# PHILIPPINE AGRICULTURAL ENGINEERING STANDARDS

## Farm to Market Roads (Earth, Gravel, Bituminous, Concrete)

### Foreword

The pursuance of this standard was initiated by the National Agricultural and Fishery Council (NAFC) through the Agriculture and Fisheries Mechanization Committee (AFMeC).

This standard has been technically prepared in accordance with BPS Directives Part 3:2003 – Rules for Structure and Drafting International Standards.

The word “shall” is used to indicate mandatory requirements to conform to the standard.

The term “should” is used to indicate that among several possibilities one is recommended as particularly suitable without mentioning or excluding others.

The word “road carriageway” shall be used to indicate a portion of a roadway intended for the use of vehicles except the shoulder. However, words such as “traffic lanes” and “traveled way” indicate the same meaning stated for roadway carriage.

In the preparation of this standard, the following documents/publications were considered;

Agrarian Reform Infrastructure Support Project Phase II (ARISP-II) Implementation Manual on Farm-to-Market Roads Development (DAR-ARISP, Volume IV), July 2002

Department of Public Works and Highways (DPWH) Standard Specifications for Highways, Bridges and Airports, Volume II, 1995 and 2004 versions.

ISO : USAF Landscape Design 18:5 Erosion Control Measures

ISO : DelDOT Road Design Manual : Cross- Section elements : 2004

ISO : ARRB Transport Research : Environmental Best Practices – Outback Roads

ISO : Nashua, New Hampshire Board of Public Works: Standard Specifications for Road Construction: June 1986

ISO : US Department of Transportation- Report No. FWA-LT- 01-002: Dust Control on low Volume Roads: May 2001

ISO : Thorndike, Maine: Thorndike, Maine road Ordinance

ISO : TxDOT Glossary

ISO : NCDFR – Access Road Construction : Design Guidelines

## 1. Scope

This standard specifies the minimum requirements for the design and construction of one-lane and two lane earth, gravel, bituminous and concrete farm-to-market roads for use in the preparation of program of works. It includes related structures such as drainage (roadside ditch and culvert), slope protection and erosion control.

## 2. References

The following normative documents contain provisions through which reference in this text constitute provisions of this National Standard:

Agrarian Reform Infrastructure Project Phase II (ARISP-II); Implementation Manual on Farm-to-Market Roads Development, Volume IV

Infrastructure for Rural Productivity Enhancement Sector (INFRES) Project

National Irrigation Administration (NIA) FMR Project

Department of Public Works and Highways (DPWH), Standard Specifications for Highways, Bridges, and Airports, Volume II, 2004.

ISO : USAF Landscape Design 18:5 Erosion Control Measures

ISO : DelDOT Road Design Manual : Cross- Section elements : 2004

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ISO : NCDFR – Access Road Construction : Design Guidelines

## 3. General Objective:

This standard aims to formulate minimum requirements for the design and construction of Earth, Gravel, Bituminous and Concrete Farm-to-Market Roads.

### 3.1 Specifically, this standard aims to:

**3.1.1** Formulate minimum requirements on the design and construction of one-lane or two-lane road which is composed of road carriageway and road shoulder;

**3.1.2** Formulate minimum requirements for drainage structures (ditches).

## 4. Definition of Terms

For the purpose of this standard, the following definitions shall apply:

**4.1 aggregates**
granular material of mineral composition such as sand, gravel, shell, crushed and uncrushed stone or light weight materials

**4.2 backfill**
the suitable material used to replace other materials removed during construction

**4.3 base course**
the layer of aggregate, soil-treated aggregate, treated soil, or soil aggregate that rests upon the Subbase or if no Subbase, upon the sub-grade. Treatment may include application of chemical-based soil additives such as soil-stabilizers and/or any approved method

**4.4 borrow**
the suitable material used for embankments

**4.5 bridge**
structure, including supports, erected over a depression or an obstruction, such as water, a highway, or a railway; having a roadway or track for carrying traffic or other moving loads; and having an opening measured along the center of the roadway between faces of abutments, spring lines of arches, or extreme ends of the opening for multiple box culverts or multiple pipes that are 60 inches or more in diameter and that have a clear distance between openings of not less than half of the smallest pipe diameter

**4.6 clearing**
removal and disposal of trees, vegetation or other unwanted materials from the ground surface

**4.7 compaction**
application of pressure to aggregates to result in a dense mass free of excessive voids. Compaction minimizes settlement, decreases permeability and increases strength

**4.8 course**
structural component of specified thickness. It may consist of one layer or more

**4.9 culvert**
drainage structure that may or may not, directly support and that extends across and beneath a highway street, driveway, alley, arterial, or other public way

**4.10 crushed gravel**
product resulting from the mechanical crushing of gravel, with substantially all fragments having at least one face resulting from fracture

**4.11 drainage**
removal of water from the road area by the use of culverts, ditches, channels and other several structures

**4.12 earthwork**
operations connected with excavating and placing embankments with soil, earth or rock

**4.13 erosion control**
protection of soil from disclosing by water, wind, or other agent

**4.14 excavation**
act of cutting, digging, or scooping to remove material
.

**4.15 field density test**
determination of the degree of compactness of the soil

**4.16 fill**
the embankment material placed above natural ground line

**4.17 farm to market roads**
access roads that connect major road arteries to the agricultural production areas where farm produce are being mobilized and transported to the market by the farmers and fishermen

**4.18 grade**
slope of a roadway, channel, or natural ground

**4.19 gradation**
property of a soil which describes the distribution of size groups

**4.20 gradient**
rate of increase or decrease in the level of the land, the slope expressed in percentage

**4.21 grading**
preparation of the sub-grade, in line and elevation, for application of pavement materials including base and surfacing materials

**4.22 grubbing**
removal and disposal of trees, and other unwanted materials below the ground surface

**4.23 lane roadway**
roadway, which is divided into two (2) or more clearly marked lanes for vehicular traffic

**4.24 masonry**
form of stone, brick, concrete block, concrete, or other similar building materials that have been bonded together with mortar to form a structure

**4.25 one-lane earth road**
earth roadway, which one way is a clearly marked lane for vehicular traffic

**4.26 one-lane gravel road**
gravel roadway, which one way is clearly marked lane for vehicular traffic

**4.27 one-lane asphalt pavement road**
asphalt pavement roadway, which one way is clearly marked lane for vehicular traffic

**4.28 one-lane concrete road**
concrete roadway, which one way is clearly marked lane for vehicular traffic

**4.29 riprap**
quarried stone especially selected, graded and placed to prevent erosion and thereby preserve the shape of a surface, slope, or underlying structure

**4.30 road bed**
graded portion of a highway between top and side slopes, prepared as a foundation for the pavement structure and shoulder

**4.31 roadway**
space/location/site intended to employ traffic consideration for the transport of agricultural products

**4.32 road carriageway**
travel way or crown portion of the roadway intended for the movement of vehicles, exclusive of shoulders

**4.33 road carriageway width**
lateral design width for one lane or two lanes strip of roadway

**4.34 roadway embankment**
raised structure of soil, soil aggregate, sand or rock

**4.35 road shoulder**
part of the roadway next to the traveled way or auxiliary lanes that provide lateral support of base and surface courses and is an emergency stopping area for vehicles

**4.36 salvage materials**
saving of different existing materials from the projects which are removed and intended to be used in other construction

**4.37 specifications**
written technical description of materials, equipment, construction systems, standards, and workmanship that, in conjunction with the drawings, detail the requirements for acceptable completion of the work

**4.38 structures**
refer to the bridges, culverts, wall, buildings, foundations, water tanks, transmission towers, cribbing, caissons or coffer dams, other similar features which may be encountered in the work and are classified as structures

**4.39 Subbase course**
refers to the layer of the specified or selected materials of designated thickness in a pavement structure immediately above the sub-grade and below the base course

**4.40 subgrade (earth road)**
roadbed upon which the pavement structures is placed

**4.41 subgrade (gravel road)**
upper portion of material which act as foundation Subbase course

**4.42 subgrade (bituminous, concrete road**)
top surface of the roadbed upon which the pavement is placed

**4.43 traffic**
vehicular and non-vehicular movement along a route such as pedestrians, vehicles, animals, etc.

**4.44 two-lane earth road**
earth roadway, which two(2) ways are marked lanes for vehicular traffic

**4.45 two-lane gravel road**
gravel roadway, which two (2) ways are marked lanes for vehicular traffic

**4.46 two-lane asphalt pavement road**
asphalt pavement roadway, which two ways are marked lanes for vehicular traffic

**4.47 two-lane concrete pavement road**
concrete pavement roadway, on which two lanes are marked for vehicular traffic

**4.48 turn-out section**
a widened, unobstructed shoulder area, about 30 meters long, that may be used for emergency purposes or allow slow-moving vehicles to pull out of the carriageway to give passing opportunity to following or incoming vehicles

## 5. TYPICAL LOCATION OF FARM-TO-MARKET ROADS

**5.1** Roads shall conform to the land use plan of the area.

**5.2** Roads shall link or be located in the key production areas of valuable crops such as rice, corn, and other high value commercial crops, livestock and fisheries.

**5.3** Roads shall be of service to mobilize agricultural products/produce from the production areas to the nearest existing roadway systems (e.g. barangay, municipal roads, etc.).

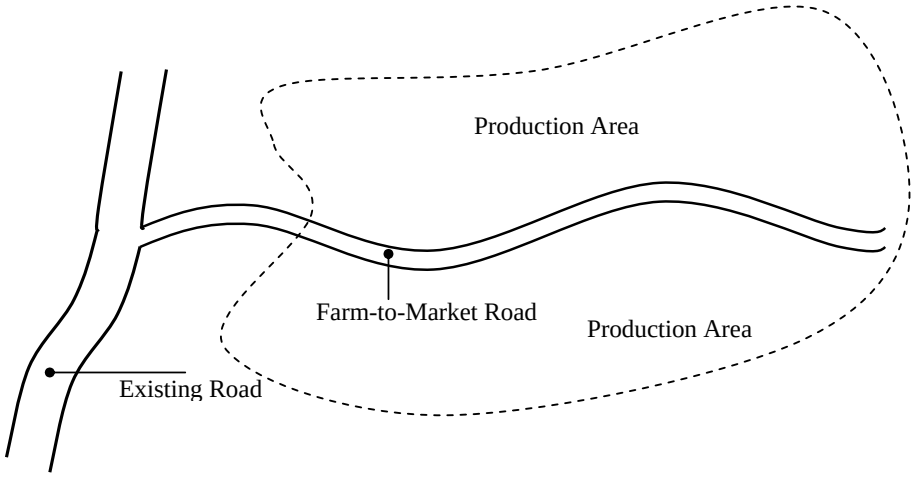



**Fig. 1: Typical Location of Farm-to-Market Road**

## 6. DESIGN CONSIDERATIONS FOR:

- Earth Road
- Gravel Road
- Bituminous Road
- Concrete Road

**6.1** The road shall provide space for the safety and comfortable movements of vehicles.

**6.2** The road shall be designed to provide ease in transportation. It should not damage the produce during transport.

**6.3** Road pavement material shall be generally stiffer than the material upon which it is placed, thus it assists the in situ material in resisting loads without excessive deformation or cracking.

**6.4** Road pavement material shall be constructed and maintained to be much smoother than in situ material. This improves riding comfort and reduces vehicle operation costs.

**6.5** The road should be constructed on high elevation and avoid going through marshy and boggy areas. It shall not be located in swampy, logged-over and flooded areas. These areas that stay wet most of the time have a lower weight bearing capacity and have a greater probability of becoming a problem area in the future.

**6.6** Steep slope shall be avoided.

**6.7** Road shall not pass through fault lines.

**6.8** Earthworks shall be minimal i.e. for sites requiring big volumes of excavation and embankments.

**6.9** Road shall minimize environmental problems such as erosion, andslides and forest denudation.

**6.10** Road shall provide adequate and efficient internal circulation within the development area.

**6.11** Minimize road congestion and unsafe conditions.

**6.12** Road shall be designed and arranged with appropriate regard for topography, creeks, wooded areas and other natural features which would enhance attractive development.

## 7. ROADWAY

### 7.1 ONE-LANE ROADWAY

- **Earth Road**
- **Gravel Road**
- **Bituminous Road**
- **Concrete Road**

There shall be provisions of turn-out (around 1-2 m wide and 30 m long) on strategic locations for maneuver of two (2) vehicles traveling in opposite directions.

A turn-out of about 1-2 meter wide and 30 meters long should be provided in critical sections especially on steep grades along mountainous areas.

Ex. If two (2) vehicles are traveling in opposite directions, each vehicle shall deviate from the lane taking the shoulder in order to give way for the other vehicle to pass.

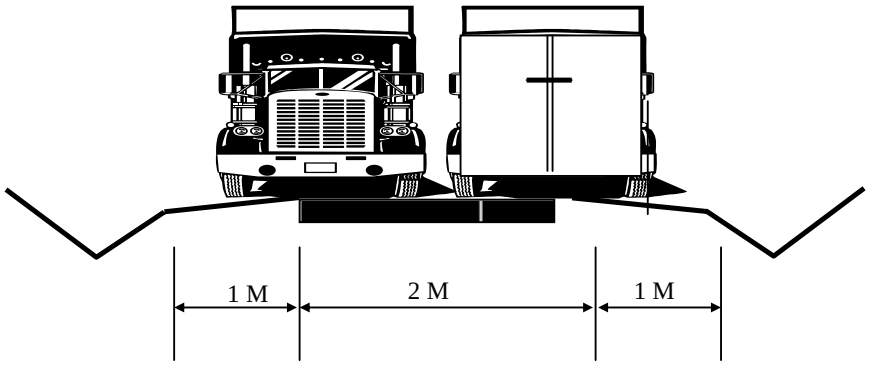



**Figure 2**

The roadway width shall be 4 meters (including shoulders).

There should be provisions of super elevations on curved sections of the road to minimize accidents.

The angle of intersection. It is preferred that the proposed roadway intersects the existing road at right angles (90 degrees). But the intersecting angles in the range of 45 – 60 degrees are acceptable. Intersection angles of 45 – 60 degrees may be used in special situations. Intersection angles less than 45 degrees are strongly discouraged.

## 7.2 ROAD CARRIAGEWAY

- Earth Road
- Gravel Road
- Bituminous Road
- Concrete Road

The road carriageway shall provide space for the safety and comfort movement of the vehicles.

The road carriageway width shall be a minimum of two (2) meters for one-lane roadway and four (4) meters for two-lane roadway.

Road carriageway width shall be measured from the edge of the roadway shoulder to the opposite side of the edge of the roadway shoulder.

The slope of the carriageway shall reduce seepage and erosion.

For earth, gravel and bituminous roads, the minimum slope shall be 3% from the center line towards the ditch. This will promote rapid runoff of surface water and minimize the amount of water which infiltrates into the roadway.

For concrete, the maximum slope shall be 1.5% from the center line towards the ditch. This will promote rapid run-off of surface water and minimize the amount of water which infiltrates into the road carriageway.

For earth, gravel and bituminous roads, the road carriageway shall be constructed with aggregate Subbase course.

For concrete, the road carriageway shall be constructed with aggregate base course.

### 7.3 ROAD SHOULDER

- **Earth Road**
- **Gravel Road**
- **Bituminous Road**
- **Concrete Road**

The shoulder provides space for stopping outside of the traffic lanes, avoiding potential accidents or reduces their severity. It shall also provide space for lateral clearance to roadside facilities such as guardrail and pedestrian use.

The shoulder shall provide structural support for the road carriageway.

The shoulder shall reduce seepage adjacent to the carriageway by discharging storm water towards the ditch.

The shoulder should provide space for occasional motorists who have to stop to consult road maps, to rest, or for other emergency reasons.

The shoulder should provide space for pedestrian and bicycle use.

The minimum road shoulder width shall be 1.0 meter. It should be filled with borrow and compacted to at least 95% density, as certified by accredited laboratory.

For concrete road, the minimum road shoulder width shall be 1.0 m. It should be Subbase compacted to the required density.

The maximum slope of road shoulder shall be 4% from the edge of the road carriageway.

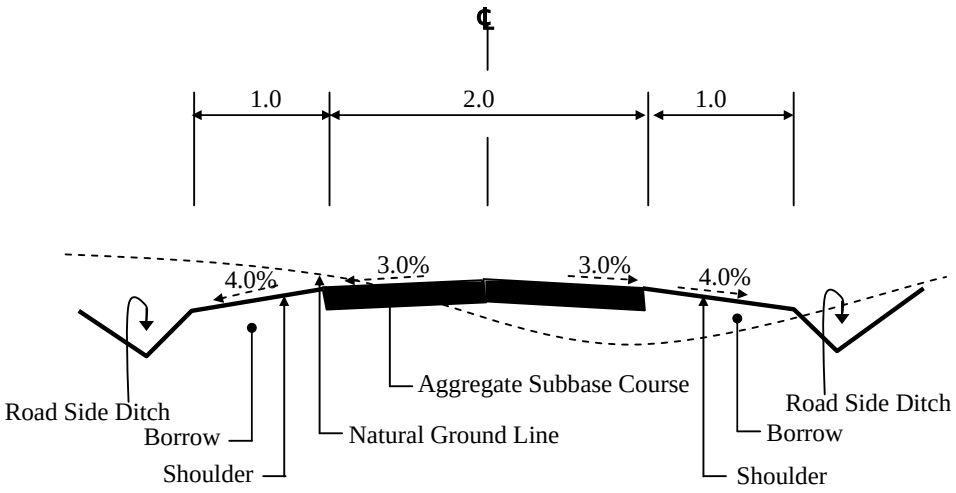



**Figure 3 – Typical Cross Section of One-Lane Earth Road**

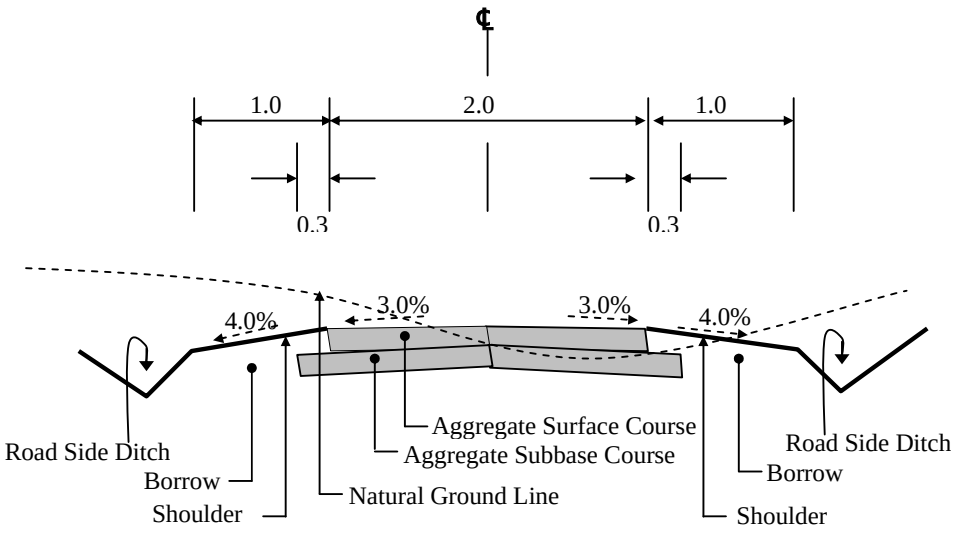



**Figure 4 - Typical Cross Section of One-Lane Gravel Road**

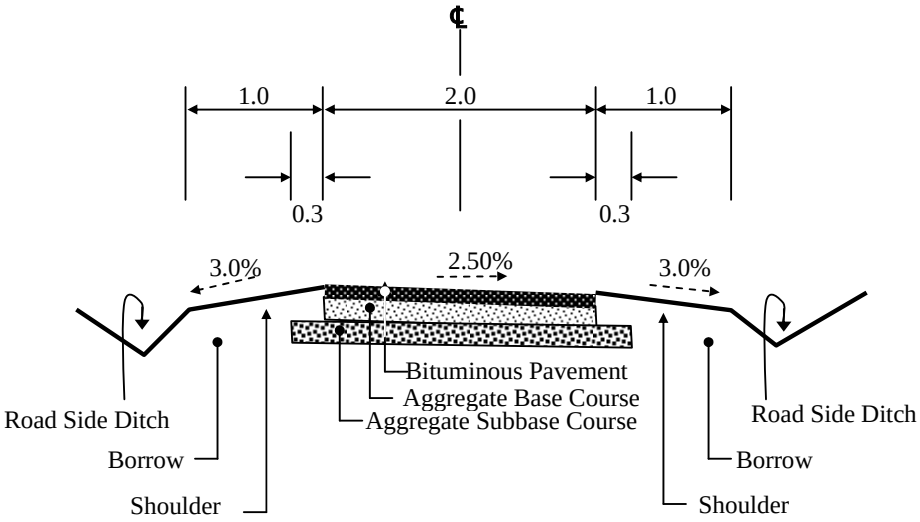



**Figure 5 - Typical Cross Section of One-Lane Bituminous Pavement**

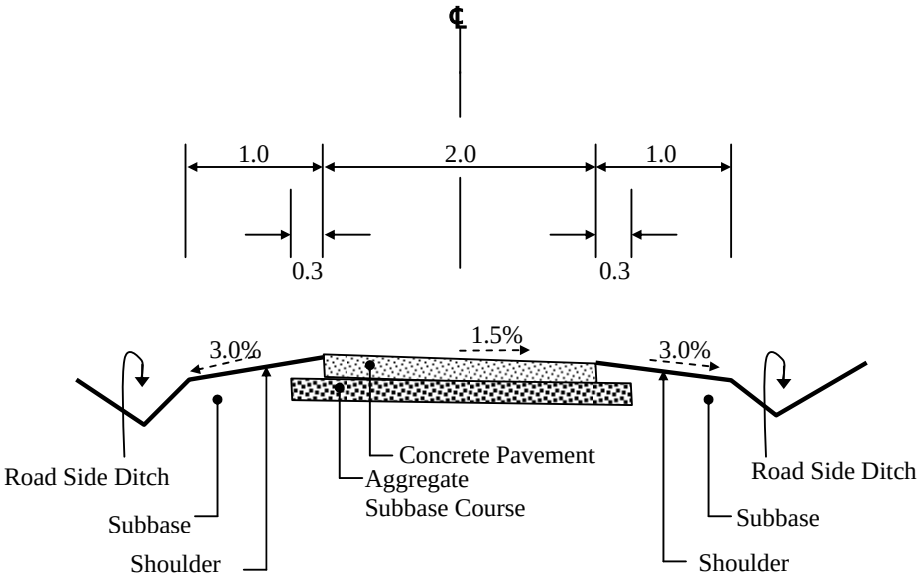



**Figure 6 - Typical Cross-Section of One Lane Concrete Road**

## 7.4 SITE OF ROAD EXPANSION FOR ONE-LANE ROAD

- **Earth Road**
- **Gravel Road**
- **Bituminous Road**
- **Concrete Road**

The road shall be constructed either left or right from the center or the existing Right of Way (ROW) in order to accommodate expansion in the future.

The design of the roadside ditch within the Right of Way (ROW) should be earth ditch, since it will be damaged during expansion. However, steep slope ditch should be constructed of other materials to prevent erosion.

