MC 30	50	60	40	50
RC/MC 70	65	80	55	70
RC/MC 250	95	115	80	90
RC/MC 800	115	135	105	115
RC/MC 3000	135	150	120	130
PENETRATION GRADES				
400/500	160	170	140	150
280/320	165	175	150	160
180/200	170	190	165	175
80/100	180	200	165	175

- (3) Bituminous slurry shall be produced by mixing 6 litres of bitumen emulsion with 20 litres of coarse sand (Max. 5 mm) in a wheelbarrow.
- (4) Other materials if necessary for work execution.

115.03 WORK PROCEDURES

- (1) Sweep, clean and ensure the dryness on the subject area.
- (2) Mark out and layout the subject area with a chalk or paint.
- (3) Treatment application is carried out by two different systems marked as follows:
 1. Sealing work for closely spaced cracks filled with bituminous slurry:
 - ✓ Spread out slurry in a thin layer approximately 5mm thick using squeegee.
 - ✓ The slurry must be allowed to dry completely before opening to the traffic.

2. Filling-in for isolated cracks:

- ✓ Filling hot cutback bitumen on specified temperature into crack using a spray lance or watering can.
- ✓ Coarse sand is followed to be scattered over the filled crack using a shovel.

115.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
115-1	Crack sealing (slightly damaged)	Metre Square

115.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 116 CRACK SEALING (SEVERELY DAMAGED)

116.01 DESCRIPTION

- (1) Work shall be done in compliance with Code 111.

116.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
116-1	Crack sealing (severely damaged)	Metre Cube

116.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 117 GRADING OF SHOULDERS

117.01 DESCRIPTION

(1) This work is to reshape the shoulder using labor and/or mechanical method that calls for the repair of high or misshaped shoulders.

117.02 MATERIALS

(1) Nil.

117.03 WORK PROCEDURES

< 1 > Labor method

- (1) Low and high surfaces should be loosened with pickaxes or mattocks.
- (2) Shoulders should be reshaped to slightly above the final level and the correct cross-fall using shovels and rakes.
- (3) The cross-fall of the un-compacted materials should be checked with the camber board or spirit level.
- (4) Excess materials should be spread over the embankment slope or transported by wheelbarrow to a convenient and safe dumping site.
- (5) Materials should not be deposited on the carriageway or in the drainage ditch.
- (6) If the materials are dry it should be sprinkled with water.
- (7) Shoulder surface is then compacted with hand guide roller or hand rammers.
- (8) The compacted surface should be smoothly levelled to the road pavement.
- (9) Check the finished cross-fall with the camber board and or the spirit level and repeat the re-shaping if necessary.
- (10) Brush all loose materials and debris from the carriageway and dispose into a safe place.

(11) Make the area clean and tidy.

< 2 > Equipment based method

- (1) Scarify existing shoulder surface using a motor or towed grader.
- (2) Shoulders should be reshaped to slightly above the final level and the correct cross-fall using motor or towed grader blade.
- (3) Care should be taken not to damage the edge of the road surface.
- (4) Check the un-compacted cross-fall with a camber board.

- (5) Excess materials and vegetation should be graded to the embankment side slope.
- (6) In cuttings, excess materials and vegetation should be graded into a windrow for removal by wheelbarrow, tractor and trailer or truck.
- (7) Materials should not be deposited on the carriageway or in the drainage ditch.
- (8) If the materials are dry it should be sprinkled with water.
- (9) Shoulder surface is then compacted using self-propelled, towed or rollers.
- (10) The compacted surface should be smoothly levelled into the road pavement.
- (11) Check the finished cross-fall with the camber board and or spirit level and repeat the re-shaping if necessary.
- (12) Sweep and remove all loose materials and debris away from the carriageway.
- (13) All debris and excess materials should be disposed into a safe place.
- (14) Make the area clean and tidy.

117.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
117-1	Grading of shoulders	Metre Square

117.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 118 PATCHING OF POTHoles BY MACADAM METHOD

This Code remains to exist. But no longer applying the code is suggested in accordance with following reasons:

- 1) The work requires skilled labor(s) and longer working period.
- 2) The work is compatible with more simplified codes such as 111, 112 and 119.

CODE 119 PATCHING POTHOLE BY HOT OR COLD MIX ASPHALT

119.01 DESCRIPTION

- (1) This work is to maintain the road surface in a condition that provides reasonable safety and adequate riding comfort and quality for the motorists.
- (2) This work is dealing with potholes (less than 5 cm) and subsidence corrugation (less than 3cm), depression (less than 5cm), rutting (less than 3cm) and surface irregularities due to shoving (less than 5cm).

112.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials to be used shall comply with the following requirements.

Spraying temperatures for binders

Cutback Grades (US Asphalt Institute)	Whirling Spray Jets		Slots Jets	
	Min	Max	Min	Max
	°C	°C	°C	°C
MC 30	50	60	40	50
RC/MC 70	65	80	55	70
RC/MC 250	95	115	80	90
RC/MC 800	115	135	105	115
RC/MC 3000	135	150	120	130
PENETRATION GRADES				
400/500	160	170	140	150
280/320	165	175	150	160
180/200	170	190	165	175
80/100	180	200	165	175

- (3) Other materials specifications as follows:
1. Binder distribution rates;
 - (a) Bitumen emulsion : 1.5 kg/m²
 - (b) Cut back bitumen : 0.5 to 1 kg/m²
- (4) Hot or cold mix asphalt produced in the approved supplier or manufacturer.
- (5) Other materials if necessary for work execution.

112.03 WORK PROCEDURES

- (1) Sweep, clean and ensure the dryness on the subject area.
- (2) Mark and layout the subject area with a chalk or paint.
- (3) Deliver the hot or cold mix asphalt to the site.
- (4) Apply bitumen for the binder to the prepared area using spray lance machine or water can. Do not overheat the bitumen; use a thermometer to check the temperature during

heating.

(5) Fill-in the material within the marked outline using a rake and leaving an excess thickness of about one third (1/3) of the depth of the depression for compaction.

(6) Compact the placed materials thoroughly using small vibrating roller, plate or a rammer until the level is 3mm above the surrounding surface.

(7) Make the area clean & tidy.

(8) After a week of completion, return to the worked area for sweeping and removing loose aggregates on the area to ensure safety.

119.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
119-1	Patching Pothole by Hot or Cold Mix Asphalt	Metre Cube

119.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A001 SPOT REPLACEMENT

A001.01 DESCRIPTION

- (1) This work is to recover strength of deeply deteriorated pavement structure and prevent further enlargement of the affected area by wholly replacing with new material.

A001.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials applied for the work should comply with following requirements.

1. Crushed stone (Corresponding to SECTION 301 and/or 302 of the STS.)

(a) Sub base course

(i) General

- 1) All material shall be free from dirt, organic matter, shale or other deleterious matter and shall be of such quality that it will bind readily to form a firm, stable course.

(ii) Grading Requirements

- 1) The material shall be tested according to AASHTO T 27, and shall consist of uniform mixtures of naturally occurring or processed materials comprising gravel and/or crushed rock fragments with sand, silt and clay conforming to the following grading requirements:

Grading Requirements of Aggregate Subbase

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Sub-base Type A	Sub-base Type B	Sub-base Type C
100			
75			
50.0		100	100
37.5	100	85 – 95	80-100
25.0	75 - 90		
19.0	60 - 82	60 – 80	60-100
9.5	45 - 66		
4.75	34 – 55	25 – 55	30-100
2.0	25 – 43	15 – 35	17-75
0.425	12 – 25	7 – 20	9-50
0.075	6 – 15	2 – 10	5-25

- 2) Depending on the availability of material at the Works site or in reasonable proximity the Contractor shall select material Type A, Type B or Type C for the Aggregate Sub-base, as approved by the Engineer.

- 3) Each location where Aggregate Sub-base is applied shall receive only one type of material (Type A, Type B or Type C). However, it is permissible to use different type of Sub-base materials on different sections of the road. If Sub-base material of one type is scarce, different types of Sub-base materials can be used in the same location of the road. In this case Type B and Type-C shall be used for the Lower Sub-base and the better quality material, grading Type A, shall be used for the Upper Sub-base. In all cases the selection and application of Sub-base material type shall be done in close coordination with the Engineer and is always subject to his final approval.

(iii) Other Requirements

- 1) Coarse aggregate shall comprise material retained on a 4.75 mm (AASHTO No. 4) sieve and shall consist of hard, durable particles or fragments of stone or gravel. Materials that break when wetted and dried shall not be used.
- 2) The coarse aggregate for sub-base shall be crushed rock (with a minimum of 50% of particles having at least two crushed faces), that for lower sub-base may comprise natural gravel materials.
- 3) Fine aggregate (material passing the 4.75 mm sieve) shall consist of natural or crushed sand.
- 4) The various fractions shall have properties according to the following table:

Properties of Coarse and Fine Aggregates	
Property/Test	Sub-base
Fraction passing 19 mm sieve	
CBR (4 days soaked), @ 95% of MDD	min 30%
AASHTO T 193	
Coarse aggregate, material retained on a 4.75 mm sieve	
Wet/Dry Strength Variation	max 45%
Los Angeles Abrasion, AASHTO T 96	max 45%
Fraction passing 0.425 mm sieve	
Liquid Limit, AASHTO T 89	max 25%
Plasticity Index, AASHTO T 90	max 12%, min 4%
Plasticity Modulus	max 175
Linear Shrinkage, AASHTO T 92	max 5%

- 5) When the material is sourced from a borrow pit, the Contractor shall demonstrate to the satisfaction of the Engineer, that the material can be excavated without being contaminated by unacceptable material. The Contractor at his own cost shall take such actions the Engineer considers necessary to ensure that the material being excavated is not being contaminated. Where in the opinion of the Engineer, the Contractor cannot extract the material

from the borrow without contamination, then the Contractor shall obtain material from another source at his own cost.

(iv) Acceptance of Production Materials

- 1) When the stationary blend method is used, the aggregate will be accepted immediately following mixing, based on periodic random samples taken from the pugmill output.
- 2) When the aggregate is a single source aggregate, it may be accepted at the borrow pit or crusher. Acceptance of the materials by the Engineer does not constitute acceptance of the sub-base, only that the materials are approved for use as sub-base.

(v) Capping Layer

- 1) This material shall be used to provide sufficient cover on weak subgrades and shall be used in the lower part of the sub-base as a substitute for a thick sub-base to reduce costs. The requirements are less strict than for an ordinary sub-base.
- 2) The 4 days soaked CBR shall be at least 15 % (AASHTO T 193) compacted in the laboratory at the minimum of 95 % of the maximum dry density (AASHTO T 180).
- 3) The fraction of material passing the 0.425 mm sieve shall have a Liquid Limit (LL) not greater than 35% and a Plasticity Index (PI) between 4% and 12%.
- 4) The quantity of the fraction passing the 0.075 mm sieve shall be not greater than two-thirds of the quantity of the fraction passing the 0.425 mm sieve.

(b) Base course

(i) General

- 1) The coarse and fine aggregates for base shall consist of crushed rock, clean, tough, durable, sharp-angled fragments free of any excess of thin or elongated pieces, and reasonably free of soft, disintegrated or decomposed stone, dirt or other deleterious matter.
- 2) The aggregate shall be obtained by crushing material, which if so directed by the Engineer, has first been screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least two mechanically fractured faces.

(ii) Grading Requirements

- 1) Material for base course shall be crushed rock and the combined aggregate shall have the following grading. Testing of grading is to be done according to AASHTO T 27:

Grading Requirements of Crushed Aggregate Base Course

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Type A	Type B	Type C
50.0	100	–	–
37.5	90 – 100	100	–
25.0	75 – 95	85 – 100	100
19.0	60 – 90	70 – 90	70 – 100
9.5	40 – 75	50 – 85	50 – 85
2.36	20 – 45	25 – 45	20 – 50
0.425	10 – 26	10 – 25	15 – 30
0.075	4 – 12	5 – 15	5 – 15

(iii) Other Requirements

- 1) The combined material passing the 19 mm sieve shall have a 4 days soaked CBR not less than 80% (AASHTO T 193) at 95% of Maximum Dry Density (AASHTO T 180).
- 2) Aggregate retained on the 2.36 mm sieve shall have a percentage of wear, by Los Angeles Abrasion test AASHTO T 96, of not more than 40%.
- 3) Coarse aggregate flakiness and elongation indices, determined by BS EN 933-3 (Flakiness index) and BS 812-105.2 (Elongation Index), shall not be greater than 35%. Soundness loss shall not be greater than 12% as determined by AASHTO T 104.
- 4) The fraction passing the 0.425 mm sieve shall have a liquid limit (AASHTO T 89) not greater than 20 and plasticity index (AASHTO T 90) not greater than 6 nor less than 2 and the Plasticity Product (PI x percentage passing the 0.425 mm sieve) shall not exceed 90.
- 5) The aggregate shall have a 10% Fines Value (wet) [AASHTO T 176] of not less than 130 kN and the Wet Dry Variation of the 10% Fines Value shall not exceed 40%.

(iv) Acceptance of Production Materials

- 1) The aggregate will be accepted immediately following mixing, based on periodic random samples taken from the mixing plant output. Acceptance of the material by the Engineer does not constitute acceptance of the base, only that the material is approved for use in the base.

2. Cement stabilized material (Corresponding to SECTION 308 of the STS.)

(i) Aggregate

- 1) Natural gravels and coarse (clayey) sands shall be stabilized with cement (or lime) the material by the Engineer does not conspecified requirements. Three types of cement stabilized layers can be used and the strengths required for each layer after stabilization are defined in below table.

Strengths Requirements after Stabilization

	Unconfined Compressive Strength, UCS (MPa)
Cement stabilised Base Course 1, CB 1	3.0 – 6.0
Cement stabilised Base Course 2, CB 2	1.5 – 3.0
Cement stabilised Sub-Base, CS	0.75 – 1.5

- 2) Samples for strength tests shall be mixed, followed by compaction in a cylinder (Modified AASHTO T 180) and then cured for 7 days in a room with a temperature of 19.5 °C – 22.5 °C, with moisture (humidity) of 95 % to 100 %. After 7 days curing in the room, the samples shall be soaked in water for at least 4 hours, before the UCS testing.
- 3) Below two tables shows desirable properties of material before stabilization.

Desirable Grading of Material before Stabilization

ASTM Test Sieve, mm	Percent passing (by weight)	
	CB 1	CB 2
50	100	100
37.5	85 – 100	80 - 100
19	60 – 90	55 – 90
4.75	30 – 65	25 – 65
2.36	20 – 50	15 – 50
0.425	10 – 30	10 – 30
0.075	5 – 15	5 - 15

Desirable Properties of Material before Stabilization

	Maximum allowable values		
	CB 1	CB 2	CS
Liquid Limit (LL), %	25	30	
Plasticity Index (PI), %	6	10	20
Linear Shrinkage (LS), %	3	5	

- 4) Materials to be stabilized shall have a Coefficient of Uniformity of at least 5. The Coefficient of Uniformity is defined as the ratio of the sieve size through which 60 per cent of the material passes, to the sieve size through which 10 percent passes (D₆₀ / D₁₀).

- 5) The Plasticity Index and the Liquid Limit shall be measured on the fraction passing the 0.425 mm sieve.
- (ii) Cement
 - 1) Cement shall conform to the requirements of Portland cement with authorized material certificate.
- (iii) Water
 - 1) Water shall be clean and free from harmful matter and may be tested in accordance with AASHTO T 26 at the Engineer's discretion. Water thus tested and found to have a pH value less than 5.0 or more than 8.5 shall not be used.
 - 2) Furthermore water shall not contain more than 400 parts per million by weight of sulphate.
3. Prime coat (Corresponding to SECTION 303 of the STS.)
 - (i) Prime coat shall consist of a medium curing cut-back, MC-30, MC-70 asphalt produced by fluxing an asphaltic base with suitable petroleum distillates or Cationic Slow Setting Emulsified Asphalt CSS-1 (AASHTO M 208). MC-30 and MC-70 shall be free from water, show no separation prior to use, and shall conform to all the requirements for Grade MC-30 and MC 70 medium curing cutback asphalt specified in AASHTO M 82.
4. Hot asphalt mixture (Corresponding to SECTION 305 of the STS.)
 - (a) Aggregate
 - (i) Course aggregate, which is the material retained on a 4.75mm (ASTM No. 4) sieve, shall consist of crushed un-weathered rock.
 - (ii) It shall be clean, hard, tough, durable and sound, and shall be of uniform quality and free from decomposed stone, shale, clay lumps and other deleterious substances. Organic impurities when tested in accordance with AASHTO T 21 shall not fail the colour comparison of being darker than the colour of Organic Colour No. 3 (Gardner No.11). Coarse aggregate for each pavement course shall be from a single source of supply. Mixing of aggregates from different sources will not be allowed.
 - (iii) River boulders will only be approved as a source of supply for coarse aggregate if the Contractor can prove, to the satisfaction of the Engineer, that suitable quarry sources are unavailable within the vicinity of the Contract. For the purposes of these specifications, "within the vicinity" shall be taken to mean within a radius of 50 km of any point within the Site. Under no circumstances will natural uncrushed gravel be allowed to be incorporated into bituminous mixes.

- (iv) The percentage of particles with a minimum of one crushed face shall be 100%. In addition, at least 85 % by weight for quarry material and 65 % for river boulders of each separate stockpile of aggregate shall have all faces crushed.

- (v) Coarse aggregate shall have properties which comply with the following values:

Los Angeles Abrasion Loss (AASHTO T 96)

Binder Course	30% max
Wearing Course	25% max

Aggregate Crushing Value (BS 812-110)

Binder Course	25% max
Wearing Course	20% max

Aggregate Impact Value (BS 812-112) 25% max

Soundness Loss (AASHTO T 104)

Sodium Sulphate	12% max
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Flakiness Index (BS EN 933-3)

Binder Course	25% max
Wearing Course	25% max

Elongation Index (BS 812-105.2)

Binder Course	25% max
Wearing Course	25% max

Polished Stone Value (BS 812-114) 75 min

Water Absorption (ASTM C128/ 127) 2% max

- (vi) Coarse aggregate shall show no detrimental amount of stripping when tested in accordance with AASHTO T 182. The minimum value of non-stripped area shall be 95 %. If stripping occurs, the aggregate shall be rejected or, with the agreement of the Engineer, a method of treatment shall be proposed by the Contractor for the approval of the Engineer to change the material from a hydrophilic to a hydrophobic state, or an approved (anti-stripping) additive shall be proposed by the Contractor for use with the bituminous binder.

- (vii) The approved additive shall be added to the bituminous material in such a proportion as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with AASHTO T 182. The approved additive shall be used in strict accordance with the technical specifications issued by the additive manufacturer.

(b) Fine Aggregate

- (i) Fine aggregate shall consist of the material passing the 4.75 mm sieve.

- (ii) Fine aggregate shall be obtained from 100 % crushed rock or boulders pre-screened to exclude natural uncrushed fine material or weathered unsound fines. The use of natural sand will not be permitted. The use of river gravel as a source of supply for fine aggregate will not be permitted unless specifically approved by the Engineer.

- (iii) Fine aggregate shall have properties which comply with the following values:

Sand Equivalent	
Binder Course	50% min
Wearing Course	40% min
Soundness Loss (AASHTO T 104)	
Magnesium Sulphate	15% max
Plasticity Index (BS 1377: Part 2: Test 5)	Non-Plastic
Acid Soluble Chlorides (BS EN 1744-1)	0.1% max
Acid Soluble Sulphates (BS EN 1744-1)	0.5% max

(c) Storage of Aggregates

Sufficient storage space shall be provided for each size of aggregate.

Aggregates for bituminous pavement courses shall be stored on specially prepared paved (asphaltic or concrete) surfaces sloped to provide satisfactory drainage. Storage arrangements shall be such that inter-mixing of difference size aggregates cannot take place.

Stockpiles of aggregates shall be protected to the satisfaction of the Engineer to avoid contamination from wind blown fine particles and debris.

(d) Mineral Filler

- (i) When necessary to meet gradation requirements and/or to satisfy the design requirements specified, mineral filler shall be added to the coarse and fine aggregates.
- (ii) Mineral filler shall consist of finely ground particles of limestone or cement in accordance with AASHTO M 17 or an approved cement manufacturing by-product. It shall be thoroughly dry and free from organic substances and clay, and shall meet the following grading requirements:

Grading Requirements of Mineral Filler

MINERAL FILLER			
ISO	BS SIEVE	ASTM SIEVE	PERCENTAGE BY MASS PASSING
600	micron25	No.30	100
300	micron52	No.50	95-100
150	micron100	No.100	90-100
75	micron200	No.200	70-100

Filler shall be non plastic when tested by AASHTO T 90.

(e) Combined Aggregate

- (i) The combined mineral aggregate/fill shall meet the following physical requirements:

Sand Equivalent (ASTM D2419) determined after all processing except for addition of asphalt binder 65 minimum

Plasticity Index(BS 1377: Part 2: Method 5) Non plastic

- (ii) When tested in accordance with AASHTO T 11 and T 27, the combined mineral aggregate shall conform to following table.

Aggregate Grading for Asphalt Concrete

Mix Class		Class A	Class B	Class C	Class D
Mix Use		Binder Course	Binder Course	Binder/Wearing Course	Wearing Course
Minimum Compacted Thickness		70 mm	50 mm	40 mm	30 mm
U.S Standard Sieve mm alternative		Percent Passing By Weight			
37.50	(1½ in)	100			
25.00	(1 in)	95-100	100		
19.00	(¾ in)	75-95	80-100	100	
12.50	(½ in)	-	-	80-100	100
9.50	(¾ in)	54-75	60-80	70-90	80-100
4.75	(No. 4)	36-50	48-65	50-70	55-75
2.36	(No. 8)	25-45	35-50	35-50	35-50
0.600	(No.30)	11-28	19-30	18-29	18-29
0.300	(No.50)		13-23	13-23	13-23
0.150	(No.100)		7-15	8-16	8-16
0.075	(No.200)	1-8	1-8	4-10	4-10

- (iii) The gradings given in Table 2 represent the extreme limits which shall determine suitability of aggregate for use from any source of supply.
- (iv) Aggregate shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, but shall be uniformly graded.

(f) Additives

- (i) When necessary to meet the requirements of the Specifications (in particular the bitumen mortar softening point and retained stability), additives may be used subject to the prior written approval of the Engineer. Such additives shall be certified by the Contractor as having no detrimental effects on the bituminous mixture, its properties, durability or load carrying characteristic under all anticipated environment and traffic induced conditions relevant to the Site.

(g) Bitumen Binder

- (i) Bitumen binder for binder and wearing courses shall be penetration grade 60 - 70 unless grade 40-50 is specified in the Contract Documents.
- (ii) The bitumen shall be prepared by refining crude petroleum by suitable method and shall be homogenous, free from water and shall not foam when heated to 175 °C (347 °F).
- (iii) The bitumen shall conform to the requirements of following table.

Bitumen Requirements

Test	AASHTO / ASTM	60	70	PEN	40	50	PEN
		Min	Max		Min	Max	
Penetration at 25 °C (100 g, 5 sec)	T 49 / D5	60	70		40	50	
Flash Point, Cleveland Open Cup. °C	T 48 / D92	232	-		232	-	
Loss on Heating (5 hr. at 163 °C), %	T 179 /-	-	0.80		-	0.80	
Ductility at 25 °C, cm	T 51 / D113	100	-		100	-	
Solubility tricolour ethylene, %	T 44 / D2402	99	-		99	-	
Thin film over test 3.2 mm, 163 °C, 5 hr. loss on heating, %	D2872	-	0.80		-	0.80	
Penetration of residue % of original	T 49 / D5	54	-		53	-	
Ductility at 25 °C (50 mm/min), cm	T 51 / D113	100	-		100	-	
Ductility of residue at 25 °C, (50 mm/min), cm	T 51 / D113	50	-		50	-	
Kinematic Viscosity (Centistokes) at 135 °C	D 2170	240	-		280	-	
Softening Point, Ring & Ball apparatus	T 53 / D36	49	54		51	55	
Parafin content, %	-	-	2		-	2	

- (iv) The bitumen mortar (bitumen binder plus filler plus additives) shall have a softening point (AASHTO T 53) not less than 60 °C.
- (v) A sample of the bitumen that the Contractor proposes to use in the work, together with a statement as to its source and properties shall be submitted to and approved by the Engineer at least 45 days before the asphalt work begins.
- (vi) No bitumen other than that represented by the approved sample shall be used by the Contractor except with the written consent of the Engineer. Blending of bitumen from different refineries will not be

permitted.

- (vii) Each consignment brought to Site shall be accompanied by the manufacturer's certificate and a test report stating the shipment number, date of shipment, purchase order number, net weight and the results of the tests specified in Table 3 above.
- (viii) For each delivery of bitumen, the bitumen shall be checked for compliance with the requirements of Table 3 and the bitumen mortar shall be checked for softening point. Any delivery not satisfying the above requirements shall be rejected and removed from the Site.
- (ix) The percentage range of bitumen by weight of total mix, for both binder- and wearing courses, to be added to the aggregate shall be in the range 4 – 6 %.

5. Cold mixed asphalt (Corresponding to SECTION 310 of the STS.)

(a) General

- (i) The cold asphalt, often referred to as "premix" or "coldmix", shall be produced from a mixture of mineral aggregates (including mineral filler) which is mixed cold to a workable condition suitable for stockpiling and/or immediate spreading and compaction.
- (ii) Cold asphalt shall be manufactured in an approved stationary mixing plant or approved mobile mixing plant, or by mixing in place, if approved and in accordance with the following requirements.

(b) Bituminous Materials

- (i) Bituminous materials for cold asphalt shall be a fluxed bitumen or a cutback bitumen or a bitumen emulsion as follows:
- (ii) Fluxed bitumen shall be a residual bitumen, 80/100 pen, the dynamic viscosity of which has been reduced by the addition of a bitumen fluxing agent (e.g. diesel fuel oil).
- (iii) Cutback bitumen shall be a residual bitumen, 80/100 pen, the dynamic viscosity of which has been reduced by the addition of bitumen cutter of an approved type (e.g., kerosene, avtur).
- (iv) Bitumen emulsion shall be a slow setting, cationic emulsion (CSS) of a type which complies with the specified requirements of AASHTO M 208.

(c) Bitumen Additive

- (i) Bitumen additives shall be used if and when directed by the Engineer. Prior approval must be obtained from the Engineer regarding the type of additive to be used.

(d) Coarse Mineral Aggregates

- (i) Coarse aggregates shall consist of crushed stone produced from rock or boulders or crushed gravel particles larger than 2.36 mm in size. The originating rock or boulder material shall be at least four times the maximum size of the final crushed stone.
- (ii) The aggregate shall be clean, hard, angular, durable and free from clay or other aggregations of fine material, silt, soil, organic matter, or other deleterious substance.
- (iii) Coarse aggregate shall, unless otherwise stipulated, conform to the quality requirements of AASHTO M 80. Only one source of coarse aggregate shall be used except by written permission from the Engineer.
- (iv) The crushed aggregate shall also meet the relevant requirements of Section 2.1 of AASHTO M 147 and not less than 75 percent by weight of the particles retained on the 4.75 mm sieve shall have at least two fractured faces and 90 percent one or more fractured faces.
- (v) The abrasion loss (AASHTO T 96) shall not exceed 40 percent. Any aggregates liable to polish shall not be used for the coarse aggregate fraction. The coarse aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required for the composition of the mix.
- (vi) The coarse aggregates shall be tested in accordance with British Standards BS EN 933-3 to determine Flakiness index and BS 812-105.2 to determine Elongation Index. When so tested, the Flakiness Index and the Elongation index shall not exceed 35 percent.
- (vii) When subjected to Coating and Stripping Tests, AASHTO T 182, the aggregates shall have a coated area of not less than 95 percent.

(e) Fine Mineral Aggregates

- (i) Fine aggregate (passing the 4.75 mm sieve) shall consist of natural sand, stone, screenings, or a combination thereof, and unless otherwise stipulated shall conform to the quality requirements of AASHTO M 29 (ASTM D1073). Fine aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required for the composition of the mixture. The sand equivalent, tested in accordance with AASHTO T 176, shall be greater than 50.

(f) Mineral Filler

- (i) Filler material for asphaltic materials shall conform to the requirements in AASHTO M 17 and shall generally consist of finely ground particles of limestone, hydrated lime, Portland cement, fly-ash or other approved

- non-plastic material.
- (ii) When the Strength Index as determined according to the Ontario Vacuum Immersion Marshall Test or the U.S. Army Corps of Engineers - Asphalt Institute Immersion Marshall Test is less than 75%. Either 1 to 2 per cent of hydrated lime or 2 to 4 per cent of Portland cement by weight may be added to the mix.
 - (iii) Hydrated lime and Portland cement shall be properly stored to prevent the lime and cement becoming moist. Lime or cement that is partially hard and contains lumps shall not be used and must be removed from the site.

(3) Other materials if necessary for work execution.

A001.03 WORK PROCEDURES

- (1) Mark out and layout the area to be replaced with chalk by drawing a rectangular alignment around the defect.
- (2) Cut and shape existing asphalt layer(s) vertically with an asphalt cutter.
- (3) Demolish existing asphalt layer(s) with a rock drill and excavate down to the surface of the sub-grade using an excavator.
- (4) Trim surface of sub-grade, and compact with the roller and the compactor.
- (5) Spread the material and compact with the roller and the compactor. The compacted thickness of 1 layer is not less than 75mm, nor exceed 150mm. Conscientious compaction is required at corner of the area because the corner is difficult to compact properly and tend to result in area of low density and/or loose material.
- (6) Spray prime coat on the surface of base course after removing dust and mud.
- (7) Spread and level hot/cold asphalt mixture on the surface of base course, and compact with the roller and the compactor. Finished surface height shall be 0.5 to 1.0cm higher than the existing surface level because the repaired surface is liable to subside after it is opened to the public.
- (8) Make the area clean & tidy.

A001.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A001-1	Spot replacement	Metre Cube

A001.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

1.1.2 CONCRETE PAVEMENT

CODE A002 PATCHING (CONCRETE PAVEMENT)

A002.01 DESCRIPTION

- (1) This work is to repair the defects such as pothole, joint settlement, crocodile crack and surface textile deficiencies on concrete pavement by placing asphalt mixture (hot or cold premixed).

A002.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials applied for the work should comply with following requirements.

1. Tack coat

Type of material and the spraying temperature are shown below.

Spraying temperatures for tack coats

Cutback Grades (US Asphalt Institute)	Whirling Spray Jets		Slots Jets	
	Min	Max	Min	Max
	°C	°C	°C	°C
MC 30	50	60	40	50
RC/MC 70	65	80	55	70
RC/MC 250	95	115	80	90
RC/MC 800	115	135	105	115
RC/MC 3000	135	150	120	130

2. Asphalt mixture

(a) Hot asphalt mixture

The material should be procured from the licensed supplier(s). The Engineer should examine the quality certificate and the site facilities to confirm the applicability of the material. Diameter of a grain should not exceed 13mm. Temperature of the mixture on site should not be less than 130 degree Celsius.

(b) Cold asphalt mixture (Premixed)

The material should be procured from the licensed supplier(s). Diameter of a grain should not exceed 5mm.

- (3) Other materials if necessary for work execution.

A002.03 WORK PROCEDURES

- (1) Mark out and layout the subject area with a chalk or paint.
- (2) Cut and shape subject area vertically with an asphalt cutter.
- (3) Sweep, clean and ensure the dryness on the subject area.

- (4) Apply hot cutback bitumen on specified temperature to the area marked using a spray lance or watering can at a rate of 1.00 (ltr/sq.m) to form tack coat.
- (5) Spread and level the asphalt mixture, and compact with the roller and the compacter. Subsidence due to joint settlement is repaired.
- (6) Finished surface height should be slightly higher than existing surface level because the repaired surface is liable to subside after it is opened to the public. 1cm extra height per 3cm repaired depth may be tentatively aimed.
- (7) Spreading and compaction work is divided into 2 times in case the repaired depth exceeds 7cm.
- (8) Make the area clean & tidy.
- (9) After a week of completion, return to the worked area for sweeping and removing loose aggregates on the area to ensure safety.
- (10) Make the area clean and tidy.

A002.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A002-1	Patching (concrete pavement)	Metre Square

A002.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A003 CRACK SEALING (CONCRETE PAVEMENT)

A003.01 DESCRIPTION

- (1) This work is to repair transverse or longitudinal cracking on cement concrete pavement.

A003.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials applied for the work should comply with following requirements.

Material Specification of Sealant Material

Material	Specifications (AASHTO/CT)	Application Type
Asphalt emulsion	M140, M208/CT Sec. 94	Filling
Asphalt cements	M20, M226/ CT Sec.94	Filling
Polymer modified emulsion	M140, M208/ CT Sec. 94	Filling (Minor Sealing)
Asphalt rubber (AR)	CT SSP 37-400	Sealing
Specialty AR Low modulus	CT SSP 37-400	Sealing

- (3) Other materials if necessary for work execution.

A003.03 WORK PROCEDURES

- (1) Clear cracks and remove all loose particles by wire brush or chisel and clean with the air compressor.
- (2) Larger cracks should be cut with a diamond cutter or other mechanical cutter prior to seal.
- (3) Material placement methods:
1. Flush Fill Method
 - ✓ Fill the sealant material into the crack by spatula.
 - ✓ Remove excess material on the surface of the pavement.
 2. Overband Method (simple band-aid)
 - ✓ Fill the sealant material into the cracks by spatula.
 - ✓ Spread the excess material on the pavement surface.
 3. Overband Method (Capped)
 - ✓ Fill the sealant material into the cracks by spatula.
 - ✓ Leave the excess material on top of the pavement (no scraping or squeezing)

4. Reservoir Method

- ✓ Crack should be cut or routed to form reservoir for filling with sealant.
- ✓ Sealant application may be left flat or slightly below the road surface.

5. Combination Method (Sand fill with Recessed finish)

- ✓ Fill crack with clean sand leaving 25 mm in depth from the pavement surface.
- ✓ Tamp or compact slightly with a steel rod or piece of rebar to reduce any large voids in the sand.
- ✓ Apply crack sealer over the top of the sand and along the crack faces leaving the sealant surface cupped slightly below the pavement surface.

6. Backer Rod

- ✓ Backer rod is usually used for joint sealing applications that requires breaker. It is placed in the joint or crack to restrict the sealant depth on level to the surface.
- ✓ After the crack has been cut and cleaned, Backer Rod is to be inserted in the crack to serve as the stopper of the sealant.
- ✓ Apply sealant on the crack until to the pavement surface level leaving the surface a recessed, flushed, or capped finish.

(4) Remove all debris and excess materials and disposed into a safe place.

(5) Make the area clean and tidy.

A003.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
A003-1	Crack sealing (concrete pavement)	Metre Square

A003.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA001 SPOT REPLACEMENT (CONCRETE PAVEMENT)

AA001.01 DESCRIPTION

- (1) This work is to recover strength of deeply deteriorated concrete pavement and prevent further enlargement of the affected area by wholly replacing with new material.

AA001.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials applied for the work should comply with following requirements.

1. Crushed stone (Corresponding to SECTION 301 and/or 302 of the STS.)

(a) Sub base course

(i) General

- 1) All material shall be free from dirt, organic matter, shale or other deleterious matter and shall be of such quality that it will bind readily to form a firm, stable course.

(ii) Grading Requirements

- 1) The material shall be tested according to AASHTO T 27, and shall consist of uniform mixtures of naturally occurring or processed materials comprising gravel and/or crushed rock fragments with sand, silt and clay conforming to the following grading requirements:

Grading Requirements of Aggregate Subbase

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Sub-base Type A	Sub-base Type B	Sub-base Type C
100			
75			
50.0		100	100
37.5	100	85 – 95	80-100
25.0	75 - 90		
19.0	60 - 82	60 – 80	60-100
9.5	45 - 66		
4.75	34 – 55	25 – 55	30-100
2.0	25 – 43	15 – 35	17-75
0.425	12 – 25	7 – 20	9-50
0.075	6 – 15	2 – 10	5-25

- 2) Depending on the availability of material at the Works site or in reasonable proximity the Contractor shall select material Type A, Type B or Type C for the Aggregate Sub-base, as approved by the Engineer.

- 3) Each location where Aggregate Sub-base is applied shall receive only one type of material (Type A, Type B or Type C). However, it is permissible to use different type of Sub-base materials on different sections of the road. If Sub-base material of one type is scarce, different types of Sub-base materials can be used in the same location of the road. In this case Type B and Type-C shall be used for the Lower Sub-base and the better quality material, grading Type A, shall be used for the Upper Sub-base. In all cases the selection and application of Sub-base material type shall be done in close coordination with the Engineer and is always subject to his final approval.

(iii) Other Requirements

- 1) Coarse aggregate shall comprise material retained on a 4.75 mm (AASHTO No. 4) sieve and shall consist of hard, durable particles or fragments of stone or gravel. Materials that break when wetted and dried shall not be used.
- 2) The coarse aggregate for sub-base shall be crushed rock (with a minimum of 50% of particles having at least two crushed faces), that for lower sub-base may comprise natural gravel materials.
- 3) Fine aggregate (material passing the 4.75 mm sieve) shall consist of natural or crushed sand.
- 4) The various fractions shall have properties according to the following table:

Properties of Coarse and Fine Aggregates	
Property/Test	Sub-base
Fraction passing 19 mm sieve	
CBR (4 days soaked), @ 95% of MDD	min 30%
AASHTO T 193	
Coarse aggregate, material retained on a 4.75 mm sieve	
Wet/Dry Strength Variation	max 45%
Los Angeles Abrasion, AASHTO T 96	max 45%
Fraction passing 0.425 mm sieve	
Liquid Limit, AASHTO T 89	max 25%
Plasticity Index, AASHTO T 90	max 12%, min 4%
Plasticity Modulus	max 175
Linear Shrinkage, AASHTO T 92	max 5%

- 5) When the material is sourced from a borrow pit, the Contractor shall demonstrate to the satisfaction of the Engineer, that the material can be excavated without being contaminated by unacceptable material. The Contractor at his own cost shall take such actions the Engineer considers necessary to ensure that the material being excavated is not being contaminated. Where in the opinion of the Engineer, the Contractor cannot extract the material

from the borrow without contamination, then the Contractor shall obtain material from another source at his own cost.

(iv) Acceptance of Production Materials

- 1) When the stationary blend method is used, the aggregate will be accepted immediately following mixing, based on periodic random samples taken from the pugmill output.
- 2) When the aggregate is a single source aggregate, it may be accepted at the borrow pit or crusher. Acceptance of the materials by the Engineer does not constitute acceptance of the sub-base, only that the materials are approved for use as sub-base.

(v) Capping Layer

- 1) This material shall be used to provide sufficient cover on weak subgrades and shall be used in the lower part of the sub-base as a substitute for a thick sub-base to reduce costs. The requirements are less strict than for an ordinary sub-base.
- 2) The 4 days soaked CBR shall be at least 15 % (AASHTO T 193) compacted in the laboratory at the minimum of 95 % of the maximum dry density (AASHTO T 180).
- 3) The fraction of material passing the 0.425 mm sieve shall have a Liquid Limit (LL) not greater than 35% and a Plasticity Index (PI) between 4% and 12%.
- 4) The quantity of the fraction passing the 0.075 mm sieve shall be not greater than two-thirds of the quantity of the fraction passing the 0.425 mm sieve.

(b) Base course

(i) General

- 1) The coarse and fine aggregates for base shall consist of crushed rock, clean, tough, durable, sharp-angled fragments free of any excess of thin or elongated pieces, and reasonably free of soft, disintegrated or decomposed stone, dirt or other deleterious matter.
- 2) The aggregate shall be obtained by crushing material, which if so directed by the Engineer, has first been screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least two mechanically fractured faces.

(ii) Grading Requirements

- 1) Material for base course shall be crushed rock and the combined aggregate shall have the following grading. Testing of grading is to be done according to AASHTO T 27:

Grading Requirements of Crushed Aggregate Base Course

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Type A	Type B	Type C
50.0	100	–	–
37.5	90 – 100	100	–
25.0	75 – 95	85 – 100	100
19.0	60 – 90	70 – 90	70 – 100
9.5	40 – 75	50 – 85	50 – 85
2.36	20 – 45	25 – 45	20 – 50
0.425	10 – 26	10 – 25	15 – 30
0.075	4 – 12	5 – 15	5 – 15

(iii) Other Requirements

- 1) The combined material passing the 19 mm sieve shall have a 4 days soaked CBR not less than 80% (AASHTO T 193) at 95% of Maximum Dry Density (AASHTO T 180).
- 2) Aggregate retained on the 2.36 mm sieve shall have a percentage of wear, by Los Angeles Abrasion test AASHTO T 96, of not more than 40%.
- 3) Coarse aggregate flakiness and elongation indices, determined by BS EN 933-3 (Flakiness index) and BS 812-105.2 (Elongation Index), shall not be greater than 35%. Soundness loss shall not be greater than 12% as determined by AASHTO T 104.
- 4) The fraction passing the 0.425 mm sieve shall have a liquid limit (AASHTO T 89) not greater than 20 and plasticity index (AASHTO T 90) not greater than 6 nor less than 2 and the Plasticity Product (PI x percentage passing the 0.425 mm sieve) shall not exceed 90.
- 5) The aggregate shall have a 10% Fines Value (wet) [AASHTO T 176] of not less than 130 kN and the Wet Dry Variation of the 10% Fines Value shall not exceed 40%.

(iv) Acceptance of Production Materials

- 1) The aggregate will be accepted immediately following mixing, based on periodic random samples taken from the mixing plant output. Acceptance of the material by the Engineer does not constitute acceptance of the base, only that the material is approved for use in the base.

2. Cement stabilized material (Corresponding to SECTION 308 of the STS.)

(a) Aggregate

- (i) Natural gravels and coarse (clayey) sands shall be stabilized with cement (or lime – see Section 309) if they comply with the specified requirements. Three types of cement stabilized layers can be used and the strengths required for each layer after stabilization are defined in below table.

Strengths Requirements after Stabilization

	Unconfined Compressive Strength, UCS (MPa)
Cement stabilised Base Course 1, CB 1	3.0 – 6.0
Cement stabilised Base Course 2, CB 2	1.5 – 3.0
Cement stabilised Sub-Base, CS	0.75 – 1.5

- (ii) Samples for strength tests shall be mixed, followed by compaction in a cylinder (Modified AASHTO T 180) and then cured for 7 days in a room with a temperature of 19.5 °C – 22.5 °C, with moisture (humidity) of 95 % to 100 %. After 7 days curing in the room, the samples shall be soaked in water for at least 4 hours, before the UCS testing.
- (iii) Below two tables shows desirable properties of material before stabilization.

Desirable Grading of Material before Stabilization

ASTM Test Sieve, mm	Percent passing (by weight)	
	CB 1	CB 2
50	100	100
37.5	85 – 100	80 - 100
19	60 – 90	55 – 90
4.75	30 – 65	25 – 65
2.36	20 – 50	15 – 50
0.425	10 – 30	10 – 30
0.075	5 – 15	5 - 15

Desirable Properties of Material before Stabilization

	Maximum allowable values		
	CB 1	CB 2	CS
Liquid Limit (LL), %	25	30	
Plasticity Index (PI), %	6	10	20
Linear Shrinkage (LS), %	3	5	

- (iv) Materials to be stabilized shall have a Coefficient of Uniformity of at least 5. The Coefficient of Uniformity is defined as the ratio of the sieve size through which 60 per cent of the material passes, to the sieve size through which 10 percent passes (D60 / D10).
- (v) The Plasticity Index and the Liquid Limit shall be measured on the fraction passing the 0.425 mm sieve.

(b) Cement

- (i) Cement shall conform to the requirements of Portland cement with authorized material certifier.

(c) Water

- (i) Water shall be clean and free from harmful matter and may be tested in accordance with AASHTO T 26 at the Engineer's discretion. Water thus tested and found to have a pH value less than 5.0 or more than 8.5 shall not be used.
- (ii) Furthermore water shall not contain more than 400 parts per million by weight of sulphate.

3. Reinforced concrete (Corresponding to SECTION 314 of the STS.)

(a) Cement

- (i) Cement used in concrete shall be ordinary Portland cement conforming to AASHTO M 85 or ASTM C150, Type I.
- (ii) Blast furnace cement (slag cement) shall not be used without the written permission of the Engineer.
- (iii) Test reports from the manufacturer shall be attached when cement is delivered to the Site, and checked for brand, grade and test results.
- (iv) At the time of use, all cement shall be free flowing and free of lumps. Cement that has been in storage for a period of 3 months if bagged, or 6 months if bulk, or if the Engineer is in doubt about its quality, shall be tested by the standard mortar test of AASHTO T 106 to determine its suitability for use and such cement shall not be used without approval by the Engineer.
- (v) All cement shall have a compressive strength of standard cement mortar samples at 28 days of not less than 25.0 MPa, tested in accordance with AASHTO T 131.
- (vi) When factory tests or field tests subsequent to the original approval tests, show that the cement does not comply with the Specifications, the entire consignment from which the sample was taken will be rejected and the Contractor shall immediately remove the rejected material from the Site and replace it with cement which meets the required specifications.

(b) Water

- (i) A thorough chemical water analysis shall be made before using water from any particular source for concrete mixing. Testing shall be in accordance with AASHTO T 26.

- (ii) Mixing water shall be reasonably clean and free from injurious amounts of oil, acid, alkali, sugar, salt, vegetable, organic matter or other deleterious substances.
 - (iii) The chloride ion concentration of the mixing water, when tested according to ASTM D512 shall not exceed 1,000 ppm.
 - (iv) Acid water with a pH value of less than 4, when tested according to AASHTO T 26 shall not be used.
 - (v) Water with a sulphate ion concentration (measured in SO₄) of more than 1,300 ppm, when tested according to ASTM D516 shall not be used.
 - (vi) Water known to be of potable quality may be used without testing, subject to the approval of the Engineer.
 - (vii) These provisions apply only for mixing water and not for water used for washing the aggregates and curing the concrete.
 - (viii) When comparative tests are made with water of known satisfactory quality, in conformance with AASHTO T 106, any indications of unsoundness, marked change in time of set (not exceeding 30 minutes when tested in accordance with AASHTO T 131) or reduction of more than 10% in mortar strength shall be sufficient cause for the rejection of the water under test.
 - (ix) Water obtained from a source which is liable to seasonal variation in water quality shall be re-tested at intervals not exceeding 3 months or as required by the Engineer.
- (c) Coarse Aggregate
- (i) Coarse aggregate shall conform to AASHTO M 80, except as otherwise specified herein, and shall consist of gravel, crushed gravel or crushed stone free from deleterious substances.
 - (ii) Crushed stones of lime rock corroded by mineral water, especially acid water, and stone material containing such irremovable foreign matter as coal, cinder coal, lime, broken bricks or burnt stones shall not be used.
 - (iii) Coarse aggregate shall have the following grading, depending on the permissible maximum particle size:

Grading of Coarse Aggregate

AASHTO T 27 Sieve (mm)	Percentage Passing (by weight)				
	Class A	Class B	Class C	Class D	Class E
63	100	-	-	-	-
50	95 - 100	100	-	-	-
37.5	-	95 - 100	100	-	-
25	35 - 70	-	95 - 100	100	-
19	-	35 - 70	-	95 - 100	100
12.5	10 - 30	-	25 - 60	-	90 - 100
9.5	-	10 - 30	-	20 - 55	40 - 70
4.75	0 - 5	0 - 5	0 - 10	0 - 10	0 - 15
2.36	-	-	-	-	0 - 5

- (iv) The content of clay lumps and friable particles when tested according to AASHTO T 112 shall not be more than 1% by weight.
- (v) Flakiness index and elongation index shall not exceed 25% when tested in accordance with BS EN 933-3 (Flakiness index), respective BS 812-105.2 (Elongation Index).
- (vi) The maximum loss when tested according to AASHTO T 104 (5 cycles) for sodium sulphate soundness shall be 10%.
- (vii) When tested for abrasion according to AASHTO T 96, after 500 revolutions, the maximum loss shall be 35%.

(d) Fine Aggregate

- (i) Fine aggregate shall conform to the requirements of AASHTO M 6, except as otherwise specified herein, and shall consist of natural sand or, subject to the approval of the Engineer, of a combination of not more than 50% by weight of stone screenings and natural sand, having hard, strong, durable particles.
- (ii) Fine aggregate from different sources shall not be mixed or stored in the same stockpile nor used alternatively in the same class of construction or mix without written permission from the Engineer.
- (iii) Fine aggregate shall have the following grading:

Grading of Fine Aggregate	
AASHTO T 27 Sieve (mm)	Percentage Passing
9.5	100
4.75	95 - 100
2.36	80 - 100
1.18	45 - 80
0.60	25 - 60
0.3	10 - 30
0.15	2 - 10

- (iv) The above grading requirements represent the extreme limits which shall determine suitability for use from all sources of supply. The grading from any one source shall be reasonably uniform, and not subject to the extreme percentages of grading specified.
 - (v) To determine the degree of uniformity, a fineness modulus determination shall be made by the Contractor upon representative samples from such sources as he proposes to use. The fineness modulus shall be determined in accordance with AASHTO M 6. The fineness modulus shall be within the range of 2.3-3.1.
 - (vi) Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative samples submitted by the Contractor may be rejected, until suitable adjustments can be made in the mix proportions to compensate.
 - (vii) When tested by the calourimetric method for organic matter according to AASHTO T 21, the colour shall be lighter than standard. The content of sulphide and sulphate (converted into SO₃) shall not be more than 0.5% by weight. The maximum loss when tested to 5 cycles for sodium sulphate soundness according to AASHTO T 104 shall be 10%.
- (e) Reinforcement
- (i) Bars
 - 1) All reinforcing bars shall be deformed and shall conform to the requirements of AASHTO M 31, as required on the Drawing.
 - (ii) Wire and Wire Mesh
 - 1) Cold drawn steel wire shall conform to the requirements of AASHTO M 32.
 - 2) Welded steel wire mesh shall conform to the requirements of AASHTO M 55.
 - (iii) Bar Mats
 - 1) Steel bar mats shall conform to the requirements of AASHTO M 54.
 - (iv) Binding Wire
 - 1) Binding wire shall be high quality black annealed mild steel wire, approximately 1.6 mm in diameter.
 - (v) Certification
 - 1) A manufacturer's certified mill test report showing physical and chemical analysis for each lot of reinforcing bars delivered shall be provided to the Engineer.

(vi) Identification

- 1) The bars in each lot shall be legibly tagged by the manufacturer before being offered for inspection. The tag shall show the manufacturer's test number and lot number or other designation that will identify the material with the mill certificate issued for that lot of steel.
- 2) The manufacturer shall furnish certificates showing the heat number or numbers from which each size of bar in the shipment was fabricated.

(f) Admixtures

- (i) The consent of the Engineer shall be obtained in writing prior to the use of admixtures or cement containing additives.
- (ii) Chemical admixtures shall conform to AASHTO M 194. Unless otherwise specified, only Type A (water-reducing), Type B (retarding) and Type D (water reducing-retarding) shall be used.
- (iii) Water reducing admixture shall be added to concrete for precast prestressed girders to improve the workability if ordered by the Engineer.
- (iv) The Contractor shall submit the manufacturer's certified formula for the proposed admixture with sufficient evidence that the proposed admixture has given satisfactory results on other similar work. Permission to use the admixture may be withdrawn at any time when unsatisfactory results are obtained.
- (v) The amount of admixture to be used shall be in accordance with the manufacturer's specification and it shall be verified by testing to the approval of the Engineer.
- (vi) Admixture containing chloride ion exceeding 1% by weight of the admixture shall not be used in reinforced concrete.
- (vii) The Contractor shall introduce the admixture in the mix in a water solution and the water so included shall be calculated as effective mix water.
- (viii) Concrete with a retarding admixture must reach initial set at least 1 hour later, but not more than 3 hours later than the reference concrete and must reach final set not more than 3 hours later than the reference concrete, when tested in accordance with AASHTO T 197.

(g) Jointing Materials

- (i) All jointing materials used in concrete shall conform to following requirements:

- (ii) Joint Fillers - non-extruding and resilient types shall conform to the requirement of AASHTO M 153, or M 213. Bituminous type filler shall conform to the requirement of AASHTO M 33.
- (iii) Joint Primer - Joint priming compound shall be Expandite No. 3 or other approved equal primer.
- (iv) Joint Sealing Compound - Horizontal joint sealing material shall be Expandite Plastic hot poured rubber-bitumen sealing compound Grade 99 or other approved equal compound. Vertical or inclined joint sealing material shall be Expandite Plastijoint bituminous putty or other approved equal compound.
- (v) Alternatively joints shall be sealed with a hot applied joint sealant conforming to the Specification for Joint and Crack Sealants, Hot-Applied, for Concrete and Asphalt Pavements, ASTM D 6690, Type II.
- (vi) Prior to applying any Jointing Material, the Contractor shall furnish a Certification of Compliance to the Engineer.

(3) Other materials if necessary for work execution.

AA001.03 WORK PROCEDURES

- (1) Mark with chalk damaged area that requires major repairs. The marking shall be at least 500mm beyond the edge of the damaged area.
- (2) Cut along the marked area with concrete cutter to remove the concrete slab and cart away to spoil to an approved pit.
- (3) Trim surface of sub-grade, and compact with roller and the compactor.
- (4) Spread the material and compact with the roller and the compactor. The compacted thickness of 1 layer is not less than 75mm, nor exceed 150mm. Conscientious compaction is required at corner of the area because the corner is difficult to compact properly and tend to result in area of low density and/or loose material.
- (5) Spray prime coat on the surface of base course after removing dust and mud.
- (6) Comply the following work sequences. (Corresponding to SECTION 314 of the STS.)

1. Pavement Base

- (a) The base upon which the concrete pavement is laid shall have been constructed or prepared under other items of the Contract and shall be smooth, compacted and true to the grades and cross sections shown on the plans and shall be so maintained, as provided under such other items, throughout the period of placing concrete pavement.
- (b) To ensure the proper depth and section, a scratch template true to depth

and section and resting on accurately set side forms shall be moved over the surface immediately before placing concrete, and any irregularities shall be immediately corrected. High spots shall be planed down, and the Contractor shall have the option of either filling low spots to the proper elevation with approved material, which shall be watered, compacted and struck-off to the required grade, or of placing additional concrete. No measurement or payment will be made for such additional concrete. Until the subgrade has been checked and approved, no material shall be deposited thereon.

- (c) Storing or stockpiling of materials on the subgrade will not be allowed. The placing of concrete paving materials or laying of pavement on a muddy or sodden subgrade will not be permitted.

2. Forms

- (a) Forms shall be made of steel of an approved section, with a base width of at least twenty (20) cm and the depth shall be equal to the thickness of the pavement at the edge as shown on the plans. The forms shall be staked with steel stakes, and stakes shall be of a length approved by the Engineer. Each section of forms shall have a stake pocket at each end and at intervals of not more than one and one-half (1.5) m between ends. The stake pockets shall have approved devices for locking the form to the steel stakes. Each section of forms shall be straight and free from bends and warps at all times. No section shall show a variation greater than three (3) mm in three (3) m from a true plane surface on the top of the form, and the inside face shall not vary more than six (6) mm from a plane surface.
- (b) Before placing forms, the underlying material shall be excavated to the required grade, and shall be firm and compact. The forms shall have full bearing upon the foundation throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement. They shall be so supported during the entire operation of placing, tamping and finishing the pavement that they will not deviate vertically at any time more than three (3) mm from the proper elevation. Forms shall be set to the required lines and grades well in advance of placing concrete, preferably not less than two hundred (200) m.
- (c) Forms shall not be removed for at least twelve (12) hours after the concrete has been placed. Forms shall be carefully removed in a manner to avoid damage to the pavement. Under no circumstances will the use of pry bars between the forms and the pavement be permitted. Pavement, which in the opinion of the Engineer, is damaged due to the careless removal of forms shall be repaired by the Contractor, at directed by the Engineer, at the Contractor's own expense.
- (d) Forms shall be thoroughly cleaned and oiled each time they are used. When pavement is placed adjoining an existing concrete pavement upon which the finishing machine will travel, any irregularities in the old pavement shall be ground down to a true, uniform surface, of sufficient width to accommodate the wheels of the finishing equipment, if necessary to obtain proper smoothness of the pavement.

3. Composition, Proportioning, Consistency, and Mixing

(a) Concrete Mix Design

(i) General Requirements

- 1) The mix shall be proportioned so as to secure a workable, finishable, durable, watertight and wear resistant concrete of the required strength.
- 2) Mixes for the grades of concrete required for the Works shall be designed by the Contractor, and shall be subject to approval by the Engineer.
- 3) Durable concrete of suitably low permeability shall be obtained by the use of strong dense aggregates, a sufficiently low water/cement ratio, complete compaction and proper curing methods to ensure sufficient hydration of the cement.
- 4) The mix shall be designed to allow it to be properly placed, and the difficulty in mixing and/or transportation shall not be considered in the mix acceptability.
- 5) Concrete as dry as it is practical to place with the available equipment shall be used.
- 6) The quantity of mixing water once approved shall not be varied without the prior written approval of the Engineer.

(ii) Strength Requirements

- 1) In calculating the water/cement ratio of the mix, the weight of water shall be the total free water in the mix which includes the mixing water, the water in any admixture solution and any water in the aggregates.
- 2) The consistency of fresh concrete shall be monitored by testing the slump in accordance with AASHTO T 119. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted in the particular location as required, and to produce concrete of the following consistencies or as otherwise approved by the Engineer.

Type of Work	Slump of Concrete	
	Nominal slump (mm)	Maximum slump (mm)
Formed elements		
Sections over 300mm	60	90
Sections under 300mm	80	90
Slabs with crossfall	60	80

- 3) The cement content in any mix shall not exceed 500 kg/m³ if not otherwise specified or directed.

- 4) Unless otherwise approved by the Engineer, the mix designs shall be on the basis of continuously graded aggregates.
- (iii) Trial Mixes
- 1) At least 56 days before the commencement of concreting the Contractor shall, have trial mixes designed and prepared in the laboratory for the approval of the Engineer. The concrete from each mix shall be tested in accordance with the following procedures and shall satisfy the strength requirements specified.

General

- a) A strength test shall consist of the average strength of three compressive strength test cylinders fabricated from material taken from a single randomly selected batch of concrete, except that, if any cylinder should show evidence of improper sampling or testing, the said cylinder shall be discarded and the strength test shall consist of the strength of the remaining cylinders.
- b) From any batch, 3 samples shall be taken, and 2 test cylinders shall be made from each of the 3 samples. Three test cylinders shall be tested at 7 days and the other three test cylinders tested at 28 days. The six test cylinders shall constitute a set of test specimens.
- c) The average value of the compressive strengths of the three test specimens will be taken as the compressive strength of the set.

Field Cured Specimens

- a) For determining the adequacy of curing and protection, and for determining when loads or stresses can be applied to concrete structures, test cylinders shall be cured at the structure site under conditions that are not more favourable than the most unfavourable conditions for the structure which they represent as described in Section 9.4 of AASHTO T 23.

Acceptance of Concrete

- a) For determining compliance with a specified 28-day compressive strength, test cylinders shall be cured under controlled conditions as described in Section 9.3 of AASHTO T 23 and tested at 28 days.

Sampling

- a) At least one set of test specimens shall be taken once every day on which concreting work is in progress.
- b) Test specimens shall be made from each separate concrete

grade and mix ratio, and shall be typical for the portion of concrete they represent.

- c) For mass concrete structures, at least one set of test specimens shall be made from each 100 cubic metres of concrete.
- d) For reinforced concrete and prestressed concrete, at least one set of test specimens shall be made from each 50 cubic metres of concrete.
- e) At least one set of test specimens shall be taken from each pier cap, column and abutment.
- f) For precast concrete girders, at least one set of test specimens shall be taken from each precast element.
- g) For small scattered work, such as minor culverts and incidental structures, at least one set of test specimens shall be taken from each grade of concrete in the structure.
- h) Where an identical mix is being placed in different parts of the same work (e.g. a bridge), sampling may be limited to one set of test specimens with the prior approval of the Engineer.

Strength Requirements

- a) No individual 28-day test cylinder from any set of test specimens shall be less than the specified 28-day compressive strength by more than 3 MPa, and the average value of the 28-day compressive strengths of any set of test specimens shall be not less than the specified 28-day compressive strength.
- b) A series of test specimen sets shall comprise sets of test specimens from each structural member of an integral structure, or sets of test specimens from one or more prefabricated members having similar mixes.

Test Results and Additional Tests

- a) Should the compressive strength value obtained from the tests fail to comply with the specified requirements, the Engineer may require core samples to be taken and tested in accordance with the standard methods of AASHTO T 24. The Contractor shall, at his own expense, furnish all equipment required for such sampling and testing.
- b) Direct loading tests may also be ordered for examination of the load capacity of the structure or member.
- c) No member shall be used until a satisfactory test result has been obtained or the specified requirement is achieved by means of strengthening methods, and approval has been given

by the Engineer.

- 2) The Contractor shall furnish single use cylinder moulds conforming to AASHTO M 205, or when approved by the Engineer, reusable vertical moulds made from heavy gauge metal.
- 3) A minimum of ten test cylinders taken from a trial batch of the proposed mix shall be made with the materials approved for use by the Engineer, with five tested at 7 days and five at 28 days. Testing shall be witnessed by the Engineer.
- 4) The average strength of the cylinders tested at 7 days shall not be less than 70% of the specified 28 day strengths.
- 5) The average strength of the cylinders tested at 28 days shall be at least 20% greater than the specified 28 days strength.
- 6) The Engineer will review the Contractor's trial mixes and cylinder strengths at 7 and 28 days. The Engineer will then determine which of the trial mixes shall be used. If none of the mixes for a given grade meets the Specifications or is acceptable to the Engineer, the Contractor shall prepare additional trial mixes.
- 7) No structural concrete shall be placed in the Works until the relevant trial mix has been approved by the Engineer.
- 8) When a trial mix has been approved, no variations shall be made in the proportions, the source of the cement and aggregates, or in the type, size and grading of the latter without the consent of the Engineer.
- 9) Should any variations be made which, in the opinion of the Engineer, could influence the strength or characteristics of the concrete, concreting operations shall cease and further trials undertaken by the Contractor. Concreting shall not recommence until a new mix has been approved by the Engineer.
- 10) When the Contractor intends to purchase factory made precast concrete units, the Engineer may dispense with trial mixes and laboratory tests provided that evidence is given which satisfies him that the factory regularly produces concrete which complies with the Specifications. The evidence shall include details of mix proportions, water/cement ratios, workability and strengths obtained at 28 days.

(b) Batching and Mixing Concrete

(i) Delivery and Storage of Materials

- 1) The batching site shall be of adequate size to permit the stockpiling of sufficient base materials, having proper and uniform moisture content to ensure continuous and uniform operation.

- 2) Aggregates shall be stockpiled in such quantities that sufficient material approved by the Engineer is available to complete any continuous pour necessary for structures.
- 3) All aggregates shall be stockpiled for at least 12 hours before use in order to promote a uniform moisture content and to provide uniform conditions for proportioning plant control. Segregation shall be avoided.
- 4) Aggregate for concrete shall not be contaminated by other materials during transport and during storage on Site, and shall be stockpiled, preferably on a concrete slab, in such a manner that will preclude the intrusion of foreign material. If aggregates are stored on the ground, the bottom 200 mm minimum thickness layer of aggregates shall not be disturbed or used without re-cleaning, and an approved system of permanent gauges shall be installed to indicate that minimum thickness.
- 5) Coarse aggregate, unless otherwise permitted by the Engineer, shall be delivered to the Site in separate sizes.
- 6) Aggregates of different sizes shall be stored in different hoppers, or different stockpiles which shall be separated from each other.
- 7) Stockpiles of coarse aggregate shall be built in horizontal layers not exceeding one metre in depth to avoid segregation. Should the coarse aggregate become segregated it shall be re-mixed to conform to the grading requirements.
- 8) Fine aggregate from different sources of supply shall not be mixed or stored in the same stockpiles nor used alternatively in the same class of construction or mix without written permission from the Engineer.
- 9) Cement shall be protected from moisture during transport and storage. Bulk transport vehicles and bins or silos for cement shall not contain any residues of a different type, or of a lower strength class or of any other materials.
- 10) Cement shall be delivered and stored in quantities sufficient to ensure that there is no suspension or interruption of the work at any time. Each consignment shall be kept separate and distinct in accordance with its mark, grade and date of production.
- 11) Cement in sacks shall be stored in a suitable weatherproof structure which shall be as airtight as practicable. Floors shall be wooden and elevated above the ground a sufficient distance to prevent the absorption of moisture. Sacks shall be stacked close together to reduce circulation of air but shall not be stacked against outside walls. The manner of storage shall permit easy access for inspection and identification of each consignment.

- 12) Bulk cement shall be transferred to elevated airtight and weatherproof bins.
- 13) In cases where only a small amount of concrete work is required, cement storage in the open may be permitted by the Engineer, in which case a raised platform and ample waterproof covering shall be provided.

(ii) Mixing Concrete

- 1) All weighing and water dispensing plant shall be maintained in good order. Their accuracy shall be checked against accurate weights and volumes when required by the Engineer. They shall be accurate to within 0.5% throughout the range of use.
- 2) The weight of each size of aggregate indicated by the mechanisms employed shall be within a tolerance of $\pm 2\%$ of the respective weight per batch agreed by the Engineer. Quantities of water, cement, and water reducing admixture shall be within a tolerance of $\pm 1\%$ respectively.
- 3) The weight of the fine and coarse aggregates shall be adjusted to allow for the free water contained in them. The water to be added to the mix shall be reduced by the quantity of free water contained in the fine and coarse aggregates, which shall be determined by the Contractor by the method of AASHTO T 255 immediately before mixing begins.
- 4) Concrete shall be mixed only in the quantities required for immediate use. Concrete that has developed initial set shall not be used. Re-tempering concrete by adding water or by other means will not be permitted. Concrete that is not within the specified slump limits at the time of placement shall not be used and shall be disposed of as directed by the Engineer.
- 5) Concrete may be mixed at the site of the work, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials are in the drum. Ready mixed concrete shall be mixed and delivered in accordance with the requirements of Sub-clause 507.05.3 herein.
- 6) Mixing of concrete shall be performed until a well distributed mixture of the various constituent materials appears with consistent colour.
- 7) When mixed at the job site or in a central mixing plant, the mixing time shall not be less than 1.5 minutes nor more than 3 minutes. Five seconds shall be added to the specified mixing time if timing starts the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Different limiting mixing times may be allowed or directed by the Engineer, based on field trials or the experience of production.

- 8) The mixer shall be operated at the drum speed shown on the manufacturer's rating plate on the mixer.
- 9) The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to continue operations while it is being repaired, provided he furnishes an approved timepiece equipped with minute and seconds hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.
- 10) Any concrete which, in the opinion of the Engineer, is mixed more or less than the specified time shall be discarded and disposed of by the Contractor at his expense.
- 11) The volume of concrete mixed per batch should not exceed the mixer's nominal capacity, as shown on the manufacturer's rating plate on the mixer. The mixer shall have a rated capacity sufficient to mix a batch of concrete containing at least one full bag of cement.
- 12) The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.
- 13) Unless otherwise agreed by the Engineer, immediately before any session of batching concrete, a preliminary part batch shall be mixed having the masses of fine aggregate, cement and water in correct proportion and no coarse aggregate. The purpose of this is to avoid loss of mortar from the first batch of concrete as specified. The preliminary batch shall be passed through all delivery equipment but not placed in the forms except with the specific approval of the Engineer.
- 14) The entire contents of the mixer shall be removed from the drum before materials for the next batch are placed therein. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.
- 15) Truck mixers, unless otherwise authorised by the Engineer, shall be of the revolving drum type, water-tight, and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass.
- 16) All solid materials for the concrete shall be accurately measured and charged into the drum at the proportioning plant.

- 17) Except as subsequently provided, the truck mixer shall be equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch, in which case a tank is not required.
- 18) Truck mixers may be required to be provided with a means by which the mixing time can be readily verified by the Engineer.
- 19) The maximum size of batch in truck mixer shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped in metal on the mixer.
- 20) Truck mixing shall unless otherwise directed be continued for not less than 100 revolutions after all ingredients, including water, are in the drum. The mixing speed shall not be less than 4 rpm, nor more than 6 rpm.
- 21) Mixing shall begin within 30 minutes after the cement has been added either to the water or aggregate, but when cement is charged into a mixer drum containing water or surface wet aggregate and when the temperature is above 32 oC, this limit shall be reduced to 15 minutes. The limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgement of the Engineer, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.
- 22) When a truck mixer is used for transportation of centrally-mixed concrete, the mixing time specified in paragraph (7) herein may be reduced to 30 seconds and mixing completed in a truck mixer. The mixing in the truck mixer shall be as specified for truck mixing.
- 23) During hot weather, the Contractor shall ensure that the constituent materials of the concrete are sufficiently cool to prevent the concrete from stiffening in the interval between its discharge from the mixer and compaction in its final position.
- 24) Manual mixing shall be only permitted with the prior approval of the Engineer for concrete in small amounts. Mixing concrete by hand shall be performed on a steel plate. Cement and fine aggregates shall be mixed uniformly in advance and then mixed with coarse aggregate and water. The mixing shall continue until a well distributed mixture of the constituent materials with uniform colour is obtained.

(iii) Ready-Mixed Concrete

- 1) Ready mixed concrete batched off the Site may be used only with the approval of the Engineer and shall comply with all relevant requirements of the Specifications for structural concrete.

(iv) Transporting Mixed Concrete

- 1) Mixed concrete may only be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturers of the equipment as agitating speed, or in non-agitating hauling equipment, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place.
- 2) Truck agitators shall be loaded not to exceed the manufacture's guaranteed capacity. They shall maintain the mixed concrete as a thoroughly mixed uniform mass during hauling.
- 3) No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point.
- 4) The rate of discharge of mixed concrete from truck mixers or agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.
- 5) When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within one hour, or before 250 revolutions of the drum or blades, whichever comes first, after the introduction of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete or when the temperature of the concrete is 30 oC, or above, a time less than one hour will be required as directed by the Engineer.

4. Placing Concrete

(a) General

- (i) The mixer shall be operated outside of the forms at all times except at locations where the Engineer deems it not feasible to do so. When ordered by the Engineer, the subgrade shall be moistened as directed, prior to the placement of the subgrade paper. The concrete shall be deposited on the subgrade in successive batches for the full width between forms and in a manner that will require as little re-handling as possible. Spreading shall be done by an approved mechanical spreader in a manner that will prevent segregation and separation of the materials. Necessary hand spreading shall be done with shovels, not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances. The amount of material deposited shall be sufficiently in excess of that required to form the pavement to the required cross section after consolidation in order to provide a roll of concrete ahead of the front screed of the finishing machine for the full length of the screed. Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all expansion joint assemblies, by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer

than fifteen (15) seconds in any one location.

- (ii) Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the hopper is well centred on the joint assembly. Damage to joint assemblies caused by dumped concrete shall be repaired immediately, as directed by the Engineer, at the Contractor's expense. Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by methods approved by the Engineer. Placement of concrete ahead of the initial spreader strike-off shall not be more than fifteen (15) minutes ahead of final spreader strike-off; if concrete is placed in one (1) layer only, the placement of concrete shall not be more than twenty (20) minutes ahead of the spreader strike-off.

(b) Adverse Weather Conditions

(i) Concreting in Cold Weather

- 1) No concrete shall be mixed at an air temperature of less than 7°C on a falling thermometer or 3°C on a rising thermometer unless proposals to counteract the effect of cold weather have been submitted by the Contractor and agreed in writing by the Engineer. Exposed surfaces of concrete shall be efficiently protected to maintain its temperature above 5°C until it has hardened.
- 2) The Contractor shall provide a thermometer suitable for measuring the temperature of aggregates and a maximum and minimum thermometer that shall be hung in a position indicated by the Engineer.

(ii) Concreting in Hot Weather

- 1) The Contractor shall take great care during hot weather to prevent the cracking or shrinking of concrete. The Contractor shall arrange for concrete to be placed in the early morning or late evening as directed by the Engineer.
- 2) The Contractor shall have particular regard to the requirements specified herein for curing.
- 3) Formwork shall be shaded from direct exposure to the sun both prior to the placement of concrete and during its setting. The Contractor shall take appropriate measures to ensure that reinforcement in and projecting from the section to be concreted is maintained at the lowest temperatures practicable. Concrete, immediately after compaction has ceased, shall have a temperature of not less than 5°C and not more than 25°C. If necessary the Contractor shall cool the aggregates and mixing water by methods approved by the Engineer.

5. Placing Reinforcement

- (a) All pavement reinforcement shall be placed as shown on the plans. Reinforcement shall have 60mm cover from the surface, except for slabs less than 150mm thick where 50mm cover shall be provided. The reinforcement shall terminate at least 40mm and not more than 80mm from the edge of the slab and from all joints except where reinforcing mats are used to span longitudinal joints instead of tie bars. At the transverse overlap of reinforcing mats the first transverse wire of one mat shall lie within the last complete mesh of the previous mat and the overlap shall be not less than 450mm. Unless otherwise directed by the Engineer, no overlap will be needed longitudinally between mats. When deformed bar reinforcement is used the overlap of the bars shall not be less than 40 bar diameters.
- (b) All marginal bars, dowel bars, and tie bars required by the plans shall be held in proper position by sufficient number of metal bar supports or pins as approved by the Engineer. If the centre joint is to be sawed instead of placing the metal centre strip, the tie bars may be installed mechanically by means of equipment and methods approved by the Engineer. The satisfactory placement of the tie bars shall depend upon the ability of the mechanical device to place the tie bars in their true position. The Engineer may require, when satisfactory placement is not obtained by mechanical means, that the tie bars be installed ahead of placing the concrete and that they be securely staked and tied if necessary to hold them in their exact position. The use of removable devices, supporting the bars from the forms, will not be permitted.
- (c) Following the placing of the concrete, it shall be struck-off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans. When reinforced concrete pavement is placed in two (2) layers, the entire width of the bottom layer shall be struck-off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the second layer of the concrete shall be placed, struck-off and screeded. Any portion of the bottom layer of concrete which has been placed more than thirty (30) minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense. Only plain concrete and bar reinforced bridge approach pavement may be placed in one (1) layer.
- (d) Where two (2) layers of wire mesh are required, as at bridge approaches, the bottom layer shall be supported in the required position with bar chairs and separators shall be used for the top layer if the strike-off cannot be properly used for the operation. Laps in adjacent sheets or mats of reinforcement shall be as shown on the plans. Laps parallel to the centreline of the pavement will not be permitted except for unusual widths of pavement lanes or for irregular areas. If the plans do not show dimensions for laps, the minimum lap either perpendicular or parallel to the centreline of the pavement shall be fifteen (15) cm. The adjacent sheets shall be fastened or tied together to hold all parts of the sheets in the same

plane.

- (e) Reinforcing steel shall be free from detrimental amounts of dirt, oil, paint, grease, loose mill scale, and loose or thick rust which could impair bond of the steel with the concrete.

6. Joints

- (a) Joints shall be constructed in accordance with the details shown on the drawings and the specifications or as directed by the Engineer and with the best of workmanship. The maximum permitted spacing of joints for reinforced concrete slabs is shown in the following table. Failure to construct the joints as called for and in the best possible manner, as determined by the Engineer, will be cause for suspension of Work until the cause of the defective Work is remedied.

Maximum Spacing of Joints for Reinforced Concrete Slabs

Minimum Weight of Mesh Reinforcement, Kg/m²	Maximum Spacing of Joints, m
2.0	12
3.0	19
4.0	25
5.0	30
6.0	35

- (b) If removal of existing pavement of any type is required to connect with the new pavement, and the termination of the removal is not at an existing joint, the new joint shall be made by sawing the existing pavement not less than five (5) cm deep before removal.

(i) Expansion Joints

- 1) The subgrade at expansion joints shall be accurately trimmed to the required cross section and to the proper depth of the pavement. A string line shall be stretched between the pavement forms along the centreline of the joint. One-half of the length of each dowel bar shall be painted in accordance with the directions shown on the plans, and then thoroughly coated with hard grease, or lubricant as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel.
- 2) The entire joint assembly shall be of a type designated on the plans and shall be installed in such a position that the centreline of the joint assembly is perpendicular to the centreline of the pavement slab and the dowels lie parallel to the centreline of the slab. Finished joints shall not deviate more than six (6) mm in the horizontal alignment from a straight line. No plugs of concrete shall be permitted anywhere within the expansion space.
- 3) A slip sleeve of the dimensions shown on the plans shall be placed

on the greased end of each dowel. The greased ends shall be free to slide in the dowel holder and shall extend in the direction as indicated on the plans. Any excess grease on the dowel holder shall be removed. The joint shall be securely staked or fastened in place prior to placing the concrete and in a manner to ensure the joint and the dowel bars will remain in their proper position after the concreting and finishing operations are completed.

- 4) Joints for pavement designed for two (2) or less lanes of traffic shall be assembled and installed in one (1) continuous piece or the connections between sections shall be made rigid and tight to prevent offsets in sections of the joints. The length of individual pieces of the expansion joint filler shall be not less than the width of one (1) traffic lane of the pavement.
- 5) The finishing machine shall be operated in a manner that will prevent displacement of the joint. If for any reason it is necessary to straighten a joint, any depressions caused by this operation shall immediately be filled with fresh concrete, respaded and to create a transverse slope prior to finishing. Any fluid laitance or mortar caused by this operation shall be removed and replaced with fresh concrete. As the finishing machine approaches the joint on the first trip, the excess concrete shall be shovelled ahead and the tamper and each screed, in turn, shall be lifted over the joint. On the second trip of the finishing machine, the screed may be operated over the joint.

(ii) Contraction Joints

- 1) Contraction joints shall be of the type and dimensions and at the spacing shown on the plans. Sawed contraction joints shall be cut by means of an approved Concrete saw.
- 2) The joints shall not be sawed until the concrete has hardened to the extent that tearing and ravelling is eliminated. All joints shall be sawed during the initial curing period as described in subparagraph 314.04.9 "Protecting and Curing of Concrete Pavement - Initial Curing", and the sawing shall begin before the pavement starts shrinking and before uncontrolled cracking takes place.
- 3) Any procedure which results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete or the removal of the curing media and the cutting of the joints. In no case shall the pavement be left overnight without having the joints sawed. The joints shall be sawed at the depth, spacing, and lines shown on the plans. Guidelines or devices approved by the Engineer shall be provided to ensure cutting the joint in a straight line and perpendicular to the centreline of the pavement.
- 4) The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of an air jet or a combination

of air and water applied under pressure immediately after the joint has been cut, and before filling with joint compound. When the plans specify that dowels be installed through contraction joints, the subgrade at the contraction joints shall be accurately trimmed to the required cross section and to the proper depth of the pavement. A string line shall be stretched between the pavement forms along the centreline of the joint. Each dowel shall be painted and thoroughly coated with hard grease, or lubricant, in accordance with the directions shown on the plans or as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel. The entire joint assembly shall be of the type designated on the plans and shall be installed in such a position that the centreline of the joint assembly is perpendicular to the centreline of the slab and the dowels lie parallel to the slab surface and parallel to the centreline of the slab. The greased ends of the dowels shall be placed in the direction as indicated on the plans and shall be free to slide in the dowel holder. Any excess hard grease on the dowel holder shall be removed.

(iii) Longitudinal Joints

- 1) Longitudinal joints shall be constructed in conformance with the details shown on the plans. When a fabricated steel strip is specified, it shall be held rigidly in place with an adequate number of pins driven into the subgrade to ensure that it will remain true to line and grade during concreting and finishing operations. On multiple lane pavements where longitudinal joints are constructed at the form line, an approved recessed form and tie bars will be required. The full depth fabricated steel strip designated for other longitudinal joints will not be permitted. When sawed joints are specified or used, suitable guidelines or devices shall be furnished to ensure cutting the longitudinal joint on the true line as shown on the plans. The sawing of longitudinal joints shall be performed at a time that will eliminate erratic or uncontrolled cracking. Sawed joints shall be filled with the type of joint compound indicated on the plans. The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of an air jet or a combination of air and water applied under pressure immediately after the joint has been cut and before filling with joint compound.

(iv) Construction Joints

- 1) A butt construction joint shall be made perpendicular to the centreline of the pavement at the close of each day's work and also when the process of depositing concrete is stopped for a length of time such that, in the opinion of the Engineer, the concrete will have taken its initial set. This joint shall be formed by using a clean plank header having a nominal thickness of five (5) cm, a width of not less than the thickness of the pavement and a length of not less than the width of the pavement. The header shall be cut true to the crown of the finished pavement and shall be accurately set and held in place in a plane at right angles to centreline and perpendicular to the surface of

the pavement.

- 2) The top surface of the header shall be protected with steel as approved by the Engineer. On the face along the centre of the header there shall be fastened a trapezoidal piece of metal or wood the full length of the header, five (5) cm wide and at least twenty-five (25) mm in depth to form a grooved joint. The header shall have drilled holes to accommodate the dowel or tie bars hereinafter specified.
- 3) Upon resumption of work any surplus concrete remaining upon the subgrade shall be removed. The header shall then be carefully removed and fresh concrete deposited against the old in such a manner as to avoid injury to the edge of the old concrete. The fresh concrete shall be vibrated into the groove in a manner to ensure an interlocking joint. Dowel bars or load transfer devices shall be used in all construction joints in accordance with the details shown on the plans. The edges of the joint shall be grooved, edged, and sealed with the material used for sealing expansion and contraction joints. No construction joint shall be placed within three (3) m of an expansion, contraction, or other construction joint.

(iv) Permanent Header Board

- 1) Immediately after the forms are removed from the ends of concrete pavement that will be exposed to other than permanent type surfacing and temporary and permanent traffic, a header board having dimensions of not less than eight (8) cm (nominal) by twenty (20) cm shall be bolted securely to the end of the pavement in a manner to protect the edge of the pavement from damage. The header board shall extend the full roadway width, but may be in two (2) sections. At the time of placing the concrete, thirteen (13) mm by twenty (20) cm bolts (three for each lane), shall be embedded in the end of the pavement in a manner that will hold the header board securely. The header board shall be shaped to conform to the crown of the pavement and shall be installed flush with the concrete pavement surface. The finishing and installing of the header board shall be considered incidental to the other items in the Bill of Quantities and will not be paid separately. The header board will not be required on concrete base course Work.

7. Consolidating and Finishing

- (a) After being spread and struck-off, as provided in section 501.04, subparagraph D.5. "Placing Concrete," the concrete shall be further struck-off and consolidated with an approved finishing machine to such an elevation that when finishing operations are completed, the surface will conform to the required grade and crown. The finishing machine shall operate over the entire surface at least twice, the first time with the finishing machine tamper and both screeds in operation. Excessive tamping or finishing resulting in bringing an excess of mortar to the surface will not be permitted.
- (b) After the last pass of the finishing machine, a mechanical longitudinal finisher

shall be operated over the concrete surface.

- (c) The forward motion of the longitudinal finisher shall be so adjusted that the screed will pass over each portion of the surface at least twice. The longitudinal finisher shall be operated in a manner that will prevent excessive slumping of the concrete at the form lines or the metal centre strip or the loss of the crown of the pavement. If necessary or when ordered by the Engineer, the finisher shall be operated in one direction only or shall be operated from only the form to the centreline in order to ensure that the proper cross section of the pavement is obtained. The leading edge of the screed shall clear the forms upon completion of each transverse pass in order to clear the pavement surface of any laitance or thin mortar.
- (d) In general, the addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted. If the application of water to the surface is permitted by the Engineer, it shall be applied as a fog spray by means of approved spray equipment.
- (e) As an alternative to the longitudinal finisher, the Contractor may use a machine composed of a cutting and smoothing float, or floats, suspended from and guided by a rigid frame. The frame shall be carried by four (4) or more visible wheels riding on, and constantly in contact with, the side forms.
- (f) When directed by the Engineer, following one of the preceding methods of longitudinal finishing, long-handled floats having blades not less than one and one-half (1.5) m in length and fifteen (15) cm in width shall be used to smooth and fill in open-textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of, or supplementing, one of the preceding methods of longitudinal finishing.
- (g) When the longitudinal finishing has been completed, the entire surface shall be tested with straightedges not less than three (3) m in length. The straightedges shall be operated parallel to the pavement centreline starting at the centre and progressing toward the forms. Advance along the pavement shall be in successive stages of not more than one-half (1/2) the length of the straightedges. All laitance, surplus water, and inert material shall be removed from the surface. All high places shall be worked down and all low places filled by combined operations of floats and straightedges until no irregularities exist. The proper crown of the pavement shall be maintained throughout the operations. After floating and straight-edging has been completed, the concrete shall be finished by using a belt made of canvas, rubber, or other approved belting not less than fifteen (15) cm in width, nor less than sixty (60) cm longer than the width of the pavement. This belt shall be worked with a longitudinal and crosswise motion. Care shall be exercised in the use of the belt to ensure that the edges of the belt do not dig into the surface of the concrete or work the crown out of the pavement. Either machine belting or hand belting will be permitted.
- (h) As soon as all excess moisture has disappeared, and while the concrete is still plastic enough to make a granular surface possible, a drag shall be used which shall consist of a seamless strip of damp burlap or cotton fabric, which shall produce a uniform surface of gritty texture after dragging it longitudinally

along the full width of pavement. For pavement five (5) m or more in width, the drag shall be mounted on a bridge that travels on the forms. The dimensions of the drag shall be such that a strip of burlap or fabric at least one and one-half (1.5) m wide is in contact with the full width of pavement surface while the drag is used. The drag shall consist of not less than two (2) layers of burlap with the bottom layer approximately fifteen (15) cm wider than the upper layer. The drag shall be maintained in such condition that the resultant surface is of uniform appearance and reasonably free from grooves over two (2) mm in depth, as determined by the Engineer. Drags shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags substituted.

- (i) After dragging the surface with burlap, the concrete over the expansion joint filler shall be completely removed and the joint finished. The edges of the concrete at expansion joints shall be grinded with an edger to the radius shown on the plans. The exposed edge of the pavement shall be finished with an edger to a radius of six (6) mm. Any tool marks appearing on the slab adjacent to the joints or on the edge of slab shall be eliminated by dragging the surface. In doing this, the rounding of the corner of the slab shall not be disturbed.

(i) Hand Finishing

- 1) Unless otherwise specified, hand-finishing methods will not be permitted except under the following conditions:
 - ✓ In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs, and no additional concrete shall be placed until such equipment is repaired to the satisfaction of the Engineer.
 - ✓ Narrow widths or areas of irregular dimensions where operations of the mechanical equipment is impractical as determined by the Engineer, may be finished by approved hand methods.
 - ✓ Short lengths of pavement, where in the opinion of the Engineer it is unreasonable to mobilize mechanical finishers and at bridge approach pavements, where the operation of mechanical equipment is impractical may be finished by approved hand methods.
- 2) Concrete, as soon as placed, shall be struck-off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking-off the bottom layer of concrete if reinforcement is used.
- 3) The screed for the surface shall be longer than the maximum width of the slab to be struck-off. It shall be of approved design, sufficiently rigid to retain its shape, and be constructed either of metal or other suitable material shod with metal.
- 4) Consolidation shall be attained by the use of a suitable vibrator or other

approved equipment.

- 5) In operation the screed shall be moved forward on the forms with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking-off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.
- 6) After the concrete has been struck-off, it shall be further smoothed, made true to line and level, and consolidated by means of a longitudinal float. The hand-operated longitudinal float shall be not less than three and one-half (3.5) m in length and fifteen (25) cm in width, properly stiffened to prevent flexing and warping. The longitudinal float, operated from foot bridges resting on the side forms and spanning but not touching the concrete, shall be worked with a sawing motion, while held in a floating position parallel to the road centreline, and passing gradually from one side of the pavement to the other. Movement ahead along the centreline of the pavement shall be in successive advances of not more than one-half (1/2) the length of the float. Any excess water or soupy material shall be wasted over the side forms on each pass. At the option of the Engineer, the long-handled floats having blades not less than one and one-half (1.5) m in length and fifteen (15) cm in width may be substituted for the hand-operated longitudinal float. All other operations after this substitution for the mechanical equipment shall be performed in the manner previously described. Concreting operations shall be performed only in daylight. Under no circumstances shall concrete pavement be placed or finished at night.

8. Removing Forms

- (a) Unless otherwise provided, forms shall not be removed from freshly placed concrete until it has set for at least twelve (12) hours, except auxiliary forms used temporarily in widened areas. Forms shall be removed carefully so as to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as specified for the surface. Major honeycombed areas will be considered as defective work and shall be removed and replaced at the Contractor's expense, as directed by the Engineer. Any area or section so removed shall not be less than three (3) m in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than three (3) m in length, shall also be removed and replaced.

9. Protecting and Curing of Concrete Pavement

(a) Initial Curing

- (i) As the surface of the newly laid pavement is progressively finished, the initial curing and protection operations shall be started. Upon completion of the finishing operation and while the surface of concrete is still moist, but no free water remains, a liquid curing membrane, as specified in

AASHTO M 148 (Type 2) shall be applied to the exposed surfaces of the pavement at the rate of not less than one (1) litre per 3.67 square meters of surface area when mechanical pressure distributors are used. The curing membrane, except on irregular areas, shall be applied by means of approved self-propelled mechanical pressure distributors or approved hand sprays. Satisfactory means shall be provided for thoroughly mixing the curing membrane compound before and during its use. The mechanical spraying equipment may be either a full width spray bar equipped with multiple nozzles or a traversing spray that travels from one edge of the pavement to the other. In either case the path of adjacent nozzles or passes of the traversing spray shall overlap a minimum of one-half (1/2) the width of the spray pattern so that all portions of the surface shall receive double applications from adjacent nozzles or passes. The pumping, pressure, and distribution arrangement shall be correlated with the forward speed to provide adequate and uniform coverage of the pavement at not less than the minimum rate required.

- (ii) Irregular areas to which the mechanical distributor cannot be adapted may be covered with hand sprays. When hand sprays are used, the curing membrane shall be applied in two (2) applications, each at a rate of not less than one (1) litre per five (5) square meters of surface area so as to provide a total rate of application of one (1) litre per two and one-half (2-1/2) square meters of surface area. The path of the spray on the second application shall be at right angles to the path of the spray on the first application. When hand operated sprays are permitted, the equipment supplying the pressure to the spray nozzle shall be capable of supplying a constant and uniform pressure to provide uniform and adequate distribution of the curing membrane compound at the rates required. If from any cause, such as rainfall soon after its application, the curing membrane is damaged, the Contractor shall immediately apply another application of curing membrane to the surface of the pavement. The rate of application for the replacement membrane shall be the same as for the original membrane.
- (iii) Unless otherwise directed by the Engineer, immediately following the application of the curing - membrane, if approved, shade-canvas shall be placed approximately thirty (30) cm above the pavement surface. The shade-canvas shall be constructed of materials and in a manner approved by the Engineer. In no case shall any portion of the shade-canvas come in contact with the pavement. The initial curing shall be continued for a period of twenty-four (24) hours from the time the curing membrane is applied. When forms are removed, whether during the initial or the final curing period, the edges of the pavement shall receive curing membrane at the rate of coverage specified for the pavement surface. The curing membrane may be applied to the vertical edges of the pavement by means of hand sprays or by nozzles attached to the mechanical distributor, but the edges of the pavement shall be covered with curing membrane at the rate specified within thirty (30) minutes after removal of the forms.
- (iv) When cold-poured joint compound is used, all joints shall be sawed

during the initial curing period. The shade-canvas may be moved at joint locations for short periods of time to permit the sawing. Before being sealed, the joints shall be thoroughly cleaned of all loose saw dust, laitance, dirt, other foreign matter, and made free of water. As the method of final curing is different from that of the initial curing, the cleaning, and sealing of joints shall be performed immediately following the removal of the shade-canvas at the end of the initial curing period and prior to the application of the plastic sheeting.

- (v) When hot-poured joint compound is used, the joints shall be sawed, cleaned, and filled with jute or other acceptable protective material in the same time sequence as for cold-poured joints. In no case shall any portion of the concrete pavement be exposed to the direct rays of the sun for more than one (1) hour.
- (vi) Following jointing operations, curing membrane shall be applied to the joint area at the rate specified for the pavement surface.

(b) Final Curing

- (i) Upon completion of the initial curing period and after the shade-canvas has been removed and jointing operation has been completed, the pavement shall be completely covered with White Opaque Polyethylene Film as specified in AASHTO M 171. Adjoining sheets shall be lapped a minimum of forty-five (45) cm. The sheeting shall be held in place in a manner approved by the Engineer.
- (ii) Final curing shall be continued until the concrete reaches an age of fourteen (14) days. During this period, the curing membrane and polyethylene film shall be protected from damage from any cause. Any damage from any cause, shall be repaired immediately, by the Contractor at his expense. No traffic, not even workmen, pedestrians, or animals shall be allowed on the surface of the pavement until the expiration of the fourteen (14) day curing period.

(c) Cold Weather Curing

- (i) When concrete is being placed during the time that the air temperature may be expected to drop below fifteen (15) degrees C, a sufficient supply of burlap, straw, hay, or other suitable blanketing material shall be provided along the work to protect the concrete and maintain a minimum temperature of fifteen (15) °C in the concrete as measured on the surface of the pavement. An approved moisture barrier such as wet burlap or plastic sheeting shall be placed on the concrete prior to placing the blanketing material. This type cure shall be maintained for a period of seventy-two (72) hours as the initial cure. After the initial cure as specified above, a final cure as specified in "9. Protecting and Curing of Concrete Pavement" - Final Curing" may be used. The final cure shall be maintained for a period of fourteen (14) days, thus making a seventeen (17) day curing period for cold weather concreting.

(d) Early Strength Concrete Curing

- (i) The curing of early strength concrete pavement shall conform to the requirements specified for concrete pavement except that the total curing period shall be a minimum of seven (7) days.

10. Sealing Joints

- (a) Joint sealing shall consist of cleaning the joint in preparation for sealing and sealing all contraction and expansion joints in the concrete pavement with hot or cold applied joint sealing material. The work shall be in accordance with the Drawings and as follows.

- (b) Application of the joint sealer shall be made when the joint surfaces are clean and dry, but joints shall not be sealed until they have been inspected and approved by the Engineer.

(i) Materials

- 1) Joints shall be sealed with material of the type designated on the drawings and these specifications or as directed by the Engineer.

(ii) Hot-Poured Joints

- 1) The joints shall be sawed and covered in properly manners. After the fourteen (14) or seventeen (17) days curing period for the pavement has elapsed, the jute or other protective covering shall be removed from the joint.
- 2) Immediately before sealing the joint thoroughly clean the joints of all laitance, curing compound and other foreign material. Exposed joint faces shall be cleaned by sandblasting, or by water blasting with sufficient pressure to thoroughly and completely clean the joint. A multiple-pass technique shall be used until the surfaces are free of material that might prevent bonding. For final cleaning immediately prior to installation of the sealer, the joints shall be blown clean with oil-free compressed air. The joint faces must be surface dry when sealant is applied.
- 3) The sealing compound shall be heated to the pouring temperature recommended by the manufacturer in an approved kettle or tank, constructed as a double boiler, with the space between the inner and outer shells filled with oil or other satisfactory heat transfer medium. The heating kettle shall be equipped with a mechanical agitator, positive temperature control and an approved dial thermometer for checking temperatures of the compound. The heating kettle, if and when operated on concrete, shall be properly insulated against the radiation of heat to the concrete surface.
- 4) The sealing compound shall not be heated above the maximum safe heating temperature. The maximum safe heating temperature shall be determined from tests made on samples from each lot or

shipment of the material delivered to the project. When so approved by the engineer, the manufacturer's recommended maximum safe heating temperature may be used in lieu of test determinations where relatively small quantities of sealer are used. Any material heated above the maximum safe heating temperature shall be discarded.

- 5) Pouring of joints shall be made when the sealing material is at the required temperature and, insofar as practicable, the sealing compound shall be maintained at a uniform temperature during pouring operations. Pouring shall not be permitted when the temperature of the sealing compound in the applicator, as it is applied to the joint, is more than the recommended pouring temperature. Pouring of the molten sealer in the joint opening shall be done with such equipment that the sealer completely fills the joint opening without overflowing on the adjoining pavement surface and when finished, after shrinkage, the sealer is approximately flush with the adjoining pavement surfaces.
- 6) In the event satisfactory sealing of a joint is not accomplished in a single pouring, the sealing compound shall be placed in two pourings. At least one-half of the required amount shall be placed in the first pouring, and the second pouring shall follow the first as soon as practicable after the first pouring has attained maximum shrinkage but not later than one hour after the first pouring..
- 7) Any joint with a depth greater than twenty-five (25) mm shall be filled with a minimum of two (2) layers, each layer being approximately equal in depth.

(iii) Cold-Poured Joints

- 1) The joints shall be sawed as provided in "6. Joints", and cleaned of all loose saw dust, laitance, dirt, other foreign matter, and free water.
- 2) The joints shall be filled immediately after cleaning. The nozzle used must be so designed that the joint is filled completely from bottom to top. The joint shall be filled so it is rounded on top about six (6) mm above the pavement surface. Immediately after the joints have been filled, they shall be covered with a strip of non absorptive paper at least four (4) cm wide. The paper shall remain on the joint until it weathers or wears off.

11. Surface Trueness

- (a) As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a three (3) m straightedge or other specified devices. Areas showing high spots of more than three (3) mm, but not exceeding twelve (12) mm in three (3) m between any two contact points, shall be marked and immediately ground down with an approved grinding tool to an elevation at which the area or spot will not show surface deviations in excess of three (3) mm when tested with a three (3) m straightedge. Where

the departure from correct cross section exceeds twelve (12) mm, the pavement shall be removed and replaced by and at the expense of the Contractor.

- (b) Any area or section so removed shall be not less than three (3) m in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than three (3) m in length, shall also be removed and replaced at the Contractor's expense.

- (7) Make the area clean and tidy.

AA001.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
AA001-1	Spot replacement (concrete pavement)	Metre Cube

AA001.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

1.2 GRAVEL AND EARTH CARRIAGEWAYS

CODE 121 HEAVY GRADING

121.01 DESCRIPTION

- (1) This work is to improve earth and gravel roads by grading the existing surface material. Grading is normally a ROUTINE MAINTENANCE task.
- (2) It is carried out by self-propelled or towed graders. The object is to restore the camber by returning material from the sides and shoulders towards the centre of the road.
- (3) This will enable water to drain off easily. A road with a flat or dished surface will collect water. Traffic and water together will quickly cause potholes and rough spots.

121.02 MATERIALS

- (1) Nil.

121.03 WORK PROCEDURES

< 1 > Preliminary Tasks

- (1) Before setting out to start the job, a check should be made to ensure that everything needed is ready.
- (2) Plant and machinery must be checked mechanically, greased and fueled. The oil and water levels must be checked.
- (3) Arrangements must be made to refuel the plant on the job if necessary. This may be with a refueling truck visiting the working site, or with an arrangement to refuel at a maintenance or temporary camp.
- (4) Traffic signs and camber board must be obtained, loaded on the grading equipment and taken to site. These must be properly stored/secured on the grading equipment.
- (5) If the grading crew is staying away overnight, arrangements must be made for accommodation, supplies, etc.

< 2 > Temporary Signposting

- (1) Before work starts, warning signs must be placed at each end of the work area to ensure the safety:
- ✓ of the road users,
 - ✓ of the personnel and plant to be deployed on the site.
- (2) Signs must be placed in the following order:
- ✓ "Men Working" signs should be placed at the approaches to the work area.
 - ✓ "End of Restriction" signs should be placed at the end of the work area.
- (3) Work should not be carried out at night.

< 3 > Grading the running surface

(1) Preparation

1. Patching of large potholes or depressions should be carried out in advance of the grading.
2. Areas of standing water should be drained. This preparation will ease the work and make the resulting surface last longer.

(2) Scarifying

1. It may be necessary to scarify the existing surface to cut to the bottom of any surface defects and loosen the material for reshaping.

(3) Machine attendants

1. These help direct traffic and grader turning, and remove large stones and other unwanted material from the path of the grader.

(4) Grading

1. The grader works on one side of the road at a time and works in passes about 200 metres long to convenient and safe turning points.
2. Grading will normally require 6 - 8 passes to reshape and achieve the required camber. Work should be completed on one side of the road at a time.
3. An even number of passes should be used to avoid a flat finished crown.
4. Normally initial cutting passes are required to bring material in from the edges of the road. Spreading passes redistribute the material away from the crown.
5. The initial passes cut to the bottom of the surface irregularity and deposit a windrow just beyond the centre line.
6. The water tanker sprays the windrow with water, if required.
7. The windrow is spread back across the road depositing all the material to give the correct camber.
8. A second application of water may be required to obtain the correct moisture content for compaction.
9. The aim should be to develop a proper crown on the road.
10. The road should be cambered to fall away from the crown at a rate of about 6 to 7 cm for each metre from the centre of the road before compaction. This should achieve a crossfall of about 4 to 6 cm per metre (4 to 6%) after compaction.
11. If there is insufficient camber, water will not drain easily from the surface of the road, potholes will form and the road will deteriorate quickly. This is particularly important on gradients, where the rain water tends to run along the road forming erosion channels.
12. Do not make a final pass down the centre of the road with the grader blade horizontal.
13. This flattens the centre of the road and causes water to pond leading to rapid deterioration of the surface.
14. Do not leave a windrow on the road overnight as this is a danger to traffic.

- (5) Compaction
 - 1. When compaction plant is being used, it must follow close up behind the grader, but only on sections where grading has been completed.
 - 2. About eight passes of a roller will be needed to achieve full compaction, working towards the centre of the road.
- (6) Shoulders are treated as part of the running surface.
- (7) Junctions and bends
 - 1. Graders must not stop near junctions or bends where they will be a danger to traffic.
- (8) Check the camber
 - 1. Camber should be checked with a camber board at about 100 metre intervals along the road.
 - 2. To use the camber board place it on its edge across the road with the shorter end pointing towards the centre line.
- (9) Check the level bubble.
 - 1. If it is central, the camber is correct.
 - 2. If it is not central, the camber is either too steep or too flat and further grading and compaction are required.
- (10) On bends the surface must be straight (at 4-6%) from shoulder to shoulder with the outer shoulder higher. This is called superelevation.
- (11) Any crown on a bend can be very dangerous to traffic.
- (12) The superelevation must be retained for the complete length of the bend.
- (13) On the transition at each end of the bend into the straight sections, the superelevation should be gradually reduced until the normal cross section shape with 1 in 20 (5%) camber is obtained again.
- (14) The shape of the road must be maintained over culverts to avoid a hump. Material should be brought in if necessary from either side of the culvert to maintain a cover to the top of the culvert of at least 3/4 culvert diameter.
- (15) Bridge decks should be kept free from gravel. Loose material should be swept away by the attendants.
- (16) It is important to have smooth approaches to the bridge. They should be smoothed out using the back of the blade with the grader working in reverse, or by hand.
- (17) For most grading work, the cutting blade is set to be vertical.

- (18) For cutting hard surfaces, the cutting blade should be set back at the top to give the most effective cutting angle.
- (19) For spreading, the cutting blade should be set forward at the top.
- (20) To form a windrow
1. Point all wheels straight ahead and angle the blade.
 2. The angle should be sharp enough to let surface material roll freely off the end of the blade.
 3. Travel forward slowly in low gear keeping the blade level and 5-10 cm into the surface material.
 4. On graders with this facility lean the front wheels in the same direction as the windrow to help counter side thrust on the blade.
 5. The windrow must be formed outside or between the rear wheels.
- (21) Handling a windrow
1. Angle the blade to left or right according to the job requirement.
 2. The angle should allow material to roll freely off the end of the blade.
 3. To move or mix material:
Travel forwards slowly in low gear.
Pick up material from one side of the machine and pass it to the other.
 4. TRY TO MATCH THE GEAR AND SPEED TO THE WORK TO BE DONE.
 5. To get more power:
 - ✓ Angle the blade towards the windrow.
 - ✓ Lean the front wheels against the side thrust.
 6. THE REAR WHEELS SHOULD NOT BE ALLOWED TO RUN OVER THE WINDROW.