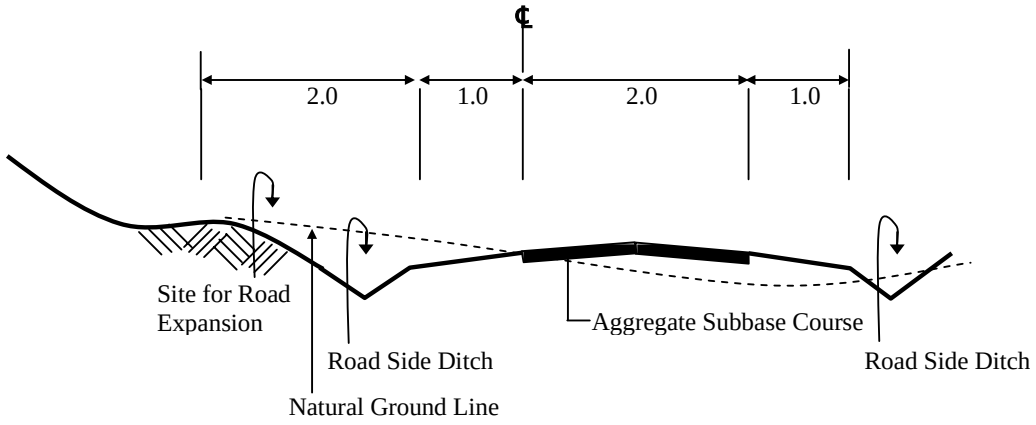



**Figure 7 - Typical Site of Earth Road for Expansion**

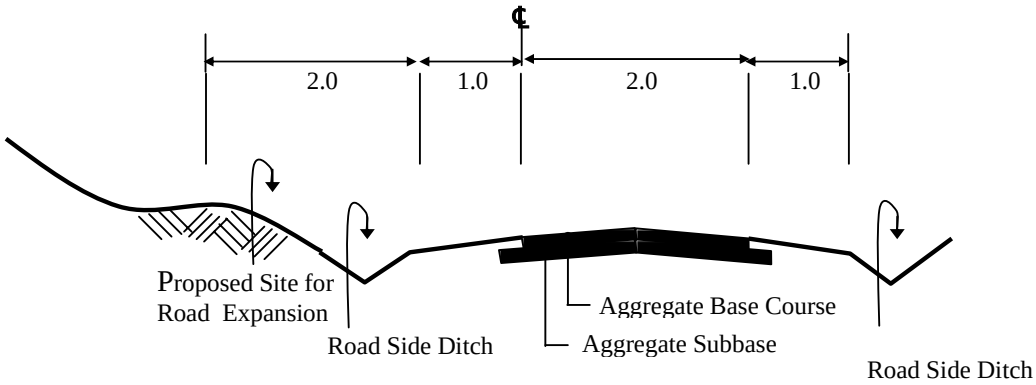



**Fig. 8 Typical Cross-section of one-lane gravel road for expansion**

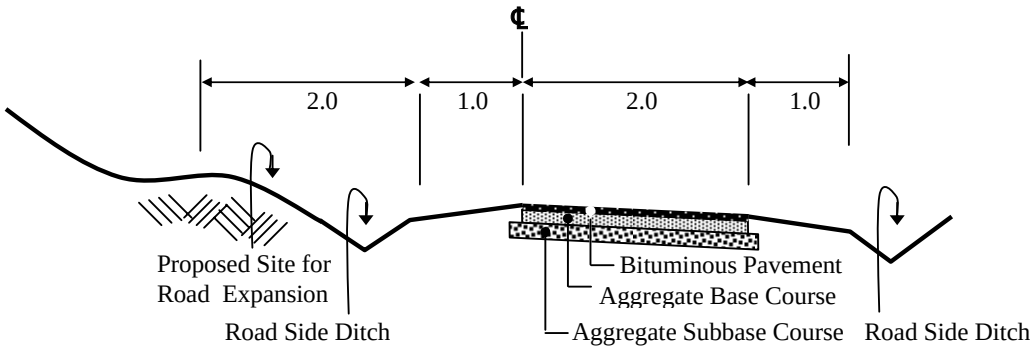



**Figure 9 - Typical Position of Bituminous Road for Stage Development**

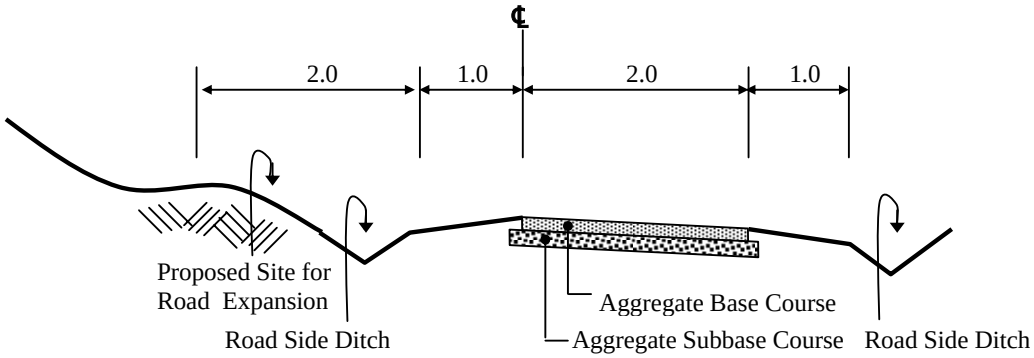



**Figure 10 - Typical Site of One-Lane Concrete Road for Expansion**

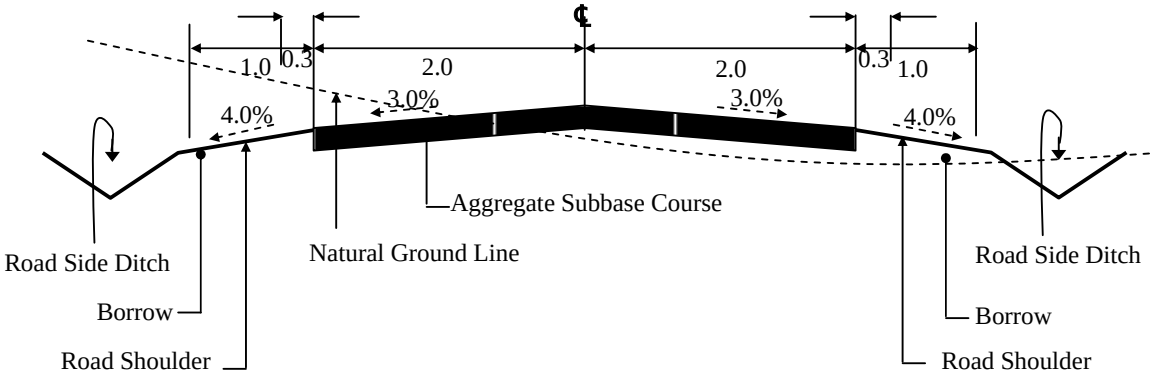



**Figure 11 - Typical Cross-Section of a Two-Lane Earth Road**

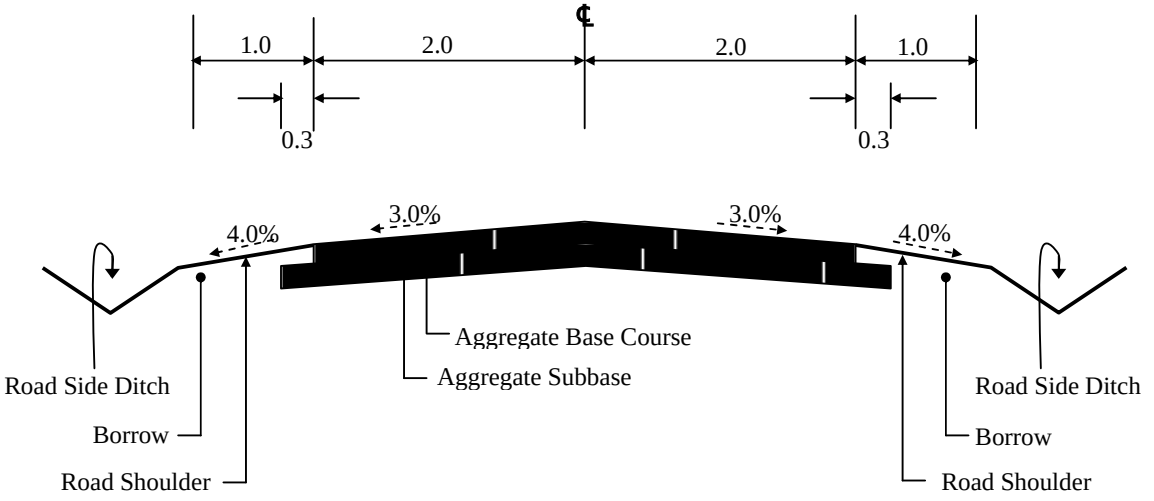



**Figure 12 - Typical Cross-Section of Two-Lane Gravel Road**

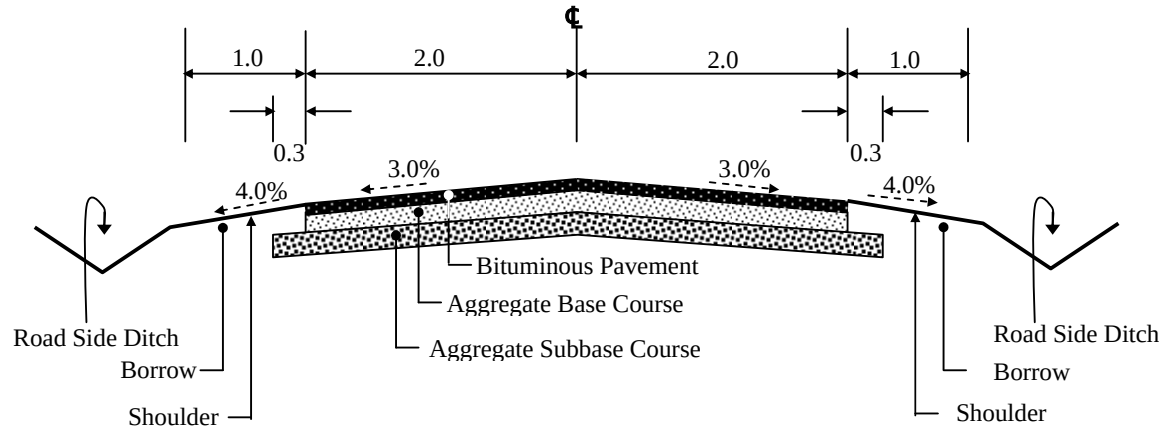



**Figure 13 – Typical-Cross-Section of Two-Lane Bituminous Road**

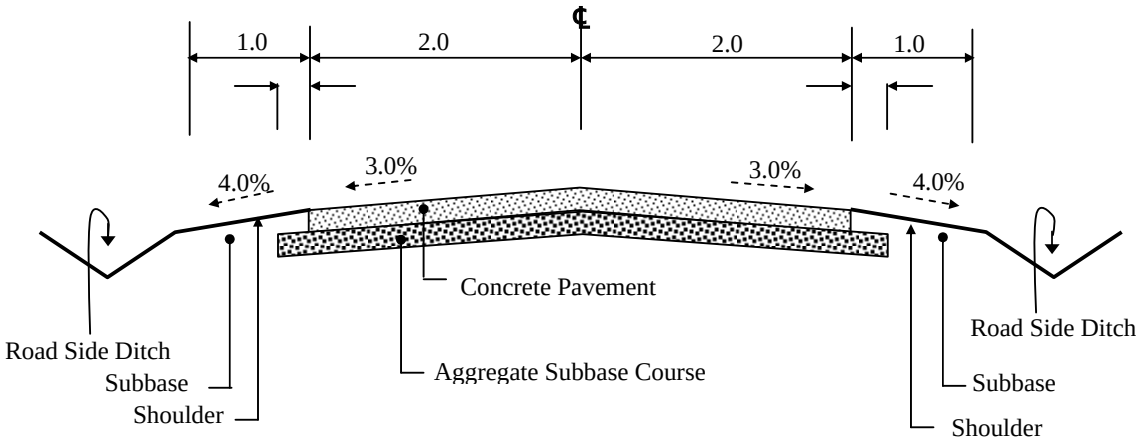



**Figure 14 -Typical Cross-Section of a Two-Lane Concrete Road**

## 7.5 Roadway on Lateral and Sub Lateral Irrigation Canals

In lateral and sub-lateral canal where the available roadway width is 3 meters, the carriageway width shall be 2 meters and the shoulder width shall be 0.5 meters. If the available roadway width is 4 meters, the shoulder shall expand to 1 meter.

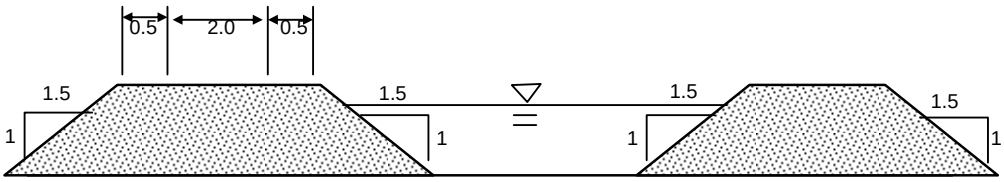



**Figure 15 - Typical Cross-Section of Roads in Lateral and Sub-lateral Canal**

## 7.6 Roadway on Main Irrigation Canals

In canal (main) where the available roadway width is 6 meters, the carriageway width shall be 4 meters and the shoulder width shall be 1.0 meter.

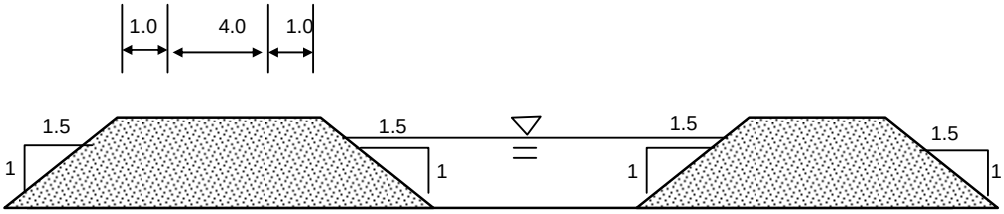



**Figure 16 - Typical Cross-Section of Roads in Main Canal**

## 7.7 Structural Requirement

Roadway pavement material shall be placed and maintained much smoother than insitu material. This helps improve riding comfort and reduces vehicle operation.

Road pavement shall be generally stiffer than the material upon which it is placed, thus, it assists the insitu material in resisting loads without excessive deformation.

Roadway shall convey storm water flow via road side ditch to predetermined roadway crossings.

The centerline of the roadway shall be the highest point which slopes down to either side. This will promote rapid runoff of excess water and minimize the

amount of water which infiltrate into the roadway soil. This also prevents ponding of water which results to weakening of the roadway base.

Excessive embankment of roadway (more than one meter from the original ground surface) should not be designed without any justifiable reasons. The necessity of high roadway embankment, (for example, indicating flood level) should be technically explained in the design documents. If no reason can be cited, the recommended embankment height shall not exceed 50 cm. from the original ground.

There shall be provisions to lessen the environmental impacts of road construction and should be specified in the erosion and sediment control plan including measures to ensure that the exposed working surface are kept to a minimum, and silt fences and sediment traps are optimally placed to prevent sediments from reaching drainage systems.

## 8. GEOMETRIC DESIGN

### 8.1 Design speed

There shall be design speed provisions to lessen the occurrence of accidents due to over speeding.

Radius of Curvature
The minimum radius design for curvature shall be 500 meters for flat terrain, 150 meters for rolling terrain and 50 meters for mountainous terrain. Avoid minimum radius at the beginning and end of all straight sections with a length of more than 5 kilometers and or isolated curves. Curves with larger radius must be used where terrain permits.

### 8.2 Intersection

Careful consideration shall be given to the intersecting roads.
Longer sight distances should be required for larger and fast moving vehicles entering/traversing existing road.

Trees shall be trimmed or cut as well as bushes, trees or other vegetation within the limit of the intersection area.

The angle of intersection, if possible, shall be at right angles (90 degrees). However the intersecting angles in the range of 45–60 degrees are acceptable. Intersection at the angles of 45–60 degrees may be used in special situations. Intersections at angles of less than 45 degrees are strongly discouraged.

Visibility shall range from 40 meters for roadway with a speed not exceeding 32 kph and 320 meters for roadway having 96 kph speed limit.

### 8.3 Longitudinal Slope

The maximum longitudinal slope shall be 10% for rolling and 12% for mountainous terrain with maximum length of 300 meters.

### 8.4 Side Slope

The maximum side slope shall be 2:1. Normal slope shall be 4:1. Provide separate design slope for cut and fill. This depends on soil classification for cut and height of fill embankment.

### 8.5 Cross Fall

The cross fall (crown) shall be 1.5 – 2.0%

## 9. CLEARING AND GRUBBING

- Earth Road
- Gravel Road
- Bituminous Road
- Concrete Road

### 9.1 Description

This item shall consist of clearing, grubbing, removing and disposing all vegetation and debris as designated to remain in place or are to be removed in consonance with other provisions of this Specification. The work shall also include the preservation from injury or defacement of all objects designated to remain.

### 9.2 Construction Requirements

Before the work starts, the Engineer shall establish the limits of work and designate all trees, shrubs, plants and other things to remain.

The Contractor shall preserve all objects designated to remain. The contractor shall be allowed to remove only trees and brushes that are absolutely necessary for his construction operation. The contractor shall save as many trees as possible.

Removal of all trees and brushes, including their stumps necessary for construction purposes, shall be done in such a manner to present a neat appearance at the end of the work.

Paint required for cut or scarred surface of trees or shrubs selected for retention shall be an approved asphalt base paint prepared especially for tree surgery.

All surface objects and all trees, stumps, roots and other protruding obstructions, not designated to remain, shall be cleared and/or grubbed, including mowing as required, except as provided below:

Removal of undisturbed stumps and roots and nonperishable solid objects with a depth of 1 meter below sub-grade for slope of embankments will not be required.

In areas outside the grading limits of cut and embankment areas, stumps and nonperishable solid objects shall be cut off not more than 150 mm (6 inches) above the ground line or low water level.

In areas to be rounded at the top of cut slopes, stumps shall be cut off flush with or below the surface of the final slope line.

Grubbing of pits, channel changes and ditches will be required only to a depth necessitated by the proposed excavation within such areas.

Except in areas to be excavated, stumps, holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted to the required density.

No burning is permitted unless otherwise done in accordance with applicable laws, ordinances and regulations. If burning is permitted, perishable materials shall be burned under the constant care of competent watchmen at such times and in such a manner that the surrounding vegetation, other adjacent property or anything designated to remain on the right of way will not be jeopardized.

The Contractor shall use high intensity burning procedures, (i.e. incinerators, high stacking or pit and ditch burning with forced air supplements) that produce intense burning with little or no visible smoke emission during the burning process. At the conclusion of each burning session, the fire shall be completely extinguished so that no smoldering debris remains.

In the event that the Contractor is directed by the Engineer not to start burning operations or to suspend such operations because of hazardous weather conditions, material to be burned which interfere with subsequent construction operations shall be moved by the Contractor to temporary locations clear of construction operations and later, if directed by the Engineer, shall be placed on a designated spot and burned.

Materials and debris which cannot be burned and perishable materials may be disposed of by methods and at locations approved by the Engineer, on or of the project.

No stumps, roots, brush or timber shall be buried within the limits of the roadway or within the limits of any lot to be dedicated for public purposes, or within the limits of any public easement. If disposal is burying, the debris shall be placed in layer with the material so distributed to avoid nesting. Each layer shall be covered or mixed with earth material by the land-fill method to fill all voids.

The top layer of material buried shall be covered with at least 300 mm (12 inches) of earth or other approved material and shall be graded, shaped and compacted to present a pleasing appearance.

If the disposal location is off the project, the Contractor shall make necessary arrangements with the property owners in writing for obtaining suitable disposal locations which are outside the limits of view from the project.

The cost involved shall be included in the unit bid price. A copy of such agreement shall be furnished to the Engineer. The disposal areas shall be seeded, fertilized and mulched at the Contractor's expense. Woody material may be disposed of by chipping. The wood chips may be used for mulch, slope erosion control or may be uniformly spread over the selected areas as directed by the Engineer. Wood chips used as mulch for slope erosion control shall have a maximum thickness of 12 mm (1/2 inch) and faces not exceeding 3900 $mm^2$ (6 square inches) on any individual surface area. Wood chips not designated for use under other sections shall be over the designated areas in layers not to exceed 75 mm (3 inches) loose thickness. Diseased trees shall be buried or disposed of as directed by the Engineer.

All merchantable timber in clearing area which has not been removed from the right of way prior to the beginning of construction shall become the property of the Contractor unless otherwise provided.

Low hanging branches or unsightly branches on trees or shrubs designated to remain shall be trimmed as directed. Branches of trees extending over the roadbed shall be trimmed to give a clear height of 6 meters above the roadbed surface. All trimmings shall be done by skilled workmen and in accordance with good surgery practices.

Timber cut inside the area staked for clearing shall be felled within the area to be cleared. Individual trees or stumps designated by the Engineer for removal and located in areas other than those established for clearing and grubbing and roadside cleanup shall be removed and disposed of as specified under (disposal) except trees removed shall be cut as nearly flush with the ground as practicable without removing stumps.

### 9.3 Method of Measurement

Measurement shall use the following alternate methods:

### 1. Area Basis

The work to be paid for shall be the number of hectares and fractions thereof acceptably cleared and grubbed within the limits indicated on the plans or as may be adjusted in the field staking by the Engineer. Areas not within the clearing and grubbing limits shown on the Plans or not staked for clearing and grubbing will not be measured for payment.

## 2. Lump-sum basis

When the Bill of Quantities contains a Clearing and Grubbing lump-sum item, no measurement of area will be made for such item.

## 3. Individual Unit Basis (Selective Clearing)

The diameter of tree will be measured at the height of 1.4 meters above the ground. Trees less than 150 mm in diameter will not be measured for payment.

When Bill of Quantities indicates measurement of tree by individual unit basis, the units will be designated and measured in accordance with the following schedule of sizes in Table 1

**Table 1**

| Diameter at height of 1.4 meter | Pay Item Designation |
|---|---|
| Over 150 mm to 900 mm | Small |
| Over 900 mm | Large |

## 9.4 Basis of Payment

The accepted quantities, measured as prescribed in (Method of measurement) shall be paid for at the contract unit price for each of the Pay Items listed below that is included in the Bill of Quantities, which price and payment shall be full compensation for furnishing all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment shall be made under the following Table 2:

**Table 2**

| Pay Item Number | Description | Unit Measurement |
|---|---|---|
| 100 (1) | Clearing and Grubbing | Hectare |
| 100 (2) | Clearing and Grubbing | Lump Sum |
| 100 (3) | Individual Removal of Tress, Small | Each |
| 100 (4) | Individual Removal of Trees, Large | Each |

## 10. EXCAVATION

- Earth Road
- Gravel Road
- Bituminous Road
- Concrete Road

## 10.1 Description

This Item shall consist of roadway and borrow excavation, and the disposal of materials in accordance with the Specifications and in conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

### 10.1.1 Roadway Excavation

Roadway excavation shall include excavation and grading for roadways, intersections, approaches, slope rounding, benching, waterways and ditches; removal of unsuitable materials from the roadbed and beneath embankment areas; and excavating selected materials found in the roadway as ordered by the Engineer for specific use in the improvement. Roadway excavation shall be classified as follows and as indicated in the Bill of Quantities.

(1) Unclassified Excavation
It shall consist of the excavation and disposal of all materials regardless of its nature, not classified and included in the Bill of Quantities under other pay items.

(2) Rock Excavation
It shall consist of igneous, sedimentary and metamorphic rocks which cannot be excavated without blasting or the use of rippers, and all boulders or other detached stones each having a volume of one (1) cubic meter or more as determined by physical measurements or visually by the Engineer.

(3) Common Excavation
It shall consist of all excavations not included in the Bill of Quantities under “rock excavation” or other pay items.

(4) Muck Excavation
It shall consist of the removal and disposal of deposits of saturated or unsaturated mixtures of soils and organic matter not suitable for foundation material regardless of the moisture content.

### 10.1.2 Borrow Excavation

It shall consist of the excavation and utilization of approved material required for the construction of embankment as for other portions of the work, and shall be obtained from approved sources, in accordance with the following:

(1) Case I Consists of materials obtained from sources designated on the Plans or in the Special Provisions.
(2) Case II Consists of materials obtained from sources provided by the Contractor.

## 10.2 Construction Requirements

### 10.2.1 General

When there is evidence of discrepancies between the actual elevations and that shown on the Plans, a pre-construction survey referred to the datum plane used in the approved Plan shall be undertaken by the Contractor under the control of the Engineer to serve as the basis for the computation of the actual volume of the excavated materials.

All excavations shall be finished to reasonably smooth and uniform surfaces. No materials shall be wasted without authority of the Engineer. No excavation operation shall be conducted so that material outside of the limits of the slope will not be disturbed. Prior to excavation, all necessary clearing and grubbing in that area shall have been performed in accordance with the requirements of Clearing and Grubbing.

### 10.2.2 Conservation of Topsoil

Where provided for on the Plans or in the Special Provisions, all suitable topsoil encountered in excavation and on areas where embankments is to be placed shall be removed to such extent and to such depth as the Engineer may direct. The removed topsoil shall be transported and deposited in storage piles at locations approved by the Engineer.

The topsoil shall be completely removed to the required depth from any designated area prior to the beginning of regular excavation or embankment work in the area and shall be kept separate from other excavated materials for later use**.**

### 10.2.3 Utilization of the Excavated Material

All suitable materials removed from the excavation shall be used in the formation of embankment, sub-grade, shoulders, slopes, bedding and backfill for structures. All unsuitable materials shall be disposed of as shown on the plans or as directed by the Engineer.

The Engineer will designate as unsuitable soil that cannot be properly compacted in the embankments. All unsuitable materials shall be disposed off as shown in the Plans or as directed without delay to the Contractor.
Only approved materials shall be used in the construction of embankments and backfills. All unsuitable materials shall be disposed off as shown on the Plans or as directed by the Engineer.

All excess material, including rocks and boulders that cannot be used in embankments shall be disposed off as directed.

Material encountered in the excavation and determined by the Engineer as suitable for topping, road finishing, slope protection, or other purposes shall be conserved and utilized as directed by the Engineer.

Borrow excavation shall not be placed until after the readily accessible roadway excavation has been placed in the fill, unless otherwise permitted or directed by the Engineer. If the Contractor places more borrow than is required and thereby causes a waste of excavation, the amount of such waste shall be deducted from the borrow volume.

### 10.2.4 Pre-watering

Excavation areas and borrow pits may be pre-watered before excavating the material. When pre-watering is used, the areas to be excavated shall be moistened to the full depth, from the surface to the bottom of excavation. The water shall be controlled so that the excavated material will contain the proper moisture to permit compaction to the specified density with the use of standard compacting equipment.

Prewatering shall be supplemented when necessary, by truck watering units, to ensure that the embankment contains the proper moisture at the time of compaction.

The Contractor shall provide drilling equipment capable of suitably checking the moisture penetration to the full depth of the excavation.

### 10.2.5 Presplitting

Unless otherwise provided in the Contract, rock excavation which requires drilling and shooting shall be presplit.

Presplitting to obtain faces in the rock and shale formations shall be performed by the following methods:

(1) Drilling holes at uniform intervals along the slope lines,
(2) Loading and stemming the holes with appropriate explosives and stemming material
**(**3) Detonating the holes simultaneously.

Prior to starting drilling operations for presplitting, the Contractor shall furnish the Engineer a plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing. The drilling and blasting plan is for record purposes only and will not absolve the Contractor of his responsibility for using proper drilling and blasting procedures. Controlled blasting shall begin with a short test section of the length approved by the Engineer. The test section shall be presplit, production drilled and blasted and sufficient material excavated whereby the Engineer can determine if the Contractor’s method are satisfactory. The Engineer may order discontinuance of the presplitting when he determines that the materials encountered have become unsuitable for being presplit.

The holes shall be charged with explosives of the size, kind, strength, and at the spacing suitable for the formations being presplit, and with stemming material which passes a 9.5 mm (3/8 inch) standard sieve and which has the qualities for proper confinement of the explosives.

The finished presplit slope shall be reasonably uniform and free of loose rock. Variance from the true plane on the excavated back slope shall not exceed 300 mm (12 inches); however, localized irregularities or surface variations that do not constitute a safety hazard or an impairment to drainage courses or facilities will be permitted.

A maximum offset of 600 mm (24 inches) will be permitted for construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern.

### 10.2.6 Excavation of Ditches, Gutters, etc.

All materials excavated from side ditches and gutters, channel changes, irrigation ditches, inlet and outlet ditches, toe ditches, furrow ditches, and such other ditches as may be designated on the Plans or staked by the Engineer, shall be utilized as provided in Subsection 102.2.3.

Ditches shall conform to the slope, grade, and shape of the required cross-section, with no projections of roots, stumps, rock or similar matter. The Contractor shall maintain and keep open and free from leaves, sticks and other debris all ditches dug by him until final acceptance of the work.

Furrow ditches shall be formed by plowing a continuous furrow along the line staked by the Engineer. The ditches shall be cleaned out by hand shovel work, by ditcher, by some other suitable method, throwing all loose materials on the downhill side so that the bottom of the finished ditch shall be approximately 450 mm (18 inches) below the crest of the loose material piled on the down hill side Hand finish will not be required, but the low lines shall be in satisfactory shape to provide drainage without overflow.

### 10.2.7 Excavation of Roadbed Level

Rock shall be excavated to a depth of 150 mm (6 inches) below subgrade within the limits of the roadbed, and the excavation backfilled with material designated on the Plans or approved by the Engineer and compacted to the required density.

When excavation methods employed by the Contractor leave undrained pockets in the rock surface, the Contractor shall, at his own expense, properly drain such depressions or when permitted by the Engineer fill the depressions with approved impermeable material.
Material below subgrade, other than solid rock shall be thoroughly scarified to a depth of 150 mm (6 inches) and the moisture content increased or reduced, as necessary, to bring materials throughout this 150 mm later to the moisture content suitable for maximum compaction. This layer shall then be compacted in accordance with the requirements of Compaction.

### 10.2.8 Borrow Areas

The Contractor shall notify the Engineer sufficiently in advance of opening any borrow areas so that cross-section elevations and measurements of the ground surface after stripping may be taken, and the borrow material can be tested before being used. Sufficient time for testing the borrow material shall be allowed.

All borrow areas shall be bladed and left in such shape as to permit accurate measurements after excavation has been completed. The Contractor shall not excavate beyond the dimensions and elevations established, and no material shall be removed prior to the staking out and cross-sectioning of the site. The finished borrow areas shall be approximately true to line and grade established and specified and shall be finished. When necessary to remove fencing, the fencing shall be replaced in at least as good condition as in the original. The contractor shall be responsible for the confinement of livestock when portion of the fence is removed.

### 10.2.9 Removal of Unsuitable Materials

Where the plans show the top portion of the roadbed to be selected topping, all unsuitable materials shall be excavated to the depth necessary for replacement of the selected topping to the required compacted thickness.

Where excavation to the finished graded section results in a subgrade or slope of unsuitable soil, the Engineer may require the contractor to remove the unsuitable material and backfill to the finished graded section with approved material. The Contractor shall conduct his operations in such a way that the Engineer can take the necessary cross-sectional measurements before the backfill is placed.

The excavation of muck shall be handled in a manner that will not permit the entrapment of muck within the backfill. The material used for backfilling up to the ground line or water level, whichever is higher, shall be rock or other suitable granular material selected from the roadway excavation, if available. If not available, suitable material shall be obtained from other approved sources. Unsuitable material removed shall be disposed of in designated areas shown on the plans or approved by the Engineer.

## 10.3 Method of Measurement

The cost of excavation of material which is incorporated in the Works or in other areas of fill shall be deemed to be included in the Items of Work where the material is used.

Measurement of Unsuitable or Surplus Material shall be the net volume in its original position.
For measurement purposes, surplus suitable material shall be calculated as the difference between the net volume of suitable material required to be used in the

embankment and the net volume of suitable material from excavation. Separate items shall be provided for common, unclassified and rock material.

The Contractor shall be deemed to have included in the contract unit prices all cost of obtaining land for the disposal of unsuitable or surplus materials.

### 10.4 Basis of Payment

The accepted quantities, measured as prescribed in the Method of Measurement shall be paid for the contract unit price for each of the Pay Items listed below that is included in the Bill of Quantities which price and payment shall be full compensation for the removal and disposal of excavated materials including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment shall be made under the following Table 3:

**Table 3**

| Pay Item | Description | Unit of Measurement |
|---|---|---|
| 102 (1) | Unsuitable Excavation | Cubic Meter |
| 102 (2) | Surplus Common Excavation | Cubic Meter |
| 102 (3) | Surplus rock excavation | Cubic Meter |
| 102 (4) | Surplus Unclassified Excavation | Cubic Meter |

## 11. EMBANKMENT

- Earth Road
- Gravel Road
- Bituminous Road
- Concrete Road

### 11.1 Description

This item shall consist of the construction of embankment in accordance with this Specification and in conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

### 11.2 Material Requirements

Embankment shall be constructed of suitable materials, in consonance with the following definitions:

1. Suitable Material**-** Material which is acceptable in accordance with the contract and which can be compacted in the manner specified in this item. It can be common material or rock.

Selected Borrow, for Topping- Soil of such gradation shows that all particles will pass a sieve with 75 mm (3 inches) square openings and not more than 15 percent of the mass will pass the 0.075 mm or 0.003 in. (No. 200) sieve, as determined by AASHTO T 11 . The material shall have a plasticity index of not more than 6 as determined by AASHTO T 90 and liquid limit of not more than 30 as determined by AASHTO T 89

2. Unsuitable Material-Material other than suitable materials such as: detrimental quantities of organic material, such as grass, root and sewerage; highly organic soils as peat and muck; soils with liquid limit exceeding 80 and/or plasticity index exceeding 55; soils with a natural water content exceeding 100%; soils with very low natural density, 800 kg/$m^3$ or lower; soils that cannot be properly compacted as determined by the Engineer.

### 11.3 Construction Requirements

#### 11.3.1 General

Prior to Construction of embankment, all necessary clearing and grubbing in the area shall have been performed in conformity with the requirements of Clearing and Grubbing.

Embankment construction shall consist of constructing roadway embankments, including preparation of areas upon which they are to be placed; the construction of dikes within or adjacent to the roadway; the placing and compacting of approved materials within roadway areas where unsuitable material has been removed; and the placing and compacting of embankment materials in holes, pits, and other depressions within the roadway area.

Embankments and backfill shall contain no muck, peat, sod, roots or other deleterious matter. Rocks, broken concrete or other solid, bulky materials shall not be placed in embankment areas where piling is to be placed or driven.

Where shown on the Plans or directed by the engineer, the surface of the existing ground shall be compacted to a depth of 150 mm (6 inches) and the specified requirements of this item.

Where provided on the Plans and Bill of Quantities, the top portions of the roadbed in both cuts and embankments, as indicated, shall consist of selected borrow for topping from excavations.

#### 11.3.2 Methods of Construction

When there is evidence of discrepancies on the actual elevations and as shown on the Plans, a pre-construction survey referred to the datum plane used in the approved Plan shall be undertaken by the Contractor under the control of the Engineer to serve as the basis for the computation of the actual volume of the embankment materials.

When embankment is to be placed and compacted on hillsides, or when the new embankment is to be placed against existing embankments, or when embankment is built one-half width at a time, the existing slope that are steeper than 3:1 when measured at the right angles to the roadway shall be continuously benched over those areas as the work is brought up in layers.

Benching will be the subject to the Engineer's approval and shall be of sufficient width to permit placement of operation and compaction equipment. Each horizontal cut shall begin at the intersection of the original ground and the vertical sides of the previous cuts. Material thus excavated shall be placed and compacted along with the embankment material in accordance with the procedure described in this section.

Unless shown otherwise on the Plans or Special Provisions, where an embankment of less than 1.2 meters (4 feet) is to be made, all sod and vegetable matter shall be removed from the surface upon which the embankment is to be placed, and the cleared surface shall be completely broken up by plowing, scarifying, or stepping to a minimum depth of 150 mm except as provided in the Construction Requirements of Excavation. This area shall then be compacted in conformity with the requirements of Compaction of Embankment. Sod not required to be removed shall be thoroughly disc harrowed or scarified before construction embankment. Wherever a compacted road surface containing granular materials lies within 900 mm (36 inches) of the sub-grade, such old road surface shall be scarified to a depth of at least 150 mm (6 inches) wherever directed by the engineer. This scarified material shall then be compacted as provided in conformity to the requirements of Compaction of Embankment.

When shoulder excavation is specified, the roadway shoulders shall be excavated to the depth and width shown on the Plans. The shoulder material shall be removed without disturbing the adjacent existing base course material, and all excess excavated materials shall be disposed of in conformity with the requirements of Utilization of Excavated Material of Excavation. If necessary, the areas shall be compacted before being backfilled.

Roadway embankment of earth material shall be placed in horizontal layers not exceeding 200 mm (8 inches), loose measurement, and shall be compacted as specified before the next layer is placed. Effective spreading equipment shall be used on each lift to obtain uniform thickness prior to compacting. As the compaction of each layer progresses, continuous leveling and manipulating will be required to assure uniform density. Water shall be added or removed, if necessary, in order to obtain the required density. Removal of water shall be accomplished through aeration by plowing, blading, discing or other methods satisfactory to the Engineer.

Where embankment is to be constructed across low swampy ground that will not support the mass of trucks or other hauling equipment, the lower part of the fill may be constructed by dumping successive loads in a uniformly distributed layer of a thickness not greater than the necessary to support hauling equipment while placing subsequent layers.

When excavated material contains more than 25 mass percent of rock larger than 150 mm in greatest diameter and cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down in pieces resulting from execution methods, such materials may be placed on the embankment in layer not exceeding in thickness the appropriate average size of the larger rocks, but not greater than 600 mm (24 inches).

Even though the thickness of layer is limited as provided above, the placing of individual rocks and boulders greater than 600 mm in diameter will be permitted provided that when placed, they do not exceed 1200 mm (48 inches) in height and provided they are carefully distributed, with the interstices filled with finer material to form a dense and compact mass.

Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spells and finer fragments of earth. Lifts of material containing more than 25 mass percent of rock larger than 150 mm in greatest dimension shall not be constructed above an elevation of 300 mm (12 inches) below the finished sub-grade. The balance of the embankment shall be composed of suitable material smoothed and placed in layers not exceeding 200 mm (8 inches) in loose thickness and compacted as specified for embankments.

Dumping and rolling areas shall be kept separate, and no lift shall be covered by another until compaction complies with the requirements of Compaction of Embankments.

Hauling and leveling equipment shall be so routed and distributed over each layer of the fill in such a manner as to make use of compaction effort afforded thereby and to minimize rutting and uneven compaction.

### 11.3.3 Compaction

- Earth Road
- Gravel Road
- Bituminous Road
- Concrete Road

**Compaction Trials**

Before commencing the formation of embankments, the Contractor shall submit in writing to the Engineer for approval his proposals for the compaction of each type of fill material to be used in the Works. The proposals shall include the relationship between the types of compaction equipment, and the number of passes required and the method of adjusting moisture content. The contractor shall carry out full scale compaction trials on areas not less than 10 meters wide and 50 meters long as required by the Engineer and using his proposed procedures or such amendments thereto as may be found necessary to satisfy the Engineer that all the specified requirements regarding compaction can be consistently achieved. Compaction trials with the main types of fill material to be used in the Works shall

be completed before work with the corresponding materials will be allowed to commence.

Throughout the periods when compaction of earthworks is in progress, the Contractor shall adhere to the procedures found from compaction trials for each type of material being compacted, each type of compaction equipment employed and each degree of compaction specified.

**Earth**

The contractor shall compact the material places in all embankment layer and the materials scarified to the designated depth below sub-grade in cut sections, until uniform density of not less than 95 mass percent of the maximum determined by AASHTO T 99 Method C, is attained, at a moisture content determined by Engineer to be suitable for such density acceptance of compaction may be based on adherence to an approved roller pattern developed in conformity with the requirements of Compaction Equipment and Density Control Strips, 1995 DPWH Standard Specification for Bridges and Airports, Volume II.

The Engineer shall, during progress of the Work, make density tests of compacted material in accordance with AASHTO T 191, T 205, or other approved field density test, including the use of properly calibrated nuclear testing devices. A correction for coarse particles may be made in accordance with AASHTO T 224. If, by such test, the engineer determines that the specified density and moisture conditions have not been attained, the Contractor shall perform additional work as may be necessary to attain the specified conditions.

At least one group of three in-situ density test shall be carried out for each 500 $m^2$ of each layer of compacted fill.

**Rock**

Density requirements will not apply to portions of embankments constructed of materials which cannot be tested in accordance with approved methods.

Embankment materials classified as rock shall be deposited, spread and leveled the full width of the fill with sufficient earth or other fine material so deposited to fill the interstices to produce a dense compact embankment. In addition, one of the rollers, vibrators or compactors meeting the requirements of Compaction Equipment and Density Control Strips, 1995 DPWH Standard Specification for Bridges and Airports, Volume II, shall compact the embankment full width with a minimum of three complete passes for each layer of embankment.

### 11.3.4 Protection of Roadbed During Construction

During the construction of the roadway, the roadbed shall be maintained in such condition that will be well drained at all times. Side ditches and gutters emptying from cuts to embankments or otherwise, shall be constructed so as to avoid damage to embankments by erosion.

### 11.3.5 Rounding and Warping Slopes

Rounding-except in solid rocks, the tops and bottoms of all slopes, including the slope of drainage ditches, shall be rounded as indicated on the Plans. A layer of earth overlying rock shall be rounded above the rock as done in earth slopes.

Warping- adjustments in slopes shall be made to avoid injury in standing trees or marring of weathered rock, or to harmonize with existing landscape features, and the transition to such adjusted slope shall be gradual. At intersections of cut and fills, slopes shall be adjusted and warped to flow into each other or into the natural ground surfaces without noticeable break.

### 11.3.6 Finishing Roadbed and Slopes

After the roadbed has been substantially completed, the full width shall be conditioned by removing any soft or other unstable material that will not compact properly or serve the intended purpose. The resulting areas and all the other low sections, holes of depression shall be brought to grade with suitable material. Scarifying, blading, dragging, rolling or other methods of work shall be used as necessary to provide a thoroughly compacted roadbed shaped to the grades and cross-sections shown on the Plans or as directed by the Engineer.

All earth slopes shall be left with rough surfaces but shall be reasonably uniform, without any noticeable break, and in reasonable close conformity with the Plans or other surfaces indicated on the Plans or as staked by the Engineer, with no variations wherefrom readily discernible as viewed from the road.

### 11.4 Method of Measurement

The quantity of embankment to be paid shall be the volume of material compacted in place, accepted by the Engineer and formed with material obtained from any source.

Material from excavation which is used in embankment and accepted by the Engineer will be paid under Embankment and such payment will be deemed to include the cost of excavating, hauling, stockpiling and all other incidentals to the work.

Material for Selected Borrow topping will be measured and paid for under the same conditions specified in the preceding paragraph.

### 11.5 Basis of Payment

The accepted quantities, measured as prescribed in the Method of Measurement shall be paid for at the Contract unit price for each of the Pay Items listed below that is included in the Bill of Quantities. The payment shall be full compensation for placing and compacting all materials including all labor, equipment tools and incidentals necessary to complete the work prescribed in this item.

Payment shall be made as stated in the following Table 4:

**Table 4**

| Pay Item Number | Description | Unit of Measurement |
|---|---|---|
| 104 (1) | Embankment | Cubic Meter |
| 104(2) | Selected, Borrow for Topping, Case 1 | Cubic Meter |
| 104(3) | Selected, Borrow for topping, Case 2 | Cubic Meter |

## 12. SUBGRADE PREPARATION

- Earth Road
- Gravel Road
- Bituminous Road
- Gravel Road

### 12.1 Description

This item shall consist of the preparation of the subgrade for the support of overlying structural layers. It shall extend to the full width of the roadway. Unless authorized by the engineer, subgrade preparation shall not be done unless the Contractor is able to start immediately the construction of the pavement structure.

### 12.2 Material Requirements

Unless otherwise stated in the Contract and except when the subgrade is in rock cut, all materials below subgrade level to a depth 150 mm or to such greater depth as may be specified shall meet the requirements of Section 104.2, Selected Borrow for Topping.

### 12.3 Construction Requirements

#### 12.3.1 Prior Works

#### 12.3.2 Subgrade Level Tolerances

The finished compacted surface of the subgrade shall conform to the allowable tolerances as specified hereunder:

| | |
|---|---|
| Permitted variation form | + 20 mm |
| Design LEVEL OF SURFACE | -30 mm |
| Permitted SURFACE IRREGULARITY MEASURED BY 3-m STRAIGHT EDGE | 30 MM |
| Permitted variation from design CROSSFALL OR CAMBER | $\pm$0.5 % |

| | |
|---|---|
| Permitted variation from Design LONGITUDINAL GRADE over 25 m length | ±0.1 % |

**12.3.3 Subgrade in Common Excavation**

Unless otherwise specified, all materials below subgrade level in earth cuts to a depth 150 mm or other depth shown on the Plans or as directed by the Engineer shall be excavated. The material, if suitable, shall be set aside for future use or if unsuitable, shall be disposed of in accordance with the requirements of Subsection 10.2.9 (Removal of Unsuitable Material).

Where material has been removed from below subgrade level, the resulting surface shall be compacted to a depth of 150 mm and in accordance with other requirements of Subsection 11.3.3 (Compaction).

All materials immediately below subgrade level in earth cuts to a depth of 150 mm, or to such greater depth as may be specified, shall be compacted in accordance with the requirements of Subsection 11.3.3.

**12.3.4 Subgrade in Rock Excavation**

Surface irregularities under the subgrade level remaining after trimming the rock excavation shall be leveled by placing specified material and compacted to the requirements of Subsection 11*.3.3.*

**12.3.5 Subgrade on Embankment**

After the embankment has been completed, the full width shall be conditioned by removing any soft or other unstable material that will not be compacted properly. The resulting areas and all other low sections, holes or depressions shall be brought to grade with suitable material. The entire roadbed shall be shaped and compacted to the requirements of Subsections 11.3.3. Scarifying, blading, dragging, rolling, or other methods of work shall be performed or used as necessary to provide a thoroughly compacted roadbed shaped to the cross-sections shown on the Plans.

**12.3.6 Subgrade on Existing Pavement**

Where the new pavement is to be constructed immediately over an existing Portland Cement concrete pavement and if so specified in the Contract the slab be broken into pieces with greatest dimensions of not more than 500 mm and the existing pavement material compacted as specified in Subsection 11.3.3 as directed by the Engineer. The resulting subgrade level shall, as part pavement construction be shaped to conform to the allowable tolerances of Subsection 12.3.2 by placing and compacting where necessary a leveling course comprising the material of the pavement course to be placed immediately above.

Where the new pavement is to be constructed immediately over an existing asphalt concrete pavement or gravel surface pavement or if so specified in the Contract, the pavement shall be scarified, thoroughly loosened, reshaped and re-compacted in accordance with Subsection 11.3.3 The resulting subgrade level shall conform to the allowable tolerances of Subsection 12.3.2

## 13. OVERHAUL

- Earth Road
- Gravel Road

### 13.1 Description

Overhaul consists of authorized hauling in excess of the free-haul distance. Free-haul distance specifies distance that excavated material shall be hauled without additional compensation. Unless otherwise provided in the Contract, the free-haul distance shall be 600 meters.

### 13.2 Method of Measurement

In determining what constitutes authorized overhaul, it will be assumed that material taken from excavation will be deposited in embankment after having been hauled the shortest distance.

The overhaul distance for material obtained and placed within the roadway limit will be measured along the centerline of the roadway. No allowance will be made for transverse or lateral movement to or from the centerline except materials moved to or from designated areas outside the roadway limits; such as Case 1, Borrow Pits, disposal areas, etc. In such case, measurement shall be along the shortest route determined by the Engineer to be feasible and satisfactory unless otherwise provided. If the Contractor chooses to haul material over some other route, and such other route is longer, the computation for payment shall be based on the overhaul distance measured along the route designated by the Engineer.

The number of cubic kilometers of overhaul to be paid for shall be the number of cubic meters of overhaul material multiplied by the overhaul distance in kilometers. The unit “cubic meter-kilometer” is the amount of hauling required to move one cubic meter a distance of one kilometer beyond the free-haul distance.

### 13.3 Basis of Payment

The accepted quantities, measured as prescribed in the Method of Measurement shall be paid for the contract unit price for Overhaul, for the particular pay Item listed below that is shown in the bill of quantities, which price and payment shall be full compensation for overhaul, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this item.

Payment will not be made for overhaul of Borrow, Case 2, Foundation Fill, bedding materials and materials removed in the rounding of cut slopes when rounding is a separate pay item.

When the bill of quantities does not show estimated quantities for “Overhaul” from the Pay Item listed below, overhaul will not be directly paid for, but will be considered as a subsidiary obligation of the Contractor under other contract items.

Payment shall be made under Table 5

**Table 5**

| Payment Item Number | Description | Unit of Measurement |
|---|---|---|
| 107 (1) | Overhaul | Cubic meter-kilometer |
| 107(2) | Overhaul of Borrow, Case 1 | Cubic meter-kilometer |

## 14. AGGREGATE SUBBASE COURSE

- **Earth Road**
- **Gravel Road**
- **Bituminous Road**
- **Concrete Road**

### 14.1 Description

This item shall consist of furnishing, placing and compacting an aggregate Subbase course on a prepared sub-grade in accordance with this Specification and the lines, grades and cross sections shown on the Plans, or as directed by the Engineer.

### 14.2 Material Requirements

Aggregate for Subbase shall consist of hard, durable particles or fragments of crushed stone, crushed slag, or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matter. The composite material shall be free from vegetable matters and lumps or balls of clay, and shall be such that it can be compacted to form a firm, stable Subbase.

The Subbase material shall conform to Table 6, Grading Requirements

**Table 6**

| Sieve Designation | | |
|---|---|---|
| Standard mm | Alternate US Standard | Mass Percent Passing |
| 50 | 2” | 100 |
| 25 | 1” | 55-85 |
| 9.5 | 3/8” | 40-75 |
| 0.075 | No. 200 | 0-12 |

The fraction passing the 0.075 mm (No. 200) shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40) sieve.

**Plasticity**
The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 and plasticity index not greater than 12 as determined by AASHTO T 89 and T 90, respectively.

**Abrasion**
The coarse portion retained on a 2.00 mm (No. 10) sieve, shall have a mass percent of wear not exceeding 50 by the Los Angeles Abrasion Test as determined by AASHTO T 96.

**California Bearing Ratio (CBR)**
The material shall have a soaked CBR value of not less than twenty five percent (25%) as determined by AASHTO T 193. The CBR shall be obtained at the maximum dry density and determined by AASHTO T 180, Method D.

### 14.3 Construction Requirements

#### 14.3.1 Preparation of Existing Surface

The existing surface shall be graded and finished in conformity to the requirements of Subgrade Preparation, before placing the Subbase material.

#### 14.3.2 Placing

The aggregate Subbase material shall be placed as a uniform mixture on a prepared quantity that will provide the required compacted thickness. The placing of material shall begin at the point designated by the Engineer. Placing shall be from vehicles especially equipped to distribute the materials in a continuous uniform layer or windrow. The layer or windrow shall be of such size that when spread and compacted, the finished layer be in reasonably close conformity to the nominal thickness shown on the Plans.

When the hauling is done over previously placed material, hauling equipment shall be dispersing uniformly over the entire surface of the previously constructed layer, to minimize rutting or uneven compaction.

#### 14.3.3 Spreading and Compacting

When uniformly mixed, the mixture shall be spread to the Plan thickness, for compaction. The maximum compacted thickness of one layer shall not exceed 150 mm.

The moisture content of Subbase material shall, if necessary, be adjusted prior to compaction by watering with approved sprinklers mounted on trucks or by drying out, as required in order to obtain the required compaction.

Immediately following final spreading and smoothening, each layer shall be compacted to the full width by means of approved compaction equipment. Rolling shall progress gradually from the side to the center, parallel to the centerline of the road and shall continue until the whole surface has been rolled. Any irregularities or depression that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform.

If the layer of Subbase material, or part thereof, does not conform to the required finished, the Contractor shall, at his own expense, make the necessary corrections.

Compaction of each layer shall continue until a field density of at least 100 percent of the maximum dry density determined in accordance with AASHTO T 180, Method D has been achieved. In-place density determination shall be made in accordance with AASHTO T 191.

### 14.3.4 Trial Section

Before Subbase construction is started, the Contractor shall spread and compact trial sections as directed by the engineer. The purpose of the trial sections is to check the suitability of the materials and the efficiency of the equipment and construction method that is proposed and to be used by the contractor. Therefore, the Contractor must use the same material, equipment and procedures that he proposes to use for the main work. One trial section of about 500$m^2$ shall be made for every type of material and/or construction equipment/procedure for use.

After final compaction of each section, the Contractor shall carry out such field density tests and other test required as directed by the Engineer.

If trial section shows the proposed materials, equipment or procedures in the engineer's opinion are not suitable for Subbase, it shall be removed at the contractor's expense, and a new trial section shall be constructed.

If the basic conditions regarding the type of material or procedure change during the execution of the work, new trial sections shall be constructed.

### 14.3.5 Tolerances

Aggregate Subbase shall be spread with equipment that will provide a uniform layer which when compacted will conform to the designated level and transverse slope as shown on the Plans. The allowable tolerances shall be specified hereunder:

| | |
|---|---|
| Permitted variation from design<br>THICKNESS OF LAYER | +20mm |
| Permitted variation from design<br>LEVEL OF SURFACE | + 10mm<br>- 20mm |

| | |
|---|---|
| Permitted SURFACE IRREGULARITY MEASURED by 3-meter straight-edge | -20 mm |
| Permitted variation from design CROSSFALL OR CAMBER | ± 0.3% |
| Permitted variation from design LONGITUDINAL GRADE over 25 meter length | ± 0.1% |

### 14.4 Method of Measurement

Aggregate Subbase course shall be measured in cubic meter ($m^3$). The quantity to be paid for shall be the design volume compacted in-place as shown on the Plans, and accepted in the completed course. No allowance will be given for materials outside the design limits shown on the cross sections. Trial sections shall not be measured separately but shall be included in the quantity of aggregate Subbase herein measured.