< 4 > Grading Ditches

- (1) Before the road surface is graded, the side ditches must be cleaned.
- (2) Narrow flat-bottomed ditches are not well suited to maintenance by grader. These are best cleaned out by hand.
- (3) Graders should be used to maintain V-shaped ditches and wide flat-bottomed ditches.
- (4) Material from the ditch should not normally be graded onto the running surface. In certain circumstances the Engineer may instruct the recovery and mixing of the ditch material, where the running surface lacks suitable fines present in the ditch.
- (5) The first pass cleans the side slope near the road and windrows the material to the bottom of the ditch.
- (6) On wide flat-bottomed ditches, the second pass cleans the ditch bottom.

- (7) The next pass cleans the ditch back slope and removes the material to the top of the ditch.
- (8) If possible, a third pass is used to push the material away from the edge of the ditch, to prevent it washing back.
- (9) The completed ditch should be at least 1 metre deep.
- (10) Turnouts should be constructed and maintained with a grader. These should lead the water away from the edge of the road and follow closely the natural contours of the ground.
- (11) Turnouts should be spaced more closely as gradients become steeper.
- (12) The discharge of water should be "little and often" to minimize erosion risk on adjoining land.

< 5 > Completion and Removal of Temporary Signs

- (1) Remove the traffic signs and load them back on the grader.
- (2) Move on to next job.
- (3) Clean the traffic signs on return to the depot.

121.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
121-1	Heavy grading	Metre Square

121.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 122 LIGHT GRADING

122.01 DESCRIPTION

- (1) This work is to improve earth and gravel roads by grading the existing surface material. Grading is normally a ROUTINE MAINTENANCE task.
- (2) It is carried out by self-propelled or towed graders. The object is to restore the camber by returning material from the sides and shoulders towards the centre of the road.
- (3) This will enable water to drain off easily. A road with a flat or dished surface will collect water. Traffic and water together will quickly cause potholes and rough spots.

122.02 MATERIALS

- (1) Nil.

122.03 WORK PROCEDURES

< 1 > Preliminary Tasks

- (1) Before setting out to start the job, a check should be made to ensure that everything needed is ready.
- (2) Plant and machinery must be checked mechanically, greased and fueled. The oil and water levels must be checked.
- (3) Arrangements must be made to refuel the plant on the job if necessary. This may be with a refueling truck visiting the working site, or with an arrangement to refuel at a maintenance or temporary camp.
- (4) Traffic signs and camber board must be obtained, loaded on the grading equipment and taken to site. These must be properly stored/secured on the grading equipment.
- (5) If the grading crew is staying away overnight, arrangements must be made for accommodation, supplies, etc.

< 2 > Temporary Signposting

- (1) Before work starts, warning signs must be placed at each end of the work area to ensure the safety:
- ✓ of the road users,
 - ✓ of the personnel and plant to be deployed on the site.
- (2) Signs must be placed in the following order:
- ✓ "Men Working" signs should be placed at the approaches to the work area.
 - ✓ "End of Restriction" signs should be placed at the end of the work area.
- (3) Work should not be carried out at night.

< 3 > Grading the running surface

(1) Preparation

1. Patching of large potholes or depressions should be carried out in advance of the grading.
2. Areas of standing water should be drained. This preparation will ease the work and make the resulting surface last longer.

(2) Scarifying

1. It may be necessary to scarify the existing surface to cut to the bottom of any surface defects and loosen the material for reshaping.

(3) Machine attendants

1. These help direct traffic and grader turning, and remove large stones and other unwanted material from the path of the grader.

(4) Grading

1. The grader works on one side of the road at a time and works in passes about 200 metres long to convenient and safe turning points.
2. Grading will normally require 4 passes to reshape and achieve the required camber. Work should be completed on one side of the road at a time.
3. An even number of passes should be used to avoid a flat finished crown.
4. Normally initial cutting passes are required to bring material in from the edges of the road. Spreading passes redistribute the material away from the crown.
5. The initial passes cut to the bottom of the surface irregularity and deposit a windrow just beyond the centre line.
6. The water tanker sprays the windrow with water, if required.
7. The windrow is spread back across the road depositing all the material to give the correct camber.
8. A second application of water may be required to obtain the correct moisture content for compaction.
9. The aim should be to develop a proper crown on the road.
10. The road should be cambered to fall away from the crown at a rate of about 6 to 7 cm for each metre from the centre of the road before compaction. This should achieve a crossfall of about 4 to 6 cm per metre (4 to 6%) after compaction.
11. If there is insufficient camber, water will not drain easily from the surface of the road, potholes will form and the road will deteriorate quickly. This is particularly important on gradients, where the rain water tends to run along the road forming erosion channels.
12. Do not make a final pass down the centre of the road with the grader blade horizontal.
13. This flattens the centre of the road and causes water to pond leading to rapid deterioration of the surface.
14. Do not leave a windrow on the road overnight as this is a danger to traffic.

- (5) Compaction
 - 1. When compaction plant is being used, it must follow close up behind the grader, but only on sections where grading has been completed.
 - 2. About eight passes of a roller will be needed to achieve full compaction, working towards the centre of the road.
- (6) Shoulders are treated as part of the running surface.
- (7) Junctions and bends
 - 1. Graders must not stop near junctions or bends where they will be a danger to traffic.
- (8) Check the camber
 - 1. Camber should be checked with a camber board at about 100 metre intervals along the road.
 - 2. To use the camber board place it on its edge across the road with the shorter end pointing towards the centre line.
- (9) Check the level bubble.
 - 1. If it is central, the camber is correct.
 - 2. If it is not central, the camber is either too steep or too flat and further grading and compaction are required.
- (10) On bends the surface must be straight (at 4-6%) from shoulder to shoulder with the outer shoulder higher. This is called superelevation.
- (11) Any crown on a bend can be very dangerous to traffic.
- (12) The superelevation must be retained for the complete length of the bend.
- (13) On the transition at each end of the bend into the straight sections, the superelevation should be gradually reduced until the normal cross section shape with 1 in 20 (5%) camber is obtained again.
- (14) The shape of the road must be maintained over culverts to avoid a hump. Material should be brought in if necessary from either side of the culvert to maintain a cover to the top of the culvert of at least 3/4 culvert diameter.
- (15) Bridge decks should be kept free from gravel. Loose material should be swept away by the attendants.
- (16) It is important to have smooth approaches to the bridge. They should be smoothed out using the back of the blade with the grader working in reverse, or by hand.
- (17) For most grading work, the cutting blade is set to be vertical.

- (18) For cutting hard surfaces, the cutting blade should be set back at the top to give the most effective cutting angle.
- (19) For spreading, the cutting blade should be set forward at the top.
- (20) To form a windrow
1. Point all wheels straight ahead and angle the blade.
 2. The angle should be sharp enough to let surface material roll freely off the end of the blade.
 3. Travel forward slowly in low gear keeping the blade level and 5-10 cm into the surface material.
 4. On graders with this facility lean the front wheels in the same direction as the windrow to help counter side thrust on the blade.
 5. The windrow must be formed outside or between the rear wheels.
- (21) Handling a windrow
1. Angle the blade to left or right according to the job requirement.
 2. The angle should allow material to roll freely off the end of the blade.
 3. To move or mix material:
Travel forwards slowly in low gear.
Pick up material from one side of the machine and pass it to the other.
 4. TRY TO MATCH THE GEAR AND SPEED TO THE WORK TO BE DONE.
 5. To get more power:
 - ✓ Angle the blade towards the windrow.
 - ✓ Lean the front wheels against the side thrust.
 6. THE REAR WHEELS SHOULD NOT BE ALLOWED TO RUN OVER THE WINDROW.

< 4 > Grading Ditches

- (1) Before the road surface is graded, the side ditches must be cleaned.
- (2) Narrow flat-bottomed ditches are not well suited to maintenance by grader. These are best cleaned out by hand.
- (3) Graders should be used to maintain V-shaped ditches and wide flat-bottomed ditches.
- (4) Material from the ditch should not normally be graded onto the running surface. In certain circumstances the Engineer may instruct the recovery and mixing of the ditch material, where the running surface lacks suitable fines present in the ditch.
- (5) The first pass cleans the side slope near the road and windrows the material to the bottom of the ditch.
- (6) On wide flat-bottomed ditches, the second pass cleans the ditch bottom.

- (7) The next pass cleans the ditch back slope and removes the material to the top of the ditch.
- (8) If possible, a third pass is used to push the material away from the edge of the ditch, to prevent it washing back.
- (9) The completed ditch should be at least 1 metre deep.
- (10) Turnouts should be constructed and maintained with a grader. These should lead the water away from the edge of the road and follow closely the natural contours of the ground.
- (11) Turnouts should be spaced more closely as gradients become steeper.
- (12) The discharge of water should be "little and often" to minimize erosion risk on adjoining land.

< 5 > Completion and Removal of Temporary Signs

- (1) Remove the traffic signs and load them back on the grader.
- (2) Move on to next job.
- (3) Clean the traffic signs on return to the depot.

122.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
122-1	Light grading	Metre Square

122.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 123 DRAGGING**123.01 DESCRIPTION**

- (1) This work is to improve earth and gravel roads by dragging the existing surface material. Dragging is normally a ROUTINE MAINTENANCE task.
- (2) The object of regular and frequent dragging is to smooth out minor defects in the road surface and remove loose material from the surface. This results in a better running surface for traffic.
- (3) On some roads a thin layer of sand is used to cover the road base material and protect it from traffic wear. Frequent dragging is used to redistribute the sand disturbed by the traffic.
- (4) Dragging can be carried out using self-propelled or towed graders. Towed graders weighing 1 ton or more are suitable for this task. Alternatively, specially made drags can be used, towed behind agricultural tractors.
- (5) On low-volume roads, frequent dragging may be used to reduce the need to grade the road. Grading is normally required after a number of dragging operations to mix the accumulated loose material back into the road surface.
- (6) Dragging is used to correct minor surface deformation.
- (7) Dragging will not remove corrugations once they have formed, nor will it restore camber or lost material. Grading is needed to correct these problems.

123.02 MATERIALS

- (1) Nil.

123.03 WORK PROCEDURES**< 1 > Types of drag**

- (1) Listed in order of increasing effectiveness.
1. Brushwood drag: Small branches tied together.
 2. Tyre sledge: Old truck or tractor tyres chained together.
 3. Cable drag: Bundles of steel cables bound together and fixed in a frame, weighted with concrete blocks to enable it to cut into the surface. Care must be taken that pieces of the steel cable which may break off the drag are not left lying on the road.
 4. Beam drag: Rolled steel joist(s) or steel rail(s), weighted with concrete blocks, and towed at an angle to the road.
 5. Frame drag: Steel "A" frame using old grader blades.
 6. Tolard: Three to five blades at different angles under a box weighted with concrete blocks.

< 2 > Preliminary task

- (1) Before setting out to start the job, a check should be made to ensure that everything needed is ready.
- (2) Plant and machinery must be checked mechanically, greased and fueled.
- (3) Drags must be checked to ensure that they are complete and that any weights required are loaded.

< 3 > Working with a tractor and drag

- (1) The Machine Attendant directs traffic and helps the driver when turning the tractor and drag, removes unwanted material from path of tractor and clears the drag.
- (2) If the work is being done with a tractor, it should work in the same direction as the traffic. The driver should not stop at junctions or on bends.
- (3) The tractor tows the drag at up to 5 km/hr depending on the type of drag and on the type and condition of the road surface.
- (4) The length of pass will be given on the worksheet and should be as long as possible.
- (5) The number of passes needed will depend upon the conditions and the width of the road.
- (6) The equipment should work in the same direction as the traffic flow.
- (7) DO NOT drive too fast or the drag will jump over the surface irregularities and raise a lot of dust, it will also cause a hazard to traffic.
- (8) Pieces of thorn scrub or steel cable which break off the drag must not be left on the road surface.

< 4 > Dragging with graders

- (1) When the work is to be done by motor grader or towed grader, it is most efficient if several graders can work together on the same section of road, one behind the other.
- (2) In this case, graders work in the same direction along the road for several kilometres. On narrow roads two grader passes may be sufficient.
- (3) Great care is required to warn approaching vehicles and allow them to pass the grading machines safely. If necessary a light vehicle should travel ahead of the graders with warning lights and signs.

- (4) The object is to remove the loose material from the surface of the road and spread it evenly.
- (5) There are two basic methods of working.
1. The first spreads material from the centre line to both edges of the road (Method A).
 2. The second spreads material from one side of the road to the opposite edge (Method B).
- (6) Method A
1. The grader starts from the centre of the road and works towards the edge. Shoulders are treated as part of the running surface.
 2. The first and second passes cut to the bottom of the surface irregularity and deposit a windrow at the edge of the road. Two passes may be required each side for wide roads.
 3. The other side of the carriageway is now graded in a similar way to complete the work and leave a smooth even surface between windrows.
- (7) Method B
1. The grader starts from one edge of the road and works towards the other edge. Shoulders are treated as part of the running surface.
 2. The first and second passes cut to the bottom of the surface irregularity and deposit a windrow at the centre of the road. Two passes may be required each side for wide roads.
 3. The third and fourth passes cut to the bottom of the surface irregularity and move the windrow to the edge of the road.
- (8) For both methods of dragging with a grader:
1. Slots should be cut through the windrows by the machine attendant at approximately 10 metre intervals along the edges of the road.
 2. These will enable water to drain from the road surface in the event of unexpected rain.
 3. As loose material will have been removed from the surface of the road and a hard surface should remain, rolling should not be necessary with this type of dragging.
- (9) Windrows must not be left at the edge of the road during the wet season.
- (10) They tend to dam up the water leading to erosion of shoulders and side slopes.
- (11) The windrows should be mixed back into the running surface with a full grading operation before the wet season is established.

(12) DO NOT make a final pass down the centre of the road with the grader blade horizontal.

(13) This flattens the centre of the road and causes water to pond. This leads to rapid deterioration of the surface.

123.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
123-1	Dragging	Metre Square

123.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 124 FILLING OF POTHOLES

124.01 DESCRIPTION

- (1) This work is sometimes required between grading or reshaping operations, or before grading when the potholes or depressions are large.
- (2) Patching may either be used to repair worn or eroded areas or can be used to restore areas which become soft when wet.
- (3) This maintenance activity consists of replacing or adding new gravel surfacing material over relatively small areas.
- (4) Patching may be carried out by a mobile gang or by labor based methods.
- (5) Patching is normally used to refer to resurfacing work involving less than 1 or 2 truck or trailer loads of material per day.
- (6) Large scale work is usually called Spot Regravelling or Gravelling.
- (7) Patching is used to correct;
 - ✓ Potholes
 - ✓ Ruts
 - ✓ Soft spots
 - ✓ Erosion gullies
- (8) Patching is not a satisfactory method of repairing corrugations. Grading or labor based reshaping should be used to repair these defects.
- (9) Where there are large numbers of potholes, the section will need scarifying with a self-propelled grader and possibly regravelling.
- (10) Patching may be used instead of grading on self-cementing gravels or gravels with large lumps.

124.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Gravel for patching should be stockpiled at the quarry or maintenance camp, or dumped at the side of the road near where it will be used (so that it does not block the road or drainage system).
- (3) The gravel must be at least as good a quality as the material already surfacing the road. Its use must be approved by the Maintenance Engineer and must meet Departmental specifications.
- (4) Water must be carried from the depot if it is not obtainable near the site. In either case, a container will be needed.
- (5) Other materials if necessary for work execution.

124.03 WORK PROCEDURES**< 1 > Preliminary tasks**

- (1) Before setting out to start the job, a check should be made to ensure that everything needed is ready.
- (2) The Truck or tractor and trailer must be fueled, checked mechanically and have water and oil levels checked.
- (3) Traffic signs, barriers and cones must be obtained and loaded onto the truck or trailer.
- (4) Tools and equipment must be obtained and loaded onto the truck or trailer. The roller may be loaded with the help of ramps* or a hoist.
- (5) The drum must be filled with water if none is available on site.
- (6) Arrangements must be made to load gravel onto the truck or trailer either at the depot or at a quarry.

< 2 > Temporary signposting

- (1) Before work starts, warning signs, barriers and cones must be placed around the work area.
- (2) Work should be carried out on one side of the road at a time, allowing traffic to pass on the other.
- (3) Signs must be placed in the following order;
 - ✓ "Men Working" signs should be placed 200 metres in front of the work area.
 - ✓ "Road Narrows" signs should be placed 100 metres in front of the work area.
 - ✓ "Speed Limit" signs should be placed at the start of the work area.
 - ✓ Barriers should be placed at each end of the work area.
 - ✓ Cones should be placed in a taper at the approaches to the work area and at a maximum spacing of 10 metres along the middle of the road next to the work area.
 - ✓ "End of Restriction" signs should be placed 50 metres beyond the work area.
 - ✓ Traffic controllers should stand next to the barriers in the centre of the road to operate the reversible "Stop/Go" signs.
- (4) The controller closest to the oncoming traffic should decide when to stop the flow and allow traffic to travel in the other direction. Traffic should be stopped in both directions when works vehicles enter, leave or turn at the worksite.
- (5) On low-traffic roads, the Maintenance Engineer may approve the use of a simpler system of traffic control.

< 3 > Work execution

(1) The material is off-loaded manually.

OR

(2) Tipped onto the shoulder adjacent to where the patching is required. Material must never be dumped onto the road.

(3) Loose material and standing water is brushed from the pothole or rut to be patched.

(4) Large or deep potholes should have their sides cut back to be vertical and to reach sound material.

(5) The moisture content of the material can be checked quickly by squeezing it in the hand.

(6) If the material is wet enough to stick together, it is suitable for use.

(7) If water runs out of the material, it is too wet and should not be used.

(8) If the material is dry, the area to be patched should be sprinkled with water and water should also be added to the patching material.

(9) The area is filled with gravel to a depth of about 10cm.

(10) If the material is dry, it should be sprinkled with water to help compaction.

(11) The layer is then compacted using the roller or hand rammer.

(12) In this way the thickness of the patch is built up in layers.

(13) Finally, the patched area is filled evenly with the gravel to approximately 3cm above the level of the surface and is spread and raked to the correct shape. 3cm is approximately the thickness of a rake handle.

(14) The patch is then compacted using the roller or hand rammer to give a surface which is slightly above the level of the surrounding road.

(15) Both large or small areas to be patched are repaired in the same way, the rammer is used for the smaller potholes. The roller is used for larger areas although the hand rammers will still be required for the corners and short edges.

(16) Patching work started must not be left unfinished overnight. At night the site should be made safe for traffic and all signs and obstacles removed from the road.

< 4 > Work completion and removal of temporary signs

- (1) Load tools, equipment and unused materials back onto the truck or trailer.
- (2) Remove the signs, cones and barriers and load them onto the truck or trailer in the following order;
 - ✓ "End of Restriction" signs,
 - ✓ Traffic cones,
 - ✓ "Speed Limit" signs,
 - ✓ Barriers,
 - ✓ "Road Narrows" signs,
 - ✓ "Men Working" signs.
- (3) Equipment and traffic signs must not be left at the road side for use the next day.
- (4) Ensure that the site is left clean and tidy with no stockpiles of material left on the road.
- (5) Move onto the next job.
- (6) Inspect traffic signs and clean if necessary.

124.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
124-1	Filling of potholes	Metre Cube

124.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 125 SPOT FILLING

125.01 DESCRIPTION

(1) Work shall be done in compliance with corresponding parts of code 223: REGRAVELLING.

125.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
125-1	Spot Filling	Metre Cube

125.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

1.3 DRAINAGE AND EROSION PROTECTION

CODE 131 CLEANING OF DITCH BY HAND TOOLS

131.01 DESCRIPTION

(1) This work is to;

- ✓ ensure effective transport of surface water and drainage of the pavement structure and adjacent areas,
- ✓ keep water from saturating the subgrade,
- ✓ prevent erosion of the roadway by surface water,
- ✓ control and remove surface water from within the road reserve limits and surrounding area,
- ✓ prevent erosion of shoulders and side slopes and
- ✓ control and remove unwanted vegetation.

(2) The work shall involve all work required to remove sediment, debris and other obstructions and reshape the drainage channels in order to restore the proper gradient, hydraulic capacity and unimpeded flow of water.

(3) The work covers work on all types of drains, including but not limited to side drains, median drains, cut-off drains, mitre drains and covered drains. It includes making minor repairs to short sections of paved or lined drainage channels, scour checks and eroded drains to prevent development of major damages.

131.02 MATERIALS

(1) Nil.

131.03 WORK PROCEDURES

(1) Remove rocks, loose silt and sand, weeds, trees, bushes, including their roots, debris and othering the water way on the ditch.

(2) Dispose collected materials well away from the roadside so that water flow will not be impeded and they will not fall or wash back into the drain.

(3) On unlined ditches a short grass cover can help to stabilize the invert and sides of the drain.

(4) Side drain is established to the correct depth and profile with grass cover to avoid erosion.

(5) Make the site clean and tidy.

131.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
131-1	Cleaning of ditch by hand tools	Metre Liner

131.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 132 CLEANING OF DITCH BY MACHINE

132.01 DESCRIPTION

(1) This work is to;

- ✓ ensure effective transport of surface water and drainage of the pavement structure and adjacent areas,
- ✓ keep water from saturating the subgrade,
- ✓ prevent erosion of the roadway by surface water,
- ✓ control and remove surface water from within the road reserve limits and surrounding area,
- ✓ prevent erosion of shoulders and side slopes and
- ✓ control and remove unwanted vegetation.

(2) The work shall involve all work required to remove sediment, debris and other obstructions and reshape the drainage channels in order to restore the proper gradient, hydraulic capacity and unimpeded flow of water.

(3) The work covers work on all types of drains, including but not limited to side drains, median drains, cut-off drains, mitre drains and covered drains. It includes making minor repairs to short sections of paved or lined drainage channels, scour checks and eroded drains to prevent development of major damages.

132.02 MATERIALS

(1) Nil.

132.03 WORK PROCEDURES

(1) Working in the direction of water flow in the drain, place the excavator in a position straddling the drain and excavate the silt and other debris from the drain and deposit the material behind the back slope. Proceed in this way until desired drain invert is reached.

(2) Using hand tools remove silt and debris from sumps which cannot be de-silted by machine.

(3) Spread the silt evenly in the road reserve away from the drain or load silt into truck and cart away to spoil at approved spoil pits.

(4) Trim the sides of the drain to desired slopes.

(5) Check the depth and gradient of the drain and make corrections as necessary to ensure free flow of storm water. The base of the drain shall be at least 450 mm below the edge of the road shoulder or as directed by the Engineer.

(6) Working backward from the drain outfall, tamp the drain bottom and sides with the excavator bucket to attain a dense surface.

(7) Measure and record the length of de-silted drain

(8) Tidy up the site.

132.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
132-1	Cleaning of ditch by machine	Metre Liner

132.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 133 CLEARING OF CULVERT**133.01 DESCRIPTION**

(1) The work is to maintain the culvert clear and clean in order to function properly and the culvert must retain the full opening over its complete length.

In addition, the upstream approaches and the downstream area must be free from obstructions. Floating debris (tree branches, bushes, etc.) carried by water is a great danger to culverts and this may be a completely blockage on the culvert inlet.

133.02 MATERIALS

(1) Nil.

133.03 WORK PROCEDURES

(1) Remove all debris and other accumulated obstruction materials on the subject area.

(2) Sanding or silting of culverts should be cleared, especially those with openings smaller than 1 meter. These culverts can be cleaned by pulling a cable or rope through with an attachment of any suitable object (e.g. a bucket). Alternatively a long handled trowel and spike can be used for clearing.

(3) Materials and debris collected must be spread or dumped where they cannot cause an obstruction to the flow of water.

(4) Make area clean and tidy.

133.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
133-1	Cleaning of culverts	Metre Cube

133.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 134 REPAIR OF CULVERTS

134.01 DESCRIPTION

(1) The work is to:

- ✓ extend the life of the drainage facility,
- ✓ maintain the unimpeded flow of water through the structure,
- ✓ prevent collapse of the walls and subsequent slippage of retained material and
- ✓ prevent damage to the roadway of the structures.

(2) The activity involves carrying out repair or replacement of corroded or buckled metal culverts, broken or failed concrete culvert elements or culvert bases, damaged wooden culverts and damaged polystyrene culverts in order to extend the life of the drainage facility maintain unimpeded flow of water through the structure and prevent damage to the roadway of the structures.

134.02 MATERIALS

(1) All materials shall be subject to approval of the Engineer prior to work execution.

(2) Cement, sand, concrete aggregates, water, formwork, chalk for marking, gravel for pavement layers, soilcrete, mesh reinforcement, road surfacing materials, precast concrete culvert, penetration grade bitumen or rubber bitumen, diesel fuel for cleaning tools

(3) Other materials if necessary for work execution.

134.04 WORK PROCEDURES

< 1 > Repair of metal culverts

(1) For repair of corroded metal culvert using bitumen coating proceed as follows:

1. Remove any rust from steel sections using steel wire brushes.
2. Heat up penetration grade bitumen or rubber bitumen in a suitable container until it becomes pourable, preferably not to more than 165 deg. C.
3. Apply a 3-4mm thick bitumen coat over the corroded area of the culvert, trying to achieve as smooth a surface as possible. During heating and handling of bitumen, protective gloves and clothing should be worn.
4. Do not leave excess bitumen on culvert invert as it will lead to stagnation of water in the culvert.
5. Count the number of metal culverts repaired, the area coated with bitumen and quantity of bitumen used.
6. Make area clean and tidy.

(2) For repair of corroded metal culvert invert using concrete lining proceed as follows:

1. Remove any rust from steel sections using steel wire brushes.
 2. Mark out the edges of the concrete slab along the inside walls of the culvert using string line or chalk.
 3. Make concrete of specified strength and pour it over the complete length of the culvert invert to attain a minimum specified thickness. The concrete surface should slope slightly to the centre line axis of the culvert and then be troweled smooth.
 4. Concrete the inlet/outlet aprons to adjust to the new culvert inverts.
 5. Measure and record the length of each culvert repaired and the volume of concrete used.
 6. Make area clean and tidy.
- (3) For repair of buckled metal culvert proceed as follows:
1. Mark the area on road surface under which the metal culvert has buckled.
 2. Excavate using pick-axes to expose the buckled area. Stockpile excavated material on the road side for re-use in backfilling. Widen the excavated area to create an anchorage area for the slab of at least 1m width on either side of the culvert and an overlap of 500mm on either side of buckled area along the culvert.
 3. Remove any rust from steel sections using steel wire brushes. Using a hammer, panel beat the buckled culvert to bring it to original shape.
 4. Where necessary fix formwork around the buckled area.
 5. Put mesh reinforcement over the area.
 6. Make concrete of specified strength and pour it over the area to attain a minimum specified thickness.
 7. Cure concrete for three days by covering it with sand and spraying with water.
 8. Backfill the area with either excavated material or approved imported gravel in layers not exceeding 150mm compacted to 93% MDD. AASHTO for fill and subgrade layers, 95% MDD. AASHTO for subbase layers and 98% MDD. AASHTO for base course layers. Use soilcrete for backfilling in areas not easy to compact.
 9. Surface the area using the relevant method for the existing surface.
 10. Record the number of culverts and volume of concrete used.
 11. Make area clean and tidy.

< 2 > Repair of damaged concrete culvert

(1) Mark the area on road surface under which the culvert base slab or culvert has broken or failed.

(2) Excavate using pick-axes and shovels to expose the broken culvert or the failed base slab. Stockpile excavated material on the road side for re-use in backfilling.

(3) For failed base slab, proceed as follows:

1. Carefully lift and remove the concrete culvert element using manual winch.
2. Remove and dispose the broken or failed base slab.
3. Lay bedding sand minimum thickness 100mm.
4. Make concrete of specified strength and cast new base slab with minimum specified thickness. The concrete surface should slope slightly to the centre line axis of the culvert and then be troweled smooth.
5. Cure concrete for three days by covering it with sand and spraying with water.
6. Re-lay the concrete culvert over the new base slab and seal joint with cement mortar.
7. Backfill with either excavated material or approved imported gravel in layers not exceeding 150mm compacted to 93% MDD. AASHTO for fill and subgrade layers, 95% MDD. AASHTO for subbase layers and 98% MDD. AASHTO for base course layers. Use soilcrete for backfilling in areas not easy to compact.
8. Measure and record the length of each culvert base slab repaired and the volume of concrete used.
9. Make area clean and tidy.

(4) For failed concrete culvert proceed as follows:

1. Carefully lift and remove the broken concrete culvert element using manual winch.
2. Lay bedding sand minimum thickness 100mm.
3. Lay new culvert on the base slab and seal joints with cement mortar. Leave to cure for one day.
4. Backfill with either excavated material or approved imported gravel in layers not exceeding 150mm compacted to 93% MDD. AASHTO for fill and subgrade layers, 95% MDD. AASHTO for subbase layers and 98% MDD. AASHTO for base course layers. Use soilcrete for backfilling in areas not easy to compact.
5. Measure and record the number and size of culvert units replaced.
6. Make area clean and tidy.

< 3 > Repair of damaged/failed wooden culvert

- (1) Mark the area on road surface under which the culvert has broken or failed.
- (2) Excavate using pick axes, mattocks and shovels to expose the damaged or failed wooden culvert. Stockpile excavated material on the road side for re-use in backfilling.
- (3) Carefully lift and remove the damaged wooden culvert barrel using manual winch.
- (4) Lay bedding sand minimum thickness 100mm.
- (5) Lay new culvert on the bedding.
- (6) Backfill with either excavated material or approved imported gravel in layers not exceeding 150mm compacted to 93% MDD. AASHTO for fill and subgrade layers, 95% MDD. AASHTO for subbase layers and 98% MDD. AASHTO for base course layers. Use soilcrete for backfilling in areas not easy to compact.
- (7) Measure and record the number and size of wooden culvert barrel replaced.
- (8) Make area clean and tidy.

< 4 > Repair of damaged/failed polystyrene culvert

- (1) Mark the area on road surface under which the polystyrene culvert has broken or failed.
- (2) Excavate using pick axes, mattocks and shovels to expose the damaged or failed polystyrene culvert. Stockpile excavated material on the road side for re-use in backfilling.
- (3) Carefully lift and remove the damaged polystyrene culvert barrel using manual winch.
- (4) Lay bedding sand minimum thickness 100mm.
- (5) Lay new culvert on the bedding.
- (6) Backfill with either excavated material or approved imported gravel in layers not exceeding 150mm compacted to 93% MDD. AASHTO for fill and subgrade layers, 95% MDD. AASHTO for subbase layers and 98% MDD. AASHTO for base course layers. Use soilcrete for backfilling in areas not easy to compact.
- (7) Measure and record the number and size of polystyrene culvert barrel replaced.
- (8) Make area clean and tidy.

134.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
134-1	Repair of culverts	Number

134.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 135 REPAIR OF EROSION DAMAGE

135.01 DESCRIPTION

- (1) This work is to provide scour protection at the toe of slopes, culvert inlets and outlets and in ditches prone to scouring.

135.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Mixing ratio of grout concrete mix shall be 1-cement : 4-sand : 8-gravel.
- (3) Other materials if necessary for work execution.

135.03 WORK PROCEDURES

- (1) When only light erosion of the stream bed has taken place at the culvert outlet proceeds as follows:
- (2) Fill eroded area with stone blocks of about 30 cm size to produce a rough energy dissipater.
- (3) Install block pitching or riprap beyond the eroded area.
- (4) Installed blocks should be grouted once the water subsides or during dry season.
- (5) When stone is not available, logs can be used, lined across the stream bed and extending into the stream banks for anchorage. For additional stability use steel cramps to tie logs to one another.
- (6) Jute (or plastic) sacks, filled with soil can also be used as an alternative to rock lining. The soil can be mixed with about 5% cement for extra stability.
- (7) Lay sacks flat in layers, the sacks in one layer covering the joints in the layer below.
- (8) Collect all excess materials and debris and dispose into a safe place.
- (9) Make the site clean and tidy.

135.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
135-1	Repair of erosion damage	Metre Cube

135.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 136 REPAIR OF RETAINING WALL

136.01 DESCRIPTION

(1) This work is to repair headwalls/apron damaged by erosion or settlement to prevent further erosion and settlements on the foundations.

136.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Mixing ratio of mortar shall be 1-cement : 4-sand.
- (3) Other materials if necessary for work execution.

136.03 WORK PROCEDURES

- (1) Remove settled or damaged section of the headwall/apron.
- (2) Compact the underlying soil.
- (3) Rebuild the headwall or apron using similar materials to the original.
- (4) Grout up all joints with mortar.
- (5) When the walls are strong enough (after 2 or 3 days curing) backfill behind walls with soil.
- (6) Remove all debris and excess materials and dispose into a safe place.
- (7) Make the site clean and tidy.

136.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
136-1	Repair of retaining wall	Metre Cube

136.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 137 REPAIR OF DITCH LININGS

137.01 DESCRIPTION

(1) This work is to restore and repair the damage lined ditches immediately due to settlements.

137.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Mixing ratio of mortar shall be 1-cement : 4-sand.
- (3) Other materials if necessary for work execution.

137.03 WORK PROCEDURES

- (1) Remove settled or damaged precast sections or loose stone blocks.
- (2) Compact the underlying soil by hand rammer.
- (3) Backfill with suitable material and compact to correct levels.
- (4) Replace the precast sections or blocks to the correct line and grade, bed them on mortar.
- (5) Grout up any open joints with mortar and leave 3days for curing.
- (6) All excess materials should be disposed into a safe place.
- (7) Make the site clean and tidy.

137.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
137-1	Repair of ditch lining	Metre Square

137.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA002 REPAIR OF DRAIN COVER**AA002.01 DESCRIPTION**

- (1) This work is to:
- ✓ allow pedestrians to pass over drain without danger,
 - ✓ protect sides of drains against scour or erosion,
 - ✓ ensure that broken or missing covers are replaced without delay for purposes of public safety and
 - ✓ control of debris ingress into drain.
- (2) The work shall involve removal, repair, realignment or replacement of damaged or missing drain cover to ensure that the cover is in place, functional and in good repair.
- (3) The work also includes clearing of drain blockage at the concerned location of the drain cover. This activity shall be carried out using labor based method.

AA002.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Metal drain cover and frame or precast concrete drain cover, aggregates, sand, water, cement and preservative/bituminous paint.
- (3) Other materials if necessary for work execution.

AA002.03 WORK PROCEDURES

- (1) If the repair or replacement of the drain cover will not be completed in one day the area should be properly barricaded and protected with danger tape around the area.
- (2) Before repair or replacement of the cover, the drain shall be cleaned of any debris or dirt that may have fallen inside the drain.
- (3) If the cover is displaced from the drain or misaligned, using crow bar push it back to its original position ensuring that it is properly seated, flush with the sides and level around the complete rim.
- (4) If it is a metal cover and the cover frame is damaged, remove the cover and place it on the side of the drain. Remove the frame by breaking the concrete surround using chisel and hammer then cast in concrete the new cover frame. Cure the concrete for at least three days. Dip in approved preservative/bituminous paint and replace the cover ensuring that it is properly seated and level around the complete rim.
- (5) If it is a metal cover and the cover is bent, remove the cover, panel beat it to its original shape, apply bituminous paint and reinstate on the existing frame ensuring that it is properly seated and level around the complete rim.
- (6) If the cover is damaged or broken, remove the cover including parts that may have fallen into the drain and replace with a new similar cover ensuring that it is properly seated, flush with the sides and level around the complete rim.

(7) Count and record the number of covers and/or frames repaired, reinstated or replaced.

(8) Make the site clean and tidy.

AA002.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
AA002-1	Repair of drain cover	Number

AA002.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A004 REPAIR OF INVERT**A004.01 DESCRIPTION**

- (1) Corrugated steel culverts will corrode if the protective galvanizing or coating is damage and when the inverts are particularly at risk from this type of damage.
- (2) This work is to repair when the surface rust starts. Do not wait until holes appear in the steel.

A004.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Bitumen emulsion, cement, sand and gravel.
- (3) Other materials if necessary for work execution.

A004.03 WORK PROCEDURES

- (1) Type of treatment methods are as follows:

1. Method A: Painting with bitumen

- (a) Clean the area and ensure the dryness of the area to be painted.
- (b) Remove any rust using steel wire brush or other suitable tools.
- (c) Heat straight run (penetration) bitumen in a suitable bitumen heater until pourable but preferably not heated to more than 100 °C. Care must be taken when heating and handling the bitumen, protective gloves and clothing should be worn.
- (d) Apply a thick coat (3-4 mm) of bitumen over the lower half of the culvert. The bitumen can be poured and brushed well into the surface. Try to achieve as smooth a surface as possible.
- (e) Excess bitumen should not be left on the invert which might allow accumulation of water.
- (f) Make the site clean and tidy.

2. Method B: Concrete lining

- (a) Remove any rust using steel wire brush or other suitable tools.
- (b) Mark out the edges along the inside wall using string line or chalk line.
- (c) Pour concrete slab of 10 cm minimum thickness over the complete length of the culvert invert. The concrete surface should slope slightly to the centre line axis of the culvert and then be troweled smooth.
- (d) Inlet and outlet aprons to be concreted and finish adjusted to the new invert culvert levels.
- (e) Curing has to be done for minimum 3days to attain maximum strength of the concrete.
- (f) Make the site clean and tidy.

A004.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
A004-1	Repair of invert	Metre Square

A004.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A005 REALIGNMENT

A005.01 DESCRIPTION

(1) This work is to re-align lined ditch in a way that the water will flow smoothly around the sharp bends and extend with a flat outfall to reduce the speed of the water along the ditches.

A005.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Aggregates, sand, cement, Masonry stone, brick and blocks
- (3) Other materials if necessary for work execution.

A005.03 WORK PROCEDURES

- (1) Stretch string line for the new alignment of the drain location following the contour lines to reach safely discharge.
- (2) Drain has to extend with a flat outfall to reduce the speed of water at a gradient of 2% to 5%.
- (3) Relay drain sections should be smoothly easy curve and grouted on the open joints to prevent collapse on the side walls. Special pre-cast curve ditch is highly recommended.
- (4) Excavate and remove all materials on the new drain alignment.
- (5) Materials excavated from the drain must be removed and spread out clearly.
- (6) Grout smoothly any open joints of drain sections.
- (7) Remove all excess materials and debris and dispose into a safe place.
- (8) Make the site clean and tidy.

A005.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A005-1	Realignment	Metre Liner

A005.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A006 RE-GRADE/REALIGNMENT/DEEPEN

A006.01 DESCRIPTION

- (1) This work is to re-grade, realign and deepen unlined ditches to obtain correct cross-section and grade using labor method.

A006.02 MATERIALS

- (1) Nil.

A006.03 WORK PROCEDURES

- (1) Stretch string line on the edge of the ditch for excavation.
- (2) Excavate a trapezoidal ditch shape in order that flat invert to lessen water concentration on the ditch line.
- (3) Check excavation ditch shape in every 10m using template of 50cm wide slot.
- (4) Gradients should also checked by using ranging rods and profile or abney level to ensure no ponding.
- (5) Excavate all surplus materials between the slots and correct the shape using stretched string line between the slots.
- (6) Materials excavated from the drain must be removed and spread clearly away from the drain.
- (7) When excavating a completely new ditch it is preferable to split the task into two operations:
 1. Cut the central rectangular shape and check with the template (invert).
 2. Cut the slopes and check with the full template (Slopes).
- (8) Remove all excess materials and debris and dispose to a safe place.
- (9) Make the site clean and tidy.

A006.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A006-1	Re-grade/Realignment/Deepen	Metre Liner

A006.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A007 CLEARING AND CLEANING OF MANHOLE

A007.01 DESCRIPTION

(1) This work is to remove all soil, vegetation, materials and objects from the manhole that could possibly interfere with water flow or cause an eventual blockage of the drainage line.

A007.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Water.
- (3) Other materials if necessary for work execution.

A007.03 WORK PROCEDURES

- (1) Remove manhole cover or grating.
- (2) Ensure that the manhole is free from noxious gases.
- (3) Remove all debris, sand and silt from manhole using hand tools and buckets.
- (4) If water still cannot flow, insert the rod on the manhole downstream of the clog until it has been removed and water flows freely.
- (5) If rodding is not successful or not possible, use the aid of the water pump.
- (6) Waste material from manholes, catch-pits or pipes shall be removed and cleared on the surrounding area and disposed to a safe place.
- (7) Make the site clean and tidy.

A007.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A007-1	Clearing and cleaning of manhole	Number

A007.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A008 REPLACE COVER/GRATING**A008.01 DESCRIPTION**

- (1) This work is to maintain the manhole cover and/or grating for the safety of the road users.

A008.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Prefabricated Manhole cover and/or grating.
- (3) Other materials if necessary for work execution.

A008.03 WORK PROCEDURES

- (1) Remove manhole cover or grating if damaged or broken including parts that may have fallen into the manhole.
- (2) When cover or grating is missing, search the vicinity and if it is found undamaged, put back to the uncovered manhole. Be sure that the cover or grating is seated properly and level around the complete rim.
- (3) If a new cover or grating has to be provided, be sure that the correct size is used.
- (4) Provide temporary cover on open manholes that cannot be immediately replaced. Use wooden planks of adequate thickness.
- (5) Make the area clean and tidy.

A008.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A008-1	Replace cover/grating	Number

A008.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A009 CLEAN MANHOLE AREA**A009.01 DESCRIPTION**

- (1) This work is to remove all silt and debris covering on manhole area.

A009.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Prefabricated Manhole cover and/or grating.
- (3) Other materials if necessary for work execution.

A009.03 WORK PROCEDURES

- (1) Locate manhole using the drainage plan or by trial excavations.
- (2) Remove all vegetation within the distance of 2 to 3 metres from the manhole and remove from the site.
- (3) Excavate all deposits of silts or soil covering the manhole down a depth of at least 10 cm below manhole invert level for a distance of at least 1 metre from the manhole edges.
- (4) Check that the manhole is free of sand or silt and return the cover.
- (5) Make the site clean and tidy.

A009.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A009-1	Clean manhole area	Number

A009.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

1.4 ROUTINE BRIDGE MAINTENANCE

CODE 141 REPLACEMENT OF MINOR BAILY BRIDGE PARTS

141.01 DESCRIPTION

- (1) This work is to ensure all structural components of bailey bridge are safe and well-functioning.
- (2) The work shall involve maintenance and minor repair of damaged steel structural components including bent, cracked, delaminated, scaled, loose or corroded elements. These are minor maintenance works of routine nature on steel structural elements. The work shall be carried out using labor based method.

141.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Replacement parts for steel components, welding rods, bolts and nuts, primer and paint.
- (3) Other materials if necessary for work execution.

141.03 WORK PROCEDURES

- (1) Place warning signs before commencing with any activity for safety of workmen and traffic control.
- (2) Use the crane or hydraulically operated jacks to support temporarily the steel bridge section with damaged members to enable removal and replacement of the damaged members.
- (3) Carefully remove the damaged steel members without damaging the connecting members.
- (4) Repair the damaged elements using approved methods to restore them to their original shape. If not repairable, replace them with new similar elements.
- (5) Replace with new missing or damaged bolts and nuts.
- (6) Panel beat bent members to original shape ensuring that the member is not structurally dented or disfigured. Buckled members shall be replaced with new members.
- (7) Steel members with cracks less than 1mm shall be repaired by welding on site. Members with cracks greater than 1mm and less than 3mm shall be taken to a workshop for controlled welding. Members with cracks wider than 3mm shall be replaced with new elements.
- (8) Carefully reinstate the members to their original position on the bridge.
- (9) Prime and paint the fixed members to match color with existing members.
- (10) Remove the temporary supports.

(11) Measure and record the number and size of steel bridge elements repaired or replaced.

(12) Tidy up the area.

(13) Remove all temporary signs and devices.

141.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
141-1	Replacement of minor baily bridge parts	Number

141.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 142 CLEANING OF BRIDGE

142.01 DESCRIPTION

- (1) This work is to prevent:
- ✓ Accumulation of dirt and soil on bridge deck
 - ✓ Blocked scuppers
 - ✓ Stones, soil, dirt in joints and around bearings
 - ✓ Vegetation, soil in weep holes or in backfill drainage* outlets
 - ✓ Flood debris at bridge
 - ✓ Wind blown debris on bridge.

142.02 MATERIALS

- (1) Nil.

142.03 WORK PROCEDURES

< 1 > Deck

- (1) Broom the bridge deck and sidewalks clear of all loose soil, dirt, aggregate, debris, and remove these from site.

< 2 > Planking

- (1) Remove all dirt and stones lodged between deck planking.

< 3 > Scuppers

- (1) Clear all drainage scuppers of dirt and debris so that rainwater can drain freely.

< 4 > Joints, Bearings

- (1) Remove all dirt and debris in joints between beams and abutment walls, and around beam bearings or supports.

142.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
142-1	Cleaning of Bridge	Metre Square

142.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 143 CLEARING OF RIVER CHANNELS FROM DEBRIS ETC.

143.01 DESCRIPTION

- (1) This work is to prevent:
- ✓ Flood debris under bridge
 - ✓ Wind blown debris under bridge.

143.02 MATERIALS

- (1) Nil.

143.03 WORK PROCEDURES

- (1) Remove debris carried by floodwater or wind and lodged at piers and abutments, or at any point under bridge.
- (2) Remove growing trees and bushes from area under bridge and directly upstream and downstream, by cutting off near ground level. Dispose of material away from bridge and stream.
- (3) Any signs or reflectors on, or at, the bridge should be examined and if necessary washed clean, taking care not to scratch any reflective paint surfaces.

143.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
143-1	Clearing of River Channels from Debris etc.	Metre Cube

143.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 144 BRIDGE BUSH CLEARING

144.01 DESCRIPTION

- (1) Work shall be done in compliance with Code 161/162/163.

144.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
144-1	Bridge Bush Clearing	Metre Square

144.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 145 REPAIR OF STEEL DECKING

145.01 DESCRIPTION

- (1) This work is to ensure all structural steel bridge components are safe and well-functioning.
- (2) The work shall involve maintenance and minor repair of damaged decks including bent, cracked, delaminated, scaled, loose or corroded elements. These are minor maintenance works of routine nature on steel structural elements. The work shall be carried out using labor based method.

145.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Replacement parts for steel components, welding rods, bolts and nuts, primer and paint.
- (3) Other materials if necessary for work execution.

145.03 WORK PROCEDURES

- (1) Place warning signs before commencing with any activity for safety of workmen and traffic control.
- (2) Use the crane or hydraulically operated jacks to support temporarily the steel bridge section with damaged members to enable removal and replacement of the damaged members.
- (3) Carefully remove the damaged steel members without damaging the connecting members.
- (4) Repair the damaged elements using approved methods to restore them to their original shape. If not repairable, replace them with new similar elements.
- (5) Replace with new missing or damaged bolts and nuts.
- (6) Panel beat bent members to original shape ensuring that the member is not structurally dented or disfigured. Buckled members shall be replaced with new members.
- (7) Steel members with cracks less than 1mm shall be repaired by welding on site. Members with cracks greater than 1mm and less than 3mm shall be taken to a workshop for controlled welding. Members with cracks wider than 3mm shall be replaced with new elements.
- (8) Carefully reinstate the members to their original position on the bridge.
- (9) Prime and paint the fixed members to match color with existing members.
- (10) Remove the temporary supports.

(11) Measure and record the number and size of steel bridge elements repaired or replaced.

(12) Tidy up the area.

(13) Remove all temporary signs and devices.

145.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
145-1	Repair of steel decking	Number

145.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 146 REPAIR OF TIMBER DECKS AND RUNNING STRIPS

146.01 DESCRIPTION

- (1) Work shall be done in compliance with Code 231 and 232.

146.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
146-1	Repair of Timber Decks and Running Strips	Number

146.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A010 REPAIR OF DRIFT/CAUSEWAY**A010.01 DESCRIPTION**

- (1) This work is to seal cracks, filling of potholes and erosion cavities to prevent settlements on the structure.

A010.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Bitumen, aggregates, sand and cement.
- (3) Other materials if necessary for work execution.

A010.03 WORK PROCEDURES

- (1) The work method and procedure is divided into 3 types by damage type as shown below.

1. Cracks

- (a) Sweep, clean and ensure the dryness on the subject area.
- (b) Mark out and layout the subject area with a chalk or paint.
- (c) Treatment application carries two different systems marked as follows:
- Closely spaced cracks will be filled with bituminous slurry:
 - ✓ Production of slurry by mixing 6 litres of bitumen emulsion with 20 litres of coarse sand (D=5mm) in a wheelbarrow.
 - ✓ Spread out slurry in a thin layer approximately 5mm thick over the marked area using squeegee.
 - ✓ The slurry must be allowed to dry completely before opening to the traffic.
 - Isolated cracks:
 - ✓ Fill-in the cracks with hot cut back bitumen using a spray lance or watering can.
 - ✓ Coarse sand is followed to be scattered over the fill-in binder using a shovel.

2. Potholes

- (a) Break damage area down to the bottom of the slab.
- (b) Clean and sweep the area.
- (c) Fill up with concrete (1 cement: 2 sand: 4 aggregate), mortared stone works or bricks as appropriate.

3. Erosion

- (a) Fill up with large stones or riprap.
- (b) In case of serious or recurring erosion, gabion mattresses should be laid on the bed of the watercourse with their top surface at the same level as, or slightly below the level of, the drift or causeway inverts.

(2) All excess materials should be disposed into a safe place.

(3) Make the site clean and tidy.

A010.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
A010-1	Repair of drift/causeway	Meter Square

A010.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A011 CLEARING AND CLEANING ON DRIFT/CAUSEWAY

A011.01 DESCRIPTION

(1) This work is to remove debris and silt from drifts and causeways to avoid danger to the traffic.

A011.02 MATERIALS

(1) Nil.

A011.03 WORK PROCEDURES

(1) Remove and sweep all debris and silt on the drift or causeway.

(2) Waste material from drift cleaning shall be spread 1m clear of the downstream of the drift, or removed clear of the road and deposited in a suitable location.

(3) A motor or towed grader may be used for clearing the paved surface.

(4) The windrow must be spread clear on the downstream of the crossing to allow free passage of water.

(5) Make the site clean and tidy.

A011.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
A011-1	Clearing and cleaning	Meter Square

A011.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA003 REPAIR BRIDGE STEEL COMPONENT

AA003.01 DESCRIPTION

- (1) This work is to ensure all structural steel bridge components are safe and well-functioning.
- (2) This work shall involve maintenance and minor repair of damaged steel structural components on bridges including bent, cracked, delaminated, scaled, loose or corroded elements.
- (3) These are minor maintenance works of routine nature on steel structural bridge elements.

AA003.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Replacement parts for steel components, welding rods, bolts and nuts, and primer and paint.
- (3) The material shall be in compliance with requirements stipulated in the original design documents.
- (4) Other materials if necessary for work execution.

AA003.03 WORK PROCEDURES

- (1) Use the crane or hydraulically operated jacks to support temporarily the steel bridge section with damaged members to enable removal and replacement of the damaged members.
- (2) Carefully remove the damaged steel members without damaging the connecting members.
- (3) Repair the damaged elements using approved methods to restore them to their original shape. If not repairable, replace them with new similar elements.
- (4) Replace with new missing or damaged bolts and nuts.
- (5) Panel beat bent members to original shape ensuring that the member is not structurally dented or disfigured. Buckled members shall be replaced with new members.
- (6) Steel members with cracks less than 1mm shall be repaired by welding on site. Members with cracks greater than 1mm and less than 3mm shall be taken to a workshop for controlled welding. Members with cracks wider than 3mm shall be replaced with new elements.
- (7) Carefully reinstate the members to their original position on the bridge.
- (8) Prime and paint the fixed members to match colour with existing members.

(9) Remove the temporary supports.

(10) Make the site clean and tidy.

AA003.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
AA003-1	Repair of bridge steel component	Number

AA003.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA004 REPAIR SUBSURFACE DRAINAGE**AA004.01 DESCRIPTION**

(1) This work is to remedy failure occurred in subsurface drainage and ensure smooth transport of subsurface water under the pavement.

AA004.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The material shall be in compliance with requirements stipulated in the original design documents.
- (3) Other materials if necessary for work execution.