### 14.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 14.4 shall be paid for at the contract unit price for aggregate Subbase course which price and payment shall be full compensation for furnishings and placing of materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this item. Payment will be made under Table 7:

**Table 7**

| Pay Item Number | Description | Unit Measurement |
|---|---|---|
| 200 | Aggregate Subbase Course | Cubic meter |

## 15. AGGREGATE BASE COURSE

- Gravel Road
- Bituminous Road
- Concrete Road

### 15.1 Description

This item shall consist of furnishing, placing and compacting an aggregate base course on a prepared subgrade/Subbase in accordance with this Specification and the lines, grades and cross sections shown on the Plans, or as established directed by the Engineer.

## 15.2 Material Requirements

Aggregate for base course shall consist of hard, durable particles or fragments of crushed stone, crushed slag, or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matter. The composite material shall be free from vegetable matter and lumps or balls of clay, such that it can be compacted to form a firm, stable base.

In some areas where the conventional base course materials are scarce or unavailable, the use of 40% weathered limestone blended with 60% crushed stones or gravel shall be allowed, provided that the blended materials meet the requirements of this item.

The base course material shall conform to Table 8 which ever is called for in the Bill of Quantities.

**Table 8. Grading Requirements**

| Sieve Designation | | Mass Percent Passing | |
|---|---|---|---|
| Standard Mm | Alternate US Standard | Grading A | Grading B |
| 50 | 2” | 100 | |
| 37.5 | 1 ½” | - | 100 |
| 25.0 | 1” | 60-85 | - |
| 19.0 | ¾” | - | 60-85 |
| 12.5 | ½” | 35-65 | - |
| 4.75 | No. 4 | 20-50 | 30-55 |
| 0.425 | No.40 | 5-20 | 8-25 |
| 0.075 | No. 200 | 0-12 | 2-14 |

The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No.40) sieve.

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 25 and plasticity index not grater than 6 as determined by AASHTO T 89 and T 90, respectively.

The coarse portion, retained on a 2.00 mm (No. 10) sieve shall have a mass percent of wear not exceeding 50 by the Los Angeles Abrasion test determined by AASHTO T 96.

The material passing the 19 mm (3/4 inch) sieve shall have a soaked CBR value of not less than 80% as determined by AASHTO T 193. The CBR value shall be obtained at the maximum dry density (MDD) as determined by AASHTO T 180, Method D.

If filler, in addition to that naturally present, is necessary for meeting the grading requirements or for satisfactory bonding, it shall be uniformly blended with the

base coarse material on the road or in a pugmill unless otherwise specified or approved. Filler should be taken from sources approved by the Engineer, shall be free from hard lumps and shall not contain more than 15 percent of material retained on the 4.75 mm (No. 4) sieve.

### 15.3 Construction Requirements

#### 15.3.1 Preparation of Existing Surface

The existing Surface shall conform to the requirements of Subgrade Preparation.

#### 15.3.2 Placing

Placing shall be in accordance with all the requirements of Placing of Aggregate Subbase Course (Subsection 14.3.2).

#### 15.3.3 Spreading and compacting

It shall be in accordance with all the requirements of Spreading and Compacting, except that the field density required of each layer is not less than 100 percent of the maximum dry density determined in accordance with AASHTO T 180 Method D. The field density is determined in accordance with AASHTO T 191.

#### 15.3.4 Trial Sections

Trial Section shall conform to all the requirements specified in Subsection 14.3.4 (Trial Section of Aggregate Subbase Course).

#### 15.3.5 Tolerances

The aggregate base course shall be laid to the designed level and transverse slopes shown on the Plans. The allowable tolerances shall be in accordance with the following:

| | Permitted variation from design |
|---|---|
| THICKNESS OF LAYER | ± 10mm |
| Permitted variation from design<br>LEVEL OF SURFACE | + 5mm<br>-10mm |
| Permitted SURFACE IRREGULARITY<br>MEASURED by 3-meter straight-edge | 5 mm |
| Permitted variation from design<br>CROSSFALL OR CAMBER | ± 0.2% |
| Permitted variation from design<br>LONGITUDINAL GRADE over<br>25 meter length | ± 0.1% |

### 15.4 Method of Measurement

Aggregate base course shall be measured by cubic meter ($m^3$). The quantity to be paid for shall be the design volume compacted in-place as shown on the Plans, and accepted in the completed course. No allowance will be given for materials outside the design limits shown on the cross sections. Trials shall not be measured separately but shall be included in the quantity of aggregate base herein measured.

### 15.5 Basis of Payment

The accepted quantities, measured as prescribed in the Method of Measurement shall be paid for at the contract unit price for aggregate base course for which price and payment shall be full compensation for furnishings and placing of materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this item.

Payment shall be made under:

**Table 9**

| Pay Item Number | Description | Unit Measurement |
|---|---|---|
| 201 | Aggregate Base Course | Cubic meter |

## 16. AGGREGATE SURFACE COURSE (0PTIONAL)

- **Gravel Road**

### 16.1 Description

This item shall consist of a wearing or top course composed of gravel or crushed aggregate and binder material, whichever is called for in the Bill of Quantities, constructed on a prepared base in accordance with this Specification and in conformity with lines, grades and typical cross-sections shown on the Plans.

### 16.2 Material Requirements

The aggregate base course shall consist of hard, durable particles or fragments of stone or gravel and sand or other fine mineral particles free from vegetable matter and lumps or balls of clay, and shall be such that it can be compacted to form a firm, stable layer. It shall conform to the grading requirements shown in Table 10. When tested by AASHTO T 11 AND T 27.

**Table 10**

| Sieve Designation | | Mass Percent Passing | | | |
|---|---|---|---|---|---|
| Standard Mm | Alternate US Standard | Grading A | Grading B | Grading C | Grading D |
| 25 | 1” | 100 | 100 | 100 | 100 |
| 9.5 | 3/8” | 50-85 | 60-100 | - | - |
| 4.75 | No. 4 | 35-65 | 50-85 | 55-100 | 70-100 |
| 2.00 | No. 10 | 25-50 | 40-70 | 40-100 | 55-100 |
| 0.425 | No. 40 | 15-30 | 25-45 | 20-50 | 30-70 |
| 0.075 | No. 200 | 5-20 | 5-20 | 6-20 | 8-25 |

The coarse aggregate material retained on the 2.00 mm (No. 10) sieve shall have a mass percent of wear by the Los Angeles Test (AASHTO T 96) of not more than 45.

When crushed aggregate is called for in the Bill of Quantities, not less than fifty (50) mass percent of the particles retained on the 4.75 mm (No. 40 sieve shall have at least one (1) fractured face.

The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than two-thirds of the fraction passing the 0.425 mm (No. 40) sieve.

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 and a plasticity index range of 4 to 9, when tested by AASHTO T 89 and T 90 respectively.

Materials for gravel surface course and crushed aggregate surface course shall have a soaked CBR Value of not less than 25% and 80% respectively as determined by AASHTO T 193. The CBR Value shall be obtained at the maximum dry density and determined by AASHTO T 180, Method D.

### 16.3 Construction Requirements

#### 16.3.1 Placing

Aggregate Surface Course shall be placed in accordance with the requirements of Aggregate Base Course.

#### 16.3.2 Compacting Requirements

Aggregate surface course shall be compacted in accordance with the requirements on Aggregate Base Course

### 16.3.3 Trial Sections

Trial Sections shall be carried out in accordance with the requirements of Aggregate Base Course.

### 16.3.4 Surface Course Thickness and Tolerances

The aggregate surface course shall be laid to the designed level and transverse slopes shown on the Plans. The allowable tolerances shall be as specified hereunder:

| | |
|---|---|
| Permitted variation from design THICKNESS OF LAYER | +15mm<br>-5mm |
| Permitted variation from design LEVEL OF SURFACE | +15mm<br>-5mm |
| Permitted SURFACE IRREGULARITY MEASURED by 3-meter straight-edge | 5 mm |
| Permitted variation from design CROSSFALL OR CAMBER | +0.2% |
| Permitted variation from design LONGITUDINAL GRADE over 25 meter length | +0.1% |

### 16.4 Method of Measurement

Aggregate surface course shall be measured by the cubic meter ($m^3$). The quantity to be paid for shall be the number of cubic meters of aggregate including all filler, placed, compacted and accepted in the completed course. No allowance will be given for material placed outside the design limits shown on the cross sections. Trial sections shall not be measured separately but shall be included in the quantity of aggregate base herein measured above.

### 16.5 Basis of Payment

The accepted quantities, measured as prescribed in Method of Measurement shall be paid for at the contract unit price for Aggregate Surface Course for which price and payment shall be full compensation for furnishing, handling, placing, watering, and rolling all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this item.

Payment will be made under:

**Table 11**

| Pay Item Number | Description | Unit Measurement |
|---|---|---|
| 300 | Aggregate Surface Course | Cubic meter compacted in place |
| 300(1) | Gravel Surface course | |
| 300(2) | Crushed Aggregate Surface Course | |

## 17. BITUMINOUS PRIME COAT

- **BITUMINOUS ROAD**

### 17.1 Description

This item shall consist of preparing and treating an aggregate course with material in accordance with the Plans and Specifications, preparatory to the construction of a bituminous surface course.

### 17.2 Material Requirements

Bituminous material shall be either Rapid Curing (RC) or Medium curing (MC) Cut-back Asphalt, whichever is called for in the Bill of Quantities. It shall conform to the requirements of Item 702, Bituminous Materials, 1995 DPWH Standards Specifications for Bridges and Airports, Volume II. The type and grade shall be specified in the Special Provisions.

### 17.3 Construction Requirements

#### 17.3.1 Surface Condition

Prime coat shall be applied only to surfaces which are dry or slightly moist. No prime coat shall be applied when the weather is foggy or rainy.

#### 17.3.2 Equipment

The liquid bituminous material shall be sprayed by means of a pressure distributor of not less than 1000 liters capacity, mounted on pneumatic tires of such width and number that the load produced on the road surface will not exceed 1 kN (1000kgf) per cm width of tire.

The tank shall have heating device able to heat a complete charge of bituminous liquid to 180 $^{0}$C. The heating device shall be such that overheating will not occur. Consequently, the flames must not directly touch the casing of the tank containing the bituminous liquid. The liquid shall be insulated in such a way that the drop in

temperature when the tank is filled with bituminous liquid at $180^0$C and not heated will be less that $2^0$C per hour. A thermometer shall be fixed to the tank in order to be able to measure continuously the temperature of the liquid. The thermometer shall be placed in such a way that the highest temperature in the tank is measured. The tank shall be furnished with a calibrated dipstick to indicate the contents. The pipes for filling the tank shall be furnished with an easily changeable filter.

The distributor shall be able to vary the spray width of bituminous liquid in maximum steps of 100 mm to a total width of 4 meters. The spraying bar shall have nozzles from which the liquid is sprayed fan-shaped on the road surface equally distributed over the total spraying width.

For adding the liquid bituminous material, the distributor shall have a pump either driven by a separate motor or with a device to synchronize its speed of the distributor. The pump shall be furnished with an indicator showing the rate of flow. The suction side of the pump shall have an easily changeable filter. A thermometer shall be fixed, such that it indicates the temperature of the liquid immediately before it leaves the spraying bar.

The distributor shall be furnished with a tachometer, indicating its forward speed, which shall be visible from the driver's seat. The distributor shall be designed so that the deviation from the prescribed rate of application does not exceed 10% and shall be equipped with device for hand spraying on the bituminous liquid.

**17.3.3 Application of Bituminous Material**

Immediately before applying the prime coat, the full width of surface to be treated shall be swept with a power broom and if necessary, scraped to remove all dirt and other objectionable materials. Where required by the engineer, immediately prior to the application of prime coat, the surface shall be slightly sprayed with water but not saturated. Bituminous material shall be applied by means of pressure distributor at the temperature given in Bituminous Materials. The rate of application of the bituminous material shall be within the range of 1 to 2 liters/$m^2$, the exact rate to be ordered by the Engineer.

The prime coat shall be left undisturbed for a period of at least 24 hours and shall not be opened to traffic until it has penetrated and cured sufficiently so that it will not be picked up by the wheels of passing vehicles. The Contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amount, any excess shall be blotted with sand or removed as directed by the Engineer. All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying. The surface structures and trees adjacent to the areas being treated shall be protected to prevent their being spattered or marred.

### 17.4 Method of Measurement

Bituminous Prime Coat shall be measured by the tonne (t). The quantity to be paid for shall be the number of tonnes of bituminous material applied and accepted in the completed work.

### 17.5 Basis of Payment

The accepted quantity, measured as prescribed in Method of Measurement, shall be paid for at the contract unit price for Bituminous Prime Coat for which price and payment shall be full compensation for furnishing and placing all materials, including labor, equipment, tools and incidentals necessary to complete this item.

Payment shall be made in accordance with Table 12:

**Table 12**

| Payment Item No. | Description | Unit of Measurement |
|---|---|---|
| 301<br>301 (1)<br>301 (2) | Bituminous Prime Coat<br>MC - Cut-back Asphalt<br>RC – Cut-back Asphalt | <br>tonne<br>tone |

## 18. BITUMINOUS PLANT-MIX SURFACE COURSE - GENERAL

### 18.1 Description

This item includes general requirement that are applicable to all types of bituminous plant-mix surface courses irrespective of gradation of aggregate or kind and amount of bituminous material. Derivations from these general requirements will be indicated in the specific requirements for each type.
This work shall consist of constructing one or more bituminous bound layers on a prepared foundation in accordance with the Specifications and the specific requirements of the type under contract, and in reasonable close conformity with lines, grades, thickness and typical cross-sections shown on the Plans within the tolerances specified or established by the Engineer.

### 18.2 Material Requirements

#### 18.2.1 Composition and Quality of Bituminous Mixture

The bituminous mixture shall be composed of aggregate, mineral filler, hydrated lime, and bituminous material.

At least three weeks prior to production, the Contractor shall submit in writing a job-mix formula for each mixture supported by laboratory test data along with samples and sources of the components and viscosity-temperature relationships information to the Engineer for testing and approval (Job-Mix-Formula).

Each job-mix formula submitted shall propose definite single values for:

1. The percentage of aggregate passing each specified sieve size.
2. The percentage of bituminous material to be added.
3. The temperature of the mixture delivered on the road.
4. The kind and percentage of additive to be used.
5. The kind and percentage of mineral filler lo be used.

After the job-mix is established, all mixture furnished for the project shall conform thereto within the following ranges of tolerances:

| | |
|---|---|
| Passing No. 4 and larger sieves | ±7 percent |
| Passing No. 8 to No. 100 sieves (inclusive) | ±4 percent |
| Passing No. 200 sieve | ±2 percent |
| Bituminous Materials | ±0.4 percent |
| Temperature of Mixture | $\pm 10^0$C |

Should a change in source of material be proposed or should a job-mix formula proved unsatisfactory, a new job-mix formula shall be submitted by the contractor in writing and be approved by the Engineer prior to production.

Approval of new job-mix formula may require laboratory testing and verification.

The mixture shall have a minimum dry compressive strength of 1.4 MPa (200 psi).

The mixture shall have a mass percent air voids with the range of 3 to 5.

The mixture shall also have an index of retained strength of not less than 70 when tested by AASHTO T 165. For aggregates having maximum sizes over 25 mm (1 inch), AASHTO T 165 will be modified to use 150 mm x 150 mm (6 x 6 inches) cylindrical specimens. The 150 mm (6 inches) cylinder will be compacted by the procedures outlined in AASHTO T 167 modified to employ 10 repetitions of a molding load of 9.6 MPa (1400 psi), with no appreciable holding time after application of the full load.

### 18.2.2 Bituminous Materials

The kind of bituminous material to be used will be as called for in the Bill of Quantities, while the type and grade will be specified in the Special Provisions. The grade may be changed one step by the Engineer at no change in unit price. It shall conform to the applicable requirements of Item 702, Bituminous Materials, 2004 DPWH Standard Specifications.

**a. Asphalt Cements**

Asphalt cement shall conform to the requirements of AASHTO M 226.

**b. Liquid Asphalts**

Liquid asphalt shall conform to the requirements of the following specifications:

| | | |
|---|---|---|
| Rapid Curing Liquid Asphalts | - | AASHTO M 81 |
| Medium Curing Liquid Asphalts | - | AASHTO M 82 |

**c. Emulsified Asphalts**

Emulsified Asphalts shall conform to the requirements of the following specifications:

| | | |
|---|---|---|
| Emulsified Asphalt (Anionic) | - | AASHTO M 140<br>(AASHTO D 977) |
| Emulsified Asphalt (Cationic) | - | AASHTO M 208 |

**d. Acceptance Procedure for Bituminous Materials**

**1) General**

Bituminous materials will be accepted at the source of shipment subject to the following conditions:

a. The supplier shall conduct laboratory tests of all materials intended for shipment to the Government and certify that the materials meet the Contract Specifications.

b. Before loading, the producer shall examine the shipping container, remove all remnants of previous cargoes which might contaminate the material to be loaded and certify that it was clean and free of contaminating material and loaded.
c. The contractor shall furnish with each shipment two copies of the delivery ticket. The delivery tickets shall contain the following information:

Consignees _____ Destination _____
Project Number _____ Date _____
Grade _____ LoadignTemp _____
Net Liters _____ Specific Gravity _____
At 15.5 $^{0}$C (60 $^{0}$F

Net Weight _____
Identification No. (Truck, Car, Tank, etc.)

d. The contractor or the supplier as his agent, shall deliver to the Engineer or his representative a certification signed by an authorized representative of the supplier to cover the quality and quantity of material and the condition of container for each

shipment. The certification shall be essentially in the following form and may be stamped, written or printed on the delivery tickets.

"This is to certify that this shipment of _____(tonnes/liters) or _____ of asphalt meets all Contract Specification requirements of the DPWH, and the shipping container was clean and free from contaminating material when loaded.

Producer _____
Signed _____

Failure to sign the certification will be a cause to withhold use of the material unit it can b stamped, tested and approved.

**2) Quality Control Reviews**

Quality control reviews will be conducted by the Government, or an authorized representative at the point of production, at frequencies prescribed by the DPWH, to determine the reliability of the producer's certifications.

If this review indicates that the certifications are not reliable, the acceptance of bituminous materials by certification will be discontinued and the contents of each shipping container will be sampled at point of delivery, tested and accepted prior to incorporation into the work. This procedure will be followed until the engineering determination is made that the supplier's quality control and testing procedures are such that material meeting Contract Specifications is being consistently produced.

**3) Alternate Acceptance Procedures for Asphalt Materials**

Where required by the Special Provisions, the following alternate acceptance plan for asphalt material will apply in lieu of (a) and (b) above. The Contractor shall provide, deliver tickets and certifications as set out in (a), above.

Acceptance samples of bituminous materials shall be obtained in accordance with AASHTO T 40, Sampling Bituminous Materials, at the applicable point of acceptance as defined herein:

a. Bituminous materials used in direct application on the road. Acceptance samples shall be obtained under the supervision of the Engineer from the conveyances containing the bituminous material at the point of delivery. Single samples shall be taken of each separate tank load of bituminous material delivered, at the time of the discharge, into distributors or other conveyance on the project.

b. Bituminous materials initially discharged into storage tanks on the project. Acceptance samples shall be obtained from the line between the storage tank and the distributor of the bituminous mixing plant after each delivery. A single acceptance sample shall be taken after sufficient period of circulation of such

bituminous material has taken place to insure samples representative of the total materials then in the storage tank.

As soon after sampling as practicable, the acceptance sample shall be delivered by the Engineer to the nearest authorized laboratory for tests to determine compliance.

**4) Requirements for Bituminous materials containing Anti-stripping Additives**

a. All the foregoing requirements of Item 702 shall apply for the type of bituminous material involved.

b. Additionally, the Contractor or the supplier as his agent, shall furnish the Engineer or his representative along with and the time of delivery of the initial shipment of fortified bituminous material to the project, and thereafter with the subsequent shipments when ordered by the Engineer, 1 litre (1 quart) sealed sample of the bituminous material taken at the time of loading at the refinery and prior to introduction of the additive, along with the separate 0.5 litre (1 pint) sample of the anti-stripping additive involved.

**5) Application Temperatures**

Bituminous materials for the several application indicated in the Specifications shall be applied within the temperature ranges indicated in Table 13.

**Table 13- Application Temperatures**

| Type and Grade of Material | Application Spray (Min./Max) | Temperature Range ($^0$C)Mix (Min./Max.) |
|---|---|---|
| RT 1-2-2 | 15.5 – 54 | 15.5 – 54 |
| RT 4-5-6 | 29—65.5 | 29 – 65.5 |
| RT 7-8-9 | 65.5 – 107 | 65.5 – 107 |
| RT 10-11-12 | 79 – 121 | 70 – 121 |
| RTCB 5-6 ….30 | 15.5 – 48.9 | 15.5 – 48.9 |
| MC……30 | 21 – 62.8 | 15.5 – 40.5 |
| RC-MC……70 | 40.5 – 85 | 32 – 68 |
| RC-MC …..250 | 60 – 107 | 51.7 – 93 |
| RC-MC…..800 | 79 – 129 | 71 – 107 |
| RC-MC …3000 | 106.7 – 143 | 93 – 126.7 |
| All Emulsions | 10-71 | 10-71 |
| Asphalt Cement (All Grades) | 204 Max. | As required to achieve viscosity of 75 – 150 seconds to achieve a Kinematic Viscosity of 150-300 mm$^2$/s (150-300 centi-stokes |

Table 13 shall apply unless temperature ranges applicable to specific lots of material delivered to the job are supplied by the producer.

**6) Material for Dampproofing and Waterproofing Concrete and Masonry Surfaces**

Material shall conform to the requirements of the following specifications:

| | |
|---|---|
| a. Primer for use with asphalt | AASHTO M 116 |
| b. Primer for use with tar | AASHTO M 121 (ASTM D 43) |

or

It may be a liquid water-gas tar conforming to the following requirements:

| | |
|---|---|
| Specific gravity, 25/25 $^0$C | 1.030 – 1.100 |
| Specific viscosity at 40 $^0$C (Engler), not more than | 3.0 |
| Total distillate, mass percent 300$^0$, not more than | 50.0 |
| Bitumen (soluble in carbon disulphide), not less than | 98.0 percent |
| Water not more than | 2.0 percent |

| | |
|---|---|
| c. Tar for mop or seal coats: Coal tar pitch (heated to free Flowing but not to exceed 149$^0$C (300 $^0$F) | ASSHTO M 118, Type B (ASTM D 450) |
| Or | |
| Tar applied at about 27 $^0$C (80 F) Rubberized tar (heated to free Flowing but not to exceed 121 $^0$C(250 $^0$F) | AASHTO M 52, RTCB 5 or ASTM D 2993 |
| d. Asphalt for mop coat | AASHTO M 115 |
| e. Waterproofing fabric | AASHTO M 117(ASTM D) |

Fabric should be waterproofed with tar or asphalt in agreement with the material specified for prime and mop coats.

f. Mortar materials shall conform to Section 705.5 except that the mortar shall be uniformly mixed to spreading consistency in the proportion of 1 part Portland Cement to 3 parts of fine aggregate.

| | |
|---|---|
| g. Asphalt plank | AASHTO M 46 (ASTM D 517) |

Unless otherwise shown on the plans, planks shall be 30 mm thick and may be from 150 to 300 mm in width but all pieces for one structure shall be of the same width except such “closers” as may be necessary. The lengths shall be such as to permit the laying of the planks to the best advantage on the surface to be covered but shall not be less than 0.9 nor more than 2.5 m.

h. Asphalt roll roofing grade ASTM D 224, 65 pound

**7) Membrane Material for Waterproofing Bridge Decks**

Bridge deck waterproofing membrane shall be mesh-reinforced self-sealing rubberized asphalt performed membrane and shall have the following properties:

| | | |
|---|---|---|
| Thickness | 1.65 mm (655 mils) | ASTM E 96 |
| Permeance-Perms Kg./Pa.s.$m^2$ (grains/sq.ft./hr./in. Hg) | 57.2123 x $10^{-11}$(0.10) | Method B |
| Tensile strength | 344.5 kPa (50 lb/in) | ASTM D 882 Modified for 25.4 mm (1inch)opening |
| Puncture resistance (mesh) | 90.8 kg (200 lb) | ASTM E 154 |
| Pliability – 6.35 mm (1/4”) mandrel $180^0$ Bend at -8.3$^0$C (-15$^0$F) | No cracks in rubberized asphalt | ASTM D 146 |

Primer and mastic shall be as recommended by the manufacturer and shall be compatible with the membrane.

**8) Tars**

Tars shall conform to the requirements of AASHTO M 52.

**9) Dust Oils**

Dust oils and clarified dust shall conform to the following requirements:

| General Requirements | ASTM METHOD | Light | Dust Oil Medium | Heavy | Clarified Dust Oil |
|---|---|---|---|---|---|
| Flash Point, $^0$C (Open tag.), min. | D 1310 | 51.6 | 51.6 | 51.6 | 93.3 |
| Viscosity at 38$^0$C | D 2170 | 40-70 | 90-135 | 145-200 | 20-100 |

| | | | | | |
|---|---|---|---|---|---|
| ($100^0$F) Kinematic, CS | | | | | |
| Water, % Maximum | D 95 | 2.0 | 2.0 | 2.0 | 2.0 |
| Asphaltness % | *D2006 | 3.0-6.0 | 4.0-7.0 | 5.0-8.0 | 0-5.0 |
| Saturates % minimum | *D2006 | 25 | 25 | 25 | 10 |
| | | Distillation | | | |
| Total Distillate to $288^0$ ($550^0$F), Max. % | **D402 | 35 | 30 | 30 | 5 |

Test on residue from Distillation to $288^0$C ($550^0$F)

| | | | | | |
|---|---|---|---|---|---|
| Viscosity at $100^0$T, Kinematic, CS | D2170 | 75-250 | 200-630 | 540-1500 | 20-150 |
| Solubility in Trichloroethylene, % Min. | ***2042 | 97.0 | 97.0 | 97.09 | 97.0 |

As modified in procedure as "Test Method for Determination of Asphaltene and Saturate Content of Dust Oils" by Materials Testing Laboratory, Region 1, USDA Forest Service, Missoula, MT dated November 1970. Copies of the procedure are available from the Regional Materials Engineer, Region 1, USDA Forest Service Missoula, MT 590811

**Except that the residue remaining after a temperature of $288^0$C (instead of $360^0$C) shall be used for further testing. As modified in procedure identified as "Standard Method of Test for Distillation of Forest Service Dust Oil" dated July 1972. Copies of the procedure are available from the Regional Materials Engineer, Region 1, USDA Forest Service, Missoula, MT, 59801.