AA004.03 WORK PROCEDURES

- (1) Pipe or conduit networks, under the pavement or at some critical area in an embankment, are often installed to draw moisture moving through the soil and granular material of the roadway structure into the pipe network and to release the water into the ditches or natural channels.
- (2) The pipe networks are open at the discharge end only. However, pavement edge drains may have frequent discharge points into the roadside ditch. The drain discharge points should be checked annually during the wet season to ensure that the drain system of perforated pipes or the discharge opening is not clogged.
- (3) If root and vegetation growth are clogging a drain, herbicides may be applied to kill the vegetation. Before applying any herbicide in response to a clogged underdrain system, assess what the peripheral impact may be (e.g. introducing possible toxins in the groundwater or killing trees that may be nearby and have feeder roots in the area).
- (4) If the conduits are plugged with silt or granular material, it is probable that the drain network will have to be excavated and replaced.
- (5) Suction pumps, high-pressure water jets, and power rotary sewer cleaners can be used to clean out long sections of pipe that have been clogged with roots and sand if the original design and construction provided clean-out access points.
- (6) If the pipe has to be excavated and replaced, placing a synthetic geotextile fabric between the pipe and soil or granular material will help prevent a return of the clogging condition.
- (7) Installation of an underdrain in the shoulder should have included backfilling the trench with a compacted layer of impervious material and capping the trench with paving material to seal its surface from infiltrating water to minimize future settlement.
- (8) When underdrains have been installed after the original pavement was constructed and in service, the additional joints created by the underdrain trench cut need to be inspected and sealed along with the longitudinal joint along the pavement and shoulder.

(9) In all joint and crack sealing, as well as any pavement undersealing operations, work near underdrains should be done in a manner that does not fill the underdrain pipe with sealant.

(10) Make the site clean and tidy.

AA004.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
AA004-1	Repair of subsurface drainage	Meter Liner

AA004.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA005 CRACK SEALING ON CONCRETE WEARING SURFACE

AA005.01 DESCRIPTION

(1) This work is to repair transverse or longitudinal cracks on concrete wearing surface that may only extend partway through the deck or it may occur as a failure plane running completely through the concrete structural element.

AA005.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials applied for the work should comply with following requirements.

Material Specification of Sealant Material

Material	Specifications (AASHTO/CT)	Application Type
Asphalt emulsion	M140, M208/CT Sec. 94	Filling
Asphalt cements	M20, M226/ CT Sec.94	Filling
Polymer modified emulsion	M140, M208/ CT Sec. 94	Filling (Minor Sealing)
Asphalt rubber (AR)	CT SSP 37-400	Sealing
Specialty AR Low modulus	CT SSP 37-400	Sealing

- (3) Other materials if necessary for work execution.

AA005.03 WORK PROCEDURES

- (1) Cracks may be categorized to either “working” (i.e. the crack is expanding and contracting, is growing length, or is opening and closing, with elapsed time or with changing environmental conditions), or “non-working” (i.e. the cracks are stable in their character and extent of their existence).
- (2) Non-working cracks may be filled or sealed, or both, with any material deemed suitable for the bridge’s material and for the environmental conditions the bridge experiences.
- (3) Working cracks, on the other hand, typically are more difficult to treat. Structural engineers need to assess the working crack for its danger to the structural member and to the bridge as a whole.
- (4) If the crack is deemed to not present any immediate danger to the bridge, the cracking condition may be recorded and monitored for changes until such time as an engineering assessment suggests some treatment is needed.
- (5) If the working crack is deemed to present a danger to the bridge, a structural engineering and an engineering material assessment should be undertaken to determine if the bridge member can be repaired or whether the cracked member should be replaced.
- (6) Make the site clean and tidy.

AA005.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
AA005-1	Crack sealing on concrete wearing surface	Meter Square

AA005.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA006 REPAIR OF CONCRETE BEAM

AA006.01 DESCRIPTION

- (1) Bridge beams under deck joints, under drains, and along any bridge fascia are potentially exposed to corrosive elements. Bridge beams on overpass bridges are subject to damage from collisions caused by vehicles and loads exceeding the underpass clearance height.
- (2) When bridge beams have been damaged by such collisions, it is especially important to inspect for collateral damage to bearings, piers, and other elements of the structure, so a complete repair can be made.
- (3) If responsible agency has a policy of recovering damages for over height vehicle collisions all associated damage should be documented at the initial inspection

AA006.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The material shall be in compliance with the original design documents.
- (3) Other materials if necessary for work execution.

AA006.03 WORK PROCEDURES

- (1) Concrete beams should be kept clean and protected from saltwater, saltwater spray, or water from the deck containing deicing chemicals.
- (2) Concrete sealers and coatings protect concrete exposed to saltwater if they are applied to a clean surface before the concrete surface is contaminated.
- (3) If the concrete surface has already been contaminated, the surface must be blast-cleaned before the sealers are applied; even then, the effectiveness may be reduced because of chlorides penetrating below the surface.
- (3) Before agency personnel attempt to repair any concrete beam that has been damaged, a professionally qualified structural engineer should evaluate the damage, determine the type of repair needed, and evaluate if the agency can perform the repair or if it should be contracted to a firm having capacities not present in the agency.
- (4) Such repairs include repairing impact damage from over-height vehicles and spalling from corrosion of reinforcing steel.
- (5) While many factors must be considered when determining the best repair method, two key factors are the location and the severity of the damage. For instance, a small area of damage is not structurally significant in a tension area of a beam if the reinforcing steel is not damaged; thus, it may be sufficient to protect the steel from exposure to elements that cause corrosion.
- (6) This protection can be provided by placing a surface patch with hand methods or even by coating the exposed reinforcing bars (if appearance is not an issue) or applying

shotcrete to the area (if it is cost effective).

(7) If a beam has a large damaged area that will permit a formed repair to be made, make the formed repair because it will likely be a more permanent patch. Generally, placing the aggregate inside the formed area and injecting a grout into the formed aggregate area gives the best results.

(8) Structural repairs to beams may require supporting the superstructure during the repair process. Temporary bents or carrier beams designed by a professionally qualified structural engineer will provide the necessary support.

(9) If the reinforcing steel is damaged or if the damage extends into a compression area of the beam, however, it may be necessary to jack the dead-load stresses out of the damaged area before repairs are made.

(10) Concrete beam ends can be repaired by observing the following generally accepted steps.

1. Direct traffic to the far side of the bridge until repairs on the beam end are completed.
2. If the superstructure cannot be jacked and supported from the existing substructure, construct a temporary bent for this purpose.
3. Place jacks and raise the entire end of the bridge a fraction of an inch. The lift should be only that required to insert a piece of sheet metal as a bond breaker for the new concrete.
4. Place the sheet metal bond breaker on the beam seat.
5. After cutting with a saw to avoid feathered edges, remove the damaged concrete in zigzag steps to provide horizontal bearing surfaces.
6. Place new reinforcing steel as needed, making certain it is properly lapped, anchored, or mechanically attached to the existing reinforcing steel.
7. After forming, clean the surface of the existing concrete and apply a bonding material.
8. Place new concrete with an additive to reduce concrete shrinkage during the curing process.
9. After the concrete has reached sufficient strength and the repaired area has been visually inspected and sounded, simultaneously jack all beams to sufficient height, allowing placement of the elastomeric bearing pads.
10. Uniformly lower the entire end of the bridge.
11. Make the site clean and tidy.

AA006.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
AA006-1	Repair of concrete beam	Meter Square

AA006.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

1.5 TRAFFIC SAFETY

CODE 151 REPAIR OF SIGNS

151.01 DESCRIPTION

(1) This work is to:

- ✓ Assist road users in the safe and orderly movement of traffic.
- ✓ Keep signs in good repair and easily readable at all times.

(2) The work includes repair of damaged road signs (including street name signs) in order to ensure that signs erected maintain their intended function.

151.02 MATERIALS

(1) All materials shall be subject to approval of the Engineer prior to work execution.

(2) Paint that meets specification for reflectorized signs, paint brush cleaner, sand paper, cement, aggregates, sand and water

(3) Other materials if necessary for work execution.

151.03 WORK PROCEDURES

(1) Remove the damaged sign, sign post or overhang support from supporting structure and transport to a designated workshop.

(2) Panel beat damaged areas of the sign, sign post or overhang support to original shape.

(3) Remove retro-reflective material, scales, and any oxidized paint.

(4) Apply automotive body filler to panel-beaten area and sand down to flush finish.

(5) Paint or spray paint the primer and finish coat on sign face and reverse side.

(6) Cut retro-reflective material and affix to sign face.

(7) Paint the sign post and overhang support.

(8) Transport the sign, sign post and overhang support back to the road and install the complete sign on the support structure.

(9) Make the site clean and tidy.

151.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
151-1	Repair of signs	Number

151.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA007 REPLACE OF SIGNS

AA007.01 DESCRIPTION

- (1) This work is to remove damaged sign and install new sign for assisting road users in the safe and orderly movement of traffic.

AA007.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Paint that meets specification for reflectorized signs, paint brush cleaner, sand paper, cement, aggregates, sand and water
- (3) Other materials if necessary for work execution.

AA007.03 WORK PROCEDURES

- (1) Remove the damaged sign, sign post or overhang support from supporting structure and transport to a designated workshop.
- (2) Transport new sign, sign post and overhang support back to the road and install the complete sign on the support structure.
- (3) Make the site clean and tidy.

AA007.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
AA007-1	Replace of signs	Number

AA007.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 152 REPAIR OF GUARDRAILS

152.01 DESCRIPTION

- (1) This work is to replace damaged elements of the guardrails and the posts for the safety of the road users.

152.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.

1. Posts

- (a) Posts and plates shall be of the dimensions and types shown on the Drawings and manufactured of structural steel conforming to the requirements of AASHTO M 183.

- (b) Posts and plates shall be galvanised, after fabrication and hole drilling, in accordance with the requirements of AASHTO M 111. Hardware shall be galvanised in accordance with the requirements of AASHTO M 232.

2. Beams

- (a) Beams shall conform to the requirements of AASHTO M 180, Class A, Type 1.

- (b) Slots and round holes shall be drilled, punched, burned or cut before the beams are galvanised. The same criteria shall apply for curved sections and splice plates.

- (3) Other materials if necessary for work execution.

152.03 WORK PROCEDURES

- (1) Unbolt and remove damaged guardrail panels and posts.

- (2) If the timber or steel post is damaged, it must be extracted and replaced.

- (3) New timber posts must be of the correct length, pressure treated if possible, and the top sawn at an angle to allow rainwater to run off. Drill the holes for bolts.

- (4) Excavate the post hole wide enough to allow use of the tamper to compact soil around the post. Alternatively, an excavation can be hand bored using a hand-auger for the lower half of the excavation.

- (5) Place the post in the excavation, check position, height and alignment. The post must be kept vertical and in alignment during backfilling.

- (6) Place the backfill in layers not exceeding 10cm loose soil. Compact the loose soil with a hand rammer, adding water if necessary until no further compaction is attainable. Repeat until the soil backfill is level with the ground surface.

- (7) Where steel posts are used, they should be cast into a concrete footing, allow the

concrete to set.

(8) Assemble the new guardrails, taking care that the section overlaps are installed exactly as before. The joint overlaps must correspond with the direction of the traffic in the nearest lane.

(9) Tighten all bolts and nuts.

(10) Make the site clean and tidy.

152.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
152-1	Repair of guardrails	Metre

152.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 153 REPAIR OF GUARD POSTS

153.01 DESCRIPTION

- (1) This work is to repair and/or replace damaged elements of the guard posts for ensuring safety of the road users.
- (2) The work includes cleaning, repainting, replacing and reinstating worn out, damaged or missing post.

153.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Ammonia based detergent, clean water, cleaning cloth, paint that meets specification, paint brush cleaner, glue or epoxy, cement, aggregates, sand and water
- (3) Other materials if necessary for work execution.

153.03 WORK PROCEDURES

< 1 > Cleaning

- (1) Clean existing posts using water, cleaning cloth and the ammonia based detergent.
- (2) Count and record the number of the posts cleaned.
- (3) Make the site clean and tidy.

< 2 > Repainting

- (1) Prepare surfaces to be painted by cleaning them using brushes, water and cloth. Use detergents to remove dirt that is difficult to clean by plain water.
- (2) Apply primer and paint in accordance with manufacturer's recommendations.
- (3) Count and record the number of the posts repainted.
- (4) Make the site clean and tidy.

< 3 > Replacement

- (1) Using pick axes, excavate holes for the post to a minimum depth of 300mm from ground level.
- (2) Place the post in the hole and backfill the hole in hand rammed thin layers of approved soil or concrete not exceeding 100mm thick and ensure that the post is finally in a vertical position.
- (3) Count and record the number of the posts replaced.

(4) Make the site clean and tidy.

153.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
153-1	Repair of guard posts	Number

153.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 154 PAINTING TRAFFIC LINES

154.01 DESCRIPTION

(1) The work covered by this Section consists of the application of continuous or intermittent lines, letters or figures and the supply and installation of reflecting road studs, including any necessary excavation, grouting and finishing of the pavement, to the dimensions and at the locations shown in the Contract Documents or as directed by the Engineer, including the supplying of all labour, tools and equipment, materials, warning and traffic guidance signs as necessary for the safe and efficient completion of the entire work, and shall consist of hot applied thermoplastic or cold applied traffic marking paint (non-thermoplastic paint), reflectorized with glass beads, as directed. (Corresponding to SECTION 604 of the STS.)

154.02 MATERIALS

< 1 > General

(1) The retroreflective traffic markings shall meet the performance requirements specified in ASTM D4280, Section 6.2, for luminous intensity, flexural strength, compressive strength, resistance to cracking, and thermal cycling, as modified herein

(2) For each lot or batch of paint and glass beads, a certificate of compliance, including the product name, lot or batch number, and manufacture date shall be submitted.

(3) All paints shall be free from all skins, dirt and foreign objects.

1. Color

(a) White coloured materials will only be required to meet the initial daytime chromaticity requirements.

(b) White and yellow materials for pavement markings shall meet the performance requirements as shown in below table. The initial daytime chromaticity for white and yellow materials shall fall within the box created by the following coordinates:

Initial Daytime Chromaticity for White and Yellow Materials

Initial Daytime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.530	0.510	0.455	0.472
y	0.456	0.485	0.444	0.400

(c) The night-time chromaticity for yellow materials shall fall within the box created by the following coordinates:

Night-time Chromaticity for Yellow Materials

Initial Daytime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

< 2 > Bituminous Adhesive for Traffic Markers

- (1) Bituminous adhesive as recommended by the marker manufacturer shall be used for bonding the markers to the pavement.
- (2) The bituminous adhesive shall meet the properties of adhesives per ASTM D4280 Section A1, including filler-free and filler alone properties.
- (3) The performance of the adhesive shall be determined in accordance with the test methods listed in ASTM D4280.
- (4) Thermoplastic primers shall conform to current MONRE air pollution regulations, including those for the control of emissions (Volatile Organic Compounds, VOC).

< 3 > Thermoplastic Materials

- (1) The laid material shall be one of three types detailed below as required by the Contract Documents or as directed by the Engineer, and in accordance with AASHTO T 250-05.

< 3-1 > Non-Reflectorized Thermoplastic

- (1) The thermoplastic material shall be factory mixed, from an approved manufacturer and shall be suitable for the type and location of application. The material shall possess adequate thermoplastic properties over the range of climatic conditions of the location, i.e. resistance to spreading under traffic at the highest road temperatures and retention of plasticity at the lowest road temperatures and shall give a marking which is effective for at least eighteen months under normal traffic conditions. The composition of the material with minimum and maximum proportions and grading of the constituents, the acid value of the binder, the temperature range of mixing and application, the setting time, the softening point (°C) and the open flash point (°C) shall be as stated.
- (2) The thermoplastic composition shall be specifically formulated for application at temperatures greater than 205°C. The components in the compositions shall show no significant break-down, or deterioration at 246°C.
- (3) The binder component shall be formulated as a hydrocarbon resin; or it shall be formulated as a mixture of high boiling point monohydric primary alcohol and modified maleic resin; or the manufacturer may submit an optional binder formulation for Engineer's approval. The pigment, beads and filler shall be uniformly dispersed in the binder resin.

Thermoplastic Composition

Component	Test Method	% by Weight	
		White	Yellow
Binder	AASHTO T 250, Section 5 ASTM D4797	min 20	min 20
Titanium Dioxide	AASHTO T 250, Section 9 ASTM D4764, - D4797	min 10	-
Calcium Carbonate & Inert Fillers (200 mesh sieve)		max 30	max 37.5
Yellow Pigments (Lead Free)		None	min per manufacturer

- (4) The physical properties of the composition shall be as follows

Thermoplastic Physical Properties

Component	Test Method	Min	Max
Water Absorption	ASTM D570		0.5% by weight
Softening Point	AASHTO T 250, Section 15 ASTM D36/ ASTM E28	90 °C	
Specific Gravity	Water Displacement	1.9	2.3
Flash Point	AASHTO T 250, Section 20 ASTM D92	246 °C	

1. Color

- (a) White thermoplastic composition, as placed shall be white, free from dirt or tint.
- (b) Yellow thermoplastic composition, as placed, shall be yellow, free from dirt or tint.
- (c) The day-time and night-time colours of painted traffic markings shall comply with ASTM D6628.

2. Drying Time

- (a) When installed at 21 °C, and in thickness between 3 mm and 4 mm, the composition shall be completely solid and shall show no damaging effect from traffic after ten (10) minutes.

3. Yellowness Index (AASHTO T 250, Section 8)

- (a) White thermoplastic composition shall not exceed a yellowness index of 0.12 when tested and calculated in accordance with AASHTO T 250, respective ASTM E313.

4. Flowability (AASHTO T 250, Section 11)

- (a) After heating the thermoplastic for 240 ±5 minutes at 218 ±2 °C and testing for flowability, the white thermoplastic shall have a maximum percent residue of 18 and the yellow thermoplastic shall have a maximum residue of 21 %.

5. Low Temperature Stress Resistance (AASHTO T 250, Section 12)

- (a) Cracking resistance at low temperature shall be tested by heating the thermoplastic material for 240 ±5 min at 218 ±2 °C and then applying to concrete blocks, and cooling to 9.4 ±2 °C. If the material does not show any cracks, the material passes the test.

6. Impact resistance (AASHTO T 250, Section 14)

- (a) Impact resistance will be tested by heating the thermoplastic material for 240 ±5 min at 218 ±2 °C and making test specimens and testing per ASTM 256, Method A (un-notched). If the impact resistance is at least 1.0 J, the material shall be accepted.

7. Flowability with Extended Heating (AASHTO T 250, Section 17)

- (a) After heating the thermoplastic for 8.0 ± 0.5 hrs at 218 ± 2 °C, with stirring the last 6 hrs, and testing for flowability, the thermoplastic shall have a maximum residue of 28 %.

8. Skid Resistance

- (a) The surface of the pavement markings shall provide a minimum skid resistance value of 35 BPN (British Pendulum Number) when tested according to ASTM E303.

< 3-2 > Reflectorized Thermoplastic

- (1) The material shall be in accordance with (a) above except that glass beads shall be incorporated in the mixture during the manufacture of the thermoplastic material. The quantity of glass beads included shall be 40 % by weight of the total mix, according to below table.

Glass Bead Requirements

Component	Test Method	% by Weight	
		White	Yellow
Glass Beads, AASHTO Type 1	AASHTO T 250, Section 6 ASTM D4797	min 20	min 20
Glass Beads, AASHTO Type 3		min 20	min 20

- (2) The initial retro-reflectance of the applied traffic markings shall be a minimum of 450 mcd/ lx/ m² for white markings and 350 mcd/ lx/ m² for yellow markings when measured under ASTM E1710. The initial retro-reflectance shall be measured earliest 3 days after the application and latest 10 days after the application. After three years the retro-reflectance of the white and yellow traffic markings shall not be less than 250 mcd/lx·m².

< 3-3 > Reflectorized Thermoplastic with Glass Bead Surface

- (1) The material shall be in accordance with (a) above except that a layer of glass beads shall be superimposed in the surface of the hot thermoplastic immediately after laying to give immediate reflectivity. The superimposed glass beads shall be of the same quality as that incorporated in the reflectorized thermoplastic mix, but may be smaller in size.

< 4 > Glass Beads

- (1) Glass beads shall be of a composition designed to be highly resistant to traffic wear and to the effects of weathering for the production of a reflective surface, without altering day visibility of the marking.
- (2) Glass beads applied to molten thermoplastic material shall be 50% of Type 1 beads and 50% of Type 3 beads complying with AASHTO M 247 together with the requirements of this section.
- (3) The glass beads must have an adhesion-promoting and water-repellent coating complying with the paint manufacturer's instructions.
- (4) Glass beads shall have a spherical shape and at least 70 % of the glass beads shall

be true spheres when tested in accordance with ASTM D1155. The glass beads shall be free of flaws and sharp angular particles, colourless, clean, transparent, free from milkiness and do not exhibit dark spots, air inclusions, or surface scratches or surface scarring when viewed under 20X magnification.

(5) Glass beads shall be resistant to chemicals and shall retain their brightness after soaking in the following solutions.

- Buffered acid solution;
- 1 N calcium chloride;
- Distilled water which is free from carbon dioxide gas. This water when titrated with 0.1 N hydrochloric acid at the amount of not more than 2.5 millilitres will reach a neutral point;
- The glass heads when soaked in sodium sulphide shall not turn black.

(6) Each lot of glass beads shall be tested for arsenic and lead by an independent testing laboratory. Each lot of glass beads used in pavement markings must contain less than 200 ppm by weight each of arsenic and lead. Any lot of glass beads not conforming to this requirement shall be discarded in an environmentally friendly manner, as directed by the Engineer.

(7) The silica content of the glass spheres shall not be less than 60 %.

(8) All testing regarding the brightness of glass beads shall be in accordance to the requirements of Federal Specification TT-P-85 b.

(9) The index of refraction of the glass beads shall be minimum 1.50 when tested by the liquid immersion method (Becke Line Method or equal) at a temperature of 25 ± 5 °C.

(10) Glass beads shall meet the gradation requirements as specified below, when tested in accordance with ASTM D1214, except as otherwise directed.

Grading Requirements for Glass Beads

Sieve Designation	Percentage by Weight Passing	
	Type 1	Type 3
1.700 mm		100
1.400 mm		95 - 100
1.180 mm	100	80 - 95
1.000 mm		10 - 40
0.850 mm	95 - 100	0 - 5
0.710 mm		0 - 2
0.600 mm	75 - 95	
0.300 mm	15 - 35	
0.150 mm	0 - 5	

(11) The crushing resistance of the spheres shall be as follows: A 18 kg dead weight, for 850 µm to 600 µm mesh spheres, shall be the average resistance when tested in accordance with ASTM D1213.

(12) Glass spheres when superimposed in the surface of thermoplastic paint shall be treated with a moisture-proof coating.

(13) Random samples of glass beads shall be taken from each sack for testing. The number of samples shall be one percent of the total sacks of the glass beads supplied. Each sample shall contain a minimum of two kilograms of beads.

(14) If decided by the Engineer, he will perform a night-time, drive-through, making a visual inspection of the retro-reflectivity of the traffic markings and notify the Contractor of any locations with deficient retro-reflectivity. The measurement of the retro-reflectivity of deficient areas is done by using a retro-reflectorimeter under ASTM E1710 and the sampling protocol specified in ASTM D7585.

(15) All tests, trials and documentation shall be at Contractor's own cost.

< 5 > Reflectorized Durable Non-thermoplastic Paint

(1) The paint shall be a cold-applied ready mixed paint suitable for application to cement concrete or bituminous pavements. The paint shall be durable and made reflectorized by superimposing glass beads on the surface of the paint. The paint shall also be suitable for applying by brush or mechanical means. The following particulars of the paint shall be supplied:

1. composition (analysis by weight);
2. application;
3. type and maximum amount of reducer (thinner);
4. drying time (to touch);
5. setting time (to recoat);
6. recommended coverage (litres per square metre);
7. heat resistance (max. road temperature);
8. details of any primer, undercoat or tack coat required.

(2) The paint shall be supplied fresh and ready for use in sealed containers which shall be stored in accordance with the manufacturer's instructions.

(3) The paint colour shall be the type as detailed on the Drawings or as directed by the Engineer.

(4) The composition of the paint shall be as shown in below table.

Composition of Reflectorized Durable Non-thermoplastic Paint

Component	Test Method	Criteria
Total Solids, by weight	ASTM D2369	min 75 %
Pigments, by weight	ASTM D3723	min 57 %
Vehicle Solids, % on Vehicle *		min 40 %
TiO ₂ , Type II Rutile (white paint only)	ASTM D476	max 18 kg/L
Volatile Organic Content (VOC)	ASTM D3960	max 150 g/L

* Vehicle Solids, % on Vehicle = % total solids - % pigment = 100% - % pigment
Vehicle Solids shall be 100% acrylic emulsion polymer

- (5) Laboratory samples shall meet below tabled physical requirements and shall be tested in accordance with ASTM E811 and ASTM E1349:

Physical Requirements on Reflectorized Durable Non-thermoplastic Paint

Property	Test Method	Minimum	Maximum
Density	ASTM D1475	1.62 ±0.168 kg/L	N/A
Viscosity at 25 °C	ASTM D562	80 KU	100 KU
Fineness of Grind	ASTM D1210	3 (HS)	
Dry Opacity at 5 mils (0.127 mm) WFT	ASTM D2805	0.92	
Bleed Ratio	ASTM D969	0.95	
Flexibility	ASTM D522, Method B	Pass	
Abrasion Resistance	ASTM D4060	Pass	

- (6) The paint shall set to bear traffic in not more than ten minutes.
- (7) The paint shall be tested for abrasion resistance, by testing four samples using a Taber Abrader. The paint shall be applied to specimen plates using a drawdown blade having a clearance of 0.5 mm. Air dry each sample until fully cured based on the manufacturers product recommendation. Clean with a soft brush and weigh each sample. Abrade samples for 1,000 cycles with a combined load of 500 g (arm plus auxiliary weight) on each arm and CS-10 wheels. Clean the samples with a soft brush and weigh again. The average weight loss for the four plates shall not exceed 75 mg per plate.
- (8) The white and yellow pavement markings shall attain an initial retro-reflectance of not less than 450 mcd/lx·m² and 300 mcd/lx·m², respectively. The retro-reflectance of the white and yellow pavement markings at the end of the 18 month period shall not be less than 150 mcd/lx·m².

< 6 > Road Studs

- (1) All road studs, reflecting and non-reflecting, shall comply with the requirements of BS EN 1463-2. Only road studs which have been approved by the Engineer shall be incorporated in the Works. The Contractor shall submit details of the road studs he proposes to use in the Works to the Engineer for his approval.
- (2) Reflecting road studs shall be of an approved design with self-cleansing reflecting units from a reputable manufacturer. Each stud shall be provided with at least two reflecting lenses for each traffic direction and the reflecting surface of each lens shall be at least 80 mm². The lenses shall be capable of withstanding impacts and no contact shall be possible between the lenses and vehicle tyres. The studs shall not project more than 20 mm above

the level of the surrounding road surface and the lowest part of the lenses shall be more than 5 mm above the surrounding road surface. The reflecting units shall be interchangeable and capable of easy and quick replacement without disturbance of the road surface. The design shall be such as to ensure study attachment to the road pavement with adequate load distribution and such that it shall not be possible for heavy equipment such as road rollers and tracked vehicles travelling in the direction of the road axis to meet with any sharp edges whereby the stud might be removed.

< 7 > Packaging and Shipping

(1) The thermoplastic and non- thermoplastic compositions shall be shipped to the job site in containers that are strong, sturdy and capable of being sealed in a manner approved by the Engineer. The containers shall protect the contents from contamination and shall be stored in accordance with the manufacturer's instructions.

(2) The containers shall be clearly marked with the manufacturer's name and address, description of the material, date of manufacture and batch number.

(3) The reflective glass spheres to be superimposed on the surface of the paint shall be shipped in moisture resistant bags. Each bag shall be marked with the name and address of the manufacturer and the name and net weight of the material.

(4) Thermoplastic primers shall be shipped in pails, drums, or other strong sturdy containers. Each container shall be clearly marked with the name of the product, the name and address of the manufacturer, the date of manufacture, the quantity of material, and the date of the expiration or shelf life. In addition, two-component primer containers shall be identified as "Part A" and "Part B". Primers shall be shipped to the job site accompanied with written instruction for use.

< 8 > Basis of Acceptance

(1) Thermoplastic and non-thermoplastic material shall be accepted on the basis of sampling and inspection at the place of manufacture or in a warehouse as determined by the Engineer. Samples submitted shall be taken as directed by the Engineer. In addition, all samples shall be accompanied with the manufacturer's certified identification (originals to be submitted) of the binder formulation (e.g. "formulated as a hydrocarbon resin"). Any unauthorized tampering or breaking of seals on the containers between the time of sampling and delivery to the job site shall be cause for rejection of the material.

(2) Reflective glass beads shall be accepted on the basis of submission of glass beads to the Engineer for testing, together with original of the manufacturer's certification.

(3) Thermoplastic primers shall be accepted at the job site on the basis of the manufacturer's original certificate, which certifies that the primer conforms to the requirements of this specification.

154.03 WORK PROCEDURES

< 1 > Thermoplastic Materials

(1) The material shall be applied only on a surface which is clean and dry during a period of favourable weather, when the pavement surface temperature is above 10 °C. It

shall not be laid over loose detritus, mud or similar extraneous matter, or over an old paint marking, or over an old thermoplastic marking which is faulty.

(2) Mechanical wire shall be used to remove dirt, contaminants, and loose material from the pavement surface that is to receive the traffic marking. Abrasive blast cleaning shall be applied to remove laitance and curing compound from the surface of new concrete pavement that is to receive traffic marking.

(3) In the case of concrete surfaces and asphalt surfaces older than 6 months and/or where the Engineer directs, a tack coat or primer shall be applied as instructed by the manufacturer to the surface prior to the application of the material. The tack coat or primer shall be applied immediately before and concurrently with the application of the thermoplastic material. The type of tack coat/ primer and the rate of application shall be as the manufacturer of thermoplastic material recommends, with the approval of the Engineer.

(4) The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic and such that local overheating shall be avoided. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible and for thermoplastics which have natural resin binders or are otherwise sensitive to prolonged heating the material shall not be maintained in a molten condition for more than 4 hours.

(5) Centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings may be applied by hand-screed, hand-propelled machine or by self-propelled machine as approved or directed by the Engineer. After transfer to the laying apparatus the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.

(6) In the case of screeded application the material shall be laid to a thickness of not less than 3 mm or more than 4 mm when measured above the pavement surface, unless specifically authorised by the Engineer when laid over an existing marking. In the case of sprayed application the material shall be laid to a thickness of not less than 1.5 mm, unless specifically authorised by the Engineer.

(7) The thermoplastic material shall be applied in a single uniform layer and the thermoplastic material shall completely coat and fill voids in the pavement surface. In all cases the surface produced shall be uniform and free from bubbles and streaks.

(8) Where the Contract Documents require or the Engineer directs that glass beads shall be applied to the surface of the markings, these shall be applied uniformly to the surface of the hot thermoplastic, immediately after laying such that the quantity of glass beads firmly embedded and retained in the surface after completion complies with the requirements of sub-clause < 3-2 > (1) of this Code.

(9) Traffic marking of a repetitive nature, other than centre lines, lane lines, etc. shall, unless otherwise directed by the Engineer, be set out with stencils which comply with the size and spacing requirements shown on the Drawings.

(10) Glass beads shall be embedded in the freshly applied coat of thermoplastic paint to

a depth of 1/2 their diameters, immediately after laying to give immediate reflectivity. Glass beads shall be applied at rate of 250- 450 grams per square metre such that the combined total of glass beads incorporated in and superimposed on the paint shall be as shown in Table 604.5, i.e. totally minimum 40% by weight of the material, unless otherwise directed by the Engineer.

(11) At the end of the day's work as much as possible of the material remaining in the heater and/or laying apparatus shall be removed. This may be broken and used again provided that the maximum heating temperature as specified in sub-clause 604.02.3 paragraph (2) has not been exceeded and that the total time during it has been in a molten condition does not exceed the allowable time.

< 2 > Non-Thermoplastic Paint

(1) The paint shall be applied on a surface that is clean and dry during a period of favourable weather, when the pavement surface temperature is above 10 °C. It shall not be laid over loose detritus, mud or similar extraneous matter or over a traffic marking or over an old paint marking that is faulty or incompatible with the paint being applied. If a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or other discoloration the primer or undercoat shall be fully compatible with the marking paint and the road surface and shall be applied only if, and at the rate of application, approved by the Engineer.

(2) All cold-applied paint shall be thoroughly field mixed before applying in order to keep the pigments in uniform suspension. Hot-applied paints shall be heated in a properly designed heater, preferably thermostatically controlled, to the correct laying temperature at which it shall be maintained as required for the method of application. The paint shall on no account be allowed to exceed the maximum temperature specified by the paint manufacturer. The use of thinners or other additives shall not be permitted unless otherwise agreed by the Engineer.

(3) Centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings shall be applied by brush, spray, screed, hand-propelled or self-propelled machine according to the marking configuration and the type of paint approved for use or as directed by the Engineer. The rate of application of the paint for each coat shall be that recommended by the manufacturer unless otherwise directed by the Engineer.

(4) When more than one coat is used, the succeeding coat shall not be applied until the previous coat has fully set.

(5) Traffic markings of a repetitive nature, other than centre lines, lane lines etc. shall, unless otherwise directed by the Engineer, be set out with stencils that comply with the size and spacing requirements given in the Drawings.

< 3 > Road Studs

(1) Road studs shall be installed in the locations shown on the Drawings. They shall be installed exactly as prescribed by the manufacturer. Road studs not installed in compliance with these instructions shall be rejected and removed from the Site.

(2) Excavation of the road pavement to form a cavity for each stud shall be carried out

in accordance with the manufacturer's instructions. In the case of concrete surfaced roads cavities shall be at least 5 cm from an expansion joint and shall be clear of dowel bars at the joint. Care shall be taken to ensure a reasonably level floor and vertical sidewalls without projections into the cavity and that all loose material produced in excavating the cavity is cleaned out. A layer of approved stone (6.5 mm and smaller) shall be laid and compacted level on the cavity floor. The stud shall be prepared in accordance with the manufacturer's instructions and firmly bedded on the levelling layer such that the correct projection of the stud above the road surface is achieved. A template shall be used to check the line and level of the bedded stud. The cavity walls shall be brushed with asphaltic tack coat and the whole of the remaining cavity grouted with hot filled asphalt in accordance with the recommendations of the manufacturer until level with the road surface.

(3) Care shall be, taken to ensure that no asphalt is spilled on the projecting portion of the stud. Any asphalt inadvertently spilled shall be carefully removed so that a clean workmanlike job is presented with a fully effective reflector unit. Traffic shall not be permitted to pass over the stud until the grout has firmly set.

< 4 > Trials

(1) Prior to the commencement of paint application operations and the operations for installing road studs, the Contractor shall paint a trial length of at least 15 m length, as well as install one road stud as directed and in the presence of the Engineer. The method, materials and equipment used shall be that which the Contractor intends use for the work proper. The purpose of the trials is to determine the adequacy of the Contractor's equipment and methods.

(2) The Contractor may proceed with his operations only after the equipment and methods in the trials have been accepted by the Engineer.

< 5 > Defective Materials or Workmanship

(1) Materials which are defective or have been applied in an unsatisfactory manner or to incorrect dimensions or in a wrong location shall be removed, the road pavement made good and the materials replaced, reconstructed and/or properly located, all at the Contractor's expense and to the satisfaction of the Engineer.

< 6 > Protection of Traffic and Existing/ New Traffic Markers

(1) The Contractor shall protect pedestrian, vehicular and other traffic adjacent to the working area, as well as protect existing traffic markers against damage or disfigurement by construction equipment, tools and materials or by spatter, splashes and smirches of paint or other construction materials and shall during the course of the work provide and maintain adequate signs and signals for the warning and guidance of traffic.

(2) All new markings shall be protected from traffic until they have dried sufficiently to show no pick-up of tyre marks. The Engineer in the field shall determine a time period in which traffic will not be allowed to pass over the particular traffic markings being used.

154.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
154-1	Painting Traffic Lines	Metre Square

154.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 155 CLEANING OF ROAD SURFACE**155.01 DESCRIPTION**

- (1) This work is to remove debris from the road surface and/or within the right of way. Any obstruction or debris falling off from a vehicle may cause a motorist to swerve into the path of another vehicle along the same lane or into an oncoming vehicle from the opposite lane and cause an accident/damage from the collision.
- (2) Small stones and grits thrown off from the wheels of a vehicle can shatter windshields or cause other damage upon impact.
- (3) Dirt retains moisture, sulfur and other harmful compounds that can cause corrosion to vehicles and concrete.
- (4) The purpose of removing dust from the road surface is therefore to ensure safe and smooth traffic for the road users by maintaining the road functions, keeping the road and roadside environment satisfactory and preventing obstructions to traffic flow and traffic accidents attributable to dust and dirt.

155.02 MATERIALS

- (1) Nil.

155.03 WORK PROCEDURES

- (1) Collect any accumulated sand and scattered fallen materials on the road surface manually within 1.5m into the roadway from the edge.
- (2) During collection of these materials, a truck for transporting the materials runs along the shoulder.
- (3) Load collected materials on the truck for transport to the dumpsite.
- (4) During the work, due attention must be made to other road users.

155.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
155-1	Cleaning of road surface	Metre Square

155.04 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

1.6 ROADSIDE MAINTENANCE

CODE 161 GRASS CUTTING**161.01 DESCRIPTION**

(1) The work is to:

- ✓ improve vision to maintain safe sight distances, visibility of signs, markers and animals within the road reserve,
- ✓ improve the general appearance of the roadside,
- ✓ reduce the need for weed and brush control,
- ✓ prevent roots from penetrating the surface and pavement layer,
- ✓ reduce the effort required to maintain roadside ditches and shoulders,
- ✓ ensure healthy growth of landscaped areas and
- ✓ reduce fire risk during dry season.

(2) The work shall involve cutting any form of plant growth including small shrubs in the entire road reserve including medians, drains and around road furniture or elsewhere as required.

(3) Unless specified otherwise, grass shall be defined as any plant having a girth of not more than 60mm measured at a height of 300mm above ground level. Grass shall be cut by labor based methods or where instructed, by mechanical mowers.

161.02 MATERIALS

(1) Nil.

161.03 WORK PROCEDURES

(1) Labor Based Method:

1. Assign each workman an area to work.
2. Cut all the grass evenly using slashers or machetes to a maximum height of 50mm above surrounding ground level.
3. Grass shall be cut while facing the road, pedestrian walkway, cycle path or animal drawn track so that any flying objects due to slashing are not thrown onto the carriageway, pedestrian walkway, cycle path or animal drawn track.
4. When cutting grass workmen shall ensure that no damage is caused to fixed objects such as road signs, kilometre marker posts, guardrails, etc.
5. Uproot all shrubs to prevent re-growth.
6. Rake all cut grass and transport to designated disposal sites. Burning of grass is not allowed.
7. Remove cut grass from the carriageway, pedestrian walkway, cycle path or animal drawn track side drains, mitre drains and inlet and outlet structures of culverts/drainage structures and transport to designated disposal sites or as directed by the Engineer.

(2) Equipment Based Method:

1. Assign workmen to various tasks to be carried out manually.
2. Workmen to work well ahead of the mower to hand-pick and remove obstructions, debris and bush stems in the intended path of the mower.

3. Mow grass using tractor mower or a hand guided sickle-bar power mower only on level ground free from obstructions and debris. Do not mow when grass is wet.
4. Workmen to work behind the mower to clear ditches and areas around fixed road furniture of all unnecessary vegetation.
5. Workmen to remove grass cuttings left behind by machines from the carriageway, pedestrian walkway, cycle path or animal drawn track side drains, mitre drains and inlet and outlet structures of culverts/drainage structures, load onto trucks and transport to designated disposal sites.
6. Burning of grass is prohibited.

161.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
161-1	Grass cutting	Metre Square

161.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 162 BUSH CUTTING**162.01 DESCRIPTION**

(1) The work is to:

- ✓ improve vision to maintain safe sight distances, visibility of signs, markers and animals within the road reserve,
- ✓ improve the general appearance of the roadside,
- ✓ reduce the need for weed and brush control and
- ✓ prevent roots from penetrating the surface and pavement layer.

(2) The work shall involve uprooting and disposing of all bushes from the entire road reserve including at inlets and outlets of drainage structures, medians, drains and around road furniture or elsewhere as required.

(3) Unless specified otherwise, bush shall be defined as any plant with girth more than 60mm but less than or equal to 300mm measured at 300mm from the ground. Bush clearing shall include removal of stumps and root system to a minimum depth of 500mm below the natural ground level so as to prevent their re-growth.

(4) This work shall be implemented by labor based methods in general.

162.02 MATERIALS

(1) Nil.

162.03 WORK PROCEDURES

(1) Assign workmen areas to be bush cleared.

(2) Cut, uproot and remove bushes using bush knives, machetes, axes, mattocks, etc. to ensure that all bushes are cleared.

(3) Workmen must ensure that no damage is caused to fixed objects such as road signs, kilometre marker posts, guardrails etc. when removing bushes.

(4) After inspection and approval by the Engineer, backfill excavated holes and tamp to compact the materials to density of surrounding soil.

(5) Collect into heaps the cleared bush and roots away from the side drains and they must not cause visibility obstruction to traffic.

(6) Load, haul and dispose cleared bush at designated spoil sites.

(7) Make the area clean and tidy.

162.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
162-1	Bush cutting	Metre Square

162.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 163 BUSH CUTTING (THICK VEGETATION)

163.01 DESCRIPTION

(1) The work is to:

- ✓ improve vision to maintain safe sight distances, visibility of signs, markers and animals within the road reserve,
- ✓ improve the general appearance of the roadside,
- ✓ reduce the need for weed and brush control and
- ✓ prevent roots from penetrating the surface and pavement layer.

(2) The work shall involve uprooting and disposing of all bushes from the entire road reserve including at inlets and outlets of drainage structures, medians, drains and around road furniture or elsewhere as required.

(3) Unless specified otherwise, bush shall be defined as any plant with girth more than 60mm but less than or equal to 300mm measured at 300mm from the ground. Bush clearing shall include removal of stumps and root system to a minimum depth of 500mm below the natural ground level so as to prevent their re-growth.

(4) This work shall be implemented by equipment based methods in general.

163.02 MATERIALS

(1) Nil.

163.03 WORK PROCEDURES

(1) Grub bushes using motor grader or bulldozer.

(2) After inspection and approval by the Engineer, backfill excavated holes and compact the materials using motor grader or bulldozer to density of surrounding soil.

(3) Load the cleared bush onto tipper trucks using tractor-loader-backhoe or wheel loader and haul to designated or approved spoil pits.

(4) Make the area clean and tidy.

163.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
163-1	Bush cutting (thick vegetation)	Metre Square

163.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 164 CLEANING OF THE RIGHT OF WAY, ROAD RESERVE**164.01 DESCRIPTION**

- (1) This work is to remove all obstruction materials such as rocks, trees or tree branches, soil heaps, wind blow sand, and debris that are hazardous, unsafe to the road users and obstruction to the flow of water from the carriageway.
- (2) Small stones and grits thrown off from the wheels of a vehicle can shatter windshields or cause other damage upon impact.
- (3) Dirt retains moisture, sulfur and other harmful compounds that can cause corrosion to vehicles and concrete.
- (4) The purpose of removing dust from the road surface is therefore to ensure safe and smooth traffic for the road users by maintaining the road functions, keeping the road and roadside environment satisfactory and preventing obstructions to traffic flow and traffic accidents attributable to dust and dirt.

164.02 MATERIALS

- (1) Nil.

164.03 WORK PROCEDURES

- (1) Remove obstructions such as rocks, fallen trees, branches, soil heaps, windblown sand, abandoned vehicles and/or debris.
- (2) During collection of these materials, a truck for transporting the materials runs along the shoulder.
- (3) All collected obstructions should be loaded into the truck, or otherwise removed from the shoulder and dispose of on a safe area.
- (4) During the work, due attention must be made to other road users.

164.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
164-1	Cleaning of the right of way, road reserve	Metre Square

164.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A012 INSTALL GABION

A012.01 DESCRIPTION

- (1) This work is to place the gabion boxes to act as retaining structure after stabilizing the slope.

A012.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer.
- (2) Gabion wire boxes, filling material (stone), filter material (if necessary) and binding wire (D=3mm).
- (3) Other materials if necessary for work execution.

A012.03 WORK PROCEDURES

- (1) Remove all loose or unstable materials.
- (2) Backfill soil when needed and compact.
- (3) Trim slope to line and level.
- (4) Compact the surface upon which gabions are to be laid.
- (5) Assemble and install the gabions as directed on site. If filter is required, it shall be placed behind the gabion face to be in contact with existing or back filled ground.
- (6) Fill with selected stones.
- (7) Adjacent gabions should be stitched together with binder wire on all touching edges.
- (8) If gabion boxes are used, they should be laid with a broken bond to avoid continuous joints.
- (9) All debris and excess materials shall be disposed into a safe place.
- (10) Make the site clean and tidy.

A012.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A012-1	Install gabion	Metre Cubic

A012.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA008 REPAIR OF GABION

AA008.01 DESCRIPTION

- (1) This work is to;
- ✓ control erosion and scour at the protection works installed along drains and other minor drainage structures and
 - ✓ Keep erosion protection works fully functional.

AA008.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer.
- (2) Gabion wire boxes, filling material (stone), filter material (if necessary) and binding wire (D=3mm).
- (3) Other materials if necessary for work execution.

AA008.03 WORK PROCEDURES

- (1) Remove all loose or unsuitable material and cart away to spoil.
- (2) Replace missing stones to fill up gabion baskets in a way that leaves the least possible space.
- (3) Stitch together the gabions using the binder wire along the touching edges.
- (4) Where gabions are to be replaced from the ground level, prepare the foundation by levelling and compaction the ground using hand rammers.
- (5) Hand-fill the baskets with the stones and tie them together with the binder wire.
- (6) Gabions should be laid with broken bonds to avoid continuous joints
- (7) Make the site clean and tidy.

AA008.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
AA008-1	Repair of gabion	Metre Cubic

AA008.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A013 RE-CUT AND BENCHING**A013.01 DESCRIPTION**

- (1) This work is to treat unstable slopes by cutting the gradient to a flatter or to create benches or berms.

A013.02 MATERIALS

- (1) Nil.

A013.03 WORK PROCEDURES

- (1) Remove all loose or unstable materials.

1. Re-cutting

- (a) Set out the work as shown in the shop drawing(s) or as directed by the Engineer.
(b) Cut slope by hand or machine to the new slope angle.

2. Benching

- (a) Cut benches as shown in the shop drawing(s) or as directed by the Engineer.
(b) All debris and excess materials should be disposed into a safe place.
(c) Make the site clean and tidy.

A013.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A013-1	Re-cut and benching	Metre Cubic

A013.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A014 REMOVE UNSTABLE ROCKS

A014.01 DESCRIPTION

(1) This work is to remove unstable rock materials from slopes to reduce danger to the road users and to allow for the free movement of traffic and the operation of the drainage system.

A014.02 MATERIALS

(1) Nil.

A005.03 WORK PROCEDURES

- (1) Do not work under an overhanging slope.
- (2) Check the slope for unstable rock materials and remove it before starting to slip but safety should be ensuring to the workers.
- (3) Remove unstable rock materials on the slope by dislodging it with an equipment or hand tools.
- (4) Collect all rocks and debris from the carriageway, shoulder and ditches and load into trucks, tractor and trailer or wheelbarrow and dispose to a suitable dump site. Do not excavate too deep that may damage the road/ shoulder surface.
- (5) Remove the last layer of slipped material by hand to avoid damage to the road surface.
- (6) Clear the ditches and re-grade or restore if necessary.
- (7) Re-check the stability of the slope.
- (8) Clear the area and all excess materials should be disposed into a safe place.
- (9) Make the site clean and tidy.

A014.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
A014-1	Remove unstable rocks	Metre Cubic

A014.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A015 SHOTCRETE**A015.01 DESCRIPTION**

- (1) This work is to apply spraying of concrete to unsuitable slopes to provide temporary or permanent stability.

A015.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Diamond shaped wire netting (2mm x 50mm), PVC pipe (50mm dia.), spray quality concrete, anchor pins and elastite.
- (3) Other materials if necessary for work execution.

A015.03 WORK PROCEDURES

- (1) Remove all unstable rock and dust using pressurized water or air.
- (2) Attach diamond shaped steel wire netting to the slope to be treated.
- (3) Place PVC pipe for every 3 square metres for weep holes provision.
- (4) Spray concrete in a continuous process. The thickness should be 100 mm to 150 mm or as directed by the Engineer.
- (5) Where the area to be covered is large and plane, place a vertical joint every 20m to prevent the spread of shrinkage cracking.
- (6) All debris and excess materials should be disposed into a safe place.
- (7) Make the area clean and tidy.

A015.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A015-1	Shotcrete	Metre Cubic

A015.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

2. PERIODIC MAINTENANCE

2.1 RESEALING

CODE 211 RESEALING

211.01 DESCRIPTION

(1) The purpose of this activity is to:

- ✓ Restore the riding surface quality.
- ✓ Prevent penetration of water into the pavement and weaken it.
- ✓ Slow down further deterioration of the surface.
- ✓ Restore traffic safety and driving conditions.

(2) The activity involves resealing a bituminous surface using bituminous surface treatment methods. It includes all types of resealing such as chip seal and slurry seal.

211.02 MATERIALS

< 1 > Chip Seal

(1) All materials shall be subject to approval of the Engineer.

(2) Materials applied for the work should comply with following requirements.

- ✓ Aggregates conforming to specifications either pre-coated or not pre-coated.
- ✓ Bituminous binder – a cold bitumen emulsion or penetration grade 80/100 bitumen OR a highly polymer modified binder OR rubber bitumen OR bituminous binder/polymer modified binder with glass fibers OR bituminous binder/polymer modified binder with geotextile fabric.
- ✓ Appropriate agent for pre-coating aggregates where specified.
- ✓ Diesel fuel for cleaning spray lance and other tools
- ✓ Chalk or spray paint for marking on the road surface
- ✓ String lines
- ✓ Other necessary approved material

(3) Other materials if necessary for work execution.

< 2 > Slurry Seal

(1) All materials shall be subject to approval of the Engineer.

(2) Materials applied for the work should comply with following requirements.

- ✓ Fine graded aggregates nominal size 6.7mm
- ✓ Bituminous binder – a cold stable grade bitumen emulsion
- ✓ Cement
- ✓ Water
- ✓ Diesel fuel for cleaning spray lance and other tools
- ✓ Chalk or spray paint for marking on the road surface
- ✓ String lines
- ✓ Rags or paper for transverse joints
- ✓ Other necessary approved material

(3) Other materials if necessary for work execution.

212.03 WORK PROCEDURES**< 1 > Chip Seal**

- (1) Clearly mark out the extent of road to be resealed by painting a line across the full width of the road pavement at the start and finish of the area to be sealed.
- (2) Using the mechanical broom, sweep the full extent of the area to be sealed. Swept materials shall be heaped, loaded onto trucks and disposed in an environmentally friendly manner.
- (3) If specified, pre-coat the chippings a prepared surface so as to avoid contamination with dust.
- (4) Protect reflective studs with grease or similar material.
- (5) Mark by paint the start and finish of the initial bitumen sprayer run which will be dependent on the amount of chippings loaded on spreading trucks on site at the time of spraying.
- (6) Mark by paint, string line or small stones the edge line for the sprayer driver to follow.
- (7) Paper the transverse joints at the start and finish of each spray run.
- (8) Set up the bitumen sprayer 20m away from the start of the run and ensure that the spray bar is set correctly width and that the driver's guide bar is properly set.
- (9) Measure and record a dip of the volume of bitumen and sprayer temperature.
- (10) Set-up the chip spreading trucks immediately behind the bitumen sprayer.
- (11) Set-up the pneumatic tyred roller (s) immediately behind the chip spreaders.
- (12) The foreman communicates the binder application rate and corresponding road speed to the sprayer driver.
- (13) Using the bitumen distributor, spray the binder at the required rate uniformly over the whole area without stopping until it has reached the marked end of the spray run. If the use of SAMI is specified apply the binder at half the design spray rate.
- (14) At the finishing point the operator dips the distributor to record the amount of bitumen used.
- (15) If the use of SAMI is specified, lay the geotextile fabric or glass fibre immediately after applying the tack coat ensuring that it is placed evenly without creases or wrinkles. Roll the geotextile with a pneumatic roller so that it is embedded into the tack coat. Apply the binder at (the remainder) half of the design spray rate over the geotextile.
- (16) Spread a uniform single layer of chippings from the mechanical chip spreader following close behind the bitumen distributor.
- (17) Leave a 150mm wet edge, if needed, for the adjoining bitumen run.

- (18) Workmen should follow up behind the chip spreaders to ensure full coverage is achieved by addition of chippings by hand.
- (19) Embed the chippings using the pneumatic tyred roller by following close behind the chip spreaders at a speed of 10 -15 kph.
- (20) Continue rolling in straight runs until the whole mat is uniformly rolled.
- (21) Collect any excess pile of chippings from the road surface.
- (22) Repeat the setting up of the equipment as above if a second seal is required immediately after laying the first seal.
- (23) Offset the transverse joints on the second coat so as not to overlay the same position of the first coat.
- (24) Open road to traffic after minimum 12 hours with a restricted speed limit of 60kph for the next week.
- (25) Clean up and remove waste and excess material from shoulders, drains, and road surface.
- (26) Clean reflective studs and replace those damaged.
- (27) Reinstate temporary road marking (spotting).
- (28) Return the next day and remove excess chippings or windrows of chippings from the road surface to ensure a safe trafficable road.

< 2 > Slurry Seal

- (1) Clearly mark out the extent of road to be resealed by painting a line across the full width of the road pavement at the start and finish of the area to be sealed.
- (2) Using the mechanical broom, sweep the full extent of the area to be sealed. Swept materials shall be heaped, loaded onto trucks and disposed in an environmentally friendly manner.
- (3) Mark by paint the start and finish of the section to be treated.
- (4) Mix material in a slurry seal mixer in accordance with project specifications. Indicative mix proportions by mass are 100 parts of aggregates; 16 parts of stable-grade emulsion; 13 parts of cement; and 15 parts of water.
- (5) Spray a tack coat of 30% stable – grade emulsion onto the surface to be treated at an application rate of 0.5litre per m². The tack coat should be sprayed.
- (6) Spread the slurry seal uniformly using the spreader on the road surface area to be treated.
- (7) As soon as the slurry sets, allow the traffic to pass and compact the slurry. The slurry

shall be capable of carrying slow moving traffic (<40kph) within one hour of application without undue permanent damage occurring, such as rutting and ravelling. When the time before the slurry is capable of carrying traffic exceeds one hour, work shall cease if so directed by the Engineer. Otherwise, if instructed by the Engineer, compact the slurry using a pneumatic roller making six passes for each slurry application.

- (8) Remove to spoil at designated places all spilled and excess slurry.
- (9) Open road to traffic after minimum 24 hours.
- (10) Reinststate temporary road marking (spotting).

211.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
211-1	Resealing (chip seal)	Metre Square
211-2	Resealing (slurry seal)	Metre Square

211.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 212 SAND SEAL**212.01 DESCRIPTION**

- (1) This work is to reseal surface textile using sand and a bituminous binder. Sweeping back dislodged sand is a part of the sealing process.

212.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Materials applied for the work should comply with following requirements.
- ✓ Sand nominal size <8mm.
 - ✓ Bituminous binder – Bitumen emulsion or MC 3000 cutback bitumen or modified binder or rubber bitumen.
 - ✓ Diesel fuel for cleaning spray lance and other tools
 - ✓ Chalk or spray paint for marking on the road surface
 - ✓ String lines
 - ✓ Paper for transverse joints
 - ✓ Other necessary approved material

- (3) Other materials if necessary for work execution.

212.03 WORK PROCEDURES

< 1 > Labor based method (less than 1,000m²)

- (1) Use the bitumen thermometer to control the material temperature.
- (2) If bitumen emulsion is used, it will not normally require heating. However, cationic emulsions will need to be heated.
- (3) Determine the volume of each container that will be used to carry and apply the binder to the road surface.
- (4) (Using paint) fix a volume mark on each container.
- (5) Calculate the area of road surface to be covered by one container using the specified binder spray rate.
- (6) Calculate the length of road to be covered by one container by dividing the volume of the container by the width of the road surface to be sealed and by the rate of binder spray.
- (7) Sweep clean the road surface using the hand brooms. Using shovels load onto wheelbarrows and cart to spoil swept material in an environmentally friendly manner.
- (8) Protect reflective studs with grease or similar material.
- (9) Using string lines and chalk mark out the road surface area to be sprayed by each container.

- (10) Pour the hot binder or emulsion into the containers and carry carefully to the placement area.
 - (11) Apply the binder over the marked area as evenly as possible. Use the squeegees immediately to ensure even distribution.
 - (12) Spread the sand as soon as possible after the binder is distributed. The sand can be spread by shovels from stockpiles previously placed on the road shoulder or by casting the sand by hand from the rear of a truck reversing slowly over the previously laid sand.
 - (13) Follow up with a wheelbarrow of sand to top up areas where the sand is spread too thinly.
 - (14) Carefully roll the finished work with the empty sand truck as soon as the sand is spread.
 - (15) Immediately open road to traffic for 8-12 weeks limiting the speed of traffic to 40kph. During the first 2-3 weeks sand dislodged by traffic should be broomed back into the wheel tracks as required. During this period guide traffic so that it traverses the entire road width resealed.
 - (16) After 2-3 weeks excess sand can be swept off and the traffic speed and control limitation can be lifted.
 - (17) Clean up and remove waste and excess material from shoulders, drains, and road surface.
 - (18) Clean reflective studs and replace those damaged.
 - (19) Reinstate temporary road marking (spotting).
- < 2 > Equipment based method (more than 1,000m²)
- (1) Clearly mark out the extent of road to be resealed by painting a line across the full width of the road pavement at the start and finish of the area to be sealed.
 - (2) Using the mechanical broom, sweep the full extent of the area to be sealed. Swept materials shall be heaped, loaded onto trucks and disposed in an environmentally friendly manner.
 - (3) Protect reflective studs with grease or similar material.
 - (4) Mark by paint the start and finish of the initial bitumen sprayer run which will be dependent on the amount of sand loaded on spreading trucks on site at the time of spraying.
 - (5) Mark by paint, string line or small stones the edge line for the sprayer driver to follow.
 - (6) Paper the transverse joints at the start and finish of each spray run.
 - (7) Set up the bitumen sprayer 20m away from the start of the run and ensure that the spray bar is set correctly width and that the driver's guide bar is properly set.

- (8) Measure and record a dip of the volume of bitumen and sprayer temperature
- (9) Set-up the sand spreading trucks immediately behind the bitumen sprayer,
- (10) Set-up the pneumatic tyred roller (s) immediately behind the chip spreaders
- (11) The foreman communicates the binder application rate and corresponding road speed to the sprayer driver.
- (12) Using the bitumen distributor, spray the binder at the required rate uniformly over the whole area without stopping until it has reached the marked end of the spray run.
- (13) At the finishing point the operator dips the distributor to record the amount of bitumen used.
- (13) Spread a uniform layer of sand (about 5mm thick) from the mechanical chip spreader following close behind the bitumen distributor
- (14) Leave a 150mm wet edge, if needed, for the adjoining bitumen run.
- (15) Workmen should follow up behind the chip spreaders to ensure full coverage is achieved by addition of sand by hand.
- (16) Embed the sand using the pneumatic tyred roller by following close behind the chip spreaders at a speed of 10 -15 kph.
- (17) Continue rolling in straight runs until the whole mat is uniformly rolled.
- (18) Collect any excess pile of sand from the road surface.
- (19) Repeat the setting up of the equipment as above if a second seal is required immediately after laying the first seal.
- (20) Offset the transverse joints on the second coat so as not to overlay the same position of the first coat.
- (21) Immediately open road to traffic for 8-12 weeks limiting the speed of traffic to 40kph. During the first 2-3 weeks sand dislodged by traffic should be broomed back into the wheel tracks as required. During this period guide traffic so that it traverses the entire road width resealed.
- (22) After 2-3 weeks excess sand can be swept off and the traffic speed and control limitation can be lifted.
- (23) Clean up and remove waste and excess material from shoulders, drains, and road surface.
- (24) Clean reflective studs and replace those damaged.
- (25) Reinstate temporary road marking (spotting).

212.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
212-1	Sand seal	Metre Square

212.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

2.2 REGRAVELLING

CODE 221 SCARIFYING OF EXISTING ROAD

221.01 DESCRIPTION

(1) This work is to dismantle and remove existing pavement including shoulders and salvaging/disposing of the resulting materials.

221.02 MATERIALS

Nil.

221.03 WORK PROCEDURES

< 1 > Removal of Existing Pavement Surfacing

(1) This work shall comprise removing the existing surfacing for the lengths shown on the Drawings, or as instructed by the Engineer.

(2) Prior to the start of excavation operations, all necessary clearing, grubbing and top soil removal in that area shall be completed.

(3) All operations necessary for the removal of pavement which might endanger new construction shall be completed prior to the start of new work.

(4) The surfacing shall be removed by mechanical means unless approval is given by the Engineer to the use of labor based methods.

(5) Existing pavement within the right-of-way shall be removed down to the limits appointed by the Contractor after approval of the Engineer.

(6) During the work within the roadway, the formation shall be maintained in such a condition that it will be well-drained at all times. Care shall be taken to ensure that side berms are not created at the edges of the excavation trapping water within the excavation.

(7) Dismantling and removal operations shall be carried out without disturbing the adjacent pavement which is to remain.

(8) No excavated suitable material shall be wasted without permission from the Engineer, and when such material is permitted to be wasted, it shall be so placed in locations approved by the Engineer that it will present a neat appearance and not be an injury to abutting property or to the general environment.

(9) Excavated materials wasted by the Contractor without permission of the Engineer shall not be measured or paid for.

(10) All materials including (but not restricted to) bituminous surfacing, stone aggregate and lateritic materials, arising from the dismantling of existing pavements shall remain the property of the Employer.

(11) In undertaking removal and disposal works, the Contractor shall comply with all laws, ordinances, building regulations etc., as prevailing in the Lao PDR. Unless otherwise

permitted by the Engineer, the Contractor shall furnish, erect and maintain suitable barricades and safety measures to prevent personal injury or property damage during removal works.

(12) Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and thoroughly compacted in line with surrounding areas to the satisfaction of the Engineer.

< 2 > Stockpiling of Excavated Materials for Reuse

(1) The materials arising from the removal shall be stockpiled at locations agreed with/approved by the Engineer and shall be safeguarded by the Contractor until instructions are given as to eventual disposal.

(2) Stockpiles of suitable material for reuse shall be neatly and compactly constructed in an approved manner.

(3) The materials may be taken over by the Contractor for use in the Works provided the same is approved by the Engineer.

(4) Acceptability of the materials shall be determined by the Engineer and only such materials that fully satisfy the Specifications in all respects shall be permitted for incorporation in the permanent works. Materials failing to satisfy the Specifications may be used in the temporary works like diversion roads etc.

(5) Existing pavement materials containing bitumen, an excess of clay, soil or organic materials will not normally be considered suitable for reuse in the permanent works.

221.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
221-1	Scarifying of existing road	Metre Square

221.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 222 RESHAPING THE ROAD (INCL. DITCHES)**222.01 DESCRIPTION**

(1) Work shall be done in compliance with corresponding parts of code 121/122 (Heavy/Light grading).

222.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
222-1	Reshaping the road (incl. ditches)	Metre Square

222.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 223 REGRAVELLING**223.01 DESCRIPTION**

- (1) The surfacing material of unpaved roads is worn away by traffic, eroded by rain and blown away as dust.
- (2) Before all the gravel surfacing has worn away the road requires regravelling.
- (3) Regravelling is normally a PERIODIC MAINTENANCE task.
- (4) It is important that the Maintenance Engineer plans regravelling work well in advance so that work is carried out before serious defects appear.
- (5) Before regravelling is carried out, it is important to make any necessary repairs or improvements to the camber* and drainage system of the road. If this is not done, the new gravel surface will deteriorate very quickly.
- (6) Regravelling is normally carried out with one layer 15 cm thickness.
- (7) Usually a continuous layer of gravel is laid on the existing running surface, however on some occasions only short stretches showing severe defects are covered under a spot regravelling operation.

223.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Gravel obtained from a quarry or gravel pit must be of a quality that meets the Departmental specifications and also be approved by the Maintenance Engineer.
- (3) A source of water will be needed as near as possible to the site.
- (4) Other materials if necessary for work execution.

223.03 WORK PROCEDURES**< 1 > Preliminary Tasks**

- (1) The Worksheet should indicate the location and extent of the work to be carried out and the time, equipment and personnel required for the job.
- (2) Where spot regravelling is specified, the extent of the sections to be regravelled should be marked out on site.
- (3) Before the start of the job, a check should be made to ensure that everything needed is ready.
- (4) Arrangements must be made to take gravel from the borrow pit or quarry and test it for approval. This should be done well in advance of the work.
- (5) Arrangements must be made to obtain water close to the site. This should be done

well in advance of the work.

- (6) The condition and "availability" of the equipment must be checked and the numbers of each type of equipment must be decided.
- (7) Trucks and plant must be fueled, greased, checked mechanically and have water and oil levels checked. Arrangements must be made for refueling on site if required. This may either be with a refueling truck visiting the working site, or by arrangement to refuel at a maintenance camp. Arrangements must be made for the necessary mechanical support on site.
- (8) It may be necessary to make arrangements for accommodation for personnel close to the work site.
- (9) At the beginning of the job, traffic signs, barriers and cones must be obtained and loaded onto a truck.
- (10) Wherever possible, before the regravelling work starts, the grader should open a diversion adjacent to the road.
- (11) If traffic is diverted from the work site, it will enable the job to be carried out more efficiently and safely.
- (12) If the site conditions are such that it is not practical to build a diversion, then signs must be placed and working must be restricted to one side of the road at a time.
- (13) On low-traffic roads, the Maintenance Engineer may approve the use of a simpler system of traffic control.

< 2 > Temporary Signposting

- (1) After the diversion has been completed and before work starts, warning signs, barriers and cones must be placed around the work area.
- (2) Signs must be placed in the following order:
 - ✓ "Men Working" signs should be placed 200 metres in front of the work area.
 - ✓ "Turn Left/Right" arrows should be placed 100 metres in front of the work area.
 - ✓ Cones should be placed diagonally across the road to lead into the diversion.
 - ✓ "Keep Left-Right" arrows should be placed at the ends of the lines of cones.
 - ✓ Barriers should be placed behind the lines of cones.
 - ✓ "End of Restriction" signs should be placed 50 metres beyond the ends of the diversion.
 - ✓ At night yellow lamps should also be used to mark the extent of the works at the diversions.

< 3 > Work Execution

- (1) Before the regravelling work starts, gravel should be stockpiled at the quarry or borrow pit. It may also be helpful to start hauling the material to site.
- (2) Plan the quarry excavations and stockpiles so that:

- ✓ the quarry can be fully exploited with removal of the maximum amount of gravel,
 - ✓ the overburden is stockpiled so that it will not hinder future extension, and that it can be used to reinstate the quarry,
 - ✓ the best material is taken, where gravel quality is variable within the quarry,
 - ✓ material is stockpiled to minimise segregation,
 - ✓ environmental damage by poor drainage and erosion is minimised both during and after exploitation of the quarry.
- (3) The quarry layout should:
- ✓ permit efficient excavation and stockpiling of gravel,
 - ✓ allow the trucks to enter and leave without obstructions.
- (4) Repair the quarry access road, if necessary, to ensure safe passage of trucks.
- (5) After signs have been placed, the existing road surface must be graded as described in Code 121/122.
- (6) The road surface must be graded-off to provide a firm regular surface on which to work and the edges should be "boxed" to provide support for the new gravel. The graded surface should be watered and compacted.
- (7) The camber should be checked with a camber board and the road level should fall 3 to 4 cm for each one metre width of road (3-4 %).
- (8) The drainage system should be checked and repaired if necessary, otherwise the performance of the gravel surface will be affected.
- (9) At the quarry or borrow pit, the bulldozer should have stockpiled sufficient gravel for the work. The excavating and stockpiling of gravel should create low, broad heaps to prevent segregation of the coarser material.
- (10) When the initial grading of the road is complete, the loader should start to load the tippers with gravel for transport to the regravelling site.
- (11) The supervisor at the quarry should ensure that gravel is taken from the correct stockpiles and that the trucks are loaded correctly.
- (12) Tippers should always circulate continuously between the quarry and the site.
- (13) Dumping should start at the far end of the site so that the heaps of gravel do not impede tippers delivering later loads.
- (14) Material should be dumped on one side of the road only. Loads should be placed at the correct spacing as instructed by the Maintenance Engineer, necessary to give the required thickness of gravel over the complete road width.
- (15) If the road is not closed, material should be dumped on the shoulder.
- (16) The tankers should have filled up with water using the pump and then have driven

to the site.

- (17) Spreading of the gravel can start when there is a working length of at least 200 metres of dumped material.
- (18) Initially the road is sprayed with water.
- (19) The regravelling material is then spread right across the road using the grader.
- (20) The material is alternately spread by the grader and watered with the tanker until its moisture content is correct for compaction.
- (21) The amount of water to be added must be determined by moisture content tests on site or by the Maintenance Engineer.
- (22) The tankers circulate continuously between the site and the source of water.
- (23) The new material is now graded as described in Code 121/122 to produce a camber of 3 to 4 cm for each one metre width of road (3-4 %).
- (24) The camber should now be checked with the camber board at approximately 100 metre intervals along the road.
- (25) To use the camber board:
 - ✓ Place it on its edge across the road with the shorter end pointing towards the centre line.
- (26) Check the level bubble:
 - ✓ If it is central, the camber is correct.
 - ✓ If it is not central, the camber is either too steep or flat and further grading and compaction are required.
- (27) If the camber does not fall 3 to 4 cm for each one metre width of straight road, the grading must be repeated.
- (28) When the correct camber* has been achieved, rolling can start.
- (29) Water should not be added during rolling as the material may stick to the wheels or drums.
- (30) Rolling should start at the edge of the road and work towards the middle. The roller should aim to progress from section to section at the same rate as the grader.
- (31) About eight passes of the roller will be needed to achieve full compaction.
- (32) It is possible to regravell without the use of water and compaction, but it is difficult to achieve satisfactory results.

< 4 > Completion and Removal of Temporary Signs

- (1) The work proceeds along the road in sections. As each section is completed, the traffic signs, cones and barriers are moved along the road. This opens the road at the completed end for traffic, and closes it at the other end to allow new gravel to be dumped.

(2) As work proceeds, it will be necessary to open new diversions and move the diversion signs.

(3) When the work is finally completed, remove the traffic signs, cones and barriers and load them onto the truck in the following order:

- 1 "End of Restriction" signs,
- 2 Barriers,
- 3 "Keep Left/Right" arrows,
- 4 Cones
- 5 "Turn Left/Right" arrows,
- 6 "Men Working" signs.

(4) Ensure that the site is left clean and tidy with no stockpiles of material left on the road.

(5) Move on to the next job.

(6) Inspect traffic signs and clean if necessary.

223.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
223-1	Regravelling	Metre Cube

223.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

2.3 BRIDGE REPAIRS

CODE 231 REPLACEMENT OF TIMBER DECKS

231.01 DESCRIPTION

- (1) The work is to keep bridges in sound structural condition and safe for traffic by replacing damaged deck planks.

231.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) New planks must be well seasoned and treated with a wood preservative.
- (3) Other materials if necessary for work execution.

231.03 WORK PROCEDURES

- (1) Extract nails and lift off running boards and deck planks carefully to avoid damage to the timber stringers.
- (2) Examine top surface of stringers for decay or damage. (Decayed stringers will need to be replaced).
- (3) Cover top of stringer with a layer of bituminous felt, place new transverse planking, properly seasoned, and treated with wood preservative, and nail in position. Retain ventilation/drainage gaps between planks.
- (4) When new deck planks are in position, relay old running boards if in good condition. Otherwise replace these with new properly seasoned and treated planks. Nail into position using staggered joints.

231.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
231-1	Replacement of timber decks	Metre Cube

231.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 232 REPLACEMENT OF RUNNING STRIPS

232.01 DESCRIPTION

- (1) The work is to keep bridges in sound structural condition and safe for traffic by replacing damaged running strips.

232.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) New planks must be well seasoned and treated with a wood preservative.
- (3) Do not use defective timber, for example plank with:
- ✓ bows
 - ✓ crooks
 - ✓ twists
 - ✓ cups
 - ✓ excessive knots
- (4) Other materials if necessary for work execution.

231.03 WORK PROCEDURES

- (1) Extract all nails, remove defective planks and clean deck area at contact surfaces.
- (2) Use new planks of same dimensions as the planks to be replaced.
- (3) Use about 3 nails for ends of each plank and 2 nails every 25 cm along the plank. Do not drive nails near the edge of the plank; stay at least 3 cm from the edge. All nail heads must be flush with the surface of the plank.

232.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
232-1	Replacement of running strips	Metre Cube

232.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 233 REPAIR OF CONCRETE

233.01 DESCRIPTION

- (1) This work is to:
- ✓ maintain structural integrity of bridge concrete elements and
 - ✓ ensure traffic safety and prolong useful life of the bridge.
- (2) The work involves carrying out concrete repairs to spalled or damaged concrete on abutments, piers and superstructures so as to maintain their structural integrity. The work shall be carried out using labor based method.

233.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Stone, cement, sand, water, mesh reinforcement, formwork material.
- (3) Other materials if necessary for work execution.

233.03 WORK PROCEDURES

- (1) Remove damaged concrete and cut back to sound material.
- (2) If required, construct formwork around the damaged area.
- (3) If required, fix mesh reinforcement over the damaged area.
- (4) Prepare concrete as per maintenance specifications.
- (5) Place concrete in the damaged area and tamp to reduce air voids.
- (6) Allow concrete to set, and cure the concrete by water leaving the formwork in place for 3 days.
- (7) Strip the formwork, measure and record the volume of concrete used.
- (8) Make the site clean & tidy.

233.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
233-1	Repair of concrete	Metre Cube

233.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 234 REPAIR OF WOODEN BRIDGE

234.01 DESCRIPTION

- (1) This work is to sustain soundness of wooden bridge by conducting various types of repairs works.

234.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) New planks must be well seasoned and treated with a wood preservative.
- (3) Do not use defective timber, for example plank with:
- ✓ bows
 - ✓ crooks
 - ✓ twists
 - ✓ cups
 - ✓ excessive knots

- (4) Epoxy grout

- (5) Other materials if necessary for work execution.

234.03 WORK PROCEDURES

< 1 > Superstructure Elements

(1) Cleaning of Outside Timber Stringers

1. The outside stringer on a timber bridge is more susceptible to deterioration due to its increased exposure to the elements, including rain, sunlight, and debris flow.
2. All dirt and loose decayed material should be removed and consideration given to adding flashing to prevent excessive wetting and further repairs if checks or splits are present.
3. Tidy up the area.

(2) Cleaning of Deck Drainage

1. Proper drainage on timber bridges is often impeded by the collection of road debris, gravel, and sand.
2. The inability for water to quickly exit the bridge deck could promote undue deterioration.
3. It is common for debris to collect at the bridge deck edges; this debris should be removed.
4. Some bridges may have scuppers that become filled. Likewise, the scuppers should be cleared of all debris to allow proper water passage.

(3) Removal of Deck Vegetation

1. Timber decks can be susceptible to vegetation growth given that gaps between deck boards are quite common.
2. These gaps fill with dirt and gravel that, in turn, create an environment in which vegetation can begin to grow.
3. Vegetation growth is a clear indicator that debris has collected and water is being retained within the gaps.
4. As such, the vegetation and debris should be cleared to prevent deterioration of the deck.
4. Tidy up the area.

< 2 > Substructure Elements**(1) Removal of Debris from Pile Caps**

1. Commonly, gaps between deck boards on timber bridge decks form and allow at least a nominal amount of debris to pass through.
2. The debris is able to collect on top of pile caps, which can trap water against the pile cap.
3. Due to the retained moisture, deterioration of the pile cap advances at a quicker rate than would otherwise occur.
4. If left alone, the pile cap could deteriorate to a point where sufficient support of the superstructure is compromised and complete replacement of the pile cap is necessary.
5. Debris should be cleared or washed from the top side of pile caps to reduce chances of water retention.
6. Tidy up the area.

(2) Repair of Small to Medium Cracks

1. Small to medium cracks and splits caused by weathering or shrinkage create pathways for decay fungi to enter the untreated wood at the core of the timber pile.
2. Therefore, cracks and splits must be repaired regularly. Epoxy grout can be injected under pressure to fill checks and splits.
3. The epoxy seals the affected area, preventing water and other debris from entering.
4. It can also restore the bond between separated sections, increase shear capacity, and reduce further splitting. Low viscosity epoxy is injected to fill the void, which is then sealed using a sealing epoxy.

5. Tidy up the area.

234.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
234-1	Repair of wooden bridge	Number

234.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 235 REPAIR OF BRIDGE EROSION PROTECTION

235.01 DESCRIPTION

- (1) This work is to:
- ✓ prevent undermining and settlement or collapse of bridge foundations and road embankment and
 - ✓ prolong the useful life of the bridge.
- (2) The work involves the repair of stream bed or stream bank erosion around piers and abutments and erosion prevention structures at bridges. The activity shall be carried out using labor based method. Equipment based method shall be used where extensive erosion has occurred.

235.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Labor Based Method
- ✓ Rip rap stones – each weighing 7 to 10 kg
 - ✓ Gabion mattresses/boxes and binding wire
 - ✓ Other necessary approved material
- (3) Equipment Based Method
- ✓ Rip rap stones – each weighing 7 to 10 kg
 - ✓ Approved backfill material
 - ✓ Gabion mattresses/boxes and binding wire
 - ✓ Other necessary approved material
- (4) Other materials if necessary for work execution.

235.03 WORK PROCEDURES

< 1 > Labor Based Method

- (1) Repair using riprap stones
1. Stake out the area around the pier/abutment where erosion has occurred.
 2. Excavate to estimated lowest scour level, and record depth and surface area to be repaired.
 3. Place riprap stone in layers in the excavation starting with the smaller size stone in the lowest layer.
 4. Fill spaces between stones with smaller size stones.
 5. Continue work layer after layer until normal bed level is reached. The top layer should contain the heaviest stones and have a flat even surface at river bed level.
 6. Measure and record volume of material used to repair erosion.
 7. Tidy up the area.

(2) Repair using gabion mattresses

1. Remove all loose or unsuitable material and cart away to spoil.
2. Replace missing stones to fill up gabion baskets in a way that leaves the least possible space.
3. Stitch together the gabions using the binder wire along the touching edges.
4. Where gabions are to be replaced from the ground level, prepare the foundation by levelling and compacting the ground using hand rammers.
5. Hand-fill the baskets with the stones and tie them together with the binder wire.
6. Gabions should be laid with broken bonds to avoid continuous joints.
7. Measure and record the area of gabion mesh repaired and the volume of filled stones.
8. Tidy up the area.

< 2 > Equipment Based Method

(1) Repair using riprap stones

1. Stake out the area around the pier/abutment where erosion has occurred.
2. Excavate to estimated lowest scour level, and record depth and surface area to be repaired.
3. Backfill with approved gravel material and compact to 90% MDD AASHTO density.
4. Leave a depth from ground level equivalent to the specified layer of riprap stones.
5. Place riprap stone in layers in the excavation starting with the smaller size stone in the lowest layer.
6. Fill spaces between stones with smaller size stones.
7. Continue work layer after layer until normal bed level is reached. The top layer should contain the heaviest stones and have a flat even surface at river bed level.
8. Measure and record volume of material used to repair erosion.
9. Tidy up the area.

(2) Repair using gabion mattresses

1. The work shall comply with the procedures of “Labor Based Method”.

235.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
235-1	Repair of bridge erosion protection	Metre Cube

235.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 236 REPAIR OF APPROACHES

236.01 DESCRIPTION

- (1) This work is to restore the bridge approach road to original condition.

236.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Approved gravel, Approved materials for concrete or stones for stone pitching, Aggregates conforming to specifications either pre-coated or not pre-coated, Bituminous binder – a cold bitumen emulsion or penetration grade 80/100 bitumen OR a highly polymer modified binder OR rubber bitumen OR bituminous binder/polymer modified binder with glass fibers OR bituminous binder/polymer modified binder with geotextile fabric, Appropriate agent for pre-coating aggregates where specified, Diesel fuel for cleaning spray lance and other tools, Chalk or spray paint for marking on the road surface, String lines

- (3) Other materials if necessary for work execution.

< 1 > Restore of Roadway

- (1) Load gravel material into tipper trucks and transport to work area. Dump material onto or close to prepared site.
- (2) Using a bulldozer (for deep washouts) or a motor grader for shallow washouts spread material onto washout and compact with a vibrating roller in 200mm layers.
- (3) The finished surface should be provided with a camber similar to the adjacent road to ensure good drainage of the surface.
- (4) Set up the bitumen sprayer 20m away from the start of the run and ensure that the spray bar is set correctly width and that the driver's guide bar is properly set.
- (5) Measure and record a dip of the volume of bitumen and sprayer temperature.
- (6) Set-up the chip spreading trucks immediately behind the bitumen sprayer.
- (7) Set-up the pneumatic tyred roller (s) immediately behind the chip spreaders.
- (8) The foreman communicates the binder application rate and corresponding road speed to the sprayer driver.
- (9) Using the bitumen distributor, spray the binder at the required rate uniformly over the whole area without stopping until it has reached the marked end of the spray run.
- (10) At the finishing point the operator dips the distributor to record the amount of bitumen used.
- (11) Lay the geotextile fabric or glass fiber immediately after applying the tack coat ensuring that it is placed evenly without creases or wrinkles. Roll the geotextile with a pneumatic roller so that it is embedded into the tack coat. Apply the binder at (the remainder) half of the design spray rate over the geotextile.

- (12) Spread a uniform single layer of chippings from the mechanical chip spreader following close behind the bitumen distributor.
- (13) Leave a 150mm wet edge, if needed, for the adjoining bitumen run.
- (14) Workmen should follow up behind the chip spreaders to ensure full coverage is achieved by addition of chippings by hand.
- (15) Embed the chippings using the pneumatic tyred roller by following close behind the chip spreaders at a speed of 10 -15 kph.
- (16) Continue rolling in straight runs until the whole mat is uniformly rolled.
- (17) Collect any excess pile of chippings from the road surface.
- (18) Repeat the setting up of the equipment as above if a second seal is required immediately after laying the first seal.
- (19) Make the site clean and tidy.

< 2 > Restore of Slope Protection

- (1) Load and haul to worksite suitable stones. The stones should have a long flat shape with a minimum dimension of 150mm. If necessary, shape the stone using a mason's hammer.
- (2) Prepare cement: sand mortar of specified strength.
- (3) Lay stones with a bond allowing minimum overlap of $\frac{1}{4}$ the length of the smaller stone.
- (4) Joints should be a minimum of 10mm. No stone should touch another stone but should be laid fully on a mortar bed.
- (5) Mortar joints on the face of the wall should be pointed and raked to produce an aesthetic finish.
- (6) Make the site clean and tidy.

236.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
236-1	Repair of approaches	Metre Square

236.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE A016 REPLACE POST ON DRIFT/CAUSEWAY

A016.01 DESCRIPTION

(1) This work is to replace missing or damage guide posts as markers on drifts or causeway before the flood season.

A016.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Steel pipe sockets of approved diameter, steel pipe of approved diameter, paints (primer & top coat (yellow & black)), cement and sand.
- (3) Timber guide-posts are not recommended as they can easily break down. However, hardwood posts can be used if properly anchored in the socket (tight fit) so that they will not be washed away with the flood water.
- (4) Other materials if necessary for work execution.

A016.03 WORK PROCEDURES

- (1) Remove water, sand, silt, and loose materials in the pipe socket.
- (2) The pipe socket should have a minimum depth of 15 cm.
- (3) Use mason's hammer and chisels to enlarge or deepen the hole, if necessary.
- (4) Insert the pipe into the socket and make sure on the correct position and height.
- (5) Grout the space between the pipe and the socket using a mortar (1-cement : 3-sand).
- (6) Paint the pipe posts in black and white sections.
- (7) Make the site clean and tidy.

A016.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
A016-1	Replace post on drift/causeway	Number

A016.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA009 REPLACE EXPANSION JOINT

AA009.01 DESCRIPTION

- (1) This work is to remove expansion joint which is damaged by long term usage and install new joint to recover its function.

AA009.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The material shall be in compliance with the requirements stipulated in the original design documents.
- (3) Other materials if necessary for work execution.

AA009.03 WORK PROCEDURES

- (1) The contractor shall submit shop drawings and construction method statement to the Engineer for his review and approval.
- (2) Stop traffic before the work commencement.
- (3) Remove pavement and/or concrete around existing joint.
- (4) Carefully chip off surface concrete without impairing existing facilities.
- (5) Remove the existing joint.
- (6) Confirm soundness of concrete slab for placing new joint.
- (7) Place new joint and fix it by installing anchors on the slab.
- (8) Confirm elevation of the joint whether it is equivalent to road surface and sustaining flatness.
- (9) Cast rapid hardening concrete adjacent to the joint.
- (10) Make the site clean and tidy.
- (11) Open traffic after completion of curing.

AA009.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
AA009-1	Replace of expansion joint	Number

AA009.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA010 REPAIR OF DRAINAGE SYSTEMS**AA010.01 DESCRIPTION**

- (1) Proper maintenance of drainage systems to ensure the flow of water off the deck and away from the structure is just as important as keeping deck joints sealed.
- (2) It does little good to keep deck joints watertight if the water and any associated contaminants cannot flow away from the bridge structure. Furthermore, if water ponds on a deck, it can result in reduced traction for vehicles crossing the bridge under certain conditions.
- (3) If the deck drainage is not efficient and effective, dirt and debris may accumulate on the deck and in the joints, leading to increased maintenance requirements for other bridge elements.
- (4) Metal compounds, particulates, nutrients, and salts commonly found in bridge deck runoff might have a negative environmental impact on stream water. However, the concentrations normally found in ordinary rainstorm runoff were deemed not to be harmful in most cases.
- (5) This work is to repair the drainage systems by type for ensuring the expected function.

AA010.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The material shall be in compliance with the requirements stipulated in the original design documents.
- (3) Other materials if necessary for work execution.

AA010.03 WORK PROCEDURES

< 1 > Scuppers (Drop Through and Piped)

- (1) Small diameter pipes, long downspouts, and any horizontal runs with relatively flat slopes or sharp directional changes all contribute to clogged drains.
- (2) Short drops and through pipes that drain directly under the bridge may corrode structural steel, deteriorate concrete piers, and contribute to erosion of abutment earth slopes.
- (3) Dirt and debris should be removed from scuppers and downspouts by high pressure water jets or with metal probes (taking care not to puncture any pipe if metal probes are used).
- (4) Preventive maintenance requires regular, frequent inspection; cleaning to limit accumulation of dirt and debris; application of coatings to piers and structural steel as needed to prevent corrosion from water passing through the drainage system; and if deck drainage threatens abutment earth slopes, protection of them by paving the slope or using

ditch liners.

(5) Deck drains should be designed and constructed to be readily accessible to maintenance personnel for cleaning. If this is not the case, maintenance engineers and managers need to ensure that design engineers are made aware of maintenance personnel needs.

(6) Deck drains designed and constructed to drain through bridge structural elements, such as columns, must be inspected and cleaned as needed in freeze thaw climates before the onset of freezing weather, ensuring that water will not stand in the drain and damage the structural column.

(7) Make the site clean and tidy.

< 2 > Gratings

(1) Open steel grate decks or open-grid deck floors usually provide good drainage of the deck floor but tend to allow dirt and corrosive elements to accumulate on the structural members below the deck.

(2) Required maintenance activity includes removing dirt and debris from beams, girders, and pier caps on a regular basis. Regular and frequent inspection with cleaning, as needed, is necessary to prevent dirt and debris from accumulating.

(3) Applying protective coatings, covers, or shielding plates to structural members below the grating helps reduce the corrosive impact of water passing through the gratings

(4) Make the site clean and tidy.

< 3 > Open Joints with Troughs

(1) Troughs under open joints are also subject to clogging and dirt accumulation that then produces a drainage backup that can contribute to steel corrosion, concrete deterioration, and earth erosion at abutments.

(2) Maintenance activity should provide regular, frequent inspection and cleaning of troughs under open joints.

(3) Protective coatings applied to piers and abutments in the vicinity of open joints with troughs will help slow any corrosive effect of the water passing through the open joint.

(4) Earth slopes under the discharge pipes should be protected by concrete paving or rock riprap.

(5) Long-term maintenance expenditures may be less with riprap-stabilized-earth slopes.

(6) Make the site clean and tidy.

AA010.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
AA010-1	Repair of drainage systems	Number

AA010.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA011 REPAIR OF BRIDGE BEARING**AA011.01 DESCRIPTION**

- (1) Bearings transmit the dead load and the live load on the superstructure to the substructure while also allowing the superstructure to move without exceeding its design stress limits.
- (2) For example, movement can result from temperature changes, wind pressures, substructure movement, and live-load deflections.
- (3) A bearing assembly that is frozen (corroded or fouled, not moving as intended), out of position, damaged, or for any other reason not operating properly can cause the stress limits to be exceeded in a bridge seat, in beam ends, in supporting columns, or in other bridge members, which in turn will result in structural damage requiring repair or replacement.
- (4) Two general types of bridge bearings are “fixed” bearing devices and “expansion” bearing devices.
- (5) The bearing types include pot bearing, disk bearing, PTFE sliding surfaces, curved sliding surfaces, masonry and bearing plates, and “other” bearing systems.

AA011.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The material shall be in compliance with the requirements stipulated in the original design documents.
- (3) Other materials if necessary for work execution.

AA011.03 WORK PROCEDURES

< 1 > Routine maintenance category

- (1) Sliding plate bearing
 - 1. Corrosion that increases friction is the most common problem with sliding plate bearings.
 - 2. If movement in the bridge exceeds that anticipated in the design, sliding plate bearing problems can also arise.
 - 3. Repair work of a slide plate bearing requires jacking the structure, except for cleaning the bearing area, removing debris from the bearing area, and lubricating a bearing that has a grease fitting.
 - 4. If a sliding plate surface is corroded or will not allow movement, the bridge must be jacked to remove the bearing surface for cleaning, lubrication, and repositioning (if needed).
 - 5. Lubricants on the bearing plate surface can include a good waterproof grease, oil, or graphite, or lead sheets can be placed between steel plates, or a bronze plate can slide against a steel plate.
 - 6. If a sliding plate bearing assembly was not designed and constructed to include a

grease fitting, consider installing one while the assembly is being maintained so that the plate surface can be lubricated without jacking the structure.

(2) Roller bearing

1. Many roller bearing devices are enclosed units and therefore difficult to gain access to for repair work. Some units are housed in a sealed lubricant enclosure.
2. Routine maintenance consists of keeping the bearing area clean and painted. Lubrication is generally limited to keeper links and nesting mechanisms that require disassembly.
3. When roller bearings stop functioning as designed and intended, they must be removed and refurbished, which in turn requires jacking the end of the span connected to the bearing.
4. Since the nests and mechanisms normally require off-site shop maintenance to be rebuilt, many agencies fabricate spare units so that a complete change out of the roller bearing assembly can be performed in the field to avoid closing a bridge for an extended period of time.

(3) Rocker bearing

1. Rocker bearings are pedestals with circular bottoms that support a pin. Since the weight of the bridge is transmitted to the rocker through the pin, it is a critical part of the assembly.
2. The pin may become excessively worn and corroded (and then freeze up). The surface of the rocker and bearing plate can be limited in its range of movement by debris and dirt buildup.
3. If the bridge moves beyond the intended design range of the rocker bearing, the rocker can become unstable and fail.
4. Maintenance generally includes keeping the assembly clean, lubricated, and painted.
5. Debris and dirt should be removed from under the rocker, and if such a problem persists, a cover for the rocker assembly should be designed and installed to keep debris and dirt away from the rocker.
6. When pins become worn or corroded, making lack of movement a problem, they should be removed and either replaced or cleaned and lubricated, which requires jacking the bridge.
7. Special pins can be fabricated with grease fittings and installed to permit lubrication without disassembly.

(4) Pin-and-hanger bearing

1. Most modern designs do not incorporate pin-and-hanger bearings, but many existing steel beam and truss spans have these types of bearings because these bearings are located under a deck joint, the pin-and-hanger assembly is particularly susceptible to corrosion.
2. Corrosion tends to cause the assembly to freeze up, preventing movement, which in turn transmits very large forces to the assembly that can result in pin or hanger failure.
3. The pin frequently breaks while resisting torsional forces. Hangers most often fail at either end adjacent to the hole through which the pin is fitted.
4. A serious difficulty of repair work with pin-and-hanger bearings is that any corrosion of the pin and its bearing surfaces is not easily detected without

disassembling the bearing, which is also generally not feasible because these bearings are not located over substructure elements, so are difficult to gain access to.

5. Many pin-and-hanger installations were not equipped with lubrication fittings, which further complicate maintenance and often contribute to the freeze-up of the bearing.
6. Failure of a pin-and-hanger bearing can lead to catastrophic failure of the bridge; therefore, it is very important to inspect such bearings and watch for any cracking or other stress failure indications.
7. In many cases, redundancy has been added to pin-and-hanger bearings that were not initially designed and constructed to be redundant to prevent a sudden failure of the bridge.
8. However, even with redundancy improvements, bridge failures can still happen if pin-and-hanger bearings are not regularly and carefully inspected in an attempt to identify frozen or damaged assemblies.

(5) Elastomeric bearing

1. This material typically has a long life and is able to withstand repeated deformation cycles. Consequently, maintenance is rarely needed unless the bearing completely fails or gradually works out of position.
2. The bridge must be jacked to replace or reposition the bearing. If the bearing slips out of position on a recurring basis, an abrasive material can be added to the contact surface or a keeper plate can be attached to the bearing height.
3. These bearings have been designed to accommodate movements up to 75mm (approx. 3 inches) and several degrees of rotation.
4. The bearing may fail because of deterioration of the material, excessive crushing, separation of composite pad laminations, or excessive shear forces. Excessive shear is normally considered to result from longitudinal movement exceeding 25 percent of the bearing height.
5. Uneven compression and twisting of an elastomeric bearing can also contribute to problems.

(6) Pot bearing

1. Pot bearings can be damaged by movement or loading that result in uneven compression across the bearing.
2. A hydraulic pot bearing can lose its operational effectiveness if a piston seal leaks or a piston or pot is cracked.
3. Elastomeric pot bearings experience bond failures between the Teflon and the substrate, bond failures between the stainless-steel plate and the sole plate, deterioration of the stainless-plate, and cut or deteriorated Teflon.
4. Routine maintenance is normally limited to keeping the bearing area clean and free of debris.
5. When a pot bearing fails or malfunctions, the bridge must be jacked so that the bearing can be removed for repair or replacement.

< 2 > Resetting or rehabilitation

- (1) Frozen or misaligned bearings must be repaired or replaced. Good maintenance planning for this process generally includes the following items:

1. Determining the root cause of the bearing problem. Good bridge maintenance needs to address the cause of the bearing failure if it extends beyond the bearing itself. Otherwise, bearing maintenance is treating a symptom and not a cause.
2. Evaluating the existing bearings to determine if repair, replacement in kind, or upgrading to a different type or newer design bearing is needed.
3. Positioning a bearing, when setting or resetting it, so that it is centered at the median temperature for the geographical area which the bridge is located.
4. Making the site clean and tidy.

(3) To ensure a successful maintenance operation, bearing rehabilitation generally involves the following steps:

1. Constructing temporary support for the superstructure.
2. Closing the bridge to traffic.
3. Jacking the structure up to remove the load from the bearings.
4. Removing or repositioning the existing bearing assembly.
5. Making bearing set modifications as needed.
6. Positioning and setting the new or rehabilitated bearings.
7. Ensuring that the bearing assembly is properly positioned for the ambient temperature with respect to the median temperature for the geographical region.
8. Removing temporary supports.
9. Making the site clean and tidy.

< 3 > Elevating bearings to increase vertical clearance

(1) As roadway pavements deteriorate and overlays are added, the clearance under bridges commonly decreases. Replacement or repair of overpass bridge bearings is a good opportunity to consider modifying the bridge bearings to raise the vertical clearance under a bridge, if it would improve safety and commodity movement efficiency. The usual steps are as follows:

1. Jack and support the bridge slightly above the new elevation while seat and bearing modifications are made. Jack the spans together to avoid damaging the joints or if the substructure is continuous.
2. Modify the bearing seats to raise the bearings required distance. For adequate superstructure support, the seat modification should be designed by a professionally qualified structural engineer. A steel pedestal or reinforced concrete addition are typical methods of modifying the bearing sheet.
3. Modify bridge approaches to match the new elevation of the bridge deck.
4. Make the site clean and tidy.

AA011.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
AA011-1	Repair of bridge bearing	Number

AA011.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA012 REPAIR OF SUBSTRUCTURE**AA012.01 DESCRIPTION**

- (1) Problems often found in concrete bridge seats include deterioration of concrete and corrosion of the reinforcing steel. Such problems are caused by moisture and contaminants falling through leaking deck joints.
- (2) A horizontal cracks along the face of the pier cap, 75 to 100mm (approx. 3 to 4 inches) from the top, normally indicates that the top mat of reinforcing steel has expanded because of corrosion and has forced up the concrete (i.e. delaminated it).
- (3) When a superstructure moves beyond the space that is provided for it in the bearing assemblies, pressure is created on the anchor bolts. This can be caused by an inadequate design, improper placement of the bearing assemblies, or corrosion of the sliding surfaces, which produces friction.
- (4) Occasionally, lateral forces from large chunks of debris hitting a beam can also create large forces on the anchor bolts. The pressure from the anchor bolts is then transmitted to the substructure cap, which can damage the bridge seats or cause cracks in other parts of the substructure (such as the columns).
- (5) No bearing device was provided on some older concrete bridges except for a thin fabric or paper bond breaker.
- (6) Friction created by the beam or bearing device sliding directly on the bridge seat can cause the edge of the seat to shear if insufficient reinforcing steel exists in this area.

AA012.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The material shall be in compliance with the requirements stipulated in the original design documents.
- (3) Other materials if necessary for work execution.

AA012.03 WORK PROCEDURES

< 1 > General

- (1) Planning for maintenance repair of the substructure should consider the following:
 1. Identify the extent of the damage by sounding the concrete and marking the areas of unsound concrete.
 2. Make provisions to correct the cause of the damage.
 3. Plan to remove vehicular traffic from the bridge during jacking operations.
 4. Determine the size, number, and location of jacks that will be required.
 5. Ensure that jacking will not damage joints, bearing assemblies, or the area supporting jacks.
 6. Define the needed resources, which generally include jacking equipment, form carpentry, concrete sawing or chipping equipment, and any necessary staging.

(2) The substructure cap can be repaired or a new cap cast to offset any settlement that may have occurred at the substructure. Reconstruction of a bridge cap requires raising the superstructure to provide work space as well as to take the load off the bridge cap.

1. Construct a temporary bent for supporting the jacks and blocking, if jacking from abutment of pier elements cannot be done.
2. Remove vehicular traffic from the bridge while jacking the superstructure.
3. Lift the jacks in unison to prevent a concentration of stress in one area and possible damage to the superstructure.
4. If the bridge will carry vehicular traffic during repairs, restrict the traffic away from the repair area as much as possible.
5. Saw cut around the concrete to be removed and avoid cutting any reinforcing steel.
6. Remove deteriorated concrete to the horizontal and vertical planes, using pneumatic breakers.
7. Add new reinforcing steel where it is required.
8. Apply bonding material to the prepared concrete surface that must interface with the new concrete to be placed.
9. Build forms for the new concrete as required and place the new concrete.
10. Service, repair, or replace the bearings, as needed.
11. After the new concrete has cured and reached its required strength, remove forms, blocking, jacks, and temporary supports.

(3) Repairs to the substructure are usually done with basic materials and processes. Repairs underwater require special considerations, as do pile and pile bent repairs.

(4) Substructure problems include deterioration (especially at the water line), cracking (usually related to settlement), impact damage (associated with traffic under the bridge), and shear damage (associated with movement or approach pavement pressure).

(5) Since most substructure units are concrete, repairs are often concrete-related processes. If the concrete substructure is exposed to saltwater, either from the deck or from below, problems such as those found in concrete bridge decks, including corrosion of reinforcing steel and concrete spalling, are likely to have occurred.

(6) Timber substructures can be damaged by decay and vermin attack.

(7) Substructure repairs are generally very costly because of the extensive temporary supports needed to carry the superstructure. Thus, preventive maintenance is often a very cost-effective approach to limiting these expensive repairs, especially a program that removes debris and pressure-washes seats, caps, and other substructure surfaces exposed to salt.

< 2 > Repairing broken or deteriorated wing walls

(1) Portions of an otherwise sound wing wall may be broken off by frost heave, ice that forms in voids created by fill settlement adjacent to the wall, ice in cracks, voids in the concrete, or insufficient air entrainment voids.

(2) Deterioration may result from deicing and from salt-rich snow and ice being plowed onto the wing walls where it piles up.

(3) Weak aggregate in the original concrete mix can also contribute to wing wall deterioration. Losing portions of a wing wall can result in erosion of the fill and further damage to the bridge approach.

(4) The cause of the wing wall failure must be determined so it can be corrected as part of the wing wall repair process.

(5) Concrete forming should be preplanned and the forming materials cut to size in advance, if possible. Any excavation required to gain sufficient working access and to facilitate removal of defective concrete can be accomplished in advance of the wing wall repair.

(6) Materials and equipment typically needed to make this type of repair vary widely but often include excavating equipment such as a backhoe, an air drill, tie screws or equivalent bolts, wood spacers (waters, etc.), reinforcing bars, granular backfill material, hand tools, concrete removal equipment, anchor bolts and anchors, plywood forming, Portland cement concrete, epoxy bonding agent, non-shrink grout, and miscellaneous hardware.

(7) Everything needs to be readily available to limit the exposure of maintenance personnel to traffic and to expedite the repair operation.

1. Excavate as required to be able to set the dowels and the concrete forms.
2. Remove all fractured or deteriorated concrete to sound concrete by chipping and then blast-clean to remove all loosened surface material.
3. Drill and set form anchor bolts and dowels. Typically, dowels 13 mm in diameter (No. 4 bars) are placed a minimum of 225 mm (9 in.) into sound concrete and set with non-shrink grout, 150 mm (18 in.) center-to-center, both front and back.
4. Crosslace the 13-mm (No. 4) reinforcing steel bars and set the concrete forms.
5. Just before placing the concrete, apply an epoxy bonding agent to all existing concrete that will contact the new concrete.
6. Before backfilling with granular material, cure the new concrete a minimum of 7 days or until the concrete has developed sufficient strength to resist the lateral pressures of the backfill.

< 3 > Repairing abutment faces

(1) Concrete in abutments may deteriorate from the effects of water, deicing chemicals, freeze cracking, or debris impact, any of which can result in portions of the edge or face of the abutment breaking off.

(2) Repair is necessary to prevent continued deterioration, especially increased spalling due to moisture reaching the reinforcing steel and causing corrosion.

(3) Equipment and materials typically needed include an air compressor, concrete drilling equipment, tie screws (and lag studs), reinforcing steel wire mesh, forming material, reinforcing steel, Portland cement concrete, epoxy bonding agent, and gravel (stone or riprap also).

1. Establish vehicular traffic control, if needed.
2. Remove deteriorated concrete and loosened face surface material by chipping and blast-cleaning.

3. To support the form work, drill and set the tie screws and lag studs.
4. Set reinforcing steel and forms.
5. Apply epoxy bonding agent to the concrete surface just before placing the concrete.
6. Place the cement concrete, allow it to cure, and remove the forms.
7. Install any needed erosion control materials.

< 4 > Repairing spread footing

(1) Deterioration of a concrete spread footing can include breaking off of the footing projections or spalling of the sides. Severe deterioration may be caused by collision of ice and/or debris against the upstream side of the footing water penetration resulting in corrosion of reinforcing steel or initial construction using poor materials.