***Trichloroethylene shall be used as solvent instead of carbon disulphide.

**18.2 3 Aggregates**

Aggregates shall conform to the requirements of Item 703, Aggregates, 2004 DPWH Standard Specifications for Highways, Bridges and Airports Volume ll.

**18.2.3.1 Fine Aggregates for Concrete and Incidentals**

**a. Concrete**

Fine aggregate for concrete shall conform to the requirements of AASHTO M 6, with no deleterious substances in excess of the following percentages:

| | |
|---|---|
| Clay lumps | 3.0 |
| Coal and lignite | 1.0 |
| Material passing 0.075 mm sieve | 4.0 |
| Other substances – as shown in the Special Provisions | |

Lightweight aggregate, if required or permitted by the Special Provisions, shall meet the pertinent requirements of AASHTO M 195.

**b.** Granular backfill filter material for underdrains and filler for paved waterways shall be permeable and shall meet the requirements of AASHTO M 6, except that soundness tests will not be required and minor variations in grading and content of deleterious substances may be approved by the Engineer.

**c.** Aggregate for minor concrete structures shall be clean, durable, uniformly graded sand and gravel, crushed slag, or crushed stone, 100 percent of which will pass a 37.5 mm (1-1/2 inches) sieve and containing not more than 5 percent passing the 0.075 mm (No. 200) sieve.

**18.2.3.2 Coarse Aggregate for Portland Cement Concrete**

Coarse aggregate for concrete shall meet the requirements of AASHTO M 80.
Lightweight aggregate, if required or permitted by the Special Provisions, shall conform to the requirements of AASHTO M 195, for the grading specified.

**18.2.3.3 Aggregate for Portland Cement Treated and Stabilized Base Course**

The crushed and uncrushed granular material shall consist of hard durable stones and rocks of accepted quality, free from an excess of flat, elongated, soft or disintegrated pieces or other objectionable matter. The method used in obtaining the aggregate shall be such that the finished product shall be as consistent as practical.

All materials passing the 4.75 mm (No. 4) mesh produced in the crushing operation of either the stone or gravel shall be incorporated in the base material to the extent permitted by the gradation requirements. The plasticity index shall not be less than 4 nor more than 10.

### 18.2.3.4 Aggregate for Untreated Subbase, Base or Surface Courses

Aggregate shall consist of hard, durable particles or fragments of crushed stone, crushed slag, or crushed or natural gravel. Materials that break up when alternately wetted or dried shall not be used.

Coarse aggregate is the material retained on the 2.00 mm (No. 10) sieve and shall have a percentage of wear of not more than 50 for subbase and not more than 45 for Base and Surface Courses as determined by AASHTO Method T 96.

Fine aggregate is the material passing the 2.00 mm (No. 10) sieve and shall consist of natural or crushed sand and fine mineral particles. Te fraction passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40) sieve. For base courses, the fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 6, while for Subbase course, the liquid limit shall not be greater than 35 plasticity index not greater than 12.

For surface courses, the fraction passing the 0.425 mm (No.4) sieve shall have a liquid limit not greater than 35 and a plasticity index not less than or greater than 9.

All materials shall be free from vegetable matter and lumps or balls of clay.

When crushed aggregate is specified, not less than 50 mass percent of the particles retained on the 4.75 mm (No.4) sieve shall have at least one fractured face.

Gradation of each designated size of aggregate shall be obtained by crushing, screening and blending processes as may be necessary.

Materials otherwise meeting the requirements of this section will be acceptable whenever such materials produce a compacted course meeting applicable density requirements as specified in Subsections 200.3.3, 201.3.3, 202.3.3 and 203.3.6.

### 18.2.3.5 Aggregate for Bituminous Concrete

#### a. Coarse Aggregate

Coarse aggregate retained on the 2.36 mm (N0.8) sieve shall be crushed stone, crushed slag or crushed or natural gravel and unless otherwise stipulated, shall conform to the quality requirements of AASHTO M 79-74.

When crushed gravel is used, it shall meet the pertinent requirements of Section 2.1 and Section 3.1 of AASHTO M 62-74 and not less than 50 mass percent of the particles retained on the 4.75 mm (No.4) sieve shall have at least one fractured face. 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 under the composition of mixture for the specific type

under contract. Only one kind shall be used on the project except by permission of the Engineer.

**b. Fine Aggregate**

Fine aggregate passing the 2.36 mm (No.8) sieve shall consist of natural sand, stone, stone screenings or slag screenings or a combination thereof, and unless otherwise stipulated shall conform to the quality requirements of AASHTO M 29 (ASTM D 1073). 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 under the composition of mixture for the specific type under contract.

**c. Open-Graded Asphalt Concrete Friction Course**

Aggregate shall conform to Subsections 703.5.1 and 703.5.2 above and the following requirements. Relatively pure carbonate aggregates or any aggregates known to polish shall not be used for the coarse aggregate fraction (material retained on the 2.36 mm (No. 8) sieve. In addition, the coarse aggregate fraction shall have at least 75 mass percent of weight of particles with at least two fractured faces and 90 mass percent with one or more fractured faces, except that lightweight aggregates need not meet this requirement. The abrasion loss (AASHTO T 96) shall not exceed40 mass percent.

**d. Lightweight Aggregate (except slag)**

Lightweight aggregate (except slag), if required or permitted by a Special Provisions, shall be manufactured by the rotary kiln process. The material shall consist of angular-fragments uniform in density and reasonably free from flat, elongated or other deleterious substances. The material shall show an abrasion loss of less than 45 mass percent when tested in accordance with AASHTO T 96. The dry mass per cubic meter shall not exceed 1080 kg. (67pcf). After testing through five cycles of the magnesium sulfate soundness test, the loss shall not exceed ten (10) mass percent.

**18.2.3.6 Aggregate for Bituminous Plant Mix Surfacing**

Aggregate shall be uniformly graded form coarse to fine. Target values for the intermediate sieve sizes shall be established within the limits shown in table 14.

The Contractor shall submit the proposed target values in writing to the Engineer for approval. The target gradation is subject to confirmation testing in accordance with Section 307.2 before approval by the Engineer. Any changes in the target gradation are subject to confirmation testing in accordance with Section 307.2, unless otherwise approved in writing by the Engineer. No target gradation adjustment will be permitted during the span of a lot.

**Table 14-Range of Gradation Target Values**

| Sieve Designation, mm | Mass percent passing square mesh Sieves, AASHTO T 11 and T 27, Exclusive of mineral filler |
|---|---|
| | Range |
| 25 (1 inch) | 100 |
| 18 (3/4 inch) | 100 |
| 4.75 (No.4) | 50-60 |
| 2.36 (N0.8) | 38-48 |
| 0.075 (N0. 200) | 3-7 |
| | The minimum for Sand Equivalent is 35 |

No intermediate sizes of aggregate shall be removed for other purposes without written consent of the Engineer.

If crushed gravel is used, not less than 50 mass percent of the material retained on the 4.75 mm (No.4) sieve shall be particles having at least one fractured face.

That portion of the composite material passing a 4.75 mm (No. 4) sieve shall have a sand equivalent of not less than 35, as determined by AASHTO T 176, Alternate Method No. 2.

The aggregate shall show a durability index not less than 35 (coarse and fine) as determined by AASHTO T 210.

The material shall be free of clay balls and adherent films of clay or other matter that would prevent thorough coating with the bituminous material*.*

**18.2.3.7 Aggregate for Hot Plant-Mix Bituminous Pavement**

The provision of Subsection 703.5.1, 703.5.2 and 703.5.3 (2004 DPWH Standard Specifications) shall apply. The several aggregate fraction for the mixture shall be sized, graded and combined in such proportions that the resulting composite blend meets one of the grading requirements of the table 15 as specified in the Schedule.

The gradings to be used will be shown in the Special Provisions, adjusted to reflect variations in aggregate densities.

The ranges apply to aggregates with bulk specific gravity values that are relatively constant throughout a grading band. When such values vary from sieve to sieve, such as with lightweight aggregates, the ranges from each sieve size shall be adjusted to reflect the variation.

### 18.2.3.8 Aggregate for Cold Plant-Mix Bituminous Pavement

The provisions of Subsections 703.5.1 and 703.5.2 shall apply.

**a. Aggregate for Pavement**

The several aggregate fractions for the mixture shall be sized, graded and combined in such proportions that the resulting composite blends meet the respective grading requirements of Table 16 adjusted to reflect variation in aggregate densities.

**b. Aggregate for Top Dressing**

The material for top dressing shall consist of dry sand, stone screenings or slag screenings so graded that at least 95 mass percent shall pass the 4.75 mm (N0.4) sieve and not more than 40 percent shall pass the 0.300 mm (N0.50) sieve.

**Table15**

**Gradation Ranges-Hot Plant Mix Bituminous Pavements**
**(Mass percent passing square sieves, AASHTO T 11 and T 27)**

| Sieve Designation Mm | GRADING | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G |
| 37.5 (1-1/2 inch) | 100 | - | - | - | - | - | - |
| 25 (1 inch) | 95-100 | 100 | 100 | - | - | - | - |
| 19 (3/4 inch) | 75-95 | 95-100 | 95-100 | 100 | - | 100 | - |
| 12.5 (1/2 inch) | - | 68-86 | 68-86 | 95-100 | 100 | - | 100 |
| 9.5 (3/8 inch) | 54-75 | 66-78 | 56-78 | 74-92 | 95-100 | - | 95-100 |
| 4.75 (No.4) | 36-58 | 38-60 | 38-60 | 48-70 | 75-90 | 45-65 | 30-50 |
| 2.36 (No.8) | 25-45 | 27-47 | 27-47 | 33-53 | 62-82 | 33-53 | 5-15 |
| 1.18 (No. 16) | - | 18-37 | 18-37 | 22-40 | 38-58 | - | - |
| 0.600 (No. 30) | 11-28 | 13-28 | 13-28 | 15-30 | 22-42 | - | - |
| 0.300 (No. 50) | - | 6-20 | 9-20 | 10-20 | 11-28 | 10-20 | - |
| 0.075 (No. 200) | 0-8 | 0-8 | 4-8 | 4-9 | 2-10 | 3-8 | 2-5 |

### 18.2.3.9 Aggregate for Road Mix Bituminous Pavement

Aggregate for road mix bituminous pavement construction shall be crushed stone, crushed slag, or crushed or natural gravel which meet the quality requirements of AASHTO M 62-74 or M 63-74 for the specified gradation, except that the sodium sulfate soundness loss shall not exceed 12 mass percent.

When crushed gravel is used, at least 50 mass percent of the particles retained on the 2.00 mm (No. 10) sieve shall have at least one fractured face. Gradation shall conform to Grading F of Table 15.

**18.2.3.10 Aggregate for Cover Coats, Surface Treatments and Bituminous Preservative Treatment**

Cover aggregate for type 2 seal coat (Item 303) shall consist of sand of fine screenings, reasonably free from dirt or organic matter.

Aggregates for type 3 seal coat (Item 303) surface treatments or bituminous preservative treatment shall be crushed stone, crushed slag or natural gravel. Only one type of aggregate shall be used on the project unless alternative types are approved. Aggregates shall meet the quality requirements of AASHTO M 78-74.

When tested in accordance with AASHTO 182, (ASTM D 1664) aggregate shall have a retained bituminous film above 95 mass percent.

Aggregates which do not meet this requirement may be used for bituminous surface treatment s and seal coats provided a water resistant film.

Lightweight aggregate, if required or permitted by the Special Provisions, shall meet the pertinent requirements of Subsection 703.5.4

When crushed gravel is used, not less than 50 mass percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least one fractured face. Aggregates shall meet the gradation requirements called for in the Bid Schedule.

**Table 16**

**Gradation Requirements-Cold Plant Mix Bituminous Pavement (Mass percent passing square mesh sieves, AASHTO T 27)**

| Sieve Designation | | Bottom (Binder) Course | Wearing (Surface) Course |
|---|---|---|---|
| Standard, mm | Alternate US Standard | Bottom (Binder) Course | Wearing (Surface) Course |
| 37.5 | 1-1/2 | 100 | - |
| 25 | 1” | 85-100 | - |
| 19 | ¾” | 40-70 | 100 |
| 12.5 | ½” | 10-35 | 95-100 |
| 4.75 | No.4 | 4-16 | 15-40 |
| 2.36 | No.8 | 0-5 | 10-25 |
| 0.600 | No.30 | - | 4-13 |
| 0.300 | No.50 | - | 0-5 |

**Table 17**
**Gradation Requirements for Cover Coats**
**(Mass percent passing square mesh sieves, AASHTO T 27)**

| Sieve Designation | | Grading designation with corresponding size No. from AASHTO M 43 (ASTM D 448) modified | | | | | |
|---|---|---|---|---|---|---|---|
| Std. mm | Alt US Std | A(No.5) | B No. 6 | C (No.7) | D (No.8) | E(No.9) | F(No.10) |
| 37.5 | 1-1/2” | 100 | - | - | - | - | - |
| 25 | 1” | 90-100 | 100 | - | - | - | - |
| 19 | ¾” | - | 90-100 | 100 | - | - | - |
| 12.5 | ½” | 0-10 | - | 90-100 | 100 | - | - |
| 9.5 | 3/8” | - | 0-15 | - | 85-100 | 100 | 100 |
| 4.75 | No. 4 | - | - | 0-15 | - | 85-100 | 85-100 |
| 2.36 | No.8 | - | - | - | 0-10 | - | - |
| 0.075 | No. 200 | 0-2 | 0-2 | 0-2 | Te 0-2 | 0-2 | 0-10 |

**18.2.3.11 Blotter**

Aggregate for blotter material shall conform to the gradation requirements of AASHTO M 43 (ASTM D 448), size 2.00 mm (No. 10). This aggregate shall be free from vegetable or other deleterious materials.

**Table 18**
**Gradation Requirements for Bituminous Surface Treatments**

| Sieve Designation | | Grading designation with corresponding size No. from AASHTO M 43 (ASTM D 448) modified | | | | | |
|---|---|---|---|---|---|---|---|
| Std. mm | Alt US Std | A (No.5) | B (No.6) | C (No.7) | D (No.8) | E (No.9) | F(No.10) |
| 37.5 | 1-1/2” | 100 | - | - | - | - | - |
| 25 | 1” | 90-100 | 100 | - | - | - | - |
| 19 | ¾” | 20-25 | 90-100 | 100 | - | - | - |
| 12.5 | ½” | 0-10 | 20-55 | 90-100 | 100 | - | - |
| 9.5 | 3/8” | 0-5 | 0-15 | 40-70 | 85-100 | 100 | 100 |
| 4.75 | No.4 | - | 0-5 | 0-15 | 10-30 | 85-100 | 85-100 |
| 2.36 | No. 8 | - | - | 0-5 | 0-10 | 10-40 | 60-100 |
| 0.150 | No.100 | - | - | - | - | - | 0-10 |

**(Mass percent passing square mesh sieves, AASHTO T 27)**

**Table 19**
**Gradation Requirement for Bituminous Preservative Treatment**

| Sieve Designation | | Mass percent passing square Mesh Sieves, AASHTO T 27 | |
|---|---|---|---|
| Standard, mm | Alternate US Standard | Grading A Course | Grading B Course |
| 19 | ¾" | - | 100 |
| 9.5 | 3/8" | 100 | - |
| 4.75 | No.4 | 45-80 | 45-50 |
| 2.36 | No.8 | 26-64 | 28-64 |
| 0.075 | No. 200 | 0-12 | 0-12 |

**18.2.3.12 Bed Course Material**

Bed course material for side walks, paved waterways and curbing shall consist of cinders, slag, sand, gravel, crushed stone or other approved material of such gradation that all particles will Pass through a sieve having 37.5 mm (1-1/2 inches) square openings.

Bed course material for slope protection shall be a porous, free draining material consisting of sand, gravel, cinders, slag, crushed stone or other approved free-draining material. This material shall be uniformly graded and of such size that 100 percent of the material will pass through a sieve having 37.5 mm (1-1/2 inches) square opening.

**18.2.3.13 Sheathing Material**

Sheathing material shall conform to either (a) or (b) below:

a. Sound, durable particles of gravel, slag or crushed stone meeting the following gradation:

| Sieve | Mass percent passing |
|---|---|
| 75 mm (3") | 100 |
| 4.75 mm (No.4) | 0-10 |
| 0.075 mm (N0.200) | 0-2 |

b. Clean noncementitious sand meeting the requirements of Subsection 703.1.2.

### 18.2.3.14 Aggregates for Subgrade Modification

The material shall consist of hard, durable particles or fragments of slag, stone or gravel, screened or crushed to the required size and grading. The material shall be visually free from vegetable matter and lumps or balls of Crushed slag shall consist of clean, tough, durable pieces of blast furnace slag, reasonably uniform in density and quality and reasonably free from glassy pieces.

### 18.2.3.15 Aggregate for Salt Stabilization

Aggregates for salt stabilized base course shall consist of hard, durable particles of fragment of slag, stone or gravel, screened or crushed to the required size and grading.

That portion of the material passing a 0.425 mm (No.40) sieve shall have a plasticity index of not over 6, as determined by AASHTO T 90.

The material shall be visually free from vegetable matter or balls of clay and shall meet the requirements for one of the gradings given in Table 20 as called for in the Bid Schedule.

**Table 20**
**Gradation Requirements for Aggregates for**
**Salt Stabilized Base Course**

| Sieve Designation | | Mass percent passing square mesh sieves, AASHTO T 11 and T 27 | |
|---|---|---|---|
| 75 | 3” | - | - |
| 50 | 2” | - | 100 |
| 37.5 | 1-1/2” | - | 70-100 |
| 25 | 1” | 100 | - |
| 19 | ¾” | 70-100 | 50-80 |
| 9.5 | 3/8” | 50-80 | 40-70 |
| 4.75 | No. 4 | 35-45 | 30-60 |
| 2.00 | No.10 | 25-50 | 20-50 |
| 0.425 | No.40 | 15-30 | 10-30 |
| 0.075 | No.200 | 7-15 | 7-15 |

- Gradation varies with top size of material and should be based on size of largest material used. For instance, if largest size is 50 mm (2 inches), gradation should be under heading B; if 25 mm (1 inch), under A.

### 18.2.3.16 Aggregates for Emulsified Asphalt Treated Base Course

Aggregate shall consist of coarse aggregate of crushed gravel, crushed slag or crushed stone, composed of hard, durable particles or fragments and a filler of finely of finely crushed stone, sand, slag or other finely divided mineral matter. The portion of the material retained on a 4.75 mm (No.4) sieve shall be known as coarse aggregate and that portion passing a 4.75 mm (No. 4) sieve shall be known as fine aggregate. The material shall meet one of the grading requirements of Table21

**Table 21**

**Grading Requirements Aggregates for Emulsified Asphalt Treated Base Course**

| Sieve Designation | | Grading A | Grading B | Grading C |
|---|---|---|---|---|
| Standard, mm | Alternate US Standard | | | |
| 37.5 | 1-1/12” | 100 | 100 | - |
| 25 | 1” | 95-100 | 95-100 | - |
| 19 | ¾” | - | 50-85 | 100 |
| 12.5 | ½” | - | - | 95-100 |
| 4.75 | No.4 | - | 26-59 | 65-100 |
| 2.00 | No.10 | 0-9 | 17-48 | - |
| 0.300 | No.50 | - | - | 12-35 |
| 0.075 | No.200 | 0-2 | 2-10 | 3-12 |

If crushed gravel, is used, not less than 65 mass percent of the coarse aggregate particles retained on a 4.75 mm (No. 4) sieve shall be particles having at least one fractured face.

Coarse aggregate shall have a percent of wear of not more than35 at 500 revolution, as determined by AASHTO T 96.

The aggregate shall show a durability factor not less than 35 (coarse and fine) as determined by AASHTO T 210 (Production of Plastic Fines in Aggregates).

The material shall be free of clay balls and adherent films of clay or other matter that would prevent thorough coating with bituminous material.

### 18.2.4 Mineral Filler

#### 18.2.4.1 Description

Mineral filler shall consist of finely divided mineral matter such as rock dust, slag dust, hydrated lime, hydraulic cement, fly ash or other suitable mineral matter. It shall be free from organic impurities and at the time of use, shall be sufficiently dry to flow freely and shall be essentially free from agglomerations.

#### 18.2.4.2 General Requirements

**a.** Filler materials for bituminous bases or pavements shall meet the requirements of AASHTO M 17, Mineral Filler for Bituminous Paving Mixtures.

**b. Physical Requirement**

Mineral filler shall be graded within the following limits:

| Sieve | Maximum Perfect Passing |
|---|---|
| 0.600 mm (No. 30) | 100 |
| 0.300 mm (No. 50) | 95-100 |
| 0.075 mm (N0.200) | 70-100 |

The mineral filler shall have a plasticity index not greater than 4. Plasticity index limits are not appropriate for hydraulic lime and cement.

#### 18.2.4.3 Methods of Sampling

**a. Materials in Bulk**

Sampling from bins, piles or cars – A sampling tube that takes a core not less than 25 mm (1 inch) in diameter may be used to obtain a sample portions from one or more location as required to obtain a field sample of at least 5 kg (10 lb). Sample portions may be taken from holes dug into the material at 5 or more locations to provide a field sample of at least 5 kg (10 lb).

Sampling from conveyors – Sample portions shall be taken at regular intervals during the time of movement of the materials in the unit being sampled to provide a field sample of at least 5 kg (10lb).

**b. Materials in Packages**

From the unit to be sampled, select at least one percent of the packages at random for sampling, but in no case shall fewer than 5 packages be selected. Take sample portion from a hole dug into the top of each package selected for sampling .A sampling tube may be used that takes a core not less than 25 mm (1 inch) diameter. Insert the tube into the package to substantially sample the entire

length of the package. Combine the sample portions taken to obtain a field sample of at least 5 kg (10 lb).

**18.2.4.4 Shipping Samples**

Mineral filler shall be shipped in a clean, moisture-proof container and packaged securely to prevent the loss of material during handling. Reduce the field sample to a minimum size of 2.5 kg (5 lb) to submit for testing, using the method of quartering.

**18.2.4.5 Methods of Test**

The properties enumerated in this Specification shall be determined with the following AASHTO Method of Test:

| | |
|---|---|
| Gradation | T 37 |
| Plasticity Index | T 90 |

**18.2.5 Hydrated Lime**

**18.2.5.1 General**

Hydrated lime shall conform to he requirements of PHILSA 1-1-68 or ASTM C 207-76 and shall be of the following type:

| | |
|---|---|
| Type N | - Normal hydrated lime for masonry purposes. |
| Type S | - Special hydrated lime for masonry purposes. |
| Type NA | - Normal air-entraining hydrated lime for masonry purposes. |
| Type SA | - Special air-entraining hydrated lime for masonry purposes. |

Type N and S are suitable for use in mortar, in scratch and brown coats of cement plaster, for stucco and for addition to Portland Cement concrete.

Type NA and SA are air-entrained hydrated limes that are suitable for use in any of the above uses where air-entrained are desired.

Type S and SA hydrated lime develop high, early plasticity and higher water retentivity and by a limitation on their unhydrated oxide content.

It is the intent of this Specification to us either the Type N or S for soil stabilization and as filler requirement to bituminous plant mixtures. It is expected to provide pavements with greater resistance to the detrimental effects of water, especially flooding during the rainy season.

### 18.2.5.2 Chemical Requirements

Hydrated lime for construction purposes shall conform to the following standard chemical requirements

| | Percentages |
|---|---|
| Calcium and Magnesium oxides (Non- volatile basis), min. % | 60 |
| Carbon dioxide (as received basis) max % | |
| If sample is taken at the place of manufacture | 5 |
| If sample is taken at any other place | 7 |
| Unhydrated oxides (as received basis) for Type S And SA, max % | 8 |

### 18.2.5.3 Physical Requirements

Hydrated lime for construction purposes shall conform to the following physical requirements:

a. Percentage Residue

The residue retained on a 0.600 mm (No. 30) sieve shall not be more than 0.57% and not more than 15% on a 0.075 mm (No.200) sieve.

b. Plasticity

The putty made from Type S, special hydrate, or type SA, special air-entraining hydrate, shall have plasticity figure of not less than 200 when tested within 30 minutes after mixing with water.

c. Water Retention

Hydrated lime mortar mad with Type N (normal hydrated lime) or type NA (normal air-entraining lime), after suction for 60 seconds, shall have a water retention value of not less than 75 percent and not less than 85% for Type S and SA, when tested in a standard mortar made from the hydrate which has been soaked for a period of 16 to 24 hours.

### 18.2.5.4 Grading Requirement

Hydrated lime for construction purposes shall conform to the following grading requirements:

**Table 22**

| Sieve Designation | | Mass Percent Passing |
|---|---|---|
| Standard mm | Alternate US Standard | |
| 0.850 | (No. 20) | 100 |
| 0.075 | (No. 200) | 85-100 |

**18.2.5.5 Sampling**

Samples of construction lime shall be taken at the place of manufacture or at the destination as agreed upon by the parties concerned. If the samples are taken elsewhere than at the place of manufacture, such samples shall be taken within 24 hours of the receipt of the material.