(2) Because the load of the bridge was originally designed to be supported by a uniform distribution of pressure on the material under the footing, the area of the footing must not be reduced. Installing a cofferdam, pumping, and dewatering, as needed, will allow the repair to proceed in a “dry” working environment.

1. Keep the work area clear of water with diversion channels, cofferdams, sandbags, or sheet piling, as required.
2. Chip away the deteriorated concrete until sound concrete is reached. Clean away all loose concrete with air-blasting or other methods.
3. Install reinforcing steel, anchors, and rods, as needed.
4. Construct forms that adequately restore the footing dimensions of the original design size. Commonly, the footing is extended to cover a large area and the sides of the footing are extended downward if any undermining has occurred.
5. Apply any bonding compounds or a neat cement paste for bonding just before placing the new concrete into the forms.
6. Mix and place the new concrete, using a strong mix with a low slump. Vibrate the concrete thoroughly to ensure dense placement and a good bond to the existing concrete surface.
7. After the new concrete has cured for at least three days, remove any cofferdam and restore the stream channel to its proper course. Where shotcrete is used extensively on other parts of the structure, the repairs may be made using shotcrete.

< 5 > Substructure cracks

(1) A footing may crack transversely because of uneven settlement of the pier or abutment. This crack is often accompanied by a crack continuing up through the pier or abutment.

(2) It is advisable to seal the crack, preventing further intrusion of silt, debris, and water that will attack reinforcing steel. If the crack is moving, it should be filled with a flexible material; otherwise, it will open again. If the crack is not moving, it can be bonded back together.

(3) Cracks in substructures are generally vertical. Typically, the most effective method of repair is to inject epoxy into the cracks. To get maximum penetration of the epoxy filler, the first injection is made at the bottom of the crack.

(4) Starting at the bottom and working up in gradual increments toward the top increases the pressure needed to apply the epoxy and should result in greater crack filling penetration.

(5) Another repair method that prevents moisture from entering the crack is to chisel a V into the opening and fill it with grout.

1. Cut a V-shaped groove at the surface along the crack approximately 50 to 75 mm (2 to 3 in.) in width, using a small pneumatic chisel.
2. Thoroughly flush and blow out the crack, using water and high pressure air blasts.
3. Secure a retaining form on the face of the footing over the vertical portion of the crack.
4. Wet the surfaces of the crack thoroughly by pouring liberal quantities of water into it. Fill the crack with cement (or epoxy) and fine sand grout in a 1 to 2 mix that runs freely.
5. Clean out the V portion of the surface after the grout has partially set and apply bonding compound or a neat cement base to the surface of the V; then fill the V with a stiff grout mixture.

< 6 > Surface deterioration of abutments and piers

(1) To repair any deteriorated concrete, completely remove all unsound concrete. Clean, sound concrete must be exposed to bond with the new concrete.

(2) Air tools are typically the most efficient means of removing the deteriorated concrete. The edge of any area cut out should be undercut enough to allow for deep patches that aid retainment of the new material to the existing concrete.

(3) Effective bonding of the new concrete to the old concrete is usually accomplished with a bonding material and is particularly important when deep cracks need to be filled with a large volume of concrete.

(4) A grout of neat cement base can be used as an effective bonding agent. Grout can also be used when the form of the concrete is so inaccessible that an epoxy material cannot be effectively applied to the existing concrete surface.

(5) The exposed area can be sloshed liberally with grout just before placing the new concrete.

(6) Shotcrete may be used to fill the crack after it has been properly prepared. Shotcrete is a concrete mortar pneumatically projected at high velocity onto a surface area.

(7) Shotcrete repair is effective for the repair of bridge beams, caps, piers, abutments, wing walls, and decks.

(8) Since forms are not generally used for shotcrete, it is particularly effective for an overhead patch on the underside of a deck where a form cannot possibly be used.

(9) Shotcrete gives a superior surface bond, provides great strength because of its high density, exhibits low shrinkage, and does not require formwork; however, it requires lots of space to be applied, demands a high skill level of the application operators, leaves a shoddy

appearance, and is costly (especially in small quantities).

(10) When shotcrete is used, no bonding agent is necessary if the patch does not exceed a depth of 75 mm (3 in.) For deeper patches, hook anchors are installed in the existing concrete on 300-mm (12 in.) centers, and 50 mm x 50 mm (2 in. x 2 in.) wire mesh is hooked and wired to the anchors.

(11) This anchoring system may be repeated for every 75 mm (3 in.) of shotcrete depth applied. Whenever possible, use form and placing rather than shotcrete. Shotcrete tends to waste cement and requires a much higher worker skill level to obtain satisfactory results.

(12) Surface deterioration in reinforced concrete will frequently reach the first layer of reinforcing steel. When this has occurred, the concrete should be removed to a depth of 40 mm (1.5 in.) to 60 mm (2.5 in.) below this layer of reinforcing steel to provide an excellent anchor for the new concrete or shotcrete.

(13) If concrete removal is stopped at the surface of the reinforcing steel, a cleavage plane may develop at the interface of the new concrete and the old concrete, reducing the strength of the structure.

(14) All rust and other harmful materials should be removed from the exposed reinforcing steel. Where reinforcing steel is exposed, clean both the concrete and the steel by sandblasting the cracks for a good repair.

< 7 > Water line deterioration

(1) Deterioration at the water line is unique to abutments or piers in streams or marine environments. A depression or cavity forms in the concrete, extending some distance above and below the average water level.

(2) Deterioration at the water line usually occurs on the upstream face or along the sides of the pier. Repair is very similar to any surface deterioration repair, except that it is necessary to control the water flow so the work can be kept dry.

1. Dewater the abutment or pier.
2. Chip away all loose concrete in poor condition.
3. Clean the reinforcing steel of scale and loose rust.
4. Clean the surface in all areas where new concrete will be placed.
5. Chip or roughen the surface of the existing concrete, providing a better bond between the old and the new concrete.
6. Treat the entire area with epoxy or grout before placing the new concrete.
7. Construct a form of adequate strength and place concrete in the form.

(3) Since repair of deterioration at the water line can be time consuming and expensive, maintenance supervisors should have the damage situation evaluated by a professionally qualified structural engineer or materials engineer to determine if this work should be done by maintenance personnel or contracted to a firm with special skill and experience in such repairs.

AA012.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
AA012-1	Repair of substructure	Number

AA012.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA013 BRIDGE RUST REMOVAL AND REPAINTING

AA013.01 DESCRIPTION

- (1) This work is to;
- ✓ keep all steel elements of bridge structurally sound for reasons of traffic safety and
 - ✓ prolong the useful life of the bridge.
- (2) The activity involves the removal of rust from steelwork and repainting the components by applying labor based method.

AA013.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The material shall be in compliance with the requirements stipulated in the original design documents.
- (3) Other materials if necessary for work execution.

AA013.03 WORK PROCEDURES

- (1) Using wire brushes scrap off rust and loose paint from steel surfaces.
- (2) Apply a film of paint primer on exposed wire brushed steel surfaces.
- (3) Leave the surface to dry for a period recommended by paint manufacturers.
- (4) Apply at least two coats of paint on the steel surfaces. The second coat shall be applied after the first coat has dried as recommended by paint manufacturers.
- (5) Make the site clean and tidy.

AA013.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
AA013-1	Bridge rust removal and repainting	Metre Square

AA013.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE AA014 REPAIR OF BRIDGE HANDRAIL

AA014.01 DESCRIPTION

- (1) This work is to repair bridge handrail for traffic safety.
- (2) The work shall be carried out using labor based method.

AA014.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The material shall be in compliance with the requirements stipulated in the original design documents.
- (3) Other materials if necessary for work execution.

AA014.03 WORK PROCEDURES

- (1) Carefully remove damaged rails.
- (2) Repair the elements using approved methods to restore them to their original shape. If not repairable replace them with new similar elements.
- (3) Fix the repaired or new rails on the original position.
- (4) If it is steel, prime and paint repaired or replaced members to match color with existing members.
- (5) Make the site clean and tidy.

AA014.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
AA014-1	Repair of bridge handrail	Metre Liner

AA014.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

3. EMERGENCY MAINTENANCE

CODE 311 REMOVAL OF LANDSLIDES

311.01 DESCRIPTION

(1) This work is to remove unstable materials from slopes and of slip materials on the road to reduce danger to the road users and to allow for the free movement of traffic and the operation of the drainage system.

311.02 MATERIALS

(2) Nil.

311.03 WORK PROCEDURES

- (1) Do not work under an overhanging slope.
- (2) Excavate soil on top to reduce the angle of the slope.
- (3) Excavate all slipped soil from carriageway, shoulder and ditch by loader and or by hand.
- (4) Load into trucks, tractor and trailer or wheelbarrows and dispose to suitable dump sites.
- (5) Do not excavate too deep that may damage the existing road and shoulder surface.
- (6) Remove the last layer of slipped soil on the carriageway and shoulder by hand.
- (7) Clear the ditches and re-grade (slight) the area to restore the top surface if necessary.
- (8) Re-check the stability of the slope.
- (9) All debris and excess materials should be disposed into a safe place.
- (10) Make the site clean and tidy.

311.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
311-1	Removal of landslides	Metre Cube

311.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 312 EMERGENCY CULVERT REPAIR AND INSTALL/REPLACEMENT**312.01 DESCRIPTION**

- (1) This work is to repair and/or install/replace culvert damaged by unforeseen event (e.g. natural disaster and/or severe traffic accidents).
- (2) This work contains:
 1. Traffic Control, Safety Measure and Notification
 2. Construction and Removal of Diversions
 3. Excavation and Backfilling
 4. Repair Work
 5. Install/Replace with Precast Culvert

312.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Gravel materials, aggregates, sand, cement, water for concrete, formwork, chalk for marking, soilcrete, mesh reinforcement, road surfacing materials, precast concrete culvert, penetration grade bitumen or rubber bitumen, diesel fuel for cleaning tools.
- (3) Other materials if necessary for work execution.

312.03 WORK PROCEDURES**< 1 > Traffic Control, Safety Measure and Notification**

- (1) Place warning signs before commencing with any activity for the safety of workmen and for traffic control.
- (2) Inform the Employer, Engineer, Police, local authorities, relevant stakeholders and the public of the occurrence of an emergency.
- (3) Document the circumstances of the emergency and the damages caused by written notes, photographs and video recording.
- (4) Obtain from the Employer/Engineer instructions for construction of diversion and emergency works.

< 2 > Construction of Diversions

- (1) Construct and maintain the road or diversion open to traffic during emergency works.
- (2) Measure and record the traffic signs used, length and width of the diversion and volume of gravel used.

< 3 > Excavation

- (1) Set out the length and width limits of the culvert trench using 4 ranging rods.
- (2) Using the excavator shape the trench ensuring that the bottom is flat and evenly sloping at 1% - 2% towards the outlet end. Check the slope by a string line and a line level.
- (3) Extend trench excavation to the culvert inlet and outlet channels so that any flood water arriving before completion of work can be routed away from the worksite.
- (4) Where in-situ material at the bottom of the trench is poor, soft or wet, replace the top 300mm with a compacted layer of suitable gravel or sand to form bedding for the culvert.

< 4 > Repair Work

- (1) Work shall be done in compliance with code 134: Repair of Culverts.

< 5 > Install/Replace with Precast Culvert

- (1) Set out the length and width limits of the new culvert using 4 ranging rods and mason tools.
- (2) Using a levelling instrument, set out the culvert base slab ensuring sufficient gradient for flow of water through the culvert.
- (3) Where applicable, mix to specified proportions and cast concrete bedding on the bottom of the trench across its full width and length. Cure concrete for three days using sand and water.
- (4) After curing bedding concrete or immediately after laying bedding sand, gently lay in place the precast base slab. Alternatively fix formwork and cast base slab with specified concrete class and thickness. Cure the cast in situ base slab for three days using water and sand.
- (5) After curing base slab or immediately after laying precast base slab, carefully assemble in place culvert elements. Fill joints with cement: sand mortar of specified proportion.
- (6) Set out the aprons and toes and cast using concrete of specified class and cure for at least three days using continuously wetted gunny bags.
- (7) After curing, set out the formwork for the wing walls and head walls followed by casting of the walls using a specified concrete mix. Cure the concrete for at least seven days using continuously wetted gunny bags. Strip the wing wall and headwall formwork after two days.

< 6 > Backfilling

- (1) Backfill the excavations with suitable fill material and compact in 150mm layers using pedestrian rollers until camber level is achieved.
- (2) Measure and record the volume of excavation and fill material used.

< 7 > Removal of Diversions

- (1) Remove diversions till reinstating of original ground condition.

< 8 > Removal of Temporary Safety Signs

- (1) Remove all temporary signs and safety devices.
- (2) Make the site clean and tidy.

312.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
312-1	Emergency Culvert Repair and Install/Replacement	Number

312.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 313 EMERGENCY BRIDGE REPAIR**313.01 DESCRIPTION**

- (1) This work is to repair bridge damaged by unforeseen event (e.g. natural disaster and/or severe traffic accidents).
- (2) This work contains:
 1. Traffic Control, Safety Measure and Notification
 2. Construction and Removal of Diversions
 3. Repair Work

313.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Replacement parts for steel components, welding rods, bolts and nuts, primer and paint.
- (3) Well seasoned and treated plunk.
- (4) Stone, cement, sand, water, mesh reinforcement, formwork material.
- (5) Other materials if necessary for work execution.

313.03 WORK PROCEDURES

< 1 > Traffic Control, Safety Measure and Notification

- (1) Place warning signs before commencing with any activity for the safety of workmen and for traffic control.
- (2) Inform the Employer, Engineer, Police, local authorities, relevant stakeholders and the public of the occurrence of an emergency.
- (3) Document the circumstances of the emergency and the damages caused by written notes, photographs and video recording.
- (4) Obtain from the Employer/Engineer instructions for construction of diversion and emergency works.

< 2 > Construction of Diversions

- (1) Construct and maintain the road or diversion open to traffic during emergency works.
- (2) Measure and record the traffic signs used, length and width of the diversion and volume of gravel used.

< 3> Repair Work

(1) Work shall be done in compliance with codes 141: Replacement of Minor Bailey Bridge Parts, 145: Repair of Steel Decking, 146: Repair of Timber Deck and Running Strips, 231: Replacement of Timber Decks, 232: Replacement of Running Strips, 233: Repair of Concrete and 234: Repair of Wooden Bridge.

< 4 > Removal of Diversions

(1) Remove diversions till reinstating of original ground condition.

< 5 > Removal of Temporary Safety Signs

(1) Remove all temporary signs and safety devices.

(2) Make the site clean and tidy.

313.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
313-1	Emergency Bridge Repair	Number

313.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 314 EROSION DAMAGE REPAIR**314.01 DESCRIPTION**

(1) This work is to:

- ✓ prepare the washed out area for reinstatement,
- ✓ reopen the road to traffic in the shortest possible time after the occurrence of emergency,
- ✓ restore attractive appearance of the roadway,
- ✓ restore the road pavement structure and surfacing to original condition,
- ✓ minimize future damage to the road and structure and
- ✓ restore safe passage of traffic and drainage system in a safe and orderly manner.

(2) The work involves building up the road pavement in layers to its original condition and cross-section; constructing erosion protection works as required in order to prevent future damage to the road and structure, reinstate passage of traffic, and safeguard the road users in a safe and orderly manner. The work can be carried out using labor based or equipment based methods.

314.02 MATERIALS

(1) All materials shall be subject to approval of the Engineer prior to work execution.

(2) Gravel materials, materials for concrete or stones for stone pitching, materials for surfacing.

(3) Other materials if necessary for work execution.

314.03 WORK PROCEDURES**< 1 > Construction of Diversions**

(1) Construct and maintain the road or diversion open to traffic during emergency works.

(2) Measure and record the traffic signs used, length and width of the diversion and volume of gravel used.

(3) Ensure diversions are removed and ground reinstated to original condition.

(4) Tidy up the site and remove all temporary signs and safety devices after the road damaged due to washout is repaired and the road opened to traffic.

< 2 > Excavation and Removal of Unsuitable Material (Labor Based Method)

(1) Using picks and shovels remove all debris, trees and loose material in the washed out area and in the roadway and dispose off soil using wheelbarrows at least 20m downstream of the area or load trees and debris onto the tractor trailer for disposal at designated spoil areas.

(2) Measure and record the volume of unsuitable material removed.

< 3 > Excavation and Removal of Unsuitable Material (Equipment Based Method)

(1) Using the bulldozer remove all debris, trees and loose material from the washout area and in the roadway and dispose off soil downstream of the area at least 20 m away or load trees and debris onto tipper trucks for disposal at designated spoil areas.

(2) Measure and record the volume of unsuitable material removed.

< 4 > Reinstatement of Roadway Structure (Labor Based Method)

(1) Load gravel on tractor trailer and transport to the worksite. Unload material close to the site and backfill washed out area compacted in 200mm layers using an appropriate pedestrian compactor.

(2) The finished surface should be provided with a camber similar to the adjacent road to ensure good drainage of the surface.

(3) Surface the road with material equivalent to existing using the relevant methodology described under Code 211: Resealing.

(4) Protect the slopes with concrete lining or stone pitching.

(5) Measure and record the volume of gravel, surfacing materials and slope protection materials used to repair the washed out area.

(6) Tidy up the site.

< 5 > Reinstatement of Roadway Structure (Equipment Based Method)

(1) Load gravel material into tipper trucks and transport to work area. Dump material onto or close to prepared site.

(2) Using a bulldozer (for deep washouts) or a motor grader for shallow washouts spread material onto washout and compact with a vibrating roller in 200mm layers.

(3) The finished surface should be provided with a camber similar to the adjacent road to ensure good drainage of the surface.

(4) Surface the road with material equivalent to existing using the relevant methodology described under Code 211: Resealing.

(5) Protect the slopes with concrete lining or stone pitching.

(6) Measure and record the volume of gravel, surfacing materials and slope protection materials used to repair the washed out area.

(7) Tidy up the site.

314.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
314-1	Erosion damage repair	Metre Cube

314.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 315 REPAIR OF COLLAPSED ROAD EMBANKMENT

315.01 DESCRIPTION

- (1) This work is to repair road embankment collapsed by unforeseen natural disaster.
- (2) This work contains:
 1. Traffic Control, Safety Measure and Notification
 2. Construction and Removal of Diversions
 3. Repair Work

315.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Logs, trees, stumps, weeds, grass or other organic or undesirable material shall not be placed in embankments.
- (3) Materials placed in the top 300 mm of embankments shall comply with the following requirements:

Liquid limit	AASHTO T 89	maximum 40%
Plasticity index	AASHTO T 90	maximum 14%
CBR (4 days soaked)	AASHTO T 193	minimum 8%
Maximum particle size		100 mm

- (4) Materials placed more than 300 mm below sub-grade elevation shall comply with the following requirements:

Liquid limit	AASHTO T 89	maximum 45%
Plasticity index	AASHTO T 90	maximum 18%
CBR (4 days soaked)	AASHTO T 193	minimum 4%
Maximum particle size		150 mm

- (5) Subject to approval by the Engineer rock pieces may be used in embankment formation up to a level not more than 1200 mm below formation (i.e. finished embankment level).
- (6) Suitable material (except rock) arising from excavations which has a CBR value of 8% or more and/or borrow pit materials which have CBR values of 8% or more shall, unless otherwise approved by the Engineer, be reserved for the top 300 mm of embankments so that a stronger sub-grade can be assured.
- (7) Other materials if necessary for work execution.

315.03 WORK PROCEDURES

< 1 > Traffic Control, Safety Measure and Notification

- (1) Place warning signs before commencing with any activity for the safety of workmen and for traffic control.
- (2) Inform the Employer, Engineer, Police, local authorities, relevant stakeholders and

the public of the occurrence of an emergency.

(3) Document the circumstances of the emergency and the damages caused by written notes, photographs and video recording.

(4) Obtain from the Employer/Engineer instructions for construction of diversion and emergency works.

< 2 > Construction of Diversions

(1) Construct and maintain the road or diversion open to traffic during emergency works.

(2) Measure and record the traffic signs used, length and width of the diversion and volume of gravel used.

< 3 > Repair Work

(1) The Contractor shall have in operation a sufficient number of motor graders to properly spread and maintain the surface of each layer of freshly placed embankment prior to and during rolling and compaction operations.

(2) When it is feasible, trucks, tractors or other heavy hauling equipment shall be routed over the fill in such a manner as to take advantage of the compaction thereby afforded.

(3) The Engineer shall have full authority at any time to require the suspension of the delivery of material to the embankment until previously delivered materials are properly placed and preceding layers are satisfactorily compacted, finished and tested.

(4) The Contractor shall be responsible for the stability of all embankments and shall replace all parts which, in the opinion of the Engineer, have been damaged or displaced due to carelessness or neglect on the part of the Contractor, or due to natural causes such as storms, and are not due to the unavoidable movement of the natural ground under the embankment.

(5) During construction, the roadway shall be kept shaped and drained at all times. When unsuitable material has been placed in the embankment, its removal shall be at the cost of the Contractor.

(6) Embankments shall be constructed of material spread in successive layers for compaction, each layer extending over the full width of the embankment at the height of the layer. The Contractor shall ensure that the required compaction is obtained throughout each layer, including the material which after trimming will form the side slopes.

(7) Embankment shall be placed in horizontal layers not exceeding 200 mm (loose measurement) and compacted to the specified density before the next layer is placed. Compaction up to 250 mm (loose measurement) layers can be done, if the Contractor in the opinion of the Engineer has satisfactorily proved that his equipment is capable compacting up to 250 mm (loose measurement).

(8) Any hard material that is not broken down by the passage of the compacting equipment shall either be removed or be broken down by harrowing or other means into

individual pieces not exceeding in any dimensions the size specified in (1) and (2) in sub-clause 315.02.

(9) When the excavated material consists predominantly of rock, too large to be placed in 250 mm layers in the lower portions of embankments, the material may be placed in thickness up to the average rock dimension but not to exceed 450 mm. Rock shall not be end dumped directly on the previously completed layer of embankment. Rock shall be dumped on the layer being constructed, pushed into place, and such finer material added so as to produce a dense material which can be compacted.

(10) Rock, broken concrete, or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.

(11) The Contractor shall, at points to be determined by the Engineer, suspend work on embankments forming the approaches to structures until such time as the construction of the latter is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the structural work.

(12) In the event of any slip, slide or subsidence in the earthworks extending beyond the required profile of embankment, the Contractor shall dispose of the material in the slip, and make good as required by the Engineer. The classification of material from slips or slides will be in accordance with its condition at the time of removal, irrespective of its previous condition.

(13) Side slopes shall be neatly trimmed to the lines and slopes shown on the Drawings or as directed by the Engineer, and the finished work shall be left in a neat and acceptable condition.

(14) The Contractor shall protect the sub-grade from damage by exercising such precautions as the Engineer may deem necessary including overfilling and re-trimming to grade immediately prior to installation of the sub-base. At all times the sub-grade surface shall be kept in such condition that it will drain readily and correctly. The sub-grade shall be checked and approved before any sub-base material is placed thereon.

< 4 > Removal of Diversions

(1) Remove diversions till reinstating of original ground condition.

< 5 > Removal of Temporary Safety Signs

(1) Remove all temporary signs and safety devices.

(2) Make the site clean and tidy.

315.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
315-1	Repair of Collapsed Road Embankment	Metre Cube

315.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 316 BLASTING

This work requires certain time for precise preparation by site condition because of its risk. Therefore, this code should **NOT** be applied in “Emergency Work”. The code is suggested to move to the Standard Technical Specification.

316.01 DESCRIPTION

(1) This work is to remove rocky obstacle which hindering traffic by applying explosive in case that is not able to be removed in ease and safe unless crushing that into small pieces.

(2) The Contractor shall be responsible for blasting in a safe manner. The Contractor shall perform blasting where needed, in accordance with the requirements of this specification section and procedures, regulations and requirements of responsible authorities. In case of any inconsistency between the relevant requirements outlined in this specification and the authorities, the regulations and requirements the authorities shall prevail.

316.02 MATERIALS AND EQUIPMENT

(1) The Contractor may propose materials or equipment to those to be approved by the Engineer prior to the work execution.

(2) If alternative materials or equipment are proposed, the Contractor shall submit comprehensive details including technical descriptions, drawings and specifications to demonstrate that the alternative complies with either requirements of this clause. The adoption of alternative materials or equipment shall be subject to the agreement of the Engineer.

316.03 WORK PROCEDURES**< 1 > Control and Use of Explosives**

(1) All explosives for the Works shall be provided by, controlled and managed by the Contractor. The Contractor shall adhere to all local and governmental laws, regulations and requirements for the storage, transportation, use and possession of explosives and associate items and materials.

(2) The Contractor shall be fully responsible for any unlawful use of explosive and compensation for any damage or accidents that may occur from the said use, transportation or storage.

< 2 > Submittals

(1) The Contractor shall submit a two-part conception-blasting plan and individual shot plans in accordance with the specification requirements, as described herein.

(2) Prior to bringing any explosives or blasting agents on the job site and to starting any blasting, the Contractor shall submit, for approval, a two-part conceptual blasting plan as follows:

1. Part 1

Part 1 of the conceptual plan shall include a complete summary of proposed transportation, handling, storage, and use of explosives, and shall include the names of personnel who will supervise blasting operations, written evidence of past experience and competency, and a minimum of three references for each such person.

2. Part 2

Part 2 of the conceptual plan shall include:

- (a) The proposed general concept for the blasting, including individual blast-holes and delay patterns and loading diagrams to cover each type of shot anticipated, controlled blasting techniques, and controls of noise, dust, fly rock, air blast and vibrations.
- (b) Data necessary to support the adequacy of the Contractor's proposed efforts regarding the safety of structures and slopes and to assure that an adequate foundation is obtained.
- (c) Full details noting all safety precautions for the storage, transportation and use of explosives, including the control of and access to explosives, precautions during the use of explosives, warning devices and procedures and personnel(s) responsible for assuring adherence to safety and control and procedures.
- (d) Test blasts. - Information on test blasts planned by the Contractor.

< 3 > Individual Shot Plans

(1) Individual shot plans shall be submitted on a day-to-day basis for approval. Individual shot plans shall include drilling patterns; number, spacing, location, inclination, diameter, and depth of drilled holes; amount, type, diameter, and distribution of explosive per hole; weight of explosives per lineal meter for controlled perimeter holes; powder factor; delay patterns, type of initiators, time of each delay, and weight of explosive for each delay; time of blast; and total weight of explosives in place at any one time within the area to be excavated under this contract.

(2) The Contractor shall also submit any other data that the Engineer may deem pertinent to the Engineer's determination of the Contractor's intent and purpose to produce smooth and sound rock surfaces at the lines of excavation, and to protect adjacent structures.

< 4 > Table of Blasting Submittals

TABLE OF BLASTING SUBMITTALS		
Submittal	Description	Due date or delivery time
Blasting plan	Two part conception blasting plan in accordance with this sub-section.	Not later than 40 days after Notice to Proceed and at least 30 working days prior to initiating any blasting.
Shot Plans	Individual shot plans in accordance	On a day-to day bases so that plans

TABLE OF BLASTING SUBMITTALS		
Submittal	Description	Due date or delivery time
	with this sub-section.	are received by the Engineer not less than 24 hours before scheduled time for drilling provided for in the plan.

< 5 > Contractor's Responsibility for Blasting Operations

- (1) Approval of the blasting plans, of all blasting operations, and of blasting products by the Engineer, and compliance by the Contractor with provisions for protection of life and property shall not relieve the Contractor of the Contractor's responsibility or liability for the safety of persons and property.
- (2) The Contractor shall be responsible for blasting in a safe manner, for producing smooth and sound rock surfaces at the lines of excavation; and for controlling damage and vibration. Approval of the Contractor's submittals by the Engineer does not constitute nor shall it be construed to be a guarantee by the Engineer that the desired results will be achieved.
- (3) Approval by the Engineer shall not relieve the Contractor from the responsibility of complying with the requirements of these specifications and regulations and requirements of the authorities.

< 6 > Blasting Procedures

- (1) Drilling for individual blasts shall not be performed until the Engineer has approved the Contractor's blasting plan.
- (2) The Engineer will require test blasts in areas where rock is to be excavated. The test blasts shall contain not less than 50 cubic meters of rock and be located in areas selected by the Engineer.
- (3) The Contractor shall not use blast hole diameters larger than 70mm.
- (4) Each row of blast holes shall be on a later delay than the row immediately in front of it. The row of holes immediately in front of the perimeter holes shall be delayed by two delay intervals from the proceeding row. To protect rock slopes, the holes at the ends of each row shall be fired on a higher delay than the adjacent holes in that row.
- (5) Cap and fuse initiation will not be allowed.
- (6) Electric detonators, delays, and caps will not be allowed if stray electric current exists near the blast area, as determined the Engineer, and/or the Contractor's safety personnel.
- (7) A representative of the Engineer will observe the drilling and loading of shot holes for test blasting and any excavation blasting to ensure that they are in accordance with approved plans.

< 7 > Controlled Blasting Techniques

(1) Controlled blasting techniques shall be used for all perimeter surfaces when blasting to final grades or lines. Either "line drilling," "presplitting," "smooth blasting," or other controlled blasting techniques as approved by the Engineer shall be employed.

1. Line Drilling

- (a) The "line drilling" technique involves the use of a single row of unloaded, small-diameter holes usually spaced from two to four times the hole diameter along the final excavation line to provide a plane of weakness to which the primary blast can break.
- (b) The spacing and loading of the blast holes adjacent to the line holes shall be reduced from the spacing and loading of the main blast holes so as to break the rock between the line holes and produce smooth rock surfaces with a minimum amount of over-break or tights.

2. Presplitting

- (a) The "presplitting" technique involves the use of a single row of lightly loaded perimeter holes spaced along the final excavation lines that are fired before any adjoining main excavation area is blasted.
- (b) The presplitting may be accomplished during the primary blast by delaying the primary holes so that the perimeter holes will fire ahead of them. These perimeter holes shall be spaced, loaded, and fired so as to produce a tensional split or crack between the holes to which subsequent blasts can break, thus resulting in smooth rock surfaces with a minimum amount of overbreak or tights.
- (c) The perimeter holes shall be loaded with well-distributed charges, 2.5-cm diameter or smaller. Except for closer spaced guide holes, which may be required in delicate situations, every perimeter hole shall be loaded.

3. Smooth Blasting

- (a) The "smooth blasting" technique is a method of controlled blasting in which the perimeter holes along the final excavation lines are generally spaced about 1.5 meters apart. The burden distance for the perimeter holes is generally not less than 1.5 times the spacing.
- (b) The explosives in these holes are detonated after the primary blast. The perimeter holes shall be loaded with well-distributed, slender charges of relatively low density and velocity explosive.
- (c) Except for closer spaced guide holes, which may be required in delicate situations, all perimeter holes shall be loaded. "Cushion blasting" is the same as "smooth blasting" except in cushion blasting the space between the bore hole and explosive charge is filled with crushed stone or other stemming material.

4. General Requirements

- (a) For all controlled blasts, the technique, perimeter hole spacing, and loading density may vary depending on formation competency. Actual techniques, loading densities, and spacing are subject to the approval of Engineer.
- (b) The Engineer may require a change in the controlled blasting technique, perimeter hole spacing, and/or loading density if unsatisfactory results are obtained.
- (c) Perimeter blast holes shall follow the lines of the final excavation and shall not deviate more than 15 cm from their designed location in any direction along the length of the hole. Depths of blast holes shall be reduced if necessary to conform to this requirement.

< 8 > Damage and Vibration Control

(1) All blasting shall be carefully performed, and any damage to the work, environment, and adjacent property shall be repaired by and at the expense of the Contractor. The Contractor shall be responsible for performing a preblast survey to determine and document the condition of adjacent structures, utilities, wells, buried cables, and other features within 500 meter of the blast area prior to blasting.

(2) All necessary precautions shall be taken to preserve the material below and beyond the established lines of all excavation in the soundest possible condition. The Contractor is responsible for taking proper account of the geology to prevent damage to foundation or perimeter rock, concrete, grout holes, or structures resulting from permanent blast-induced rock movements or blast-induced gas pressures.

(3) The Engineer will inspect an excavation following the blast and cleanup to determine acceptability. Material beyond the required lines which is shattered or loosened by the Contractor's operations shall be removed by and at the expense of the Contractor. The Contractor shall also immediately adjust its procedures to prevent any further overbreak.

(4) The Contractor shall make every effort to prevent flyrock damage to structures and individuals and shall be responsible for ensuring that flyrock is not a problem as well as for any damage resulting from flyrock. Where necessary, as determined by the Engineer, blasting mats shall be used to protect adjacent property and installations.

316.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
316-1	Blasting	Metre Cube

316.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

4. REHABILITATION AND IMPROVEMENT

4.1 REHABILITATION OF PAVED ROAD

CODE 411 SCARIFYING OF OLD ROAD SURFACE

411.01 DESCRIPTION

- (1) Work shall be done in compliance with Code 221.

411.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
411-1	Scarifying of old road surface	Metre Cube

411.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 412 EXCAVATING UNSUITABLE MATERIAL

412.01 DESCRIPTION

(1) This work is to remove soil which is unsuitable to use for any construction works excluding to use for temporary works permitted by the Engineer.

412.02 MATERIALS

Nil.

412.03 WORK PROCEDURES

(1) Unsuitable material encountered in excavations outside the limit of cuttings as shown on the Drawings shall be removed when so instructed by the Engineer to the depths and extents directed by the Engineer and shall be backfilled and compacted with approved material as specified.

(2) When the Contractor is required to excavate unsuitable material below the existing ground surface in fill areas, the depth to which these unsuitable materials are to be removed will be determined by the Engineer. The Contractor shall schedule the work so that the authorised cross section can be taken before and after the material has been removed.

(3) Muck excavation shall be accomplished without entrapping muck within the back fill. The backfilling of the excavated area shall follow immediately behind the muck excavation so the material displaced by the backfill can be removed. The excavation shall be backfilled to the ground line or water level, whichever is higher, with rock or suitable granular material. Backfilling with rock shall consist of crushed or un-crushed rock as decided by the Engineer.

(4) Material used for temporary access or diversion roads shall not be re-used in embankment or elsewhere without the permission of the Engineer.

412.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
412-1	Excavating unsuitable material	Metre Cube

412.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 413 REPAIR OF SUB BASE INCLUDING NEW MATERIAL

413.01 DESCRIPTION

(1) This work is to repair sub base course by utilizing newly procured aggregate materials.

413.02 MATERIALS (Corresponding to SECTION 301 of the STS.)

< 1 > General

(1) All material shall be free from dirt, organic matter, shale or other deleterious matter and shall be of such quality that it will bind readily to form a firm, stable course.

< 2 > Grading Requirements

(1) The material shall be tested according to AASHTO T 27, and shall consist of uniform mixtures of naturally occurring or processed materials comprising gravel and/or crushed rock fragments with sand, silt and clay conforming to the following grading requirements:

Grading Requirements of Aggregate Subbase

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Sub-base Type A	Sub-base Type B	Sub-base Type C
100			
75			
50.0		100	100
37.5	100	85 – 95	80-100
25.0	75 - 90		
19.0	60 - 82	60 – 80	60-100
9.5	45 - 66		
4.75	34 – 55	25 – 55	30-100
2.0	25 – 43	15 – 35	17-75
0.425	12 – 25	7 – 20	9-50
0.075	6 – 15	2 – 10	5-25

(2) Depending on the availability of material at the Works site or in reasonable proximity the Contractor shall select material Type A, Type B or Type C for the Aggregate Sub-base, as approved by the Engineer.

(3) Each location where Aggregate Sub-base is applied shall receive only one type of material (Type A, Type B or Type C). However, it is permissible to use different type of Sub-base materials on different sections of the road. If Sub-base material of one type is scarce, different types of Sub-base materials can be used in the same location of the road. In this case Type B and Type-C shall be used for the Lower Sub-base and the better quality material, grading Type A, shall be used for the Upper Sub-base. In all cases the selection and application of Sub-base material type shall be done in close coordination with the Engineer and is always subject to his final approval.

< 3 > Other Requirements

- (1) Coarse aggregate shall comprise material retained on a 4.75 mm (AASHTO No. 4) sieve and shall consist of hard, durable particles or fragments of stone or gravel. Materials that break when wetted and dried shall not be used.
- (2) The coarse aggregate for sub-base shall be crushed rock (with a minimum of 50% of particles having at least two crushed faces), that for lower sub-base may comprise natural gravel materials.
- (3) Fine aggregate (material passing the 4.75 mm sieve) shall consist of natural or crushed sand.
- (4) The various fractions shall have properties according to the following table:

Properties of Coarse and Fine Aggregates	
Property/Test	Sub-base
Fraction passing 19 mm sieve	
CBR (4 days soaked), @ 95% of MDD	min 30%
AASHTO T 193	
Coarse aggregate, material retained on a 4.75 mm sieve	
Wet/Dry Strength Variation	max 45%
Los Angeles Abrasion, AASHTO T 96	max 45%
Fraction passing 0.425 mm sieve	
Liquid Limit, AASHTO T 89	max 25%
Plasticity Index, AASHTO T 90	max 12%, min 4%
Plasticity Modulus	max 175
Linear Shrinkage, AASHTO T 92	max 5%

- (5) When the material is sourced from a borrow pit, the Contractor shall demonstrate to the satisfaction of the Engineer, that the material can be excavated without being contaminated by unacceptable material. The Contractor at his own cost shall take such actions the Engineer considers necessary to ensure that the material being excavated is not being contaminated. Where in the opinion of the Engineer, the Contractor cannot extract the material from the borrow without contamination, then the Contractor shall obtain material from another source at his own cost.

< 4 > Acceptance of Production Materials

- (1) When the stationary blend method is used, the aggregate will be accepted immediately following mixing, based on periodic random samples taken from the pugmill output.
- (2) When the aggregate is a single source aggregate, it may be accepted at the borrow pit or crusher. Acceptance of the materials by the Engineer does not constitute acceptance of the sub-base, only that the materials are approved for use as sub-base.

< 5 > Capping Layer

- (1) This material shall be used to provide sufficient cover on weak subgrades and shall be used in the lower part of the sub-base as a substitute for a thick sub-base to reduce costs.

The requirements are less strict than for an ordinary sub-base.

- (2) The 4 days soaked CBR shall be at least 15% (AASHTO T 193) compacted in the laboratory at the minimum of 95% of the maximum dry density (AASHTO T 180).
- (3) The fraction of material passing the 0.425 mm sieve shall have a Liquid Limit (LL) not greater than 35% and a Plasticity Index (PI) between 4% and 12%.
- (4) The quantity of the fraction passing the 0.075 mm sieve shall be not greater than two-thirds of the quantity of the fraction passing the 0.425 mm sieve.

413.03 WORK PROCEDURES

< 1 > Spreading

- (1) Sub-base material shall be spread only when the underlying surface has been approved by the Engineer. Any material which has been placed on a surface not approved by the Engineer, shall be removed at the Contractor's expense.
- (2) The sub-base shall be constructed in compacted layers no thinner than 75 mm or 2.5 times the nominal size of the material (whichever is the greater) and no thicker than 150 mm.
- (3) The materials shall be handled so as to avoid segregation and to place the material in uniform depth. Segregated materials shall be re-mixed until uniform. Suitable measures shall be taken to prevent rutting of the sub-grade during the spreading of the sub-base material. No hauling or placement of material will be permitted when, in the opinion of the Engineer, the weather or road conditions are such that the hauling operations will cause cutting or rutting of the sub-grade or cause contamination of the sub-base material.

< 2 > Mixing

- (1) When the stationary blend method is used, the aggregate shall be mixed in a pugmill capable of incorporating water to provide the optimum moisture content for compaction and homogenous blending. Immediately after mixing, the material shall be transported and placed on the roadbed by a mechanical spreader unless otherwise approved by the Engineer.
- (2) When the road mix method is used, after placement on the roadway, the aggregate shall be uniformly mixed by motor graders or other approved equipment adding water during the mixing operation to provide optimum moisture content for compaction.

< 3 > Compaction

- (1) The moisture content of the material shall be adjusted prior to compaction, by watering with approved sprinkler trucks or by drying out, to that appropriate to obtain the specified density for sub-base with the Contractor's equipment. Sub-base shall be compacted to 95% of maximum dry density as determined by AASHTO T 180 Method D, except where the layer forms the pavement running surface when compaction shall be to 98% of the maximum dry density. During compaction the moisture content shall be so controlled that moisture content uniformly throughout the finished layer shall be within the

limits of + 2% of the optimum moisture content as determined in AASHTO test T180, or such other moisture content as shall be agreed with the Engineer as a result of compaction trials. Density determinations shall be carried out for each layer of subbase constructed, in accordance with the requirements of AASHTO test T191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and the fifth shall be not less than the required relative density minus 3 percent. The use of AASHTO T 224 to correct for oversize particles may be required.

(2) The material shall be compacted by means of approved compaction equipment progressing gradually from the outside towards the centre with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density. Rolling shall be accompanied by sufficient blading, in a manner approved by the Engineer, to ensure a smooth surface free from ruts or ridges and having the proper section and crown. The Contractor shall ensure that the required compaction is obtained throughout each layer and for the full finished width of the material. Filling outside the finished width will be necessary in order to achieve the required compaction for the full finished width of the course.

(3) Any areas inaccessible to normal compaction equipment shall be compacted by means of mechanical tampers until satisfactory compaction is obtained.

(4) Each layer of material shall be completely compacted and approved by the Engineer prior to the delivery of materials for a succeeding layer.

(5) Samples shall be taken from the compacted layers for testing to ensure that the compacted material complies with the requirements of Clause 301.02 of the Specifications.

< 4 > Compaction Trials

(1) Prior to the commencement of his sub-base operations, the Contractor shall construct trial lengths as directed by the Engineer. The materials used in the trials shall be those approved for use in the Works and the equipment used shall be that which the Contractor intends to use for the work proper.

(2) The objective of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the nominal number of compaction passes and the resulting density of the material.

(3) The Contractor shall not proceed with sub-base work until the methods and procedures established in the compaction trials have been approved by the Engineer.

(4) Each trial length shall be 100 metres long, and trials shall be repeated as necessary until compaction procedures acceptable to the Engineer are achieved. The trial lengths will be incorporated in the Works provided the requirements of this Section are met.

(5) Further trials shall be conducted if the materials comprising the sub-base are significantly amended, or if the Engineer considers that the approved methodology is not achieving satisfactory and/or consistent and acceptable results. Contractor shall perform all such compaction trials at his own expense.

< 5 > Finishing

(1) The Contractor shall programme his operations to avoid the drying out or damage by traffic of the sub-base. If any layer of sub-base material, or part thereof, is permitted to dry out after compaction, or does not conform to the required density or finish, the Contractor shall, at his own expense, re work, water or re-compact the material, as directed by the Engineer, to the density/finish specified, before the next layer is placed.

(2) The Contractor shall ensure that proper drainage of the pavement and shoulder area is maintained at all times.

(3) Immediately prior to the placing of the first layer of base on the sub-base the final layer of sub-base shall be at the specified density and to the required grade and section. In order to maintain these requirements while placing the base, the Contractor shall, if necessary, water, reshape and re-compact the surface of the sub-base at his own cost.

413.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
413-1	Repair sub base including new material	Metre Cube

413.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 414 REPAIR OF BASE COURSE INCLUDING NEW MATERIAL

414.01 DESCRIPTION

- (1) This work is to repair base course by utilizing newly procured aggregate materials.

414.02 MATERIALS (Corresponding to SECTION 302 of the STS.)

< 1 > General

- (1) The coarse and fine aggregates for base shall consist of crushed rock, clean, tough, durable, sharp-angled fragments free of any excess of thin or elongated pieces, and reasonably free of soft, disintegrated or decomposed stone, dirt or other deleterious matter.

- (2) The aggregate shall be obtained by crushing material, which if so directed by the Engineer, has first been screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least two mechanically fractured faces.

< 2 > Grading Requirements

- (1) Material for base course shall be crushed rock and the combined aggregate shall have the following grading. Testing of grading is to be done according to AASHTO T 27:

Grading Requirements of Crushed Aggregate Base Course

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Type A	Type B	Type C
50.0	100	–	-
37.5	90 – 100	100	-
25.0	75 – 95	85 – 100	100
19.0	60 – 90	70 – 90	70 – 100
9.5	40 – 75	50 – 85	50 – 85
2.36	20 – 45	25 – 45	20 – 50
0.425	10 – 26	10 – 25	15 – 30
0.075	4 – 12	5 – 15	5 – 15

< 3 > Other Requirements

- (1) The combined material passing the 19 mm sieve shall have a 4 days soaked CBR not less than 80% (AASHTO T 193) at 95% of Maximum Dry Density (AASHTO T 180).

- (2) Aggregate retained on the 2.36 mm sieve shall have a percentage of wear, by Los Angeles Abrasion test AASHTO T 96, of not more than 40%.

- (3) Coarse aggregate flakiness and elongation indices, determined by BS EN 933-3 (Flakiness index) and BS 812-105.2 (Elongation Index), shall not be greater than 35%. Soundness loss shall not be greater than 12% as determined by AASHTO T 104.

- (4) The fraction passing the 0.425 mm sieve shall have a liquid limit (AASHTO T 89) not greater than 20 and plasticity index (AASHTO T 90) not greater than 6 nor less than 2 and the Plasticity Product (PI x percentage passing the 0.425 mm sieve) shall not exceed 90.

(5) The aggregate shall have a 10% Fines Value (wet) [AASHTO T 176] of not less than 130 kN and the Wet Dry Variation of the 10% Fines Value shall not exceed 40%.

< 4 > Acceptance of Production Materials

(1) The aggregate will be accepted immediately following mixing, based on periodic random samples taken from the mixing plant output. Acceptance of the material by the Engineer does not constitute acceptance of the base, only that the material is approved for use in the base.

414.03 WORK PROCEDURES

< 1 > Placing

(1) When the thickness of base exceeds 150mm, the base shall be compacted in two equal layers. The compacted thickness of any layer shall not be less than 75mm, nor exceed 150mm.

< 2 > Combining Aggregates and Water

(1) Aggregates for base shall be combined into a uniform mixture and water added in a central mixing plant in a manner approved by the Engineer.

(2) Mixing for smaller roads, -below road class 4 as defined in Road Design Manual-, can be done by a Loader/ Excavator, if approved by the Engineer.

(3) When binder is to be added, it shall be combined in the central mixing plant.

(4) The amount of water added to the aggregate shall be that required to obtain the specified density, giving a mixture which is completely ready for compaction after spreading. In no case will the wetting of aggregates in stockpiles or trucks be permitted.

< 3 > Spreading

(1) Immediately after mixing, the base mix material shall be delivered to the roadbed as a uniform mixture and shall be placed on the prepared sub-base or sub-grade in a uniform layer or layers. On roads below road class 4 as defined in Road Design Manual, the mixture can be spread with a grader, if approved by the Engineer.

(2) The material shall be so handled as to avoid segregation. All segregated material shall be removed and replaced with well graded material. No “skin patching” shall be permitted.

(3) Unless otherwise approved by the Engineer spreading shall be done by an approved self propelled paving machine or spreader box which distributes the material to the required width and uniform depth without delay. If the paving machine or spreader causes segregation or leaves ridges or other objectionable marks on the surface which cannot be eliminated easily or prevented by adjustment of the paving machine or spreader operation, the use of such a paving machine or spreader shall be discontinued and replacement equipment provided.

(4) If works are to be carried out on mountainous and/or narrow roads, grader could be used for spreading the material, provided Engineer's approval. If the base course is covered by an AC pavement (which takes most of the traffic load) grader could be used for the spreading, as decided by the Engineer.

(5) No hauling or placing of material will be permitted when, in the opinion of the Engineer, the weather or road conditions are such that hauling operations will cause cutting or rutting of the surface or contamination of the base material.

< 4 > Compaction

(1) Immediately after placing, the base material shall be compacted to not less than 98% of maximum dry density as determined by AASHTO T 180 Method D.

(2) During compaction the moisture content shall be so controlled that moisture content uniformly throughout the finished layer shall be within the limits of $\pm 2\%$ of the optimum moisture content as determined in AASHTO T 180, or such other moisture content as shall be agreed with the Engineer as a result of compaction trials. Density determinations shall be carried out for each layer of base constructed, in accordance with the requirements of AASHTO T 191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and the fifth shall be not less than the required relative density minus 3 percent.

(3) The use of AASHTO T 224 to correct for oversize particles may be required.

(4) Rolling shall be carried out until the entire thickness of each layer is thoroughly and uniformly compacted to the density specified. Rolling shall be accompanied by sufficient blading in a manner approved by the Engineer, to ensure a smooth surface, free from ruts or ridges and having the proper section. When additional water is required it shall be added in a manner approved by the Engineer. The Contractor shall ensure that the required compaction is obtained throughout each layer and for the full finished width of the base. Filling outside the finished base width will be necessary in order to achieve the required compaction for the full finished base width.

(5) The Contractor shall plan the work and handle the various operations so that the least amount of water will be lost by evaporation from non-compacted surfaces.

(6) If the material is laid and compacted in two layers, the Contractor shall plan and coordinate the work in such a manner that the previously placed and compacted layer shall be allowed ample time for drying and development of sufficient stability before vehicles hauling materials for the succeeding layer, or other heavy equipment, are permitted on the base.

(7) Each layer of base shall be completely compacted, and approved by the Engineer, prior to the delivery of material for a succeeding layer.

(8) Prior to placing the succeeding layer of material, the top of the under-layer shall be made sufficiently moist to ensure bond between the layers.

(9) Samples shall be taken from the compacted layers for testing to ensure that the compacted material complies with the requirements of sub-clause 412.02 < 2 > herein.

(10) If after the base is compacted, any areas fail to meet the specified density and grading requirements, or are outside the specified tolerances, such areas shall be loosened and after having had additional materials added or excess material removed, as the case may be, shall be reconstructed as described herein.

(11) Edges and edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and present straight, neat and workmanlike lines and slopes as free of loose materials as practicable.

(12) Where there has been 4 hours or more between laying adjoining layers, the joints (transverse and longitudinal) shall be cut back to a full height vertical face. The material arising from this cut back may be spread in a thin layer under the layer being laid.

(13) Pins supporting wire guidance of the paver shall be spaced at a maximum of 5 meters.

< 5 > Compaction Trials

(1) Prior to the commencement of his base course operations, the Contractor shall construct trial lengths as directed by the Engineer. The material used in the trials shall be that approved for use as base and the equipment used shall be that which the Contractor intends to use for the work proper.

(2) The objective of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth necessary to result in the specified compacted layer depth, the field moisture content, and the relationship between the nominal number of compaction passes and the resulting density of the material.

(3) The Contractor may proceed with base course work only after the methods and procedures established in the trials have been approved by the Engineer.

(4) Each trial length will be 100metres long and trials shall be repeated as necessary until compaction procedures acceptable to the Engineer are achieved. The trial lengths will be incorporated in the Works provided the requirements of this Section are met, and no additional payment will be made for them.

414.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
414-1	Repair base course including new material	Metre Cube

414.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 415 PRIME COAT**415.01 DESCRIPTION**

(1) This work shall consist of the cleaning, preparing and treating the existing base surface or any other surface with a low viscosity bituminous binder and, if required, any blotter material in conformity with the extents shown on the Drawings. (Corresponding to SECTION 303 of the STS.)

415.02 MATERIALS

(1) Prime coat shall consist of a medium curing cut-back, MC-30, MC-70 asphalt produced by fluxing an asphaltic base with suitable petroleum distillates or Cationic Slow Setting Emulsified Asphalt CSS-1 (AASHTO M 208). MC-30 and MC-70 shall be free from water, show no separation prior to use, and shall conform to all the requirements for Grade MC-30 and MC 70 medium curing cutback asphalt specified in AASHTO M 82.

415.03 WORK PROCEDURES**< 1 > Preparation of Surface**

(1) Prior to the application of prime coat, the surface shall be shaped to the required grade and section, free from all ruts, corrugations, segregated materials and uniformly compacted, and cleaned by means of approved mechanical sweepers or blowers, until it is as free from dust as is deemed practicable.