Sampling shall be conducted as expeditiously as possible to avoid undue exposure of the material to the air. Samples shall not be taken from broken packages.

At least one percent of the package shall be sampled but in no case shall less than five packages be sampled. Individual packages shall be taken from various parts of the unit being sampled. Each package so taken shall be opened and not less than 0.5 kg. shall be taken by means of a sampling tube that takes core of the material of not less than 2.5 cm in diameter and that is of sufficient length to permit the taking of the sample from the top to the bottom of the mass being sampled. The material removed shall be thoroughly mixed and quartered. Triplicate samples of not less than 2.5 kg each shall be taken and sealed in properly labeled, air-tight, moisture-proof containers.

**a. Sample for Chemical Analysis**

The sample as received at the laboratory shall be thoroughly mixed, quartered, and a representative sample taken and crushed to pass a 0.150 mm (No. 100) sieve for analysis. The remaining uncrushed portion shall be resealed for further possible tests.

**b. Rejection**

Materials failing to meet the specification requirements shall be reported to the manufacturer within one (1) week after tests have been completed and the cause for rejection shall be stated.

**c. Packing**

Lime and limestone products may be shipped in bulk or in containers agreed upon by the manufacturer and the purchaser. The most common units for hydrated lime are paper bags holding 23 kg (50 lbs.), 11.5 kg (25 lbs.), 4.5 kg (10 lbs) or 2.3 kg (5lbs.).

**d. Proportioning Mixture**

The proportion of bituminous material, on the basis of total dry aggregate, shall be from 5.0 to 8.0 mass percent. The exact percentage to be used shall be fixed by the Engineer in accordance with job-mix formula and other quality requirements.

Hydrated lime shall be added to the mixture during the mixing operation in the amount of one-half to one (0.5 – 1.0) mass percent, dry aggregate basis. The

lower percentage limit is applicable to aggregates which are predominantly calcareous.

## 18.3 Construction Requirements

### 18.3.1 Weather Limitation

Bituminous Plant-mix shall not be placed on wet surface or when weather conditions would prevent the proper handling or finishing of the bituminous mixtures.

### 18.3.2 Construction Equipment

**1. Bituminous Mixing Plant**

Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall be kept separated until delivered to the cold elevator feeding drier. The storage yard shall be kept neat and orderly and the separated stockpile shall be readily accessible for sampling.

Plants used for the preparation of bituminous mixtures shall conform to the requirements for all plants under (a) except that scale requirements shall apply only where weight proportioning is used. In addition, batch mixing plants and continuous mixing plants shall conform to the respective requirements below:

**1.a Requirements for all Plants**
Mixing plants should have sufficient capacity and well coordinated to adequately handle the proposed bituminous construction.

**1.a.1 Plant Scales**
Scales shall be accurate to 0.5 percent of the maximum load that may be required. Poises shall be designed to be locked in any position to prevent unauthorized change of position. In lieu of plant and truck scales, the Contractor may provide an approved automatic printer system which will print the weight of the material delivered, provided the system is used in conjunction with an approved automatic batching and mixing control system. Such weights shall be evidenced by a weight ticker for each load.

Scales shall be inspected and sealed as often as the Engineer may deem necessary to assure their continued accuracy. The Contractor shall have on hand not less than ten 20-kg weights for testing the scales.

**1.a.2 Equipment for the Preparation of Bituminous Material**
Tanks for the storage of bituminous material shall be equipped with the proper storage devices to heat and hold the material at the required temperatures. The heating shall be accompanied by steam coils, electricity or other approved means so that no flame shall be in contact with the tank. The circulating system for the bituminous material shall be designed to assure the proper and continuous

circulation during the operating period. Provision shall be made for measuring and sampling storage tanks.

**1.a.3 Feeder for Drier**
The plant shall be provided with accurate mechanical means for uniformly feeding the aggregate into the drier for uniform production and temperature.

**1.a.4 Drier**
The plant shall include a drier or driers which continuously agitate during the heating and drying process. For cold-type bituminous mix, equipment for mechanical cooling of the dried aggregate to the temperature prescribe for cold mixtures shall be provided and shall be capable of supplying prepared material for the mixer to operate at full capacity.

**1.a.5 Screens**
Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of the full capacity of the mixer, shall be provided.

**1.a.6 Bins**
The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for filter or hydrated lime when used and the plant shall be equipped to feed such material into the mixer. Each bin shall be provided with overflow pipes, of such size and at such locations as to prevent backing up of material into other compartments or bins. Each compartment shall be provided with individual outlet gate, constructed to prevent leakage. The gates shall cut off quickly and completely. Bins shall be so constructed that samples can be readily obtained. Bins shall be equipped with adequate tell-tale devices to indicate the position of the aggregates in the bins at the lower quarter points.

**1.a.7 Bituminous Control Gate**
Satisfactory means, either by weighing or metering, shall be provided to obtain the proper amount of bituminous material in the mix within the tolerance specified. Means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer.

**1.a.8 Thermometric Equipment**
An armored thermometric of adequate range in temperature reading shall be fixed in the bituminous feed line at a suitable location near the charging valve at the mixer unit.

The plant shall also be equipped with either an approved dial-scale, mercury-actuated thermometer, an electric pyrometer, or other approved thermometric instruments placed at the discharge chute of the drier to register automatically or indicate the temperature of the heated aggregates.

The Engineer may require replacement of any thermometer by an approved temperature-recording apparatus for the better regulation of the temperature of aggregates.

**1.a.9 Dust Collector**
The plant shall be equipped with dust collector constructed to return uniformly all or any part of the material to the hot elevator collected as directed.

**1.a.10Truck Scales**
The bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales at the Contractor's expense. Such scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy.

**1.a.11Safety Requirements**
Adequate and safe stairways to the mixer platform and sampling points shall be provided, and guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a platform or other suitable device to enable the engineer to obtain sampling and mixture temperature data. A hoist or pulley system shall be provided to raise scale calibration equipment, sampling equipment and other similar equipment from ground to the mixer platform and return. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area which shall be kept free from dripping from the mixing platforms.

**1.b Requirements for Batching Plants**

**1.b.1 Weigh Box or Hopper**
The equipment shall include a means for accurately weighing each size of aggregate in a weigh bow or hopper suspended on scales which can hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

**1.b.2 Bituminous Control**
The equipment used to measure the bituminous material shall be accurate to plus or minus 0.5 percent. The bituminous material bucket shall be a non-tilting type with a loose sheet metal cover. The length of the discharge opening or spray bar shall be less than ¾ the length of the mixer and it shall discharge directly into the mixer. The bituminous material bucket, its discharge val***v***e or valves and spray bar shall be adequately heated. Stream jackets, if, used, shall be efficiently drained and all connectors shall be so constructed that they will not interfere with the efficient operation of the bituminous scales. The capacity of the bituminous material bucket shall be less 15 percent in excess of the weight of bituminous material required in any batch. The plant shall have an adequately heated quick-acting, non-drip, charging valve located directly over the bituminous material bucket.

The indicator dial shall have a capacity of at least 15 percent in excess of the quantity of bituminous material used in a batch. The controls shall be constructed so that they may be locked at any dial setting and will automatically reset to that reading after the addition of bituminous material to each batch. The dial shall be in full view of the mixer operator. The flow of bituminous material shall be automatically controlled so that it will begin when the dry mixing period is over. All of the bituminous material required for one batch shall be discharge in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of bituminous material for the full length of the mixer. The section of the bituminous line between the charging valve and the spray bar shall be provided with a valve and outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

**1.b.3 Mixer**

The batch mixer shall be an approved type capable of producing a uniform mixture with the job-mix tolerances. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust. The clearance of blades from all fixed and moving part shall not exceed 25 mm (1inch) unless the maximum diameter of the aggregate in the mix exceeds 30 mm (1 ¼ inches), in which the clearance shall not exceed 40 mm (1 ½ inches).

**1.b.4 Control of Mixing Time**

The mixer shall be equipped with an accurate time lock to control the operation of a complete mixing cycle. It shall lock the weigh box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the bituminous material bucket throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of the time between the opening of the weigh box and the start of introduction of bituminous material. The wet mixing period is the interval of time between the start of introduction of bituminous material and the opening of the mixer gate.

The control of the timing shall be flexible and capable of being set at intervals of 5 seconds or less throughout a total cycle of up to 3 minutes. A mechanical batch counter shall be installed as a part of the timing device and shall be so designed as to register only completely mixed batches.

The setting of time interval shall be performed in the presence and at the direction of the Engineer who shall then lock the case covering the timing device until in the timing periods have to be changed.

**1.c Requirement for Continuous Mixing Plants.**

**1.c.1 Aggregate Proportioning**

The plant shall include means for accurately proportioning each size of aggregate.

The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each compartment.

The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means provided with a lock.

Indicators shall be provided for each gate to show the respective gate opening in millimeters.

**1.c.2 Weight Calibration of Aggregate Feed**

The plant shall include a means for calibration of gate openings by weighing test samples. Provision shall be made so that materials fed out of individual orifices may be by-passed to individual test boxes. The plants shall be equipped to conveniently handle individual samples weighing not less than 50 kilograms. Accurate scale shall be provided by the Contractor to weigh such test samples.

**1.c.3 Synchronization of Aggregate Feed and Bituminous Material Feed**

Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device. This control shall be accomplished by interlocking mechanical means or by any other positive method satisfactory to the Engineer.

**1.c.4 Mixer**

The plants shall include a continuous mixer of an approved type, adequately heated and capable of producing a uniform mixture within job-mix tolerances. It shall be equipped with a discharge hopper with dump gates which will permit rapid and complete discharge of the mixture. The paddle shall be adjustable for angular position on the shaft and reversible to retard the flow of the mix. The mixer shall have a manufacturer's plate giving the net volumetric contents of the mixer of the several heights inscribed on a permanent gauge. Charts shall be provided showing the rate of feed or aggregate per minute for the aggregate being used.

**2. Hauling Equipment**

Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with approved material to prevent the mixture from adhering to the beds. Each truck shall have a cover of canvas or other suitable material of such size as to protect the mixture from the weather. When necessary, such that the mixture will be delivered on the road at the specified temperature, truck beds shall be insulated and covers shall be securely fastened. Truck beds shall be drained prior to loading.

**3. Bituminous Pavers**

The equipment shall be self-contained, power-propelled units, provided with an adjustable activated screed or strike-off assembly , heated if necessary, and capable of spreading and finishing courses of bituminous plant-mix material in lane widths applicable to the specified section and thickness shown on the Plans.

Pavers shall be equipped with a control system capable of automatically maintaining the screen elevation as specified herein. The control system shall be automatically actuated from either a reference line or surface through a system of mechanical sensors or sensor directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. When directed, the transverse slope control system shall be made inoperative and the screed shall be controlled by sensor directed automatic mechanisms which will independently control the elevation of each end of the screed from reference line or surface.

The control shall be capable of working in connection with any of the following attachments.

a. Ski-type device of not less than 9 meters (30 feet) in length or as directed by the Engineer.
b. Taut string line (wire) set to grade.
c. Short ski of shoe.

The contractor shall furnish the long ski, the short ski or shoe and furnish and install all the require stakes and wire for a taut string line.
Should the automatic control systems become inoperative during the day's work, the contractor will be permitted to finish the day's
The contractor shall provide and have ready for use at all times enough covers, as may be necessary, for use in any emergency such as rain, chilling wind or unavoidable delay for the purpose of covering or protecting any material that may have been dumped and not spread.

**4. Rollers**

The Equipment shall be of steel and/or pneumatic tire type and shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous material to the required density while it is still in a workable condition. The use of equipment which results in excessive crushing of the aggregate will not be permitted.

**18.3.3 Condition of Existing Surface**

Immediately before placing the bituminous mixture, the existing surface shall be cleaned of lose or deleterious material by brooming or other approved means.
Contact surface or cur***b***, gutters, manholes and other structures shall be painted with a thin, uniform coating of bituminous material prior to the bituminous mixture being placed against them.

**18.3.4 Preparation of Bituminous Material**

The Bituminous material shall be heated so as to avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature.

The temperature of the asphalt cement delivered to the mixer shall be as required to achieve a kinetic viscosity with the range of 150 – 300 $mm^2/s$, as determined by AASHTO T 201. Asphalt cement shall not be used while it is foaming nor shall be heated above $159^0$C ($230^0$ F) at any time after delivery in the project.

**18.3.5 Preparation of Aggregate**

Aggregate for pug mill mixing shall be heated, dried and delivered to the mixing unit at a temperature within the range $\pm$ $17^0$ C ($\pm$ $30^0$F) of the bitumen. Moisture content of the aggregate shall not exceed one mass percent at the time it is introduced into the mixing unit. Flames used for drying and heating shall be properly adjusted to avoid damage to the aggregate and to avoid soot on the aggregate. Moisture content of the mixture from drum dryer plants shall not exceed three (3) percent of the output, as determined by AASHTO T 110.

**18.3.6 Mixing**

The dried aggregates and the bituminous material shall be measured or formula.
After the required amounts of aggregate and bituminous material have been introduced into the mixer, the material shall be mixed until a complete and uniform gauged and introduced into the mixer in the amount specified by the job-mix coating of the particles and a thorough distribution of the bituminous material throughout the aggregate is secured.

**18.3.7 Spreading and Finishing**

The mixture shall be spread and struck off to the grade and elevation established. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.
The longitudinal joint in one layer shall offset that in the layer immediately below approximately 15 cm (6 inches); however, the joint top layer shall be at the center line of the pavement if the roadway comprises two (2) lanes.
On areas where irregularities or unavoidable obstacle makes the use of mechanical spreading and furnishing equipment impracticable, the mixture may be placed and finished by hand tools.
The mixture shall be placed at a temperature not less than $107^0$ C ($225^0$ F) as measured in the truck just prior to the dumping into the spreader.
When tar is used, the mixture shall be placed at between $66^0$ C and $107^0$ C ($150^0$ F and $225^0$ F).
When production of the mixture can be maintained and when practical, pavers shall be used in echelon to place the wearing course in adjacent lanes.

**18.3.8 Compaction**

Immediately after the mixture has been spread, struck off and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rollers.

The surface shall be rolled when the mixture is in proper condition and when the rolling does not under displacement, cracking and shoving. Rolling shall begin at

the sides and proceeds longitudinally parallel toward the center line, each trip overlapping ½ the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On superelevated curves, the rolling shall begin at the low side and progress to the high side begin at the low side and overlapping of longitudinal trips parallel to the center line.

Rollers shall move at slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until roller marks are eliminated and a minimum of 97mass percent of the density of the laboratory compacted specimens prepared in accordance with AASHTO T 166 has been obtained.

Any displacement occurring as a result of reversing of the direction of roller or from other causes, shall be corrected at once by the use of rakes and addition of fresh mixture when required. Care shall be exercised in rolling so as not to displace the line and grade of the edges of the bituminous mixture.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved materials. Excess liquid will not be permitted.

In places not accessible to the rollers, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers.

**18.3.9 Joints**

Placing of the bituminous paving shall be continuous as possible. Rollers shall not pass over the unprotected end of a freshly laid mixture unless authorized by the Engineer. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. When directed by the Engineer, a brush coat of bituminous material shall be used on contact surfaces of transverse joints before additional mixture is placed against the previous rolled material.

**18.3.10 Acceptance, Sampling and Testing**

The contractor shall cut full depth samples as directed, from the finished pavement, for testing. Samples shall be neatly cut by a saw or core drill. Each sample shall be at least 150 mm x 150 mm or 100 mm diameter full depth. At least one, but not more than three (3) samples shall be taken for each full day's operation. If no core samples were taken during the day's operation, core sample shall be taken from the completed pavement for every 100 L.M. per lane. The contractor shall supply and furnish new material to backfill boreholes left by the samples taken.
No acceptance and final payment shall be made on completed asphalt pavement unless core test for thickness determination is conducted, except for Barangay roads where the implementing office is allowed to waive such test.

The samples obtained will be used to measure the thickness of the pavement. The same samples will be used to test the density of the compacted pavement by AASHTO T 166.

The compacted pavement shall have a density equal to or greater than 97 mass percent of the density of laboratory specimen. The asphalt pavement represented by the cores shall not be accepted if the deficiency in density is more than 2%.

The compacted pavement shall have a thickness tolerances of -5 mm. Any excess in the specified thickness shall not be considered in the payment of asphalt pavement. The asphalt pavement represented by the individual core shall not be accepted if the deficiency in the core thickness as obtained in accordance with ASTM D 3549 is more than 5 mm. Averaging of the density and thickness of asphalt cores is not permitted.

If the deficiency in the core thickness is more than 5mm, additional layer may be permitted in order to meet the designed thickness; however, the minimum additional asphalt overlay thickness should be dependent on the minimum thickness capacity of asphalt paver but it should not be less than 50 mm (2 inches) and that proper construction procedures are followed.

### 18.3.11 Surface Tolerances

The surface will be checked by the used of a 3-meter straight-edge at sites selected by the Engineer. The straight-edge should be applied at right angles, as well as, parallel to the centerline of the roadbed.

The variation of the surface from the testing edge of the straight-edge between any two contacts with the surface shall not exceed 6 mm.

Tests will be made immediately after initial compaction and any variations detected shall be corrected by removing or adding materials, as may be necessary. Rolling shall then be continued as specified. After final rolling, the smoothness of the course shall be checked again and any area defective in texture or composition shall be corrected, including removal and displacement of unsatisfactory material at the Contractor’s expense, as directed by the Engineer.

## 18.4 Method of Measurement

Bituminous mixtures shall be measured by the ton. The quantity to be paid shall be the number of tones of bituminous mixture in the accepted pavement, computed based on the cores taken in accordance with Accepting, Sampling and Testing, by applying the thickness and densities of the cores obtained therein the width of the pavement represented by the core; otherwise, core samples shall be taken from the completed pavement for every 100 linear meters per lane; to determine the corresponding thickness and densities as in the above; and made as the basis for computing or estimating the weight in tons of the mix used in the accepted pavement. No deduction will be made for the weight of bituminous material in the mixture.

Batch weights shall not be permitted as a method of measurement.

### 18.5 Basis of Payment

The accepted quantity, measured as prescribed in the Method of Measurements, will be paid for as provided in the respective items for the specified type of bituminous plant mix.

## 19.0 BITUMINOUS PLANT-MIX SURFACE, COLD LAID

### 19.1 Description

This shall consist of constructing a bituminous plant-mix surface course, laid cold, on the proposed base in accordance with this Specification and in conformity with lines, grades and typical cross-section shown on the Plans.

### 19.2 Material Requirements

Composition and Quality of Bituminous Mixture (Job-Mix Formula) shall conform to requirements of Bituminous Plant-Mix Surface Course – General.

#### 19.2.1 Bituminous Material

It shall be either Medium Curing (MC) Cut-back Asphalt or Emulsified Asphalt, whichever is called for in the Bill of Quantities. It shall conform to the requirements of the Bituminous Materials. The type and grade of bituminous material will be specified in the Special Provisions.

#### 19.2.2 Aggregates

Aggregates shall conform to the requirements of Bituminous Plant-Mix Surface Course – General.

#### 19.2.3 Mineral Filler

Mineral filler shall conform to the requirements of the Bituminous Plant-Mix Surface Course – General.

#### 19.2.4 Hydrated Lime

Hydrated lime shall conform to the requirements of the Bituminous Plant-Mix Surface Course – General.

## 19. Proportioning of Mixture

The proportion of bituminous material on the basis of total dry aggregate shall be from 4.5 to 7.0 mass percent when cut-back asphalt is used and from 6. 0 to 10.0 mass percent when emulsified asphalt is used. The exact percentage to be used shall be fixed by the Engineer in accordance with the job-mix formula and the other quality control requirements.

During the mixing operation, one-half to one (0.5 to 1.0) mass percent of hydrated lime, dry aggregate basis, shall be added to the bituminous mix. The lower percentage limit is applicable to aggregates which are predominantly calcareous.

### 19.3 Construction Requirements

The construction requirements shall be in accordance with Bituminous Plant-Mix Surface Course – General, whenever applicable.

### 19.4 Method of Measurement

The bituminous mixture shall be measured by the tone (t). The quantity to be paid for shall be the number of tones of the mixture placed and compacted in the accepted pavement. No deduction shall be made for the weight of bituminous material in the mixture.

### 19.5 Basis of Payment

The accepted quantity, measured as prescribe in the Method of Measurement, shall be paid for at the contract unit price for Bituminous Plant-Mix Surface Course, Cold Laid, which price and payment shall be full compensation for furnishing all materials. Handling, mixing, hauling, placing, rolling, compacting, labor, equipment, tools and incidentals necessary to complete this item.

The recommended payment should conform to Table:

**Table 23**

| Payment Item No. | Description | Unit of measurement |
|---|---|---|
| 308 | Bituminous Plant-Mix Surface Course, Cold Laid | Tonne |

Note: Per DPWH Std. Specs, 2004, this item is measured in square meters ($m^2$)

## 20.0 BITUMINOUS PLANT-MIX (STOCK PILE MAINTENANCE MIXTURE)

### 20.1 Description

This shall consist of a bituminous stockpile maintenance mixture composed of aggregate, mineral filler, hydrated lime and bituminous material mixed in a central plant. The mixture is stockpiled for immediate or future maintenance needs.

### 20.2 Material Requirements

#### 20.2.1 Composition and Quality of Bituminous Mixture

The composition and quality of bituminous mixture shall conform to the requirements of Bituminous Plant-Mix Surface Course – General.

#### 20.2.2 Bituminous Material

The type and grade of bituminous material shall be in accordance with the following guidelines:

MC – 250 For use within short time after stockpiling
MC – 800 For immediate use under hot or moderate weather conditions, or for use within a short time after stockpiling.
CMS – 2/2S Mix can be designed for use within a short time after stockpiling or for long storage period.
*CMS – Cationic Emulsified Asphalt

#### 20.2.3 Aggregate

It shall be crushed stone, crushed or natural gravel, slag, sand, stone or slag screenings, mineral dust, or a combination of these materials. The several aggregate fractions shall be combined in such proportions that the gradation of the aggregate shall conform to the grading requirements below:

The combined aggregate after going through the drier, shall have a sand equivalent value of not less than 40.

The coarse aggregate shall have a mass percent of wear not exceeding 40 when tested by AASHTO T 96.

Slag, if used, shall weigh not less than 1120 kg/m (70 lb/cu. ft.).

**Table 24-Grading Requirements**

| Sieve Designation | | Mass Percent Passing |
|---|---|---|
| **Standard, mm** | **Alternate U.S. Standard** | |
| 19.0 | ¾ in | 100 |
| 12.5 | ½ in | 80 – 100 |
| 9.5 | 3/8 in | 70 – 90 |
| 4.75 | No. 4 | 50 – 70 |
| 2.36 | No. 8 | 35 – 50 |
| 0.60 | No. 30 | 18 – 30 |
| 0.30 | No. 50 | 15 – 25 |
| 0.15 | No.100 | 08 – 15 |
| 0.075 | No. 200 | 04 – 10 |

### 20.2.4 Mineral Filler

Mineral filler shall conform to the requirements of the Bituminous Plant-Mix Surface Course – General.

### 20.2.5 Hydrated Lime

Hydrated lime shall conform to the requirements of the Bituminous Plant-Mix Surface Course – General.

### 20.2.6 Proportioning of Mixture

The proportion of bituminous material on the basis of total dry aggregate shall be from 5.0 to 8.0 mass percent. The exact percentage to be used shall be fixed by the Engineer in accordance with the job-mix formula and other quality control requirements.

During the mixing operation, one-half to one (0.5 to 1.0) mass percent of hydrated lime, dry aggregate basis, shall be added to the mixture. The lower percentage limit is applicable to aggregates which are predominantly calcareous.

## 20.3 Construction Requirements

### 20.3.1 Preparation of Mixture

The aggregate, mineral filler, and hydrated lime shall be fed into the plant in the proportions required to approve a composite aggregate meeting the grading requirements. The aggregate shall be free from visible moisture at the time of mixing. The bituminous material shall be applied at the rate and temperature specified by the Engineer. Mixing shall be thorough and shall continue until all aggregate particles are well coated.

### 20.3.2 Stockpiling

The finished mixture shall be stockpiled on a platform level storage space.

### 20.4 Method of Measurement

The area to be paid for under this item shall be the number of square meter (m) of asphalt pavement placed, compacted, and accepted based on the thickness and density of the cores taken in accordance with subsection 307.3.10

[The bituminous plant-mix (Stockpile Maintenance Mixture) shall be measured by tonne (t). The Quantity to be paid for shall be the number of tonnes of mixture accepted in the stockpile. No deduction shall be made for the weight of bituminous material in the mixture.
Batch weight shall not be permitted as a method of measurement]

### 20.5 Basis of Payment

The accepted quantity, measured as prescribe in Mineral Filler, shall be paid for at the contract unit price for Bituminous Plant-Mix (Stockpile Maintenance Mixture) which price and payment shall be full compensation for furnishing and stockpiling the material including incidentals necessary to complete the work prescribed in this item.

The recommended payment shall conform to Table 25:

**Table 25**

| Pay Item No. | Description | Unit of Measurement |
|---|---|---|
| 309 | Bituminous Plant-Mix (Stockpile Maintenance Mixture) | Square Meter |

## 21.0 BITUMINOUS CONCRETE SURFACE, HOT LAID

### 21.1 Description

This Item shall consist of constructing bituminous concrete surface course composed of aggregate, mineral filler and bituminous material mixed in a central plant, constructed and laid hot on the prepared subgrade in accordance with this Specification and in conformity with lines, grades, thickness and typical cross-section shown on the Plans.

### 21.2 Material Requirements

#### 21.2.1 Composition and Quality of Bituminous Mixture

The composition and quality of bituminous mixture shall conform to the requirements of Bituminous Plant-Mix Surface Course – General.