(2) Immediately prior to spraying of the prime coat, the complete surface of the base shall be proof rolled. Proof rolling shall comprise 2 passes of a 6 wheeled truck with the rear 4 wheel single axle loaded to 8.2 tonnes as approved by the Engineer. Compliance of proof rolling shall be when an area withstands test rolling without visible deformation or springing. The Contractor shall at his own cost carry out any additional compaction and testing necessary to achieve the requirements specified herein for proof rolling. The proof-rolling will be performed on newly completed base using either a smooth wheel steel roller with a load intensity on the rear wheels of not less than 52.5 kN per linear metre width of roll, or a pneumatic-tyred roller loaded to 2.5 kN per tyre and each tyre inflated to 7 bar. Any areas which show visible movement shall be scarified and re-compacted at the contractor's expense. Any areas which have been allowed to stand for more than 24 hours prior to proof-rolling and which have not been maintained at approximately the optimum moisture content shall be watered and given at least 8 passes of the test roller before proof-rolling is carried out. The cost of this additional work in preparation for proof-rolling shall be at the contractor's expense. In absence of Pneumatic tyred or smooth wheel steel rollers of specified weight and type, loaded truck having axle load not less than 8 tonnes may be used for the purposes, if approved by the engineer.

(3) Where specified or where so directed by the Engineer spraying of the prime coat shall not commence until the base strength has achieved a Characteristic Impact Value of 60 or greater as determined by ASTM D 5874, or such value as may be determined by the Engineer through field trials correlated and verified to other tests, such as the sand replacement. The impact values shall be determined at a minimum of 9 locations per lot or as directed by the Engineer immediately before the spraying of prime occurs. The locations shall be selected on a random basis or as required by the Engineer.

- (4) The Characteristic Impact Value (CIV) is defined by the expression:

$$\text{CIV} = \text{IV}_m - 0.59.S$$

Where IV_m = the mean of the results of Impact Value on the lot being assessed reported to the nearest 1.0.

S = is the standard deviation of the results of the Impact Value on the lot being assess, calculated using the following relationship and reported to the nearest 0.1.

$$\text{Where } \text{IV}_m = \frac{1}{n} \times \sum_{i=1}^n X_i$$

$$\text{and } S = \sqrt{\frac{\sum_{i=1}^n [X_i - \bar{X}]^2}{[n - 1]}}$$

Where X_i is the individual Impact Value for test no. i
and n is the total number of tests for the lot
and \bar{X} is the mean of the n test results (i.e. = IV_m).

- (5) Delays in priming may require re-processing or re-shaping the roadway to provide a smooth and clean surface.
- (6) No traffic shall be permitted on the surface after it has been prepared to receive the prime coat.
- (7) Prime coat shall be applied only when the surface to be treated is dry, or contains moisture not in excess of that which will permit uniform distribution and the desired penetration of the prime coat. Prime coat shall not be applied in dusty conditions.
- (8) If deemed necessary by the Engineer, the cleaned surface shall be given a light application of water and allowed to dry to a surface dry condition before the bituminous material is applied.
- (9) Priming shall not proceed if in the opinion of the Engineer rain is threatening. If any rain falls while priming is underway, the Contractor shall immediately stop spraying.

< 2 > Heating Equipment

- (1) Heating equipment for heating the prime coat shall be of adequate capacity to heat the material thoroughly and uniformly by circulating steam or hot oil through coils of a tank or by circulating the material around a system of heated coils or pipes, or by circulating the material through a system of coils or pipes enclosed in a heated jacket or other approved means.
- (2) Heating equipment shall be operated in a manner that will not damage the prime coat material.
- (3) Heating equipment shall be so constructed that it will prevent the direct flame from a burner from striking the surface of the coils, pipes, or jacket through which the material is circulated.

- (4) If storage tanks are used, thermometers with a range of 0 to 200°C shall be fixed to the tanks so that the temperature of the material may be determined at all times.
- (5) Material which has been heated above 125 °C will be rejected, and shall be removed from the Site and disposed of by the Contractor.
- (6) All storage tanks, piping, retorts, booster tanks and distributors used in storing, handling or heating material shall be kept clean and in good condition at all times, and shall be operated in such manner that there will be no contamination by foreign material.

< 3 > Pressure Distributors

- (1) Pressure distributors shall be self propelled, pneumatic-tyred and so designated and equipped as to distribute the prime coat uniformly in variable widths at readily determined and controlled rates. They shall be operated by skilled workmen. The equipment shall include instruments for measuring the speed of travel accurately at low speeds, the rate of flow of bituminous material through the nozzles, the temperature of the contents of the tank, and the pressure and remaining contents. If after beginning the work, the distribution of bituminous material is found to be in error, the equipment shall be withdrawn from the work and calibrated to the satisfaction of the Engineer or replaced before proceeding with the work.
- (2) The manufacturing details of the pressure distributor, spray bar, and nozzles shall be provided to the Engineer for approval before the equipment is mobilised to Site. Details shall include the height of the spray bar and the angle of the nozzles so that a preliminary check can be made of the uniformity of coverage.
- (3) The distributor shall be so designed that, when not spreading, it does not drip.
- (4) The nozzles and spray bar shall be adjusted so that uniform distribution is achieved, and checked before each spraying run. Spraying shall cease immediately upon any clogging or interference of any nozzle, and corrective measures shall be taken before spraying is resumed.
- (5) The Contractor at his own expense shall arrange for the pressure distributor to be calibrated to the satisfaction of the Engineer at intervals of not less than 12 months or as required by the Engineer. Such calibration tests are to be done in the presence of the Engineer and are to demonstrate that the pressure distributor is capable of performing adequately in service. The Contractor shall gain the Engineer's approval of these tests before arranging for them to be carried out. Where in the sole opinion of the Engineer, the pressure distributor does not perform adequately, then it shall be removed from service and either repaired or replaced at the Contractor's cost.

< 4 > Application

- (1) Prime coat shall be applied by a pressure distributor in a uniform and continuous spread at the rates directed by the Engineer after the field trials. Any application so determined may be divided into two applications where necessary to prevent prime coat flowing off the surface and additional material shall be applied where localised surface conditions indicate it to be necessary.
- (2) Prime coat shall not be applied when the surrounding temperature is below +15 °C,

or windy and/or possibility to rain soon, unless otherwise permitted by the Engineer. The temperature of prime coat at the time of spraying shall be in the range of 300 °C – 900 °C for MC-30, 500 °C – 1000 °C for MC-70 and 250 °C – 550 °C for CSS-1.

(3) Distribution of the prime coat shall be so regulated and sufficient material shall be left in the distributor at the end of each application so that there is a uniform distribution of material. In no case shall the distributor be allowed to expel air, thereby causing uneven coverage.

(4) Where traffic is maintained on one side of the road while the other side is primed, not more than one half the width of the road shall be treated in one application. Care shall be taken so the application of asphalt at the junctions of spread is not in excess of the specified amount.

(5) Any skipped areas or recognised deficiencies shall be corrected by means of approved hand sprays. The use of hand sprays will only be allowed for correcting such deficiencies and for priming small patches or areas which are inaccessible to the distributor.

(6) Building paper shall be placed over the end of the previous applications, and the joining shall start on the building paper. Used building paper shall be removed and satisfactorily disposed of.

(7) Subject to the Engineer's approval, the Contractor shall spread blotting material on all areas which show an excess of prime. Blotting material shall be applied sparingly and only on areas which have not dried. Blotting material aggregate shall comply with the grading requirements of AASHTO M 43, size 10, and comprise clean non-plastic sand or fine aggregate, free from organic or deleterious material.

(8) The rate of application and areas to be treated shall be approved by the Engineer before application of prime coat.

< 5 > Field Trials

(1) Calibration of Bitumen Distributor: The Contractor shall, before he commences the work proper, calibrate the equipment by field trials to permit the Engineer To achieve the targeted application rate contractor will need to maintain the specified application temperature, determine the speed of the distributor truck per minute and check individual nozzle spray ability during each trials to ascertain the rate of application to be ordered and to test the suitability of the proposed distributor. The trial methods shall be approved by the Engineer and the trials performed by the Contractor in the presence of the Engineer. Trial spray shall be conducted outside the project roads to avoid surface damage and spillage. Necessary trials shall be carried out at contractors own expense to confirm the spray rates.

(2) The rate of application in the field trials shall vary between be 0.60 l/m² minimum and 1.20 l/m² maximum. Temperatures of bituminous materials at the time of each application shall be recorded.

(3) The Engineer may order subsequent field trials and/or change the previously established rates of application when he deems it necessary.

< 6 > Protection of Adjacent Structures

- (1) When prime coat is being applied, the surfaces of all structures, guard rails, kerbs and other roadway appurtenances and trees shall be protected in a manner approved by the Engineer to prevent them from being splattered or damaged.
- (2) The Contractor shall at his own cost make good to the satisfaction of the Engineer any appurtenances which are splattered or damaged.

< 7 > Traffic Control and Maintenance of Primed Surfaces

- (1) The Contractor shall provide all necessary detours for the public and his own construction traffic in areas where prime coat is to be applied. Where no convenient detour can be constructed or if so directed by the Engineer, the application operation shall be confined to one half of the roadway at a time, and the Contractor shall provide traffic control as directed by the Engineer, at his own cost. When the asphalt has been absorbed by the surface and, in the opinion of the Engineer, is sufficiently dry not to be picked up by traffic, but in no case less than 24 hours, traffic shall be transferred to the treated portion and the remaining width of the section shall be primed.
- (2) The Contractor shall protect all primed surfaces and keep them in acceptable condition until they are covered by succeeding courses.
- (3) All areas where the prime surface has been damaged by traffic or by the Contractor's operations shall be cleaned of all loose materials, re primed, and made good to the satisfaction of the Engineer, at the Contractor's own cost.

415.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
415-1	Prime coat	Metre Square

415.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 416 FIRST SEAL

416.01 DESCRIPTION

(1) This work is to install first seal coat composed of bituminous materials on the finishing surface of base course. (Corresponding to SECTION 304 of the STS.)

416.02 MATERIALS

< 1 > Seal Coat

(1) Bituminous materials used in Seal Coat shall be one of the types and grades listed in the following table and approved by the Engineer.

Bituminous Materials for Seal Coats		
Designation	Type of Material	Application Temperature
60 - 70	Penetration grade bitumen	160°C – 17°C
80 - 100	Bitumen Penetration grade bitumen	160°C – 170°C
RC - 250	Cutback Bitumen, Rapid Curing	80°C – 90°C
RC - 800	Cutback Bitumen, Rapid Curing	100°C - 115°C
RC - 3000	Cutback Bitumen, Rapid Curing	125°C - 135°C
RS - 2	Emulsified Bitumen	80°C - 90°C
CRS - 2	Cationic Emulsified Bitumen	75°C - 85°C
CRS - 3	Cationic Emulsified Bitumen	75°C - 85°C

(2) The materials shown above shall be in compliance with AASHTO M 20, AASHTO M 81, AASHTO M 140 or AASHTO M 208, as applicable.

(3) The use of emulsified bitumen shall be considered when the aggregate is dirty.

(4) As the process of using emulsified bitumen is very sensitive extreme care shall be taken during the process of applying emulsified bitumen.

(5) Road sections where emulsified bitumen has been used shall be kept closed for traffic at least 48 hours. In lower temperatures the closure shall be longer duration, as decided by the Engineer.

(6) Emulsified bitumen with cationic charges, CRS1 or CRS2, could have repulsive effects on some stone aggregates and therefore this could necessitate testing of the emulsified bitumen before use, as decided by the Engineer

< 2 > Adhesion Agent

(1) A proprietary additive that enhances the adhesion of the bitumen to the aggregate shall be added at the doses recommended by the Manufacturer. The additive shall be subject to the approval of the Engineer which approval shall be conditional on satisfactory field trials.

< 3 > Aggregate Pre-coating Material

(1) Aggregate pre-coating material shall be distillate or distillate based product, cutback bitumen, or proprietary product as approved by the Engineer.

< 4 > Cover Material

(1) Aggregates shall meet the requirements of as follows.

1. Coarse Aggregate

- (a) Course aggregate, which is the material retained on a 4.75mm (ASTM No. 4) sieve, shall consist of crushed un-weathered rock.
- (b) It shall be clean, hard, tough, durable and sound, and shall be of uniform quality and free from decomposed stone, shale, clay lumps and other deleterious substances. Organic impurities when tested in accordance with AASHTO T 21 shall not fail the colour comparison of being darker than the colour of Organic Colour No. 3 (Gardner No.11). Coarse aggregate for each pavement course shall be from a single source of supply. Mixing of aggregates from different sources will not be allowed.
- (c) River boulders will only be approved as a source of supply for coarse aggregate if the Contractor can prove, to the satisfaction of the Engineer, that suitable quarry sources are unavailable within the vicinity of the Contract. For the purposes of these specifications, "within the vicinity" shall be taken to mean within a radius of 50 km of any point within the Site. Under no circumstances will natural uncrushed gravel be allowed to be incorporated into bituminous mixes.
- (d) The percentage of particles with a minimum of one crushed face shall be 100%. In addition, at least 85 % by weight for quarry material and 65 % for river boulders of each separate stockpile of aggregate shall have all faces crushed.
- (e) Coarse aggregate shall have properties which comply with the following values:

Los Angeles Abrasion Loss (AASHTO T 96)	
Binder Course	30% max
Wearing Course	25% max
Aggregate Crushing Value (BS 812-110)	
Binder Course	25% max
Wearing Course	20% max
Aggregate Impact Value (BS 812-112)	
	25% max
Soundness Loss (AASHTO T 104)	
Sodium Sulphate	12% max
Flakiness Index (BS EN 933-3)	
Binder Course	25% max
Wearing Course	25% max

- | | |
|--|------------|
| Elongation Index (BS 812-105.2) | |
| Binder Course | 25% max |
| Wearing Course | 25% max |
|
Polished Stone Value
(BS 812-114) |
75 min |
|
Water Absorption (ASTM C128/ 127) |
2% max |
- (f) Coarse aggregate shall show no detrimental amount of stripping when tested in accordance with AASHTO T 182. The minimum value of non-stripped area shall be 95 %. If stripping occurs, the aggregate shall be rejected or, with the agreement of the Engineer, a method of treatment shall be proposed by the Contractor for the approval of the Engineer to change the material from a hydrophilic to a hydrophobic state, or an approved (anti-stripping) additive shall be proposed by the Contractor for use with the bituminous binder.
- (g) The approved additive shall be added to the bituminous material in such a proportion as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with AASHTO T 182. The approved additive shall be used in strict accordance with the technical specifications issued by the additive manufacturer.

2. Fine Aggregate

- (a) Fine aggregate shall consist of the material passing the 4.75 mm sieve.
- (b) Fine aggregate shall be obtained from 100 % crushed rock or boulders pre-screened to exclude natural uncrushed fine material or weathered unsound fines. The use of natural sand will not be permitted. The use of river gravel as a source of supply for fine aggregate will not be permitted unless specifically approved by the Engineer.
- (c) Fine aggregate shall have properties which comply with the following values:

Sand Equivalent	
Binder Course	50% min
Wearing Course	40% min
 Soundness Loss (AASHTO T 104)	
Magnesium Sulphate	15% max
 Plasticity Index (BS 1377: Part 2: Test 5)	 Non-Plastic
 Acid Soluble Chlorides (BS EN 1744-1)	 0.1% max
 Acid Soluble Sulphates (BS EN 1744-1)	 0.5% max

(2) Grading Requirements

Aggregate shall conform to the following grading requirements:

Grading Requirement	
AASHTO M 92 Sieve Size (mm)	Percentage Passing (by weight)
25.0	100
19.0	90 – 100
12.5	0 – 30
9.5	0 – 8
4.75	–
2.36	0 – 2
1.18	0 – 0.5

(3) Alternatively below grading can be used, as decided by the Engineer.

Alternative Grading Requirement	
BS Sieve Size, (mm)	Percentage Passing (by weight)
25.0	–
19.0	100
16.0	85 – 100
9.5	10 - 30
6.35	0 - 7
2.00	–

(4) When tested in accordance with AASHTO T 182, aggregate shall have a retained asphalt film above 95%.

(5) Aggregate stockpiled ready for use shall be kept in a concrete floored bin with side walls and shall be kept covered. Drainage measures to prevent water entering the stockpile shall be provided. The bin shall have sufficient capacity to supply aggregate for 14 days' use.

< 5 > Precoating of Aggregate

(1) Aggregate which has not been previously pre-coated shall be pre-coated with material as specified here above. Such pre-coating shall be carried out so that each aggregate particle is uniformly coated. Pre-coating shall be applied, when using Straight Run Bitumen for the sealing chips. The need for applying pre-coating when Bitumen Emulsion is used for the sealing chip, is decided at the discretion of the Engineer. However, when emulsified asphalt is used as binder, proper cleaning of aggregate by washing is required.

416.03 WORK PROCEDURES

< 1 > Preparation of Surface

(1) Immediately prior to applying the bituminous material, the surface shall be cleaned of all dirt, sand, dust and objectionable material. This cleaning shall be effected by means of a rotary power broom or a power blower, unless other methods are authorised by the

Engineer. Dried mud or other foreign material which cannot be removed otherwise shall be removed by hand methods.

(2) In no event shall bituminous seal coat be placed on newly constructed or reconditioned surfaces less than ten (10) days after such surface has been laid and opened to traffic, unless otherwise ordered in writing by the Engineer.

< 2 > Equipment

(1) Heating equipment shall comply with the following requirements.

1. Heating equipment for heating the prime coat shall be of adequate capacity to heat the material thoroughly and uniformly by circulating steam or hot oil through coils of a tank or by circulating the material around a system of heated coils or pipes, or by circulating the material through a system of coils or pipes enclosed in a heated jacket or other approved means.
2. Heating equipment shall be operated in a manner that will not damage the prime coat material.
3. Heating equipment shall be so constructed that it will prevent the direct flame from a burner from striking the surface of the coils, pipes, or jacket through which the material is circulated.
4. If storage tanks are used, thermometers with a range of 0 to 200 °C shall be fixed to the tanks so that the temperature of the material may be determined at all times.
5. Material which has been heated above 125 °C will be rejected, and shall be removed from the Site and disposed of by the Contractor.
6. All storage tanks, piping, retorts, booster tanks and distributors used in storing, handling or heating material shall be kept clean and in good condition at all times, and shall be operated in such manner that there will be no contamination by foreign material.

(2) The pressure distributor, including spray bar and nozzles, shall comply with the following requirements.

1. Pressure distributors shall be self propelled, pneumatic-tyred and so designated and equipped as to distribute the prime coat uniformly in variable widths at readily determined and controlled rates. They shall be operated by skilled workmen. The equipment shall include instruments for measuring the speed of travel accurately at low speeds, the rate of flow of bituminous material through the nozzles, the temperature of the contents of the tank, and the pressure and remaining contents. If after beginning the work, the distribution of bituminous material is found to be in error, the equipment shall be withdrawn from the work and calibrated to the satisfaction of the Engineer or replaced before proceeding with the work.
2. The manufacturing details of the pressure distributor, spray bar, and nozzles shall be provided to the Engineer for approval before the equipment is mobilised to

Site. Details shall include the height of the spray bar and the angle of the nozzles so that a preliminary check can be made of the uniformity of coverage.

3. The distributor shall be so designed that, when not spreading, it does not drip.
4. The nozzles and spray bar shall be adjusted so that uniform distribution is achieved, and checked before each spraying run. Spraying shall cease immediately upon any clogging or interference of any nozzle, and corrective measures shall be taken before spraying is resumed.
5. The Contractor at his own expense shall arrange for the pressure distributor to be calibrated to the satisfaction of the Engineer at intervals of not less than 12 months or as required by the Engineer. Such calibration tests are to be done in the presence of the Engineer and are to demonstrate that the pressure distributor is capable of performing adequately in service. The Contractor shall gain the Engineer's approval of these tests before arranging for them to be carried out. Where in the sole opinion of the Engineer, the pressure distributor does not perform adequately, then it shall be removed from service and either repaired or replaced at the Contractor's cost.

< 3 > Application of Seal Coat

- (1) Seal coat shall be applied by means of a pressure distributor in a uniform, continuous spread over the section to be treated and within the temperature range specified. The quantity of material per square metre shall be within the limits hereinafter specified and as directed by the Engineer.
- (2) A strip of building paper, at least 1 metre wide and with a length equal to that of the spray bar of the distributor plus 300 mm, shall be used at the beginning of each spread. If the cut off is not positive, the use of paper may be required by the Engineer at the end of each spread. The paper shall be removed and disposed of in an approved manner. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected in an approved manner. Junctions of spreads shall be carefully made to assure a smooth riding surface.
- (3) The length of spread of seal coat shall not be in excess of that which trucks loaded with cover material can immediately cover (maximum elapsed time of 2 to 4 minutes between binder application and spreading of sealing aggregate and commencing rolling for compaction).
- (4) The width of spread of seal coat shall not be more than 150 mm wider than the width covered by the cover material from the spreading device. Under no circumstances shall operations proceed in such a manner that seal coat is allowed to cool or otherwise impair retention of the cover material.
- (5) Distribution of the seal coat shall be so regulated and sufficient material shall be left in the distributor at the end of each application so that there is a uniform distribution of material. In no case shall the distributor be allowed to expel air, thereby causing uneven coverage.
- (6) The angle of the spray nozzles and the height of the spray bar shall be so adjusted and frequently checked that uniform distribution is obtained. If the raise of the spray bar as

the load is removed is excessive and contributes to drilling and streaking of the seal coat/bituminous material, the frame of the distributor shall be blocked or snubbed to the axle of the truck to maintain a constant height of the spray bar above the road surface. The distribution shall cease immediately upon any clogging or interference of any nozzle and corrective measures shall be taken before distribution is resumed.

(7) Application temperature of binder shall be maintained within the range as specified in sub-clause 416.02 < 1 > (1).

< 4 > Application of Cover Material

(1) Immediately following the application of the seal coat (within 2 to 4 minutes), cover material shall be uniformly spread with an approval self-propelled aggregate spreader, supported by at least four wheels equipped with pneumatic tyres on two axles, in quantities ordered by the Engineer and within the limits specified herein. Spreading shall be accomplished in such a manner that the tyres of the trucks or aggregate spreader at no time come in contact with uncovered and newly applied seal coat. The spreader shall produce a uniform closely packed carpet of chippings one stone thick.

(2) Sufficient trucks and loading equipment shall be employed to ensure an adequate, prompt and continuous supply of chippings.

(3) Should it become apparent that the supply of chipping is about to run out, the seal coat spraying shall be immediately stopped and not recommenced until an adequate supply of chippings is assured.

(4) The aggregate shall be clean and dust free when spread.

(5) The aggregate shall have been pre-coated at least 4 days and not more than 28 days prior to the use of the aggregate. Where in the opinion of the Engineer the pre-coating of the aggregate is not satisfactory, or for any reason the aggregate is not satisfactory then the Contractor shall either pre-coat the aggregate again or replace the sealing aggregate at his own cost.

(6) Starting, stopping or turning any piece of equipment which results in displacement of the cover material or damage to the seal coat shall be prohibited.

(7) The spreading equipment shall be of such width and arrangement that as the aggregate is placed, complete coverage is obtained. No brooming of the cover material shall be permitted prior to initial rolling. Any rearrangement of the cover material shall be done by manual methods. Overlapping applications of cover material shall be avoided and all spillage shall be removed from the surface.

Before rolling commences, the seal coat shall be uniformly covered. Any deficient areas shall be covered by additional material.

< 5 > Rates of Application

(1) The rate of application of seal coat shall be as specified by the Engineer following the construction of the trial lengths. When spraying seal coat in lanes, the applications should provide full coverage of the surface, but should not overlap.

(2) The rate of application of cover material shall be as specified by the Engineer

following the construction of the trial lengths.

(3) Application rates for both aggregate and bitumen to be used for the initial field trials shall be determined as follows:

1. Aggregate

A preliminary value of the aggregate quantity to provide for a thickness equal to the average least size dimension with 20% voids is as follows:

$A \text{ (kg/sq-m)} = 0.8 F \times G \times H$; where

F is the Wastage Factor 1.07 for 9.5mm and 12.5mm aggregate
 1.02 for 19.0mm and 25.0mm aggregate
G is the Bulk specific gravity (AASHTO test Method T 85) and
H is the Average Least Dimension (mm)

The above equation assumes voids in the loose aggregate to be 50%. Control tests shall be carried out to determine the loose density according to AASHTO T 19 and the loose voids content determined as follows:

$V = 1 - J / G$ where

V is the loose voids content
J is the loose unit weight (t/cu-m.)
G is the Bulk specific gravity
The final design aggregate quantity shall then be calculated as:

$A \text{ (kg/sq-m)} = (1 - 0.4 V) F \times G \times H$

The design quantity shall be checked by packing the aggregate one stone thick on a sample tray and by field trials.

2. Bitumen

The theoretical bitumen application rates for each layer to embed the aggregate to about 70% of its average least size dimension can be determined from the following formula:

$B \text{ (litres/sq-m)} = [(0.4 \times H \times V \times T) + S] / R$ where

B is the theoretical "cold" bitumen application rate for each layer.
T is the Traffic factor (0.70 - 0.75)
R is the Residual bitumen factor

S is the Surface texture correction for first layer only.

= -0.1 to -0.3 litre / sq.m., for black flushing surface;
= nil for smooth surface, good priming;
= +0.1 to +0.3 litre / sq.m., for absorbent and rough surfaces.

For double surface treatment, the theoretical bitumen quantities for each layer shall be added together and converted to “hot” rates at the spraying temperature (ASTM D1250-56). For warm season construction, 60% of this combined rate shall be applied for the first layer and 40% for the second. For cool season construction, 50% of the combined rate shall be applied for the first layer and 50% for the second layer.

The final design quantity shall be determined by field trials. The actual quantity to be used in the work shall be as directed by the Engineer.

- (4) The Engineer may alter the rates of application whenever he deems it necessary or desirable.

< 6 > Manipulation

(1) Rollers shall be self-propelled, pneumatic tyred, multi-wheeled rollers having an unballasted weight not less than 8 tonnes and tyres of equal size. Rear wheels be offset relative to the front wheels to give overlapping tyre paths and complete coverage for the effective width of the roller. Rollers will be capable of providing a wheel load from 1,000kg per wheel with a maximum tyre pressure of 6 Bar.

(2) Rolling shall commence immediately after spreading and continue, in conjunction with drag brooming, until the aggregate is well embedded in the binder and a uniform surface is obtained. At least 4 passes of the roller over all parts of the surface shall take place and in the first layer may be followed by 2 passes of a steel wheeled roller not exceeding 8,000 kg to make a smooth surface without any crushing of the aggregate for the second layer. Rolling shall continue until the aggregate is bound properly to the binder. If satisfactory embedment does not occur, then further rolling shall be carried out the following day. When the binder has hardened to the stage that not more aggregate can be pressed into it by rolling, all loose aggregate shall be removed by sweeping. If the Engineer considers that the adhesion of the binder to the aggregate is unsatisfactory, he shall reject the work and direct that no further work be carried out until the conditions improve.

(3) Steel wheel rollers shall be operated at a maximum speed of 5 km/h and pneumatic-tyre rollers at a maximum speed of 8 km/h. The weight of rollers may be varied as directed by the Engineer to obtain the most satisfactory embedment of the cover material without undue crushing of the aggregate.

(4) After the aggregate has been rearranged as may be necessary to provide uniform and complete coverage, it shall be thoroughly embedded in the seal coat by rolling in the manner described below.

(5) The initial rolling shall begin immediately behind the spreader and shall consist of one complete pass with a self-propelled pneumatic-tyre roller. The initial rolling shall be accomplished within ten (10) minutes of the seal coat being sprayed.

(6) Pneumatic-tyre manipulation rolling shall begin immediately after the completion of the initial rolling.

(7) The number of passes of the roller shall be as directed by the Engineer based on the results of the trial lengths, but shall be at least four. Minor crushing of the cover material is permissible, but should any general shattering occur, the Engineer may direct that rolling

shall cease, regardless of the number of passes completed.

(8) The sequence of rolling may be varied by the Engineer at any time, if in his opinion satisfactory results are not being obtained.

(9) Rolling shall be longitudinal and shall generally be commenced at the outer edges and progress towards the centre, but from the lower edge to the upper edge on super-elevated sections. The speed of the rollers or the rolling sequence shall be so controlled that it is unnecessary for one roller to turn out to permit another roller to pass. Turning of rollers on the surface is prohibited.

(10) If, in the opinion of the Engineer, the cover material furnished is subject to excessive crushing under the steel wheel rollers, pneumatic-tyre rollers may be substituted for finishing work.

(11) If necessary, and when ordered by the Engineer, additional cover material shall be added and the additional material shall receive additional rolling.

(12) Two additional passes of previously completed section may be given by the pneumatic-tyred roller in the heat of the day (termed “back rolling”) as may be ordered by the Engineer.

< 7 > Maintenance of Completed Work

(1) After manipulation of cover material, the surface shall be lightly broomed or otherwise maintained for 4 days.

(2) When directed by the Engineer, the Contractor shall make good defective areas by further applications of seal coat and/or cover material, and further manipulation as described above, at his own cost.

(3) Maintenance of the surface shall include the distribution of cover material to absorb free asphalt and cover any area deficient in cover material. The maintenance shall be conducted so that embedded material is not displaced.

(4) After all other work has been completed, the excess loose cover material along the edges of the surface shall be swept by means of rotary brooms, at a time determined by the Engineer.

< 8 > Tolerances

(1) The final average overall width of the dressed surface measured at seven equidistant points over any length of 100 m shall be at least equal to the width specified or ordered. At no point shall the distance between the centre-line of the road and the edge of the bitumen surface be narrower than that specified or ordered by more than 25 mm.

(2) The rate of application of seal coat and cover material along or across the road shall not vary by more than 10% of the rate ordered. The average rates of application of the seal coat and the cover material, calculated over a length of 200 metres shall be at least equal to the rates ordered.

(3) The completed surface dressing shall be of uniform mosaic without bleeding or

balding and shall be free of any loose cover material or seal coat spillage.

(4) Any area showing signs of bleeding or loss of cover material after opening of the section to traffic shall be rectified to the satisfaction of the Engineer at the cost of the Contractor.

(5) The corrective work may be effected as a third seal, by removal and replacement of the defective work or by other approved measures, and the Contractor shall carry out these promptly to the satisfaction of the Engineer. The corrective works shall be executed in such a manner that they blend in colour, textures and finish with the adjacent work.

< 9 > Trial Lengths

(1) The Contractor shall, before he commences the work proper, construct a trial length of at least 30 metres to check all operations he proposes to use in the Permanent Works and to ascertain all necessary information to establish application rates and manipulation requirements. The trial shall be undertaken, in the presence of the Engineer, using the same materials, plant and equipment and shall mirror the application and manipulation procedures proposed for the Permanent Works.

(2) Prior to the trial the Contractor shall prepare and submit to the Engineer a draft Technical Method Statement for this work, and will obtain the approval of the Engineer thereto before he commence the trial.

(3) The trial length shall be repeated if in the opinion of the Engineer the previous trial was unsatisfactory and/or failed to provide the necessary information for determination of application rates and manipulation requirements.

(4) Trial lengths shall be constructed as required, and trial lengths shall not form part of the Permanent Works. Trial length shall be done outside project road on a surface approved by the Engineer. They may, however, form part of a temporary traffic detour subject to the approval of the Engineer.

(5) Construction of trial lengths shall continue until all aspects are, in the opinion of the Engineer, fully satisfactory, following which the Contractor shall finalise and submit to the Engineer for approval the Technical Method Statement for the work.

(6) This Method Statement is to be approved by the Engineer before the Permanent Works for the work commence. The Method Statement will define the rates of application of seal coat and cover material, the number of manipulation passes and all other aspects to clearly and unambiguously specify the procedures to be used in the Permanent Works.

(7) All work carried out for Permanent Works construction will follow the approved final Technical Method Statement and deviations thereto will not be allowed except with the specific written approval of the Engineer. Deviations will not only cover the procedures adopted but will also encompass changes of equipment, and replacement of personnel including distributor and spreader operators and roller drivers.

(8) Where, in the opinion of the Engineer, deviations are of such magnitude that the results of the trial length are no longer applicable and/or where the quality of the finished work is being prejudiced, the Engineer will order the works to cease until such time as further trial length(s) are constructed and approved.

< 10 > Other Requirements

(1) Weather and Temperature Limitations

1. Seal coat shall not be applied on a damp surface or when the surrounding surface temperature is below 15 °C or when, in the opinion of the Engineer, weather conditions prevent the proper construction of the seal coat.

(2) Protection of Adjacent Structures

1. When bituminous materials are being applied, the surface of all structures, guard rails, kerbs and gutters, and other roadway appurtenances and trees shall be protected in an approved manner to prevent them from being splattered with bituminous material or marred by equipment operation. In the event that any appurtenances become splattered or marred, the Contractor shall at his own expense, remove all traces of bituminous materials, and repair all damage, and leave the appurtenances in an approved condition.

(3) Working Periods

1. Surface dressing operations shall be so conducted that all manipulation work specified can be completed before sunset and under favourable weather conditions as determined by the Engineer.

< 11 > Traffic Control

(1) Traffic shall be prevented from running on the surface courses until at least 24 hours after the manipulation work has been completed, unless otherwise ordered or permitted by the Engineer.

(2) When directed by the Engineer the Contractor shall direct both the construction traffic and the passing traffic onto the completed first seal.

(3) The Contractor shall at his own cost provide any necessary speed restriction and warning and diversion signs and barriers for traffic control, and traffic shall be so regulated to ensure that it causes no damage to the seal.

(4) The Contractor shall post signs restricting the speed of traffic to 20 km/h on the surface dressing for such periods as directed by the Engineer. When instructed by the Engineer for the first two weeks the Contractor shall erect barriers restricting the width of the road and daily move them such that traffic runs across the complete width of the aggregate in the course.

(5) The Contractor shall make good at his own cost and in a manner approved by the Engineer any defects or damage to the seal for a period of 14 days, or other such period specified by the Engineer, before the application of any additional surface dressing courses or asphalt.

416.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
416-1	First seal	Metre Square

416.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 417 SECOND SEAL

417.01 DESCRIPTION

(1) This work is to install first seal coat composed of bituminous materials on the finishing surface of base course. (Corresponding to SECTION 304 of the STS.)

417.02 MATERIALS

< 1 > Seal Coat

(1) Bituminous materials used in Seal Coat shall be one of the types and grades listed in the following table and approved by the Engineer.

Bituminous Materials for Seal Coats		
Designation	Type of Material	Application Temperature
60 - 70	Penetration grade bitumen	160°C – 17°C
80 - 100	Bitumen Penetration grade bitumen	160°C – 170°C
RC - 250	Cutback Bitumen, Rapid Curing	80°C – 90°C
RC - 800	Cutback Bitumen, Rapid Curing	100°C - 115°C
RC - 3000	Cutback Bitumen, Rapid Curing	125°C - 135°C
RS - 2	Emulsified Bitumen	80°C - 90°C
CRS - 2	Cationic Emulsified Bitumen	75°C - 85°C
CRS - 3	Cationic Emulsified Bitumen	75°C - 85°C

(2) The materials shown above shall be in compliance with AASHTO M 20, AASHTO M 81, AASHTO M 140 or AASHTO M 208, as applicable.

(3) The use of emulsified bitumen shall be considered when the aggregate is dirty.

(4) As the process of using emulsified bitumen is very sensitive extreme care shall be taken during the process of applying emulsified bitumen.

(5) Road sections where emulsified bitumen has been used shall be kept closed for traffic at least 48 hours. In lower temperatures the closure shall be longer duration, as decided by the Engineer.

(6) Emulsified bitumen with cationic charges, CRS1 or CRS2, could have repulsive effects on some stone aggregates and therefore this could necessitate testing of the emulsified bitumen before use, as decided by the Engineer

< 2 > Adhesion Agent

(1) A proprietary additive that enhances the adhesion of the bitumen to the aggregate shall be added at the doses recommended by the Manufacturer. The additive shall be subject to the approval of the Engineer which approval shall be conditional on satisfactory field trials.

< 3 > Aggregate Pre-coating Material

(1) Aggregate pre-coating material shall be distillate or distillate based product, cutback bitumen, or proprietary product as approved by the Engineer.

< 4 > Cover Material

(1) Aggregates shall meet the requirements of as follows.

1. Coarse Aggregate

- (a) Course aggregate, which is the material retained on a 4.75mm (ASTM No. 4) sieve, shall consist of crushed un-weathered rock.
- (b) It shall be clean, hard, tough, durable and sound, and shall be of uniform quality and free from decomposed stone, shale, clay lumps and other deleterious substances. Organic impurities when tested in accordance with AASHTO T 21 shall not fail the colour comparison of being darker than the colour of Organic Colour No. 3 (Gardner No.11). Coarse aggregate for each pavement course shall be from a single source of supply. Mixing of aggregates from different sources will not be allowed.
- (c) River boulders will only be approved as a source of supply for coarse aggregate if the Contractor can prove, to the satisfaction of the Engineer, that suitable quarry sources are unavailable within the vicinity of the Contract. For the purposes of these specifications, "within the vicinity" shall be taken to mean within a radius of 50 km of any point within the Site. Under no circumstances will natural uncrushed gravel be allowed to be incorporated into bituminous mixes.
- (d) The percentage of particles with a minimum of one crushed face shall be 100%. In addition, at least 85 % by weight for quarry material and 65 % for river boulders of each separate stockpile of aggregate shall have all faces crushed.
- (e) Coarse aggregate shall have properties which comply with the following values:

Los Angeles Abrasion Loss (AASHTO T 96)	
Binder Course	30% max
Wearing Course	25% max
Aggregate Crushing Value (BS 812-110)	
Binder Course	25% max
Wearing Course	20% max
Aggregate Impact Value (BS 812-112)	
	25% max
Soundness Loss (AASHTO T 104)	
Sodium Sulphate	12% max
Flakiness Index (BS EN 933-3)	
Binder Course	25% max
Wearing Course	25% max

Elongation Index (BS 812-105.2)	
Binder Course	25% max
Wearing Course	25% max
Polished Stone Value (BS 812-114)	75 min
Water Absorption (ASTM C128/ 127)	2% max

- (f) Coarse aggregate shall show no detrimental amount of stripping when tested in accordance with AASHTO T 182. The minimum value of non-stripped area shall be 95 %. If stripping occurs, the aggregate shall be rejected or, with the agreement of the Engineer, a method of treatment shall be proposed by the Contractor for the approval of the Engineer to change the material from a hydrophilic to a hydrophobic state, or an approved (anti-stripping) additive shall be proposed by the Contractor for use with the bituminous binder.
- (g) The approved additive shall be added to the bituminous material in such a proportion as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with AASHTO T 182. The approved additive shall be used in strict accordance with the technical specifications issued by the additive manufacturer.

2. Fine Aggregate

- (a) Fine aggregate shall consist of the material passing the 4.75 mm sieve.
- (b) Fine aggregate shall be obtained from 100 % crushed rock or boulders pre-screened to exclude natural uncrushed fine material or weathered unsound fines. The use of natural sand will not be permitted. The use of river gravel as a source of supply for fine aggregate will not be permitted unless specifically approved by the Engineer.
- (c) Fine aggregate shall have properties which comply with the following values:

Sand Equivalent	
Binder Course	50% min
Wearing Course	40% min
Soundness Loss (AASHTO T 104)	
Magnesium Sulphate	15% max
Plasticity Index (BS 1377: Part 2: Test 5)	Non-Plastic
Acid Soluble Chlorides (BS EN 1744-1)	0.1% max
Acid Soluble Sulphates (BS EN 1744-1)	0.5% max

(2) Grading Requirements

Aggregate shall conform to the following grading requirements:

Grading Requirement	
AASHTO M 92 Sieve Size (mm)	Percentage Passing (by weight)
25.0	100
19.0	90 – 100
12.5	0 – 30
9.5	0 – 8
4.75	–
2.36	0 – 2
1.18	0 – 0.5

(3) Alternatively below grading can be used, as decided by the Engineer.

Alternative Grading Requirement	
BS Sieve Size, (mm)	Percentage Passing (by weight)
25.0	–
19.0	100
16.0	85 – 100
9.5	10 - 30
6.35	0 - 7
2.00	–

(4) When tested in accordance with AASHTO T 182, aggregate shall have a retained asphalt film above 95%.

(5) Aggregate stockpiled ready for use shall be kept in a concrete floored bin with side walls and shall be kept covered. Drainage measures to prevent water entering the stockpile shall be provided. The bin shall have sufficient capacity to supply aggregate for 14 days' use.

< 5 > Precoating of Aggregate

(1) Aggregate which has not been previously pre-coated shall be pre-coated with material as specified here above. Such pre-coating shall be carried out so that each aggregate particle is uniformly coated. Pre-coating shall be applied, when using Straight Run Bitumen for the sealing chips. The need for applying pre-coating when Bitumen Emulsion is used for the sealing chip, is decided at the discretion of the Engineer. However, when emulsified asphalt is used as binder, proper cleaning of aggregate by washing is required.

417.03 WORK PROCEDURES

< 1 > Equipment

(1) Heating equipment shall comply with the following requirements.

1. Heating equipment for heating the prime coat shall be of adequate capacity to

heat the material thoroughly and uniformly by circulating steam or hot oil through coils of a tank or by circulating the material around a system of heated coils or pipes, or by circulating the material through a system of coils or pipes enclosed in a heated jacket or other approved means.

2. Heating equipment shall be operated in a manner that will not damage the prime coat material.
3. Heating equipment shall be so constructed that it will prevent the direct flame from a burner from striking the surface of the coils, pipes, or jacket through which the material is circulated.
4. If storage tanks are used, thermometers with a range of 0 to 200 °C shall be fixed to the tanks so that the temperature of the material may be determined at all times.
5. Material which has been heated above 125 °C will be rejected, and shall be removed from the Site and disposed of by the Contractor.
6. All storage tanks, piping, retorts, booster tanks and distributors used in storing, handling or heating material shall be kept clean and in good condition at all times, and shall be operated in such manner that there will be no contamination by foreign material.

(2) The pressure distributor, including spray bar and nozzles, shall comply with the following requirements.

1. Pressure distributors shall be self propelled, pneumatic-tyred and so designated and equipped as to distribute the prime coat uniformly in variable widths at readily determined and controlled rates. They shall be operated by skilled workmen. The equipment shall include instruments for measuring the speed of travel accurately at low speeds, the rate of flow of bituminous material through the nozzles, the temperature of the contents of the tank, and the pressure and remaining contents. If after beginning the work, the distribution of bituminous material is found to be in error, the equipment shall be withdrawn from the work and calibrated to the satisfaction of the Engineer or replaced before proceeding with the work.
2. The manufacturing details of the pressure distributor, spray bar, and nozzles shall be provided to the Engineer for approval before the equipment is mobilised to Site. Details shall include the height of the spray bar and the angle of the nozzles so that a preliminary check can be made of the uniformity of coverage.
3. The distributor shall be so designed that, when not spreading, it does not drip.
4. The nozzles and spray bar shall be adjusted so that uniform distribution is achieved, and checked before each spraying run. Spraying shall cease immediately upon any clogging or interference of any nozzle, and corrective measures shall be taken before spraying is resumed.
5. The Contractor at his own expense shall arrange for the pressure distributor to be calibrated to the satisfaction of the Engineer at intervals of not less than 12

months or as required by the Engineer. Such calibration tests are to be done in the presence of the Engineer and are to demonstrate that the pressure distributor is capable of performing adequately in service. The Contractor shall gain the Engineer's approval of these tests before arranging for them to be carried out. Where in the sole opinion of the Engineer, the pressure distributor does not perform adequately, then it shall be removed from service and either repaired or replaced at the Contractor's cost.

< 2 > Application of Seal Coat

- (1) The second seal coat shall not be applied until the first seal coat has been under traffic for 28 days or such other length of time as specified by the Engineer.
- (2) Immediately prior to application of the second seal coat, the surface of the first course shall be cleaned in an approved manner of all dust and loose cover material. Care shall be taken that no embedded material is dislodged.
- (3) The application of the second seal coat shall conform to the requirements specified for the first seal coat.
- (4) The Contractor shall give 28 days written notice of his intention to carry out second seal coat of a section of work in order to allow the Engineer to carry out an inspection and any required testing of the completed seal. At his own cost, the Contractor shall provide such traffic control devices as the Engineer deems necessary and any additional labour and plant to carry out this inspection/testing.
- (5) Where in the opinion of the Engineer the results of this inspection/testing warrant further investigation, or indicate that the completed pavement may not be meeting the design criteria, then he shall have full authority to suspend further works in that area.
- (6) At his own cost, the Contractor shall provide any additional plant and labour the Engineer deems necessary to carry out these additional tests and investigations.

< 3 > Application of Cover Material

- (1) Immediately following the application of the seal coat (within 2 to 4 minutes), cover material shall be uniformly spread with an approved self-propelled aggregate spreader, supported by at least four wheels equipped with pneumatic tyres on two axles, in quantities ordered by the Engineer and within the limits specified herein. Spreading shall be accomplished in such a manner that the tyres of the trucks or aggregate spreader at no time come in contact with uncovered and newly applied seal coat. The spreader shall produce a uniform closely packed carpet of chippings one stone thick.
- (2) Sufficient trucks and loading equipment shall be employed to ensure an adequate, prompt and continuous supply of chippings.
- (3) Should it become apparent that the supply of chipping is about to run out, the seal coat spraying shall be immediately stopped and not recommenced until an adequate supply of chippings is assured.
- (4) The aggregate shall be clean and dust free when spread.
- (5) The aggregate shall have been pre-coated at least 4 days and not more than 28

days prior to the use of the aggregate. Where in the opinion of the Engineer the pre-coating of the aggregate is not satisfactory, or for any reason the aggregate is not satisfactory then the Contractor shall either pre-coat the aggregate again or replace the sealing aggregate at his own cost.

(6) Starting, stopping or turning any piece of equipment which results in displacement of the cover material or damage to the seal coat shall be prohibited.

(7) The spreading equipment shall be of such width and arrangement that as the aggregate is placed, complete coverage is obtained. No brooming of the cover material shall be permitted prior to initial rolling. Any rearrangement of the cover material shall be done by manual methods. Overlapping applications of cover material shall be avoided and all spillage shall be removed from the surface.

Before rolling commences, the seal coat shall be uniformly covered. Any deficient areas shall be covered by additional material.

< 4 > Rates of Application

(1) The rate of application of seal coat shall be such rate as is ordered by the Engineer following the construction of the trial lengths according to < 8 >.

(2) The rate of application of cover material shall be such coverage as is ordered by the Engineer following the construction of the trial lengths according to < 8 >.

(3) The Engineer may alter the rates of application whenever he deems it necessary or desirable.

< 5 > Manipulation

(1) The second course shall be manipulated in the manner specified for the first course.

< 6 > Maintenance of Completed Work

(1) The second course shall be maintained in the manner specified for the first course.

< 7 > Tolerances

(1) The final average overall width of the dressed surface measured at seven equidistant points over any length of 100 m shall be at least equal to the width specified or ordered. At no point shall the distance between the centre-line of the road and the edge of the bitumen surface be narrower than that specified or ordered by more than 25 mm.

(2) The rate of application of seal coat and cover material along or across the road shall not vary by more than 10% of the rate ordered. The average rates of application of the seal coat and the cover material, calculated over a length of 200 metres shall be at least equal to the rates ordered.

(3) The completed surface dressing shall be of uniform mosaic without bleeding or balding and shall be free of any loose cover material or seal coat spillage.

(4) Any area showing signs of bleeding or loss of cover material after opening of the section to traffic shall be rectified to the satisfaction of the Engineer at the cost of the

Contractor.

(5) The corrective work may be effected as a third seal, by removal and replacement of the defective work or by other approved measures, and the Contractor shall carry out these promptly to the satisfaction of the Engineer. The corrective works shall be executed in such a manner that they blend in colour, textures and finish with the adjacent work.

< 8 > Trial Lengths

(1) The Contractor shall, before he commences the work proper, construct a trial length of at least 30 metres to check all operations he proposes to use in the Permanent Works and to ascertain all necessary information to establish application rates and manipulation requirements. The trial shall be undertaken, in the presence of the Engineer, using the same materials, plant and equipment and shall mirror the application and manipulation procedures proposed for the Permanent Works.

(2) Prior to the trial the Contractor shall prepare and submit to the Engineer a draft Technical Method Statement for this work, and will obtain the approval of the Engineer thereto before he commence the trial.

(3) The trial length shall be repeated if in the opinion of the Engineer the previous trial was unsatisfactory and/or failed to provide the necessary information for determination of application rates and manipulation requirements.

(4) Trial lengths shall be constructed as required, and trial lengths shall not form part of the Permanent Works. Trial length shall be done outside project road on a surface approved by the Engineer. They may, however, form part of a temporary traffic detour subject to the approval of the Engineer.

(5) Construction of trial lengths shall continue until all aspects are, in the opinion of the Engineer, fully satisfactory, following which the Contractor shall finalise and submit to the Engineer for approval the Technical Method Statement for the work.

(6) This Method Statement is to be approved by the Engineer before the Permanent Works for the work commence. The Method Statement will define the rates of application of seal coat and cover material, the number of manipulation passes and all other aspects to clearly and unambiguously specify the procedures to be used in the Permanent Works.

(7) All work carried out for Permanent Works construction will follow the approved final Technical Method Statement and deviations thereto will not be allowed except with the specific written approval of the Engineer. Deviations will not only cover the procedures adopted but will also encompass changes of equipment, and replacement of personnel including distributor and spreader operators and roller drivers.

(8) Where, in the opinion of the Engineer, deviations are of such magnitude that the results of the trial length are no longer applicable and/or where the quality of the finished work is being prejudiced, the Engineer will order the works to cease until such time as further trial length(s) are constructed and approved.

< 9 > Other Requirements

(1) Weather and Temperature Limitations

1. Seal coat shall not be applied on a damp surface or when the surrounding surface temperature is below 15 °C or when, in the opinion of the Engineer, weather conditions prevent the proper construction of the seal coat.

(2) Protection of Adjacent Structures

1. When bituminous materials are being applied, the surface of all structures, guard rails, kerbs and gutters, and other roadway appurtenances and trees shall be protected in an approved manner to prevent them from being splattered with bituminous material or marred by equipment operation. In the event that any appurtenances become splattered or marred, the Contractor shall at his own expense, remove all traces of bituminous materials, and repair all damage, and leave the appurtenances in an approved condition.

(3) Working Periods

1. Surface dressing operations shall be so conducted that all manipulation work specified can be completed before sunset and under favourable weather conditions as determined by the Engineer.

< 10 > Traffic Control

(1) Traffic shall be prevented from running on the surface courses until at least 24 hours after the manipulation work has been completed, unless otherwise ordered or permitted by the Engineer.

(2) When directed by the Engineer the Contractor shall direct both the construction traffic and the passing traffic onto the completed first seal.

(3) The Contractor shall at his own cost provide any necessary speed restriction and warning and diversion signs and barriers for traffic control, and traffic shall be so regulated to ensure that it causes no damage to the seal.

(4) The Contractor shall post signs restricting the speed of traffic to 20 km/h on the surface dressing for such periods as directed by the Engineer. When instructed by the Engineer for the first two weeks the Contractor shall erect barriers restricting the width of the road and daily move them such that traffic runs across the complete width of the aggregate in the course.

(5) The Contractor shall make good at his own cost and in a manner approved by the Engineer any defects or damage to the seal for a period of 14 days, or other such period specified by the Engineer, before the application of any additional surface dressing courses or asphalt.

417.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
417-1	Second seal	Metre Square

417.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

4.2 REHABILITATION OF GRAVEL ROAD

CODE 421 EXCAVATING UNSUITABLE MATERIALS

421.01 DESCRIPTION

(1) This work is to remove unsuitable material and install graded material which is approved by the Engineer.

421.02 MATERIALS

< 1 > Sources of Material

(1) Material for gravel wearing course may be obtained from (i) Borrow pits, (ii) Spoil areas, (iii) Excavation in cuttings (widened if necessary) or Crusher.

(2) If crushed aggregate is used, it shall first be screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least one mechanically fractured face.

(3) Where a source of material is available for inspection during the Tender Period the Contractor shall satisfy himself as to the nature and amount of work involved, particularly in respect of the volume of overburden, the quality of material, the degree of selection necessary, the method of extraction, and access to the source of the material.

< 2 > Grading Requirements

(1) The material shall consist of natural soil or a mixture of natural soils, containing mainly gravel and coarse sand or can consist of a crushed aggregate. The gravel wearing course shall contain a higher clay content than granular base course and shall have a higher plastic limit in order to provide for sufficient binding and cementing of the gravel wearing course. Sometimes natural gravel will meet these specifications, but often the natural gravel has to be screened or two materials be mixed to improve the gradation.

(2) The gravel material shall conform to the following grading requirements and the grading shall be a smooth curve within and approximately parallel to the below envelope. Testing of grading shall be done according to AASHTO T 27.

Grading Requirements

AASHTO Sieve (mm)	Percent Passing (by weight)		
	< 50 mm*	< 25 mm	< 9.5 mm
50.0	100		
37.5	95 – 100		
25.0	70 – 100	100	
19.0	55 – 100	85 – 100	
9.5	50 – 80	65 – 100	100
4.75	40 – 60	50 – 85	80 – 100
2.36	30 – 50	40 – 70	50 – 80
0.425	15 – 30	25 – 45	25 – 45
0.075	5 – 15	10 – 25	10 – 25

* This gravel material (<50 mm) should be used only in areas with lack of better materials and after decision by the Engineer.

< 3 > Other Requirements

(1) Materials shall comply with the following requirements:

Gradation	According to Table 312.1	AASHTO T 27
CBR (4 days soaked)	minimum 30 %	AASHTO T 193
Liquid limit	maximum 40 %	AASHTO T 89
Plasticity index	6 – 15 %	AASHTO T 90
Compaction	95 % MDD	AASHTO T 180, Method D
Maximum size of aggregate	25 mm	

(2) In dry areas, ideally the Plasticity Index shall be 10 %, otherwise corrugation and gravel loss could be excessive.

(3) Minimum three tests, -covering Gradation, CBR, Liquid Limit and Plasticity Index-, on the material in each borrow pit are required. After the material has been placed on the road, as least 2 tests per kilometre shall be made.

(4) When the material is sourced from a borrow pit, the Contractor shall demonstrate to the satisfaction of the Engineer, that the material can be excavated without being contaminated by unacceptable material. The Contractor at his own cost shall take such actions the Engineer considers necessary to ensure that the material being excavated is not being contaminated. Where in the opinion of the Engineer, the Contractor cannot extract the material from the borrow pit without contamination, then the Contractor shall obtain material from another source at his own cost.

(5) Every reasonable effort shall be made to prevent segregation of material during the loading, hauling, dumping, spreading, mixing, trimming and compacting operations.

(6) The Contractor shall make the tests required to achieve the specified quality and prior to usage of materials, approval must be given by the Engineer.

412.03 WORK PROCEDURES

< 1 > Remove Unsuitable Material

(1) Unsuitable material encountered in excavations outside the limit of cuttings as shown on the Drawings shall be removed when so instructed by the Engineer to the depths and extents directed by the Engineer and shall be backfilled and compacted with approved material as specified.

(2) When the Contractor is required to excavate unsuitable material below the existing ground surface in fill areas, the depth to which these unsuitable materials are to be removed will be determined by the Engineer. The Contractor shall schedule the work so that the authorised cross section can be taken before and after the material has been removed.

(3) Muck excavation shall be accomplished without entrapping muck within the back fill. The backfilling of the excavated area shall follow immediately behind the muck excavation so the material displaced by the backfill can be removed. The excavation shall be backfilled to the ground line or water level, whichever is higher, with rock or suitable granular material. Backfilling with rock shall consist of crushed or un-crushed rock as decided by the Engineer.

(4) Material used for temporary access or diversion roads shall not be re-used in

embankment or elsewhere without the permission of the Engineer.

< 2 > Install New Material

(1) Surface Preparation

1. Existing formation shall have been prepared as appropriate. The surface shall be shaped and compacted to the right camber and ditches shall be cleared before the gravel wearing source is placed.
2. The formation shall be cleaned of all foreign matter, and any potholes, loose material, ruts, corrugations, depressions and other defects which have appeared due to improper drainage, traffic or any other cause, shall be corrected, and if considered necessary by the Engineer, the Contractor shall scarify, water, grade and re-compact the subgrade to line and level all at his own expense.
3. Immediately prior to placing gravel wearing coarse the complete surface of the sub-grade shall be proof rolled. All subgrade and embankment layers, cuttings, benches and original ground shall be proof rolled with a loaded truck or similar with a minimum axle load of 8 tonnes. Proof rolling shall be satisfactorily completed in the presence of the Engineer and for his approval. Compliance of proof rolling shall be when an area withstands proof rolling without visible deformation or springing. Such proof rolling shall be at the Contractor's own expense. The Contractor shall at his own cost carry out any additional compaction and testing necessary to achieve the requirements specified herein for proof rolling.

(2) Placing and Spreading

1. Unless otherwise instructed by the Engineer, the Contractor shall commence placing wearing course, starting as close as possible to the source and shall work away from it so that the maximum amount of compaction is given to the wearing course by the Contractor's vehicles. The Contractor shall route his vehicles to give even wear and compaction over the whole width of the wearing course.
2. Where black cotton, or other high-swelling material, is used in the upper subgrade layers, the Contractor shall place wearing course material upon this section immediately after compaction of formation level.
3. Gravel wearing course material shall be spread only when the underlying surface has been approved by the Engineer, according to section < 2 > (1). Any material which has been placed on a surface not approved by the Engineer shall be removed at the Contractor's expense.
4. The gravel wearing course shall be constructed in compacted layers with minimum compacted thickness 100 mm and the maximum compacted thickness 150 mm. Where a greater compacted thickness is required, the material shall be laid and processed in two or more layers. The minimum gravel wearing coarse thickness shall in all cases not be less than 150 mm.
5. The gravel material shall be deposited in such quantity and spread in a uniform

layer across the full width required, so that the final compacted thickness is nowhere less than shown upon the Drawings or instructed by the Engineer.

6. When spreading the material the moisture content shall be adjusted by either uniformly mixing in water or drying out the material so that the moisture content during compaction will be between 80% and 105% of the Optimum Moisture Content (AASHTO T 180). The material shall be graded and trimmed to final line and level. Light compaction may be applied before the final trim is carried out but once approximately 25% of the compactive effort has been applied no further trimming or correction of surface will be allowed.
7. The final trim shall be done by cutting and the Contractor shall ensure that material from the trim is neither deposited in low areas nor spread across the section but graded clear of the works.
8. Following the final trim the material shall be compacted to a dry density of at least 95% MDD (AASHTO T 180). During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out by applying fog sprays of water or other approved means sufficient to maintain the surface and material within the specified limits of moisture content.
9. The material shall be handled so as to avoid segregation and the material shall be placed in uniform depth. Segregated materials shall be re-mixed until uniform. Suitable measures shall be taken to prevent rutting of the sub-grade during the spreading of the gravel wearing course material.
10. No hauling or placement of material will be permitted when, in the opinion of the Engineer, the weather or road conditions are such that the hauling operations will cause cutting or rutting of the sub-grade or cause contamination of the gravel wearing course material.
11. Gravel materials which are naturally excessively coarse needs to be brought to the required gradation as specified in sub-clause 421.02 < 2 >. This shall be done on the road by using grid-, cleat- or sheep foot rollers. Oversized particles which cannot be broken down to the required size shall be removed.

(3) Mixing

1. Mechanical stabilization of the gravel wearing course, if required, shall be done by using a grader for mixing the gravel wearing course with sand or stone or both.

(4) Compaction

1. The moisture content of the material shall be adjusted prior to compaction, by watering with approved sprinkler trucks or by drying out, so that the specified density for Gravel wearing course can be achieved with Contractor's compaction equipment. During compaction the moisture content shall be so controlled that moisture content uniformly throughout the finished layer shall be within the limits of +2% of the Optimum Moisture Content as determined in AASHTO T 180, or such other moisture content as agreed with the Engineer as a result of compaction trials. Density determinations shall be carried out in accordance with the requirements of AASHTO T 191, at a rate of 5 tests for every 2,000 square metres of completed

layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and the fifth shall be not less than the required relative density minus 3 percent. The use of AASHTO T 224 to correct for oversize particles may be required.

2. The material shall be compacted by means of approved compaction equipment progressing gradually from the outside towards the centre with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density. Rolling shall be accompanied by sufficient blading, in a manner approved by the Engineer, to ensure a smooth surface free from ruts or ridges and having the proper section and crown. The Contractor shall ensure that the required compaction is obtained throughout the Gravel wearing course layer and for the full finished width of the material. Filling outside the finished width will be necessary in order to achieve the required compaction for the full finished width of the gravel wearing course.
3. Any areas inaccessible to normal compaction equipment shall be compacted by means of mechanical tampers until satisfactory compaction is obtained.
4. Samples shall be taken from the compacted layers for testing to ensure that the compacted material complies with the requirements of sub-clause 421.02 < 3 > of the Specifications.

(5) **Compaction Trials**

1. Prior to the commencement of his gravel wearing course operations, the Contractor shall construct trial lengths as directed by the Engineer. The materials used in the trials shall be those approved for use in the Works and the equipment used shall be that which the Contractor intends to use for the work proper.
2. The objective of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the nominal number of compaction passes and the resulting density of the material.
3. The Contractor shall not proceed with gravel wearing course work until the methods and procedures established in the compaction trials have been approved by the Engineer.
4. Each trial length shall be 100 metres long, and trials shall be repeated as necessary until compaction procedures acceptable to the Engineer are achieved. The trial lengths will be incorporated in the Works provided the requirements of this Section are met.
5. Further trials shall be conducted if the materials comprising the gravel wearing course are significantly amended, or if the Engineer considers that the approved methodology is not achieving satisfactory and/or consistent and acceptable results. Contractor shall perform all such compaction trials at his own expense.

(6) Finishing

1. If the gravel wearing course, or part thereof, does not conform to the required density or finish, the Contractor shall, at his own expense, re work, water and re-compact the material, as directed by the Engineer, to the density/finish specified.
2. The Contractor shall ensure that proper drainage of the gravel wearing course is maintained at all times.
3. The gravel wearing surface shall be maintained by the Contractor in its finished condition and shall be watered, graded, reshaped, or re-compacted as necessary, until the Certificate of Completion is issued, or until the Engineer instructs that the road shall be opened to public traffic, whichever is sooner.

421.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
421-1	Excavating unsuitable materials	Metre Cube

421.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 422 RAISING OF ROAD EMBANKMENT, INCLU. NEW MATERIAL

422.01 DESCRIPTION

(1) This work is to reshape existing embankment and place additional material for rising of the height. (Corresponding to SECTION 204 and 205 of the STS.)

422.02 MATERIALS

(1) All materials shall be subject to approval of the Engineer prior to work execution.

(2) Logs, trees, stumps, weeds, grass or other organic or undesirable material shall not be placed in embankments.

(3) Materials placed in the top 300 mm of embankments shall comply with the following requirements:

Liquid limit	AASHTO T 89	maximum 40%
Plasticity index	AASHTO T 90	maximum 14%
CBR (4 days soaked)	AASHTO T 193	minimum 8%
Maximum particle size		100 mm

(4) Materials placed more than 300 mm below sub-grade elevation shall comply with the following requirements:

Liquid limit	AASHTO T 89	maximum 45%
Plasticity index	AASHTO T 90	maximum 18%
CBR (4 days soaked)	AASHTO T 193	minimum 4%
Maximum particle size		150 mm

(5) Subject to approval by the Engineer rock pieces may be used in embankment formation up to a level not more than 1200 mm below formation (i.e. finished embankment level).

(6) Suitable material (except rock) arising from excavations which has a CBR value of 8% or more and/or borrow pit materials which have CBR values of 8% or more shall, unless otherwise approved by the Engineer, be reserved for the top 300 mm of embankments so that a stronger sub-grade can be assured.

(7) Other materials if necessary for work execution.

422.03 WORK PROCEDURES

(1) The Contractor shall have in operation a sufficient number of motor graders to properly spread and maintain the surface of each layer of freshly placed embankment prior to and during rolling and compaction operations.

(2) When it is feasible, trucks, tractors or other heavy hauling equipment shall be routed over the fill in such a manner as to take advantage of the compaction thereby afforded.

(3) The Engineer shall have full authority at any time to require the suspension of the delivery of material to the embankment until previously delivered materials are properly placed and preceding layers are satisfactorily compacted, finished and tested.

- (4) The Contractor shall be responsible for the stability of all embankments and shall replace all parts which, in the opinion of the Engineer, have been damaged or displaced due to carelessness or neglect on the part of the Contractor, or due to natural causes such as storms, and are not due to the unavoidable movement of the natural ground under the embankment.
- (5) During construction, the roadway shall be kept shaped and drained at all times. When unsuitable material has been placed in the embankment, its removal shall be at the cost of the Contractor.
- (6) Embankments shall be constructed of material spread in successive layers for compaction, each layer extending over the full width of the embankment at the height of the layer. The Contractor shall ensure that the required compaction is obtained throughout each layer, including the material which after trimming will form the side slopes.
- (7) Embankment shall be placed in horizontal layers not exceeding 200 mm (loose measurement) and compacted to the specified density before the next layer is placed. Compaction up to 250 mm (loose measurement) layers can be done, if the Contractor in the opinion of the Engineer has satisfactorily proved that his equipment is capable compacting up to 250 mm (loose measurement).
- (8) All layers in embankment shall be compacted to 95% of the maximum dry density as determined according to AASHTO T 180, except for the top 300 mm of the Sub-grade where compaction shall be 98% of the maximum dry density as determined according to AASHTO T 180 Method D.
- (9) In-place field density measurements shall be determined using AASHTO T 191.
- (10) Any hard material that is not broken down by the passage of the compacting equipment shall either be removed or be broken down by harrowing or other means into individual pieces not exceeding in any dimensions the size specified in sub-clause 422.02 herein.
- (11) When the excavated material consists predominantly of rock, too large to be placed in 250 mm layers in the lower portions of embankments, the material may be placed in thickness up to the average rock dimension but not to exceed 450 mm. Rock shall not be end dumped directly on the previously completed layer of embankment. Rock shall be dumped on the layer being constructed, pushed into place, and such finer material added so as to produce a dense material which can be compacted.
- (12) Rock, broken concrete, or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.
- (13) The Contractor shall, at points to be determined by the Engineer, suspend work on embankments forming the approaches to structures until such time as the construction of the latter is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the structural work.
- (14) In the event of any slip, slide or subsidence in the earthworks extending beyond the required profile of embankment, the Contractor shall dispose of the material in the slip, and make good as required by the Engineer. The classification of material from slips or slides will be in accordance with its condition at the time of removal, irrespective of its previous

condition.

(15) Side slopes shall be neatly trimmed to the lines and slopes shown on the Drawings or as directed by the Engineer, and the finished work shall be left in a neat and acceptable condition.

(16) The Contractor shall protect the sub-grade from damage by exercising such precautions as the Engineer may deem necessary including overfilling and re-trimming to grade immediately prior to installation of the sub-base. At all times the sub-grade surface shall be kept in such condition that it will drain readily and correctly. The sub-grade shall be checked and approved before any sub-base material is placed thereon.

422.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
422-1	Raising of Road Embankment, inclu. New Material	Metre Cube

422.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

4.3 REHABILITATION OR IMPROVEMENT OF DRAINAGE AND EROSION PROTECTION

CODE 431 CONSTRUCTION OF NEW CULVERTS WITH HEADWALLS

431.01 DESCRIPTION

(1) This work is to construct new pipe culvert with its auxiliary facilities. (Corresponding to SECTION 402 of the STS.)

431.02 MATERIALS

< 1 > General

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Reinforced concrete pipe culvert shall be precast unless cast-in-place construction is shown on the Drawings or approved by the Engineer.
- (3) All materials shall comply with the requirements prescribed elsewhere in the Specifications for the various items which constitute the complete structures.
- (4) Other materials if necessary for work execution.

< 2 > Precast Pipes Manufactured Off Site

- (1) Precast pipes shall meet all applicable requirements of AASHTO M 170 or ASTM C76 (these two standards are the same), Classes I to V, or otherwise as shown on the Drawings or directed by the Engineer.
- (2) Acceptability of pipe shall be based on inspection of the finished pipe by the Engineer and/or the results of one or more of the following AASHTO T 280 tests as may be deemed necessary by the Engineer:
 - (a) the three edge bearing test for the load to produce a 0.25 mm crack and/or the ultimate load, performed on not less than 2% of all pipes furnished;
 - (b) the loading to destruction of selected pieces of pipe to determine ultimate strength, area and placement of steel and absorption characteristics of the concrete; and
 - (c) absorption tests on selected samples from the wall of the pipe.

< 3 > Precast Pipes Manufactured On Site

- (1) Pipe cast on the site shall be as detailed on the Drawings.
- (2) The acceptability of pipes manufactured on site shall be based on results obtained from laboratory cured concrete compressive strength cylinders tested in accordance with AASHTO T 22, and conforming to the other requirements stated herein.
- (3) Pipes represented by tests cylinders which fail to meet the strength requirements shown on the Drawings (but are in no case below 80% of the specified design strength), shall be marked accordingly, and may be used provided that the full length of the culvert in which they are used shall be carefully bedded in a Grade 15 concrete cradle. The minimum

thickness of the cradle under the pipe shall be 1/4 of the nominal internal diameter of the pipe, and it shall extend up the sides of the pipe to a height equal to 1/4 of the external diameter of the pipe. The concrete cradle shall extend the full width of the trench, or as ordered by the Engineer, but in no case shall it extend, at its narrowest point, less than 150 mm from the outside of the pipe on each side. Concrete cradle bedding installed for the purpose of counteracting under-strength pipe shall be at the cost of the Contractor.

(4) Pipes represented by test cylinders that fail to meet 80% of the specified design strength shall be destroyed and disposed of by the Contractor as directed by the Engineer.

< 4 > Cast in Place Pipes

(1) Cast in place pipes shall be constructed to the details shown on the Drawings or as otherwise proposed by the Contractor and approved by the Engineer. Where the Engineer determines that there has been a deviation from the approved manner of construction, this will be a basis for rejection, and the subsequent removal and reconstruction of the culvert. Cast-in-place pipes shall conform to the requirements of the appropriate Clauses of Section 500 of the Specifications.

(2) Acceptability of cast in place pipes shall be based on results obtained from laboratory cured concrete compressive strength cylinders tested in accordance with AASHTO T 22, and conformance to the other requirements stated herein.

< 5 > Testing of Precast Concrete Pipe

(1) If the Contractor elects to purchase pipe from a source off the Contract, all relevant provisions of these Specifications shall apply. Pipe not available for testing and inspection during manufacture shall be tested on the Site.

(2) The Contractor shall at his own cost, when directed by the Engineer, provide three edge bearing test equipment to allow on site testing in accordance with AASHTO T 280.

(3) The test equipment shall remain on site until such time as the Engineer releases it. The Contractor shall carry out the three edge bearing tests as ordered by, and in the presence of, the Engineer.

< 6 > Requirements for Finished Products

(1) Pipe ends shall be perpendicular to the walls and the longitudinal axis of the pipe.

(2) The inner and outer surface of the pipe shall be even and smooth. The whole pipe shall be free from fractures, cracks, honeycombing, open texture, spalls and surface roughness.

(3) The permissible variations in dimensions shall be as specified in AASHTO M 170, unless otherwise permitted by the Engineer.

(4) A wall thickness more than that required by the Drawings shall not be a cause for rejection. Pipes having local variations in wall thickness exceeding those specified in AASHTO M 170 may be accepted if the three edge bearing strength and minimum steel cover requirements are met.

(5) The following information shall be clearly marked on each section of the precast concrete pipe:

- ✓ pipe class and internal diameter
- ✓ date of manufacture
- ✓ name or trademark of the manufacturer

< 7 > Inspection and Rejection

(1) The quality of all materials, the process of manufacture and the finished pipes shall be subject to inspection, testing and approval at the place of manufacture. The Contractor shall make the necessary arrangements to set aside, in a separate area, all pipes for which he desires approval.

(2) Pipes shall be rejected if they fail to conform to any of the specified requirements or if they have:

- (a) serious fractures or cracks; or
- (b) defects that indicate imperfect proportioning, mixing and moulding; or
- (c) surface defects indicating honeycombed or open texture or exposure of reinforcement; or
- (d) exposed or seriously misplaced reinforcement (verified by checking with an approved concrete reinforcement cover meter); or
- (e) damaged or cracked ends where such damage would prevent a satisfactory joint.

(3) Precast pipes with minor damage resulting from imperfections in manufacture or from handling and transporting may be repaired in the field, subject to the approval of the Engineer. The repairs shall be sound, properly finished and cured and the repaired pipe shall conform to the requirements of the Specifications in all respects. The repairs shall be subject to the approval of the Engineer before being utilised in the works.

431.03 WORK PROCEDURES

< 1 > Preliminaries

(1) Existing culverts and roadside ponds are currently used by the local population for a variety of uses. Prior to starting work at any culvert location the Contractor shall consult with the village head and take steps to ensure the work has a minimum detrimental impact on the use by the local population. The findings of each consultation shall be reported in writing to the Engineer.

(2) Proposed culvert locations/levels as shown on the Drawings are approximate only and may need to be adjusted to best suit the existing topographic conditions on site.

(3) At least 4 weeks before the Contractor proposes to commence construction at a culvert location (proposed or existing) he shall conduct a detailed topographical area measurement of the culvert location including the upstream and downstream stream

channels. The Contractor shall document the survey as a plan with appropriate cross sections and submit the same to the Engineer who will instruct the exact levels/extents to which the culvert works are to be constructed.

< 2 > General

- (1) Pipe culverts shall be installed in trenches excavated through previously constructed and compacted embankment or natural ground.
- (2) Trenches shall be excavated straight and true to the lines and levels shown on the Drawings.
- (3) When pipes are placed in embankment, the trench shall be made after completing the embankment to the height above the pipes as shown on the Drawings or directed by the Engineer.
- (4) All trenches shall be excavated to such width as will give adequate room in the trench for the proper support of the sides of the trench, and shall be excavated to a sufficient depth and width to enable the pipe and any specified or agreed joint, bedding, haunching and surround to be accommodated. If not shown otherwise on the Drawings, trenches shall be of sufficient width to accommodate Contractor's available compaction equipment (e.g. plate compactor) in the trench at both sides of the culvert for proper compaction, up to a level 300 mm above the top of the pipe barrel, to facilitate backfilling.
- (5) The Contractor shall replace at his own cost any pipes damaged by compaction equipment when embankment is placed over previously installed pipes.
- (6) Once a trench has been excavated, the laying of bedding and pipes and the backfilling shall be performed as soon as practicable. If delay is inevitable for any reason, the Contractor shall take all necessary steps to protect the exposed trench.
- (7) Masonry works on headwalls, wing-walls and aprons shall be done according to the design documents.

< 3 > Additional Requirements

- (1) Before any pipes are laid or any bedding material placed in the trench, the base of the excavation shall be trimmed true to cross section and gradient.
- (2) Any part of the trench bottom which is disturbed or damaged shall be excavated to such additional depth as may be required by the Engineer and be made up to the proper level with suitable material and compacted to the approval by the Engineer.
- (3) A layer of soil of adequate thickness above the base level shall be left to be compacted down to the designated level. The base of the excavation shall be tamped or rammed firm.

< 4 > Bedding

- (1) The type of bedding shall be as ordered by the Engineer, and will vary depending on the type of soil encountered.

(2) The shape, dimensions and the construction requirements for the bedding type shall be in acceptable conformance with the Drawings.

< 5 > Installation

(1) The pipe shall be carefully laid true to the lines and grades given, with groove ends upstream, and with the tongue end entered the full length into the adjacent section of pipe.

(2) The pipe placement shall begin at the downstream end.

(3) Each segment of pipe shall be in contact with the shaped bedding throughout its full length. Where variable shell thickness is encountered, the interior surface of those pipes shall be reasonably flush and even.

(4) Any pipe which is not in true alignment or which shows any undue settlement after laying shall be taken up and re-laid at the Contractor's cost. When shown on the Drawings or directed by the Engineer, sufficient camber shall be built into the pipe structure to allow for settlement from fill loads.

< 6 > Joints in New Culverts and Culvert Extensions

(1) All joints shall be sealed with an approved jointing mortar consisting of 1 part Portland cement to 2 parts sand by volume. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar, but shall in no case exceed 27 litres per 50 kg sack of cement. Sand shall conform to AASHTO M 45 and cement shall conform to AASHTO M 85.

(2) The contact areas shall be clean and damp when mortar is applied. After applying mortar to the entire interior surface of the groove, the tongue end shall be forced into position. Any remaining voids in the groove shall be filled with a bead of mortar built up around the joint. Internal joints shall be finished flush with the surface of the pipe. The external surface of joints shall be cured with burlap, and kept thoroughly moist for a minimum of 3 days.

(3) If rubber gasket type of pipe is used, the joints shall be installed in accordance with the manufacturer's recommendations and care shall be taken that the gasket is not displaced.

(4) The interiors of pipes shall be kept free from all dirt, excess mortar and other foreign material as the laying work progresses, and shall be left clean on completion.

(5) At joints between existing culverts and culvert extensions, the head wall shall be broken out carefully to expose the end of the pipe. The joint between the new pipe and the existing shall be as detailed for the joints between new pipes.

< 7 > Existing Joints Sealed with Sand/Cement Mortar

(1) These joints are generally to be found in pipes with diameters greater than 1 metre.

(2) Where instructed by the Engineer the existing joint shall be raked out to a minimum depth of 50 mm and the joint cleaned with a high pressure hose of water or otherwise to the satisfaction of the Engineer.

(3) The joint shall be backfilled with a cement sand mortar with proportions in the range of 1:2 to 1:2.5. The amount of water shall be no more than is required to produce a stiff mix with sufficient workability to be applied so as to fill the joint.

< 8 > Existing Joints Sealed with Bituminous Material

(1) These joints are generally to be found in pipes of 1 metre diameter or less.

(2) Where instructed by the Engineer the existing joint shall be raked out to a minimum depth of 20 mm or to sound existing joint material, and the joint cleaned. The method of cleaning shall be in accordance with the printed instructions of the manufacturer of the replacement material and good practice, as approved by the Engineer.

(3) The replacement material shall be a proprietary rubberised bituminous joint sealant manufactured specifically for the intended purpose by a reputable manufacturer, supported by documentary evidence of test results, and approved by the Engineer.

< 9 > Handling

(1) During loading and unloading operations pipes must be handled by approved lifting tackle. Unloading by rolling down planks or any other form of inclined ramp will not be allowed without the specific written approval of the Engineer.

(2) Lifting devices shall have a sufficient bearing area on the pipe to prevent damage resulting from a concentration of stresses.

(3) Movement of construction equipment over a culvert shall be at the Contractor's risk. Any pipe damaged thereby shall be repaired or replaced to the satisfaction of the Engineer at the Contractor's cost.

< 10 > Cast in Place Concrete Pipe

(1) The pipes shall be constructed in accordance with the details shown on the Drawings, or in an alternative manner proposed by the Contractor and approved by the Engineer. The pipe shall be carefully formed true to the required lines and grades.

(2) When the Contractor elects to construct the pipe in a trench with no external vertical forms, 40 mm of additional reinforcing steel clearance shall be provided. No additional payment will be made for the increased quantity of concrete required.

(3) Longitudinal construction joints will only be permitted as shown on the Drawings. Transverse construction joints may be permitted subject to the prior approval of the Engineer. Continuance of such approval shall be contingent on the construction of the joints in a satisfactory and acceptable manner.

(4) All forms for cast in place pipe shall be approved by the Engineer prior to their use. The internal forms shall be of metal suitably stiffened and supported so as not to yield during the placing of the concrete. The face of the forms shall be such as to provide a smooth and even internal surface.

< 11 > Pipe Culvert Inlet and Outlet Structures

(1) Inlet and outlet structures shall be of concrete or stone masonry as specified on the Drawings, and shall be adapted to the drainage system to form a natural and smooth water course.

< 12 > Backfilling

(1) Backfilling shall conform to the requirements as specified herein.

(2) Whenever practicable, backfilling shall be undertaken immediately after the preceding operations have been inspected and approved by the Engineer, so as to reduce the length of trenches open at any one time.

(3) Materials for backfill on each side of the culvert for the full trench width and to an elevation of 300 mm above the top of the culvert shall be fine, readily compatible soil or granular material selected from excavation or from a source of the Contractor's choice, and shall not contain stones that would be retained on a 50 mm sieve, lumps of highly plastic clay, or other objectionable material.

(4) Granular backfill material shall have not less than 95 percent passing a 12.5 mm sieve and not less than 95 percent retained on a 4.75 mm sieve. Oversized material, if present, shall be removed at the source of the material unless otherwise approved by the Engineer.

(5) Backfill material shall be placed at or near optimum moisture content and compacted in layers not exceeding 150 mm (compacted) on both sides to an elevation 300 mm above the top of the pipe. Care shall be exercised to thoroughly compact the backfill under the haunches of the pipe. The backfill shall be brought up evenly on both sides of the pipe for the full required length.

431.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
431-1	Construction of New Culverts with Headwalls	Metre Liner

431.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 432 CONSTRUCTION OF BOX CULVERT**432.01 DESCRIPTION**

- (1) This work is to construct new box culvert with its auxiliary facilities.
- (2) It also includes the resealing of damaged joints in existing culverts, as required. (Corresponding to SECTION 401 of the STS.)

432.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) All materials shall comply with the requirements prescribed elsewhere in the Specifications for the various items which constitute the complete structures.
- (3) Other materials if necessary for work execution.

432.03 WORK PROCEDURES

< 1 > Preliminaries

- (1) Existing culverts and roadside ponds are currently used by the local population for a variety of uses. Prior to starting work at any culvert location the Contractor shall consult with the village head and take steps to ensure the work has a minimum detrimental impact on the use by the local population. The findings of each consultation shall be reported in writing to the Engineer and work shall not proceed without the Engineer's approval.
- (2) Proposed culvert locations/levels as shown on the Drawings are approximate only and may need to be adjusted to best suit the existing topographic conditions at the site.
- (3) At least 4 weeks before the Contractor proposes to commence construction at a culvert location (existing or proposed) he shall conduct a detailed topographical area of the culvert location including the upstream and downstream stream channels. The Contractor shall document the survey as a plan with appropriate cross sections, and submit the same to the Engineer who will instruct the exact levels/ extents to which the culvert works are to be constructed.

< 2 > Excavation of Trenches

- (1) Excavation of foundation trenches and backfilling shall conform to the design documents.
- (2) Aprons and key walls shall generally be carried down to the depth shown on the Drawings at both ends, but the Engineer may order such additional depth as is necessary to prevent undermining.
- (3) Where, in the opinion of the Engineer, the bearing capacity at the foundation level is insufficient or the foundation material is otherwise unsuitable, the Contractor shall remove the unsuitable material to at least 0.50 metres below foundation level and replace it with an approved free draining material, or a granular backfill and compacted as directed by the

Engineer.

(4) Where rock, hardpan or other unyielding material is encountered less than 0.30 metres below the bottom of the base slab under box culverts, or in rock cuts where rock is not uniform over the whole length of culvert, trenches for box culverts shall be excavated down to 0.30 metres below the bottom of the base slab. This extra depth excavation shall be backfilled with an approved free draining material, or a granular backfill. The backfill material shall be uniformly distributed in layers not exceeding 150 mm and compacted to the required density.

(5) Where rock is uniform over the whole length of a box culvert, trench excavation shall be carried down only to the bottom of the slab. If the Contractor excavates below the required levels, he shall backfill the over-depth excavation with Grade 15 blinding concrete at his own cost.

(6) Where the Contractor is instructed to replace an existing roof slab on an existing culvert, excavation will be measured in the same way as structural excavation for a footing having the same plan area as the slab to be replaced. The volume shall be that between the top of the slab and the surveyed section through the existing road along the centreline of the culvert. Removal of the roof slab will be measured as removal of structure.

< 3 > General

(1) After the foundation material has been approved by the Engineer and before the foundation deteriorates in any way, it shall be covered with Grade 15 blinding concrete with a minimum thickness of 50 mm.

(2) Box culverts shall be cast in situ in general accordance with the details shown on the Drawings, as adapted to the actual site conditions.

(3) The construction methods used shall conform to the design documents.

(4) In general, the base slab of box culverts shall be placed and allowed to set before the culvert is constructed. The side walls and top slab may be constructed as a monolith.

(5) If the concrete in the walls and top slab is placed in two separate operations, special care shall be exercised in order to secure bonding in the construction joint and appropriate keys shall be left in the sidewalls for anchoring the top slab.

(6) Each wing-wall shall be constructed, if possible, as a monolith. Construction joints where unavoidable, shall be horizontal and so located that no joints will be visible in the exposed face of the wing-wall above the ground line.

(7) Vertical construction joints shall be at right angles to the axis of the culverts.

(8) Masonry works on headwalls, wing-walls and aprons shall be done according to applicable parts of the design documents.

< 4 > Inlet and Outlet Structures

(1) The layout of the inlet and outlet structures may be modified at the discretion of the Engineer, based on the actual natural conditions at each site, and the standard details shown

on the Drawings.

(2) The inlet and outlet scour and erosion protection measures shall be constructed from gabions, mattresses or masonry as specified on the Drawings and shall be adapted to the drainage system to form a natural and smooth watercourse.

< 5 > Extension of Existing Box Culverts

(1) Existing box culverts shall be extended in reasonably close conformity with the details shown on the Drawings.

(2) Concrete and reinforcement details and dimensions shall be as shown on the Drawings for new box culverts, but adapted to the size of the culvert to be extended.

(3) Where required, existing inlet or outlet structures and culvert barrels shall be removed to the satisfaction of the Engineer.

(4) The joints between existing and new parts shall be deformation joints conforming to the details shown on the Drawings and specified herein.

< 6 > Culvert Joints

(1) The existing wing-walls and headwall shall be broken out carefully and to the extent necessary to expose sound concrete the end face of the barrel. Any longitudinal steel through the joint shall be cut back to give 30 mm of cover to the new end faces. The exposed end shall be made good to a vertical plane.

(2) The joint between the existing concrete and the extension shall consist of an approved 12 mm thick, bitumen impregnated fibre board that remains resilient when saturated.

< 5 > Repairs and Refurbishment

(1) Any other repair or refurbishment to box culverts instructed by the Engineer, will be deemed to be refurbishment of structure and will covered and paid for.

432.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
432-1	Construction of Box Culvert	Metre Liner

432.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 433 CONSTRUCTION OF NEW DITCHES

433.01 DESCRIPTION

(1) This work is to construct new ditches with its auxiliary facilities. (Corresponding to SECTION 404 of the STS.)

433.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) All materials shall comply with the design documents
- (3) Other materials if necessary for work execution.

433.03 WORK PROCEDURES

< 1 > Excavation

- (1) Excavation operations shall be conducted without disturbing the material outside the staked construction limits.
- (2) Prior to the start of excavation operations, all necessary clearing, grubbing and top soil removal in that area shall be completed.
- (3) In steeply side-sloping terrain, unless otherwise specifically approved by the Engineer in writing, surplus material blasted or excavated from the upper side slope shall not be allowed to be deposited over the lower side slope, and special care shall be taken to preserve vegetation on the lower side slope for the purpose of erosion protection. No material shall be disposed of close to culvert or bridge locations or adjacent to any water course or irrigation facility or at locations where any private properties or crops etc. on the lower side slope, could be damaged.
- (4) If services or obstructions not shown on the Drawings are discovered prior to or during excavation, the Engineer shall be notified immediately.
- (5) Over-depth excavation below the elevation approved by the Engineer and over-width excavation beyond the lateral limits shown on the Drawings or directed by the Engineer, shall be backfilled with grouted rip-rap or concrete, at the Contractor's cost.

< 2 > Reinforced Concrete for Drains, Wash Checks, and Inlet and Outlet Structures

- (1) These shall be constructed to the dimensions shown on the Drawings with Grade 25 concrete in accordance with the design documents.
- (2) The locations shown on the drawings may be subject to variation based on the final road alignment and therefore all locations shall be confirmed by the Engineer prior to construction.
- (3) The foundation surface shall be compacted to not less than 95% of maximum dry density as determined by AASHTO T 180.

- (4) Reinforcement for drains shall be 8 mm bars at 150 mm C-C in either direction, both faces.
- (5) Reinforcement for inlet and outlet structures shall be as indicated on the drawings.
- (6) Construction joints for drains shall be provided at intervals of 4 metres or as otherwise directed by the Engineer.

< 3 > Grouted Rip-rap or Stone Masonry Ditch Lining, Aprons, Wash Checks, and

- (1) The construction shall be in accordance with the design documents.
- (2) The foundation surface shall be compacted to not less than 95% of maximum dry density as determined according to AASHTO T 180.
- (3) The stones shall be placed in rows transversely to the centreline of the ditch and be placed with ends and sides abutting and the joints between stones in each row breaking with the joints in the preceding row.
- (4) After completing the laying work, the edges of the paved ditch adjoining the ground surface and shoulders shall be shaped and compacted to the required cross section.
- (5) The stones for wash checks shall be laid to form a structure of the dimensions shown on the Drawings. The sides and ends of the stones shall be in contact as much as the sizes and shapes of the stones will permit.

< 4 > Loose Rip-rap Erosion Protection

- (1) The construction of loose rip-rap erosion protection shall be in accordance with the design documents.

< 5 > Gabion Apron Protection

- (1) The construction shall be in accordance with the design documents.
- (2) The foundation surface shall be compacted to not less than 95% of maximum dry density determined according to AASHTO T 180.

433.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
433-1	Construction of New Ditches	Metre Square

433.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 434 CONSTRUCTION OF SCOUR CHECKS**434.01 DESCRIPTION**

(1) This work is to construct scour checks by using masonry, wood, stone and/or concrete to reduce the speed and erosion force of the water within unlined ditch.

434.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Masonry (gravel-8: sand-4: cement-1), stone/rock, wood and turf.
- (3) Other materials if necessary for work execution.

434.03 WORK PROCEDURES

- (1) Excavate a slot across the ditch to 100mm below the ditch invert level.
- (2) Place wooden stakes, masonry, or stone such that the cross-section of the ditch is fully covered and the top level of the scour check is 100mm below the level of the edge of the ditch.
- (3) Place masonry or stones in the ditch invert downstream of the scour check for a distance of 0.5 m to prevent scouring in this area.
- (4) The scour checks must not be too high otherwise water will be forced onto the surrounding ground, the shoulder or the carriageway. The scour check construction should therefore be controlled with the aid of a template.
- (5) Scour checks should not be constructed on ditches with gradients of less than 4%. This will encourage too much silting of the drain and could lead to road damage.
- (6) The gradient of the side drain should be checked with an abney level or line and level to determine the requirements for scour checks.
- (7) After the basic scour check has been constructed, an apron should be built immediately downstream either using stones or grass turfs pinned to the ditch invert with wooden pegs. The apron will help resist the forces of the water flowing over the scour check.
- (8) Grass sods should be placed against the upstream face of the scour check, to prevent water seeping through the scour check and to encourage the silting behind the scour check.
- (9) The long term objective is to establish complete grass cover over the silted scour checks to stabilize them.
- (10) All unnecessary and excess materials should be disposed to the safe place.
- (11) Make the site clean and tidy.

434.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
434-1	Construction of scour checks	Metre Liner

434.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 435 EROSION PROTECTION BY GABIONS

435.01 DESCRIPTION

- (1) This work is to install gabion boxes for prevention of collapse and erosion on slope. (Corresponding to SECTION 601 of the STS.)

435.02 MATERIALS

< 1 > Stones

- (1) Stones for box gabions and gabion mattresses shall be hard, durable, quarried or natural stone with no obvious planes of weakness, weak laminations and cleavages, and shall not disintegrate when submerged in water or exposed to severe weathering.
- (2) At least 30 days before delivery to the site, the contractor shall inform the engineer in writing of the source from which the rock will be obtained. The test data and other information by which the material was determined by the contractor to meet the specification are included. The contractor shall provide the engineer free access to the source for the purpose of obtaining samples for testing and source approval.
- (3) The apparent specific gravity shall be not less than 2.5, and absorption shall be a maximum of 6% when tested in accordance with AASHTO T 85.
- (4) Abrasion loss shall not be more than 45% when tested according to AASHTO T 96 (500 revolutions).
- (5) Rock for box gabions shall have a dimension of between 100 mm and 250 mm. The minimum dimension shall not be less than half the maximum dimension.
- (6) Gabion mattress rock shall have a maximum dimension of between 80 mm and 200 mm. The minimum dimension shall not be less than half the maximum dimension.

< 2 > Mesh and Wire

- (1) Gabions shall be constructed of wire mesh of galvanised steel wire of minimum diameter of 2.70 mm with a 0.5 mm thick PVC coating, capable of resisting effects of exposure and highly corrosive environment. Alternatively, if approved by the Engineer, galvanised steel wire of minimum diameter of 3.0 mm without a PVC coating can be used. The tensile strength of the wire shall be in the range of 400 to 600 MPa, determined in accordance with ASTM A392. The minimum zinc coating of the wire shall be 240 g/m² of uncoated wire surface in accordance with ASTM A90.
- (2) The mesh shall be twisted to form hexagonal openings of uniform size. The linear dimension of the mesh opening shall not exceed 100 mm and the area of the mesh opening shall not exceed 8,000 mm². The mesh shall be fabricated in such a manner as to be non-ravelling, where non-ravelling is defined as the ability to resist pulling apart at any of the twists or connections forming the mesh when a single wire in a section is cut.
- (3) Gabions shall be delivered folded flat to facilitate transport and handling, and shall be furnished in dimensions corresponding to the various basket lengths and heights required by the Drawings.

- (4) Gabions shall be fabricated in such a manner that the sides, ends, lid and diaphragms can be assembled at the construction site into rectangular baskets of the specified sizes. Gabions shall be of single unit construction, lids, ends and sides shall be either woven into a single unit or one edge of these members connected to the base section of the gabion in such a manner that the strength and flexibility at the point of connection is at least equal to that of the mesh.
- (5) The gabion shall be equally divided into cells by diaphragms of the same mesh and gauge as the body of the gabion. The cells shall be no more than 1.0 m x 1.0 m plan size.
- (6) The gabion shall be furnished with the necessary diaphragms secured in proper position on the base in such a manner that no additional tying at this junction will be necessary.
- (7) All perimeter edges of the mesh forming the gabion shall be securely selvaged so that the joints, by tying the selvages, have at least the same strength as the body of the mesh.
- (8) Selvage wire used through all the edges (perimeter wire) shall not be less than 3.40 mm diameter (0.134 inch) U.S. Wire Gauge No. 10 and shall meet the same specifications as the wire mesh.
- (9) Tie and connection wires shall be supplied in sufficient quantity to securely fasten all edges of the gabion and diaphragms and to provide for four cross-connecting wires in each cell whose height is 1/3 or 1/2 the width of the gabion, and 8 cross-connecting wires in each cell whose height equals the width of the gabion. The wire shall meet the same specifications as for wire used in the mesh.
- (10) Box gabions shall have the following dimensions: length 2.0 m or 3.0 m, width 1.5 m, 1.0 m or 0.5 m, and height 0.5 m or 1.0 m.
- (11) Gabion mattresses shall have the following dimensions: length 3 m or 6 m, width 2 m or 3 m, and height 0.25 m, 0.30 m, 0.35 m or 0.50 m.

< 3 > Geotextile Sheeting

- (1) Fibres used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 85% by weight of polyolefins, polyesters, or polyimids conforming to AASHTO M 288 Class A or B. The density shall be at least 200 g/ m² or as approved by the Engineer.
- (2) Geotextile sheeting rolls shall be furnished with a wrapping for protection against moisture and ultraviolet exposure before placement.

435.03 WORK PROCEDURES

< 1 > Foundations

- (1) The foundations shall be excavated to a smooth surface and to the depth shown on the Drawings or ordered by the Engineer.

(2) Soft, unstable material at foundation level shall be removed and replaced with suitable materials approved by the Engineer.

(3) The foundation shall be firm and compacted to the Engineer's satisfaction. Geotextile sheeting shall be placed on the foundation where shown on the Drawings or ordered by the Engineer.

< 2 > Positioning

(1) Gabions shall be installed in a workmanlike manner.

(2) The baskets shall be positioned in accordance with the Drawings and shall be held in place by tie rods to prevent deformation. The tie rods shall be bars with a minimum diameter of 12 mm.

(3) All perimeter edges of the gabion mesh shall be securely clip bound or selvaged. The baskets shall be lifted into a vertical position and attached together with binding wire. Binding shall be carried out in a continuous lacing operation. The wire shall be passed through each mesh and around the selvages.

(4) Tie wire shall be supplied to provide at least four cross connecting wires in each cell whose height is equal to the cell width, and at least two cross connecting wires in each cell whose height is one half of the cell width.

< 3 > Filling Stones

(1) Before stones are placed in the baskets, each gabion unit shall be assembled and the empty gabion units set to line and grade as shown on the Drawings or as directed by the Engineer. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure. A fence stretcher, chain fall, or iron rod may be used to stretch the wire baskets and hold alignment.

(2) The placing of stones shall be done by hand by skilled labour. The baskets shall be slightly over filled to allow for subsequent settlement. Voids shall be minimised.

(3) Rounded stone shall not be used unless permitted by the Engineer, in which case the Contractor shall exercise the maximum care to obtain gabions with plane faces, sharp corners, and sides completely filled with stones.

(4) The cells in any row shall be filled in stages so that the depth of rock placed in any one cell does not exceed the depth of rock in any adjoining cell by more than 25 cm. Along the exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to ensure a neat, compact placement with a uniform appearance.

(5) Gabions shall be levelled and aligned to the satisfaction of the Engineer. Where there is more than one course of gabions, the upper course shall be laced to the lower course.

(6) Vertical joints in the completed work shall be staggered at approximately 1/3 or 1/2 the length of the full baskets.

(7) After the gabion has been filled, the lid shall be bent over until it meets the sides and edges. If necessary only by the Engineer approved lid closing tools shall be used. The use of crowbars or other single point leverage bars for lid closing is prohibited as they may damage the baskets. The lid shall then be secured to the sides, ends and diaphragms, with spiral binders, approved alternate fasteners, or lacing wire wrapped with alternating single and double half-hitches in the mesh openings.

(8) Any damage to the wire or coatings during assembly, placement, and filling shall be repaired promptly in accordance with the manufacturer's recommendations or replaced with undamaged gabion baskets.

435.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
435-1	Erosion Protection by Gabions	Metre Cube

435.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 436 EROSION PROTECTION BY ROCKS

This Code remains to exist. But no longer applying the code is suggested in accordance with following reasons:

- 1) Fine grains of soil in the slope may flow out through gaps of the rocks and it may cause the slope deformation in case applying this method.
- 2) The work is compatible with other codes such as 435 and 437.

CODE 437 RIP RAP

437.01 DESCRIPTION

- (1) The purpose is to provide scour protection at the toe of slopes, culvert inlets and outlets and in ditches prone to scouring.

437.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) Cement, stone and sand.
- (3) Other materials if necessary for work execution.

437.03 WORK PROCEDURES

- (1) The section to be treated shall be trimmed to line and level with the slope of 1 to 1.5.
- (2) Stones shall be delivered and unloaded on site.
- (3) Compact the slope to the desired shape.
- (4) Lay the stones in one layer with close joints, starting at the bottom of the slope.
- (5) Stones should be supported by soil. Smaller stones will be used to wedge them in place.
- (6) Fill voids with suitably shaped and tightly wedged spalls.
- (7) The top of the pitching should be flush with adjacent material.
- (8) When grout is specified, fill mortar cement mixture (1 cement: 4 sand) shall be filled into the spaces between stones.
- (9) Remove all excess and unwanted materials on site and disposed to a safe place.
- (10) Make the site clean and tidy.

437.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
437-1	Rip rap	Metre Square

437.05 PAYMENT

- (1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.

CODE 438 EROSION PROTECTION BY VEGETATION**438.01 DESCRIPTION**

- (1) This work is to prevent erosion on slope by vegetation (i.e. laying of live sod). (Corresponding to SECTION 609 of the STS.)

438.02 MATERIALS

- (1) All materials shall be subject to approval of the Engineer prior to work execution.
- (2) The sod shall consist of healthy, dense, well-rooted growth of permanent and desirable grasses indigenous to the general locality where it is to be used. It shall be free from weeds or undesirable grasses. The sod shall be deep rooted and sufficiently rapid growing and spreading to give complete cover over the planted area within two years of planting.
- (3) At the time the sod is cut, the grass on the sod shall have a length of approximately 50mm (if longer, the grass shall be cut to approximately this length) and the sod shall have been raked free from debris.
- (4) For block sodding, the sod shall be cut into uniform squares approximately 300mm x 300mm.
- (5) For strip sodding, the sod shall be cut into uniform strips 300mm wide and approximately 1.0metre long, rolled for convenience of handling and transportation.
- (6) The thickness of the sod shall be as uniform as possible, approximately 40mm or more depending on the nature of the sod, so that practically all of the dense root system of the grasses will be retained, but exposed in the sod strip so and that the sod can be handled without undue tearing or breaking.
- (7) In the event that the sod to be cut is in a dry condition so as to cause crumbling or breaking during cutting operations, the Contractor, at his own expense, shall apply water in sufficient quantities at least 12hours before cutting to provide a well-moistened condition of the sod to the depth to which it is to be cut.
- (8) All sods shall be subject to the approval of the Engineer.
- (9) Fertiliser shall be approved lime or mixtures of plant nutrients or both.
- (10) Other materials if necessary for work execution.

438.03 WORK PROCEDURES**< 1 > Scheduling of the Work**

- (1) Grass shall be planted at such a time and the work shall be done in such a way that at the time of the final construction inspection all areas to be grassed are substantially covered with healthy, well established, firmly rooted grass and the planted area is free from erosion channels.

< 2 > Preparation of the Earth Bed

- (1) The area to be sodded shall be constructed to the required cross-section and contour, and the tops and bottoms of the slopes shall be rounded as shown in the typical roadway section Drawings.
- (2) The areas to be sodded shall be free from stones, roots or other undesirable foreign materials.
- (3) The soil on the area to be sodded shall be loosened and brought to a reasonably fine texture to a depth of not less than 30 cm by means of equipment or hand methods adapted for the purpose.

< 3 > Placing the Sod

- (1) The earth bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be placed thereon within 24 hours after the sod has been cut.
- (2) Unless otherwise required, the sod on slopes shall be laid in horizontal strips beginning at the bottom of the slope and working upwards. When placing sod in ditches, or in the construction of sod ditch checks or similar appurtenances, the length of the strips shall be laid at right angles to the direction of the flow of the water.
- (3) Sod shall be laid so that the joints caused by abutting ends of sod strip are not continuous. Each sod strip shall be so laid as to abut snugly against strip previously laid.
- (4) As the sod is being laid it shall be lightly tamped with suitable wooden or metal tampers sufficiently to set or press the sod into the underlying soil.
- (5) At points where it is anticipated that water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil to be below the adjacent area and a layer of earth place over this juncture and thoroughly compacted. At the limits of sodded areas, the end strips shall be turned in and treated similarly.
- (6) Fertiliser shall be added at the time of planting if required in the Contract Documents or if it is necessary to ensure good ground cover within the required time.

< 4 > Staking the Sod

- (1) On all slopes steeper than one vertical to four horizontal, sod shall be pegged with stakes 200 – 300mm in length, spaced as required by the nature of the soil and steepness of slope. Stakes shall be driven into the sod at right angles to the slope until being in the same plane as the bottom of the grass blades.

< 5 > Top Dressing

- (1) After staking has been complete, the surface shall be cleared of loose sod, excess soil or other foreign material, whereupon a thin layer of topsoil shall be scattered over the sod as a top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

< 6 > Watering and Maintenance

(1) The Contractor shall regularly water and maintain sodded areas in a satisfactory condition for the duration of the Contract and until final acceptance of the Works by the Engineer. Such work shall include cutting the grass if so directed by the Engineer.

438.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
438-1	Erosion Protection by Vegetation	Metre Square

438.05 PAYMENT

(1) Payment shall be made at the rates entered in the Bill of Quantities and shall include for all operations necessary to complete the work as specified herein.