### 21.2.2 Bituminous Material

It shall be either Medium Curing (MC) Cut-back Asphalt or Asphalt Cement, whichever is called for in the Bill of Quantities. It shall conform to the requirements of the Bituminous Materials. The type and grade of bituminous material will be specified in the Special Provisions.

### 21.2.3 Aggregates

Aggregates shall conform to the requirements of Bituminous Plant-Mix Surface Course – General.

### 21.2.4 Mineral Filler

Mineral filler shall conform to the requirements of the Bituminous Plant-Mix Surface Course – General.

### 21.2.5 Hydrated Lime

Hydrated lime shall conform to the requirements of the Bituminous Plant-Mix Surface Course – General.

### 21.2.6 Proportioning of Mixture

The proportion of bituminous material on the basis of total dry aggregate shall be from 5.0 to 8.0 mass percent. The exact percentage to be used shall be fixed by the Engineer in accordance with the job-mix formula and the other quality control requirements.
During the mixing operation, one-half to one (0.5 to 1.0) mass percent of hydrated lime, dry aggregate basis, shall be added to the bituminous mix. The lower percentage limit is applicable to aggregates which are predominantly calcareous.

## 21.3 Construction Requirements

The construction requirements shall be in accordance with Bituminous Plant Mix Surface Course – General, whenever applicable.

## 21.4 Method of Measurement

The bituminous mixture shall be measured by the tone (t). The quantity to be paid for shall be the number of tones of the mixture placed and compacted in the accepted pavement. No deduction shall be made for the weight of bituminous material in the mixture.

Batch weights shall not be permitted as a method of measurement.

### 21.5 Basis of Payment

The accepted quantity, measured as prescribed in the Method of Measurement, shall be paid for at the contract unit price for Bituminous Plant-Mix Surface Course, Hot-Laid, which price and payment shall be full compensation for furnishing all materials, handling, mixing, hauling, placing, rolling, compacting, labor, equipment, tools and incidentals necessary to complete this item.

The recommended payment should conform to Table 26:

**Table 26**

| Payment Item No. | Description | Unit of Measurement |
|---|---|---|
| 310 | Bituminous Concrete Surface Course, Hot Laid | Square Meter |

## 22.0 PORTLAND CEMENT CONCRETE PAVEMENT

### 22.1 Description

This item shall consist of pavement of Portland Cement Concrete, with or without reinforcement, constructed on the prepared base in accordance with this Specification and in conformity with the lines, grades, thickness and typical cross-sections shown on the plans.

### 22.2 Material Requirement

#### 22.2.1 Portland Cement

It shall conform to the applicable requirements of item 700, Hydraulic Cement. Only Type I Portland Cement shall be used unless otherwise provided for in the Special Provisions. Different brands or the same brands from different mills shall not be mixed nor they shall be used alternately unless the mix is approved by the Engineer. However, the use of Portland/Pozzolan Cement Type IP meeting the requirements of AASHTO M 240/ ASTM C 695, Specification for Blended Hydraulic Cement shall be allowed, provided that trial mixes shall be done and that the mixes meet the concrete strength requirements. The AASHTO/ASTM provisions pertinent to the use of Portland/Pozzolan Type 1P shall be adopted.

Cement, which for any reason has become partially set or which contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

Samples of Cement shall be obtained in accordance with AASHTO T 127.

### 22.2.2 Fine Aggregates

It shall consist of natural sand, stone screenings or other inert materials with similar characteristics or combinations thereof, having hard, strong and durable particles. Fine aggregate from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of concrete without the approval of the Engineer.

It shall not contain more than three (3) mass percent of material passing the 0.075 mm (No. 200 sieve) by washing nor more than one (1) mass percent each of clay lumps or shale. The use of beach sand will not be allowed without the approval of the Engineer.
If the fine aggregate is subjected to five (5) cycles of the sodium sulfate soundness test, the weighted loss shall not exceed 10 mass percent.

The fine aggregate shall be free from injurious amounts of organic impurities. If subjected to the colorimatic test for organic impurities and a color darker than the standard is produced, it shall be rejected. However, when tested for the effect of organic impurities of strength of mortar by AASHTO T 71, the fine aggregate may be used if the relative strength at 7 and 28 days is not less than 95 mass percent.

The fine aggregate shall be well-graded from coarse to fine and shall conform to Table 27.

**Table 27 – Grading Requirements for Fine Aggregate**

| Sieve Designation | Sieve Designation |
|---|---|
| 9.5 mm (3/8 in) | 100 |
| 4.75 mm (No. 4) | 95-100 |
| 1.18 mm (No. 16) | 45-80 |
| 0.300 mm (No. 50) | 5-30 |
| 0.150 mm (No. 100) | 0-10 |

### 22.2.3 Coarse Aggregate

It shall consist of crushed stone, gravel, blast furnace slag, or other approved inert materials of similar characteristics, or combinations thereof, having hard, strong, durable pieces and free from any adherent coatings.
It shall contain not more than one (1) mass percent of material passing the 0.075 mm (No. 200) sieve, not more than 0.25 mass percent of clay lumps, nor more than 3.5 mass percent of soft fragments.
If the coarse aggregate is subjected to five (5) cycles of the sodium sulfate soundness test, the weighted loss shall not exceed 12 mass percent.
It shall have a mass percent of wear not exceeding 40 when tested by AASHTO T 96.

If the slag is used, its density shall not be less than 1120 kg/cu. meter (70 lb/cu. Feet). The gradation of the coarse aggregate shall conform to Table 28.

Only one grading specification shall be used from any one source.

**Table 28 –** Grading Requirement for Coarse Aggregate

| Sieve Designation | | Mass Percent Aggregate | | |
|---|---|---|---|---|
| Standard Mm | Alternative U.S. Standard | Grading A | Grading B | Grading C |
| 75.00 | 3 in. | 100 | - | - |
| 63.00 | 2-1/2 in. | 90-100 | 100 | 100 |
| 50.00 | 2 in. | - | 90-100 | 95-100 |
| 37.50 | 1-1/2 in. | 25-60 | 35-70 | - |
| 25.00 | 1 in. | | 0-15 | 35-70 |
| 19.00 | ¾ in. | 0-10 | - | - |
| 12.50 | ½ in. | 0-5 | 0-5 | 10-30 |
| 4.75 | No. 4 | - | - | 0-5 |

### 22.2.4 Water

Water used in mixing, curing or other designated application shall be reasonably clean and free of oil, salt, acid, alkali, grass or other substance injurious to the finished product. Water will be tested in accordance with and shall meet the requirements of Item 714, Water. Water which is drinkable, may be used without test. Where the source of water is shallow, the intake shall be enclosed as to exclude silt, mud, grass or other foreign materials.

### 22.2.5 Reinforcing Steel

It shall conform to the requirements of Item 404, Reinforcing Steel. Dowel and tie bars shall conform to the requirements of AASHTO M 31 or M 42, except that rail steel shall not be used for tie bars that are to be bent and re-straightened during construction. Tie bars shall be deformed bars. Dowels shall be plain round bars. Before delivery to the site of work, one-half of the length of each dowel shall be painted with one coat of approved lead or tar paint.

The sleeves for dowel bars shall be metal of approved design to cover 50 mm (2 inches), plus or minus 5 mm (1/4 inches) of the dowel, with a closed end, and with a suitable stop to hold the end of the sleeve at least 25 mm (1 inch) from the end of the dowel so that they will not collapse during construction.

### 22.2.6 Joint Fillers

Poured joint fillers shall be mixed asphalt and mineral or rubber filler conforming to the applicable requirements of Item 705, Joint Materials.
Preformed joint filler shall conform to the applicable requirements of Item 705. The filler for each joint shall be punched to admit the dowels were called for in the Plans. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint.

### 22.2.7 Admixtures

Air-entraining admixtures shall conform to the requirements of AASHTO M 154.

Chemical admixtures, if specified or permitted, shall conform to the requirements of AASHTO M 194.

### 22.2.8 Curing Materials

Cotton mats, burlap cloth (AASHTO M182), water-proof paper, liquid membrane (AASHTO M148 forming compounds, or sheeting (film) (AASHTO (M 171) materials shall conform to the applicable requirements of Item 708, Concrete Curing Materials and Admixtures.

### 22.2.9 Calcium Chloride/Calcium Nitrate

It shall conform to AASHTO M 144, if specified or permitted by the Engineer as accelerator.

### 22.2.10 Storage of Cement and Aggregate

All cement shall be stored immediately upon delivery at the Site, in weatherproof building which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample, and the shipments of cement as received shall be separately stored in such a manner as to allow the earliest deliveries to be used first and to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity for storage of a sufficient quantity of cement to allow sampling at least twelve (12) days before the cement is to be used. Bulk cement, if used, shall be transferred to elevated air tight and weatherproof bins. Stored cement shall meet the test requirements at any time after storage when retest is ordered by the Engineer. At the time of use, all cement shall be free-flowing and free of lumps.
The handling and storing of concrete aggregates shall be such as to prevent segregation or the inclusion of foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations.

In order to secure greater uniformity of concrete mix, the Engineer may require that the coarse aggregate be separated into two or more sizes. Different sizes of aggregate shall be stored in separate bins or in separate stock piles sufficiently

removed from each other to prevent the material at the edges of the piles from becoming intermixed.

### 22.2.11 Proportioning, Consistency and Strength of Concrete

The Contractor shall prepare the design mix based on the absolute volume method as outlined in the American Concrete Institute (ACI) Standard 211.1, "Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete".

It is the intent of this Specification to require approximately 9.0 bags of cement per cubic meter of concrete based on a 40 kg per bag of cement to meet the minimum strength requirement. The Engineer shall determine from laboratory tests the materials to be used, the cement content and the proportions of aggregate and water that will produce a workable concrete having a slump of between 40 and 75 mm (1-1/2 and 3 inches) if not vibrated or between 10 and 40 mm (1/2 and 1-1/2 inches) if vibrated, and a flexural strength of not less than 3.8 MPa (550 psi) when tested by the third-point method or 4.5 MPa (650 psi) when tested by the mid-point method; or a compressive strength of 24.1 MPa (3500 psi) for cores when tested at fourteen days in accordance with AASHTO T 97, T 177 or T 24, respectively.

Slump shall be determined using AASHTO T 119.
The designer shall consider the use of lean of concrete (eco-concrete) mixtures using local materials or specifically modified conventional concrete mixes in base course and in the lower course composite, monolithic concrete pavements using a minimum of 75 mm (3 inches) of conventional concrete as the surface course.

The mix design shall be submitted to the Engineer for approval and shall be accompanied with certified test data from an approved laboratory demonstrating the adequacy of the mix design. A change in the source of materials during the progress of work may necessitate a new design mix.

## 22.3 Construction Requirements

### 22.3.1 Quality Control of Concrete

#### 22.3.1.1 General

The Contractor shall be responsible for the quality control of all materials during the handling, blending, and mixing and placement operations.

#### 22.3.1.2 Quality Control Plan

The Contractor shall furnish the Engineer a Quality Control Plan detailing his production control procedures and the type and frequency of sampling and testing to insure that the concrete produced complies with the Specifications. The Engineer shall be provided free access to recent plant production records, and if requested, copies of mix design, materials certifications and sampling and testing reports.

### 22.3.1.3. Qualification of Workmen

Experienced and qualified personnel shall perform all batching or mixing operations for the concrete mix, and shall be present at the plant and job site to control the concrete productions whenever the plant is in operation.

They shall be identified and their duties are defined as follows:

**a.** Concrete Batcher. The person performing the batching or mixing operation shall be capable of accurately conducting aggregate surface moisture determination and establishing correct scale weights for concrete materials. He shall be capable of assuring that the proportioned batch weights of materials are in accordance with the mix design.

**b.** Concrete Technician. The person responsible for concrete production control and sampling and testing for quality control shall be proficient in concrete technology and shall have a sound knowledge of the Specifications as they relate to concrete production. He shall be capable of conducting tests on concrete and concrete materials in accordance with these Specifications. He shall be capable of adjusting concrete mix designs for improving workability and Specification compliance and preparing trial mix designs. He shall be qualified to act as the concrete batcher in the batcher's absence.

### 22.3.1.4. Quality Control Testing

The Contractor shall perform all sampling, testing and inspection necessary to assure quality control of the component materials and the concrete.

The Contractor shall be responsible for determining the gradation of fine and coarse aggregates and for testing the concrete mixture for slump, air content, water-cement ratio and temperature. He shall conduct his operations so as to produce a mix conforming to the approved mix design.

### 22.3.1.5 Documentation

The Contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantities approved and rejected, and nature of any corrective action taken.

The Engineer may take independent assurance samples at random locations for acceptance purposes as he deems necessary.

### 22.3.2 Equipment

Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity and mechanical

condition. The equipment shall be at the jobsite at a time sufficiently ahead of the start of construction operations to be examined thoroughly and approved.

**22.3.2.1 Batching Plant and Equipment**

**a.** General. The batching shall include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a bin, a hopper, and separate scale for cement shall be included. The weighing hopper shall be properly sealed and vented to preclude dusting operation. The batch plant shall be equipped with a suitable non-resettable batch counter which will correctly indicate the number of batches proportioned.

**b.** Bins and Hoppers. Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

**c.** Scales. Scales for weighing aggregates and cement shall be of either the beam type or the springless-dial type. They shall be accurate within one-half percent (0.5%) throughout the range of use. Poises shall be designed to be locked in any position and to prevent unauthorized change.
Scales shall be inspected and sealed as often as the Engineer may deem necessary to assure their continued accuracy.

**d**. Automatic Weighing Devices. Unless otherwise allowed on the Contract, batching plants shall be equipped with automatic weighing devices of an approved type to proportion aggregates and bulk cement.

**22.3.2.2 Mixers**

**a.** General
Concrete may be mixed at the Site of construction or at a central plant, or wholly or in part in truck mixers. Each mixer shall have a manufacturer's plate attached in a prominent place showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

**b.** Mixers at Site of Construction
Mixing shall be done in an approved mixer capable of combining the aggregates, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and discharging and distributing the mixture without segregation on the prepared grade. The mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and released at the end of the mixing period. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, provided that each batch is mixed for 90 seconds. The mixer shall be equipped with a suitable non-resettable batch counter which shall correctly indicate the number of the batches mixed.

**c.** Truck Mixer and Truck Agitators. Truck mixers used for mixing and hauling concrete, and truck agitators used for hauling central-mixed concrete, shall conform to the requirements of AASHTO M 157.

**d.** Non-Agitator Trucks. Bodies of non-agitating hauling equipment for concrete shall be smooth, mortar-tight metal containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation.

### 22.3.2.3 Paving and Finishing Equipment

The concrete shall be placed with an approved paver designed to spread, consolidate, screed and float finish the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement in conformance with the Plans and Specifications.

The finishing machine shall be equipped with at least two (2) oscillating type transverse screed.

Vibrators shall operate at a frequency of 8,300 to 9,600 impulses per minute under load at a maximum spacing of 60 cm.

### 22.3.2.4 Concrete Saw

The Contractor shall provide sawing equipment in adequate number of units and power to complete the sawing with a water-cooled diamond edge saw blade or an abrasive wheel to the required dimensions and at the required rate. He shall provide at least one (1) stand-by saw in good working condition and with an ample supply of saw blades.

### 22.3.2.5 Forms

Forms shall be of steel, of an approved section, and of depth equal to the thickness of the pavement at the edge. The base of the forms shall be of sufficient width to provide necessary stability in all directions. The flange braces must extend outward on the base to not less than 2/3 the height of the form. All forms shall be rigidly supported on bed of thoroughly compacted material during the entire operation of placing and finishing the concrete. Forms shall be provided with adequate devices for secure setting so that when in place, they will withstand, without visible spring or settlement, the impact and vibration of the consolidation and finishing or paving equipment.

### 22.3.3 Preparation of Grade

After the subgrade or base has been placed and compacted to the required density, the areas which will support the paving machine and the grade on which the pavement is to be constructed shall be trimmed to the proper elevation by means of a properly designed machine extending the work at least 60 cm beyond each edge of the proposed concrete pavement. If loss of density results from the

trimming operations, it shall be restored by additional compaction before concrete is placed. If any traffic is allowed to use the prepared subgrade or base, the surface shall be checked and corrected immediately ahead of the placing concrete.

The subgrade or base shall be uniformly moist when the concrete is placed.

### 22.3.4 Setting Forms

#### 22.3.4.1 Base Support

The foundation under the forms shall be hard and true to grade so that the form when set will be firmly in contact for its whole length and at the specified grade. (Any roadbed, which at the form line is found below established grade, shall be filled with approved granular materials to grade in lifts of three (3) cm or less, and thoroughly rerolled or tamped.)Imperfections or variations above grade shall be corrected by tamping or by cutting as necessary.

#### 22.3.4.2 Form Setting

Forms shall be set sufficiently in advance of the point where concrete is being placed. After the forms have been set to correct grade, the grade shall be thoroughly tamped, mechanically or by hand, at both the inside and outside edges of the base of the forms. The forms shall not deviate from true line by more than one (1) cm at any point.

#### 22.3.4.3 Grade and Alignment

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete. Testing as to crown and elevation, prior to placing of concrete can be made by means of holding an approved template in a vertical position and moved backward and forward on the forms.
When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

### 22.3.5 Conditioning of Subgrade or Base Course

When side forms have been securely set to grade, the subgrade or base course shall be brought to proper cross-section. High areas shall be trimmed to proper elevation. Low areas shall be filled and compacted to a condition similar to that of surrounding grade. The finished grade shall be maintained in a smooth and compacted condition until the pavement is placed.

Unless waterproof subgrade or base course cover material is specified, the subgrade or base course shall be uniformly moist when the concrete is placed. If it subsequently becomes too dry, the subgrade or base course shall be sprinkled, but the method of sprinkling shall not be such as to form mud or pools of water.

### 22.3.6 Handling, Measuring and Batching Materials

The batch plant site, layout, equipment and provisions for transporting material shall be such as to assure a continuous supply of material to the work. Stockpiles shall be built up in layers of not more than one (1) meter in thickness. Each layer shall be completely in place before beginning the next which shall not be allowed to "cone" down over the next lower layer. Aggregates from different sources and of different grading shall not be stockpiled together.

All washed aggregates and aggregates produced or handled by hydraulic methods, shall be stockpiled or binned for draining at least twelve (12) hours before being batched.

When mixing is done at the side of the work, aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers of adequate capacity and construction to properly carry the volume required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or being dumped. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, with chute, boot or other approved device, to prevent loss of cement, and to provide positive assurance of the actual presence in each batch of the entire cement content specified.

Bulk cement shall be transported to the mixer in tight compartments carrying the full amount of cement required for the batch. However, if allowed in the Special Provisions, it may be transported between the fine and coarse aggregate. When cement is placed in contact with the aggregates, batches may be rejected unless mixed within 1-1/2 hours of such contact. Cement in original shipping packages may be transported on top of the aggregates, each batch containing the number of sacks required by the job mix.

The mixer shall be charged without loss of cement. Batching shall be so conducted as to result in the weight to each material required within a tolerance of one (1) percent for the cement and two (2) percent for aggregates.

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not more than one (1) percent. Unless the water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

### 22.3.7 Mixing Concrete

The 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 will be

measured from the time all materials, except water, are in the drum. Ready-mixed concrete shall be mixed and delivered in accordance with requirements of AASHTO M 157, except that the minimum required revolutions at the mixing speed for transit-mixed concrete may be reduced to not less than that recommended by the mixer manufacturer. The number of revolutions recommended by the mixer manufacturer shall be indicated on the manufacturer's serial plate attached to the mixer. The Contractor shall furnish test data acceptable to the Engineer verifying that the make and model of the mixer will produce uniform concrete conforming to the provision of AASHTO M 157 at the reduced number of revolutions shown on the serial plate.

When mixed at the Site or in a central mixing plant, the mixing time shall not be less than fifty (50) seconds nor more than ninety (90) seconds, unless mixer performance tests prove adequate mixing of the concrete is a shorter period.

Four seconds shall be added to the specified mixing time if timing starts at the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

The mixer shall be operated at the drum speed as shown on the manufacturer's name plate attached on the mixer. Any concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at his expense. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meter, as shown on the manufacturer's standard rating plate on the mixer, except that an overload up to ten (10) percent above the mixer's nominal capacity may be permitted provided concrete test data for strength, segregation, and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

The batches 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 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.
Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators or non-agitating trucks specified in Subsection 20.3.2, Equipment (p. 74). The time elapsed from the time water is added to the mix until the concrete is deposited in place at the Site shall not exceed 45 minutes when the concrete is hauled in non-agitating trucks, 90 minutes when hauled in truck mixers or truck agitators, except that in hot weather or under other conditions contributing to quick hardening of the concrete, the maximum allowable time may be reduced by the Engineer.

Re-tempering concrete by adding water or by other means shall not be permitted, except that when concrete is delivered in truck mixers, additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements, if permitted by the Engineer, provided all these operations are performed within 45 minutes after the initial mixing

operation and the water-cement ratio is not exceeded. Concrete that is not within the specified slump limits at the time of placement shall not be used. Admixtures for increasing the workability or for accelerating the setting of the concrete will be permitted only when specifically approved by the Engineer.

**22.3.8 Limitation of Mixing**

No concrete shall be mixed, placed or finished when natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

During hot weather, the Engineer may require that steps be taken to prevent the temperature of mixed concrete from exceeding a specified maximum temperature of 90 F (32 C).

Concrete not in place within 90 minutes from the time the ingredients were charged into the mixing drum or that has developed initial set shall not be used. Retempering of concrete or mortar which has partially hardened, that is remixing with or without additional cement, aggregate, or water, shall not be permitted.

In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the Contractor will be required to have available at all times materials for the protection of the edges and surface of the unhardened concrete.

**22.3.9 Placing Concrete**

Concrete shall be deposited in such a manner to require minimal rehandling. Unless truck mixers or non-agitating hauling equipment are equipped with means to discharge concrete without segregation of the materials, the concrete shall be unloaded into an approved spreading device and mechanically spread on the grade in such a manner as to prevent segregation. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. 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.

When concrete is to be placed adjoining a previously constructed lane and mechanical equipment will be operated upon the existing lane, that previously constructed lane shall have attained the strength for 14-day concrete. If only finishing equipment is carried out on the existing lane, paving in adjoining lanes may be permitted after three (3) days.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all 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 side a form. In no case shall the vibrator be operated longer than 15 seconds in any one location.

Concrete shall be deposited as near as possible to the expansion and contraction joints without disturbing them, but shall not be dumped from the discharge bucket or hopper into a joint assembly unless the hopper is well centered on the joint assembly. Should any concrete material fall on the surface of a complete slab, it shall be removed immediately.

**22.3.10Test Specimens**

As work progresses, at least one(1) set consisting of three (3) concrete beam test specimens, 150mm x 150mm x 525mm or 900mm shall be taken from each 330 $m^2$ of pavement, 230 mm depth, or fraction thereof placed each day. Test specimens shall be made under the supervision of the Engineer, and the Contractor shall provide all concrete and other facilities necessary in making the test specimens and shall protect them from damage due to construction operations.
The beams shall be made, cured, and tested in accordance with AASHTO T 23 and T 97.

**22.3.11Strike-off of Concrete and Placement of Reinforcement**

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 bottom layer shall be struck off and consolidated 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 top 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 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement may be firmly positioned in advance of concrete placement or it may be placed at the depth shown on the Plans in plastic concrete, after spreading by mechanical or vibratory means.

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

**22.3.12 Joints**

Joints shall be constructed of the type and dimensions, and at the locations required by the Plans or Special Provisions. All joints shall be protected from the intrusion of injurious foreign material until sealed.

**22.3.12.1 Longitudinal Joint**

Deformed steel tie bars of specified length, size, spacing and materials shall be placed perpendicular to the longitudinal joints, they shall be placed by approved mechanical equipment or rigidly secured by chair or other approved supports to

prevent displacement. Tie bars shall not be painted or coated with asphalt or other materials or enclosed in tubes or sleeves. When shown on the Plans and when adjacent lanes of pavement are constructed separately, steel side forms shall be used which will form a keyway along the construction joint. Tie bars, except those made of rail steel, may be bent at right angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed, or in lieu of bent tie bars, approved two-piece connectors may be used.

Longitudinal formed joints shall consist of a groove or cleft, extending downward from and normal to, the surface of the pavement. These joints shall be effected or formed by an approved mechanically or manually operated device to the dimensions and line indicated on the Plans and while the concrete is in a plastic state. The groove or cleft shall be filled with either a pre-molded strip or poured material as required.

The longitudinal joint shall be continuous, there shall be no gaps in either transverse or longitudinal joints at the intersection of the joints.
Longitudinal sawed joints shall be cut by means of approved concrete saws to the depth, width and line shown on the Plans. Suitable guide lines or devices shall be used to assure cutting the longitudinal joint on the true line. The longitudinal joint shall be sawed before the end of the curing period or shortly thereafter and before any equipment or vehicles are allowed on the pavement. The sawed area shall be thoroughly cleaned and, if required, the joint shall immediately be filled with sealer.
Longitudinal pavement insert type joints shall be formed by placing a continuous strip of plastic materials which will not react adversely with the chemical constituent of the concrete.

**22.3.12.2 Transverse Expansion Joint**

The expansion joint filler shall be continuous from form to form, shaped to subgrade and to the keyway along the form. Preformed joint filler shall be furnished in lengths equal to the pavement width or equal to the width of one lane. Damaged or repaired joint filler shall not be used.

The expansion joint filler shall be held in a vertical position. An approved installing bar, or other device, shall be used if required to secure preformed expansion joint filler at the proper grade and alignment during placing and finishing of the concrete. Finished joint shall not deviate more than 6 mm from a straight line. If joint fillers are assembled in sections, there shall be no offsets between adjacent units. No plugs of concrete shall be permitted anywhere within the expansion space.

**22.3.12.3 Transverse Contraction Joint**

When shown on the Plans, it shall consist of planes of weakness created by forming or cutting grooves in the surface of the pavement and shall include load transfer assemblies. The depth of the weakened plane joint

should, at all times, not be less than 50 mm, while the width should not be more than 6 mm.

**a.** Transverse Strip Contraction Joint. It shall be formed by installing a parting strip to be left in place as shown on the Plans.

**b.** Formed Groove. It shall be made by depressing an approved tool or device into the plastic concrete. The tool or device shall remain in place at least until the concrete has attained its initial set and shall then be removed without disturbing the adjacent concrete, unless the device is designed to remain in the joint.

**c.** Sawed Contraction Joint. It shall be created by sawing grooves in the surface of the pavement of the width, depth, and at the spacing and lines shown on the Plans, with an approved concrete saw. After each joint is sawed, it shall be thoroughly cleaned including the adjacent concrete surface.

Sawing of the joints shall commence as soon as the concrete has ' hardened sufficiently to permit sawing without excessive ravelling, usually 4 to 24 hours. All joints shall be sawed before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on during the day or night, regardless of weather conditions. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discounted when a crack develops ahead of the saw. In general, all joints should be sawed in sequence. If extreme conditions prevent erratic cracking by early sawing, the contraction joint groove shall be formed prior to initial set of concrete as provided above.

### 22.3.12.4 Transverse Construction Joint

It shall be constructed when there is an interruption of more than 30 minutes in the concreting operations. No transverse joint shall be constructed within 1.50 m of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has been mixed at the time of interruption to form a slab of at least 1.5 m long, the excess concrete from the last preceding joint shall be removed and disposed of as directed.

### 22.3.12.5 Load Transfer Device

Dowel, when used, shall be held in position parallel to the surface and center line of the slab by a metal device that is left in the pavement.
The portion of each dowel painted with one coat of lead or tar, in conformity end of the dowel.

In lieu of using dowel assemblies at contraction joints, dowel may be placed in the full thickness of pavement by a mechanical device approved by the Engineer.

### 22.3.13 Final Strike-off (Consolidation and Finishing)

#### 22.3.13.1 Sequence

The sequence of operations shall be the strike-off and consolidation, floating and removal of laitance, straight-edging and final surface finish. Work bridges or other devices necessary to provide access to the pavement surface for the purpose of finishing straight-edging, and make corrections as hereinafter specified, shall be provided by the Contractor.

In general, the addition of water to the surface of the concrete to assist in finishing operations will not be permitted. If permitted, it shall be applied on the surface as fog spray by means of an approved spray equipment.

#### 22.3.13.2 Finishing Joints

The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material, also under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in Subsection 20.3.2 Placing Concrete (p 80).

After the concrete has been placed and vibrated adjacent to the joints as required in Subsection 20.3.9, the finishing machine shall be brought forward, operating in a manner to avoid damage or misalignment of joints. If uninterrupted operation of the finishing machine, to, over and beyond the joints causes segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the front screed is approximately 20 cm (8 inches) from the joint. Segregated concrete shall be removed from in front of and off the joint. The front screed shall be lifted and set directly on top of the joint and the forward motion of the finishing machine resumed. When the second screed is close enough to permit the excess mortar in front of it to flow over the joint, it shall be lifted and carried over the joint. Thereafter, the finishing machine may be run over the joint without lifting the screeds, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

#### 22.3.13.3 Machine Finishing

**a.** Non-vibratory Method. The concrete shall be distributed or spread as soon as placed. It shall then be struck off and screeded by an approved finishing machine. The machine shall go over each area of pavement as many times and at such intervals as necessary to give the proper compaction and leave a surface of uniform texture. Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without wobbling or other variation tending to affect the precision finish.

During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed in its entire length.

**b.** Vibratory Method. When vibration is specified, vibrators for full width complete of concrete paving slabs, shall meet the requirements in Subsection 311.3.2, Equipment. If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and method which will produce pavement conforming to the Specifications. All provisions in Item (a) above not in conflict with the provisions of the vibratory method shall govern.

### 22.3.13.4 Hand Finishing

Hand finishing methods may only be used under the following conditions:

**a.** In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade.
**b.** In narrow widths or areas of irregular dimensions where operations of the mechanical equipment is impractical, hand methods may be used.

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.

The screed for the surface shall be at least 60 cm (2 feet) 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 constructed either of metal or other suitable material shod with metal.

Consolidation shall be attained by the use of suitable vibrator or other approved equipment.

In operation, the screed shall be moved forward on the forms with a ombined 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.

### 22.3.13.5 Floating

After the concrete has been struck off and consolidated, it shall be further smoothed, trued, and consolidated by means of a longitudinal float, either by hand, or alternative mechanical method.

**a.** Hand Method. The hand-operated longitudinal float shall be not less than 365 cm (12 feet) in length and 15 cm (6 inches) in width, properly stiffened to prevent flexibility 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 center line, and moving gradually from one side of the pavement to the other. Movement ahead

along the center line of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water or soupy material shall be wasted over the side forms on each pass.

**b.** Mechanical Method. The mechanical longitudinal float shall be of a design approved by the Engineer, and shall be in good working condition. The tracks from which the float operates shall be accurately adjusted to the required crown. The float shall be accurately adjusted and coordinated with the adjustment of the transverse finishing machine so that a small amount of mortar is carried ahead of the float at all times. The forward screed shall be adjusted so that the float will lap the distance specified by the Engineer on each transverse trip. The float shall pass over each areas of pavement at least two times, but excessive operation over a given area will not be permitted. Any excess water or soupy material shall be wasted over the side forms on each pass.

**c.** Alternative Mechanical Method. As an alternative, 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 or more visible wheels riding on, and constantly in contact with the side forms. If necessary, following one of the preceding methods of floating, long handled floats having blades not less than 150 cm (5 feet) in length and 15 cm (6 inches) in width may 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 floating. When strike off and consolidation s are done by the hand method and the crown of the pavement will not permit the use of the longitudinal float, the surface shall be floated transversely by means of the long-handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, any excess water and laitance shall be removed from the surface of the pavement by a 3-m straight-edge or more in length. Successive drags shall be lapped one-half the length of the blade.

### 22.3.13.6 Straight-edge Testing and Surface Correction

After the floating has been completed and the excess water removed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 300 cm long straight-edge. For this purpose, the Contractor shall furnish and use an accurate 300-cm straight-edge swung from handles 100 cm (3 feet) longer than one-half the width of the slab. The straight-edge shall be held in contact with the surface in successive positions parallel to the road center line and the whole area gone over from one side of the slab to the other as necessary. Advances along the road shall be in successive stages of not more than one-half the length of the straight-edge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Straight-edge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straight-edge and the slab conforms to the required grade and cross-section.

### 22.3.13.7 Final Finish

If the surface texture is broom finished, it shall be applied when the water sheen has practically disappeared. The broom shall be drawn from the center to the edge of the pavement with adjacent strokes slightly overlapping. The brooming operation should be so executed that the corrugations produced in the surface shall be uniform in appearance and not more than 1.5 mm in depth. Brooming shall be completed before the concrete is in such condition that the surface will be unduly roughened by the operation. The surface thus finished shall be free from rough and porous areas, irregularities, and depressions resulting from improper handling of the broom. Brooms shall be of the quality size and construction and be operated so as to produce a surface finish meeting the approval of the Engineer. Subject to satisfactory results being obtained and approval of the Engineer, the Contractor will be permitted to substitute mechanical brooming in lieu of the manual brooming as herein described.

If the surface texture is belt finished, when straight-edging is complete and water sheen has practically disappeared and just before the concrete becomes non-plastic, the surface shall be belted with 2-ply canvass belt not less than 20 cm wide and at least 100 cm longer than the pavement width. Hand belts shall have suitable handles to permit controlled, uniform manipulation. The belt shall be operated with short strokes transverse to the center line and with a rapid advances parallel to the center line.

If the surface texture is drag finished, a drag shall be used which consists of a seamless strip of damp burlap or cotton fabric, which shall produce a uniform of gritty texture after dragging it longitudinally along the full width of pavement. For pavement with 5 m or more in width, the drag shall be mounted on a bridge which travels on the forms. The dimensions of the drag shall be such that a strip of burlap or fabric at least 100 cm wide is in contact with the full width of pavement surface while the drag is used. The drag shall consist of not less than 2 layers of burlap with the bottom layer approximately 5 cm wider than the layer. The drag shall be maintained in such condition that the resultant surface is of uniform appearance and reasonably free from grooves over 1.5 mm in depth. Drag shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags substituted.

Regardless of the method used for final finish, the hardened surface of pavement shall have a coefficient of friction of 0.25 or more. Completed pavement that is found to have a coefficient of friction less than 0.25 shall be grounded or scored by the Contractor at his expense to provide the required coefficient of friction.

### 22.3.13.8 Edging at Forms and Joints

After the final finish, but before the concrete has taken its initial set, the edges of the pavement along each side of each slab, and on each side of transverse expansion joints, formed joints, transverse construction joints, and emergency construction joints, shall be worked with an approved tool and rounded to the radius required by the Plans. A well-defined and continuous radius shall be

produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting the tool during the use.

At all joints, any tool marks appearing on the slab adjacent to the joints shall be eliminated by brooming the surface. In doing this, the rounding of the corner of the slab shall not be disturbed. All concrete on top of the joint filler shall be completely removed.

All joints shall be tested with a straight-edge before the concrete has set and corrections made if one edge of the joint is higher than the other.

### 20.6.14 Surface Test

As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 3-m straight edge or other specified device. Areas showing high spots of more than 3 mm but not exceeding 12 mm in 3 m shall be marked and immediately ground down with an approved grinding tool to an elevation where the area or spot will not show surface deviations in excess of 3 mm when tested with 3 m straight-edge. Where the departure from correct cross section exceeds 12 mm, the pavement shall be removed and replaced by and at the expense of the Contractor.
Any area or section so removed shall be not less than 1.5 m in length and not 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 1.5 m in length, shall also be removed and replaced.

### 22.3.15 Curing

Immediately after the finishing operations have been completed and the concrete has sufficiently set, the entire surface of the newly placed concrete shall be cured in accordance with either one of the methods described herein. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 hour between stages of curing or during the curing period.

#### 22.3.15.1 Cotton or Burlap Mats

The surface of the pavement shall be entirely covered with mats which shall be of such length (or width) that when laid, they will extend at least twice the thickness of the pavement beyond the edges of the slab. The mat shall be placed so that the entire surface and the edges of the slab are completely covered. Prior to being placed, the mats shall be saturated thoroughly with water. The mat shall be so placed and weighted down so as to cause them to remain in intimate contact with the covered surface. The mats shall be maintained fully wetted and in position for 72 hours after the concrete has been placed unless otherwise specified.

### 22.3.15.2 Waterproof Paper

The top surface and sides of the pavement shall be entirely covered with waterproof paper, the units shall be lapped at least 45 cm. The paper shall be so placed and weighted down so as to cause it to remain in intimate contact with the surface covered. The paper shall have such dimension but each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement, or at pavement width and 60 cm strips of paper for the edges. If laid longitudinally, paper not manufactured in sizes which will provide this width shall be securely sewed or cemented together, the joints being securely sealed in such a manner that they do not open up or separate during the curing period. Unless otherwise specified, the covering shall be maintained in place for 72 hours after the concrete has been placed. The surface of the pavement shall be thoroughly wetted prior to the placing of the paper.

### 22.3.15.3 Straw Curing

When this type of curing is used, the pavement shall be cured initially with burlap or cotton mats, until after final set of the concrete or, in any case, for 12 hours after placing the concrete. As soon as the mats are removed, the surface and sides of the pavement shall be thoroughly wetted and covered with at least 20 cm of straw or hay, thickness of which is to be measured after wetting. If the straw or hay covering becomes displaced during the curing period, it shall be replaced to the original depth and saturated. It shall be kept thoroughly saturated with water for 72 hours and thoroughly wetted down during the morning of the fourth day, and the cover shall remain in place until the concrete has attained the required strength.

### 22.3.15.4 Impervious Membrane Method

The entire surface of the pavement shall be sprayed uniformly with white `pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place, or if the pavement is cured initially with jute or cotton mats, it may be applied upon removal of the mass. The curing compound shall not be applied during rainy days.

Curing compound shall be applied under pressure at the rate 4 L to not more than 14 $m^2$ by mechanical sprayers equipped with wind guards. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application, the compound shall be stirred continuously by effective mechanical means. Hand spraying of odd widths or shapes and concrete surface exposed by the removal of forms will be permitted. Curing compound shall not be applied to the inside faces of joints to be sealed, but approved means shall be used to insure proper curing for at least 72 hours and to prevent the intrusion of foreign material into the joint before sealing has been completed. The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film be damaged from any cause within the 72-hour curing period, the damaged portions shall be repaired immediately with additional compound.

### 22.3.15.5 White Polyethylene Sheet

The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. The units used shall be lapped at least 45 cm. The sheeting shall be so placed and weighted down so that it remains in intimate contact with the covered surface. The sheeting as prepared for use shall have such dimension that each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement. Unless otherwise specified, the covering shall be maintained in place for 72 hours after the concrete has been placed.

### 22.3.16 Removal of Forms

All forms for concrete shall remain in place undisturbed for not less than twenty four (24) hours after concrete pouring. In the removal of forms, crowbars should be used in pulling out nails and pins. Care should be taken so as not to break the edges of the pavement. In case portions of the concrete are spaded, they shall be immediately repaired with fresh mortar mixed-in the proportion of one part of Portland Cement and two parts fine aggregates. Major honeycombed areas will be considered as defective work and shall be removed and replaced at the expense of the Contractor. Any area or section so removed shall not be less than the distance between weakened plane joint nor less than the full width of the lane involved.

### 22.3.17 Sealing Joints

Joints shall be sealed soon after completion of the curing period and before the pavement is opened to traffic, including the Contractor's equipment. Prior to sealing, each joint shall be thoroughly cleaned of all foreign materials including membrane curing compound and the joint faces shall be clean and surface dry when the seal is applied.

The sealing material shall be applied to each joint opening to conform to the details shown on the Plans or as directed by the Engineer. Material for seal applied hot shall be stirred during heating so that localized overheating does not occur. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. The use of sand or similar material as a cover for the seal will not be permitted.

Preformed elastomeric gaskets for sealing joints shall be of the cross-sectional dimensions shown on the Plans. Seals shall be installed by suitable tools, without elongation and secured in placed with an approved lubricant adhesive, which shall cover both sides of the concrete joints. The seals shall be installed in a compressive condition and shall at time of placement be below the level of the pavement surface by approximately 6 mm.

The seals shall be in one piece for the full width of each transverse joint.

### 22.3.18 Protection of Pavement

The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by his own employees and agents. This shall include watchmen to direct traffic and the erection of and maintenance of warning signs, lights, pavement bridges or crossovers, etc. The Plans or Special Provisions will indicate the location and type of device or facility required to protect the work and provide adequately for traffic.

Any damage to the pavement, occurring prior to final acceptance, shall be repaired or the pavement replaced.

### 22.3.19 Concrete Pavement - Slip Form Method

If the Contract calls for the construction of pavement without the use of fixed forms, the following provisions shall apply:

#### 22.3.19.1 Grade

After the grade or base has been placed and compacted to the required density, the areas which will support the paving machine shall be cut to the proper elevation by means of a properly designed machine. The grade on which the pavement is to be constructed shall then be brought to the proper profile by means of properly designed machine. If the density of the base is disturbed by the grading operation, it shall be corrected by additional compaction before concrete is placed. The grade should be constructed sufficiently in advance of the placing of the concrete. If any traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placing of concrete.

#### 22.3.19.2 Placing Concrete

The concrete shall be placed with an approved slip-form paver designed to spread, consolidate, screed and float-finish the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finish will be necessary to provide a dense and homogeneous pavement in conformance with the Plans and Specifications. The machine shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Such vibration shall be accompanied with vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface of the concrete. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms. The forms shall trail behind the paver for such a distance that no appreciable slumping of the concrete will occur, and that necessary final finishing can be accomplished while the concrete is still within the forms. Any edge slump of the pavement, exclusive of edge rounding, in excess of 6 mm shall be corrected before the concrete has hardened.

The concrete shall be held at a uniform consistency, having a slump of not more than 40 mm (1-1/2 inches). The slip form paver shall be operated with as nearly as possible a continuous forward movement and that all operations of mixing,

delivering and spreading concrete shall be coordinated so as to provide uniform progress with stopping and starting of the paver held to a minimum. If, for any reason, it is necessary to stop the forward movement of the paver the vibratory and tamping elements shall also be stopped immediately. No traction force shall be applied to the machine, except that which is controlled from the machine.

**22.3.19.3 Finishing**

The surface smoothness and texture shall meet the requirements of Subsections 20.3.13 (Final Strike-off p-84) and 20.3.14 (Surface Test p-88).

**22.3.19.4 Curing**

Unless otherwise specified, curing shall be done in accordance with one of the methods included in Subsection 20.3.15. The curing media shall be applied at the appropriate time and shall be applied uniformly and completely to all surfaces and edges of the pavement.

**22.3.19.5 Joints**

All joints shall be constructed in accordance with Subsection 20.3.1 (Joints p-81

**22.3.19.6 Protection against Rain**

In order that the concrete may be properly protected against rain before the concrete is sufficiently hardened, the Contractor will be required to have available at all times, materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of standard metal forms or wood planks having a nominal thickness of not less than 50 mm (2 inches) and a nominal width of not less than the thickness of the pavement at its edge for the protection of the pavement edges, and covering materials such as burlap or cotton mats, curing paper or plastic sheeting material for the protection of the surface of the pavement. When rain appears imminent, all paving operations shall stop and all available personnel shall begin placing forms against the sides of the pavement and covering the surface of the unhardened concrete with the protective covering.

**22.3 20 Acceptance of Concrete**

The strength level of the concrete will be considered satisfactory if the averages of all sets of three (3) consecutive strength test results equal or exceed the specified strength, f' and no individual strength test result is deficient by more than 15% of the specified strength, f'.
Concrete deemed to be not acceptable using the above criteria may be rejected unless the Contractor can provide evidence, by means of core tests, that the quality of concrete represented by failed test results is acceptable in place. At least three (3) representative cores shall be taken from each member or area of concrete in place that is considered deficient. The location of cores shall be determined by the Engineer so that there will be least impairment of strength of the

structure. The obtaining and testing of drilled cores shall be in accordance with AASHTO T 24.

Concrete in the area represented by the cores will be considered adequate if the average strength of the cores is equal to at least 85% of, and if no single core is less than 75% of, the specified strength, f'.

If the strength of control specimens does not meet the requirements of this Subsection, and it is not feasible or not advisable to obtain cores from the structure due to structural considerations, payment of the concrete will be made at an adjusted price due to strength deficiency of concrete specimens as specified hereunder:

| Deficiency in Strength of Concrete Specimens, Percent (%) | Percent (%) of Contract Price Allowed |
|---|---|
| Less than 5 | 100 |
| 5 to less than 10 | 80 |
| 10 to less than 15 | 70 |
| 15 to less than 20 | 60 |
| 20 to less than 25 | 50 |
| 25 or more | 0 |

### 22.3.21 Opening to Traffic

The Engineer will decide when the pavement may be opened to traffic. The road will not be opened to traffic until test specimens molded and cured in accordance with AASHTO T 23 have attained the minimum strength requirements in Subsection 20.2.11 (p-73). If such tests are not conducted prior to the specified age, the pavement shall not be operated to traffic until 14 days after the concrete was placed. Before opening to traffic, the pavement shall be cleaned and joint sealing completed.

### 22.3.22 Tolerance and Pavement Thickness

#### 22.3.22.1 General

The thickness of the pavement will be determined by measurement of cores from the completed pavement in accordance with AASHTO T 148.

The completed pavement shall be accepted on a lot basis. A lot shall be considered as 1000 linear meters of pavement when a single traffic lane is poured or 500 linear meters when two lanes are poured concurrently. The last unit in each slab constitutes a lot in itself when its length is at least 1/2 of the normal lot length. If the length of the last unit is shorter than 1/2 of the normal lot length, it shall be included in the previous lot.
Other areas such as intersections, entrances, crossovers, ramps, etc., will be grouped together to form a lot. Small irregular areas may be included with other unit areas to form a lot.

Each lot will be divided into five (5) equal segments and one core will be obtained from each segment in accordance with AASHTO T 24.

**22.3.22.2 Pavement Thickness**

It is the intent of this Specification that the pavement has a uniform thickness as called for on the Plans for the average of each lot as defined. After the pavement has met all surface smoothness requirements, cores for thickness measurements will be taken.

In calculating the average thickness of the pavement, individual measurements which are in excess of the specified thickness by more than 5 mm will be considered as the specified thickness plus 5 mm and measurement which are less than the specified thickness by more than 25 mm shall not be included in the average. When the average thickness for the lot is deficient, the contract unit price will be adjusted for thickness in accordance with paragraph (3) below.
Individual areas within a segment found deficient in thickness by more than 25 mm shall be evaluated by the Engineer, and if in his judgment, the deficient areas warrant removal, they shall be removed and replaced by the Contractor with pavement of the specified thickness at his entire expense. However, if the evaluation of the Engineer is that the deficient area should not be removed and replaced, such area will not be paid.

When the measurement of any core is less than the specified thickness by more than 25 mm, the actual thickness of the pavement in this area will be determined by taking additional cores at no less than 5 m intervals parallel to the center line in each direction from the affected location until a core is found in each direction, which is not deficient in thickness by more than 25 mm. The area of slab for which no payment will be made shall be the product of the paving width multiplied by the distance along the center line of the road between transverse sections found not deficient in thickness by more than 25 mm. The thickness of the remainder of the segment to be used to get the average thickness of each lot shall be determined by taking the average thickness of additional cores which are not deficient by more than 25 mm.

**22.3.22.3 Adjustment for Thickness**

When the average thickness of the pavement per lot is deficient, payment for the lot shall be adjusted as follows:

| Deficiency in the Average Thickness per lot (mm) | Percent (%) of Contract Price per Lot |
|---|---|
| 0-5 | 100% payment |
| 6-10 | 95% payment |
| 11-15 | 85% payment |
| 16-20 | 70% payment |
| 21-25 | 50% payment |

| | |
|---|---|
| More than 25 | Remove and replace/No payment |

### 22.4 Method of Measurement

The area to be paid for under this Item shall be the number of square meters ($m^2$) of concrete pavement placed and accepted in the completed pavement. The width for measurements will be the width from outside edge to outside edge of completed pavement as placed in accordance with the Plans or as otherwise required by the Engineer in writing. The length will be measured horizontally along the center line of each roadway or ramp. Any curb and gutter placed shall not be included in the area of concrete pavement measured.

### 22.5 Basis of Payment

The accepted quantity, measured as prescribed in Section 20.4 (Method of Measurement), shall be paid for at the contract unit price for Portland Cement Concrete Pavement, for which price and payment shall be full compensation for preparation of roadbed and finishing of shoulders, unless otherwise provided by the Special Provisions, furnishing all materials, for mixing, placing, finishing and curing all concrete, for furnishing and placing all joint materials, for sawing weekend plane joints, for fitting the prefabricated center metal joint, for facilitating and controlling traffic, and for furnishing all labor, equipment, tools and incidentals necessary to complete the Item.

Payment will be made under:

| Pay Item Number | Description | Unit of Measurement |
|---|---|---|
| 311(1) | PCC Pavement (Plain) | Square meter |
| 311(2) | PCC Pavement (Reinforced) | Square meter |

Construction Requirement shall also conform to the requirements of the DPWH, Standard Specifications for Public Works and Highways, Volume II, 2004.

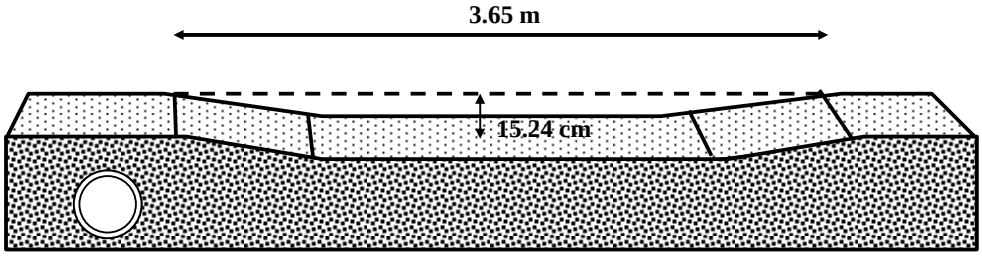
## 23. RELATED STRUCTURES

### 23.1 Pipes Culverts and Storm Drains

The design of culvert and storm drains including drainage areas shall consider factors such as watershed, land use, local rainfall, soil type, slope of pipe, and fill over pipe. All culverts should be designed using the two-year, 24-hour storm as a minimum. The designers should also evaluate the impact of the 10-year, 24-hour storm. No culvert less than 910mm in diameter should be used.

To prevent sedimentation from silting in and blocking the culvert, a minimum water flow rate of 2.5 feet per second is required. Slope of 2 – 4 % are ideal and a slope of 0.5% is the absolute minimum that is acceptable for use. Care must be taken to install the culvert on a smooth surface having a uniform slope to prevent the formation of low spots.

Where it is impractical to install the proper size of culvert, an adequate overflow area should be provided to allow storm flows to overtop the road and discharge on natural ground, not fill material. The overflow should be protected as needed to prevent road washouts or erosion.




Overflow channel should be approximately 3.65 meters wide and 15.24 centimeter.

**Figure 17 – Overflow Channel**

## 23.2 Roadside Ditch

The data shall be designed on channel dimensions such as the width, depth, slope (Front slope and back slope), velocity, particle size distribution, sediment load, and discharge necessary to maintain stable channel.

This shall be constructed to drain water from the subgrade.

This shall be constructed to collect surface water either from the roadway surface or adjacent.

### 23.2.1 Types of Roadside Ditch

### a. Roadside Trapezoidal Ditch

This shall reduce the risk of erosion for a lower water velocity.
Below is a preferred designed ditch shaped with relatively flat front slope and back slope, and a wide flat bottom.

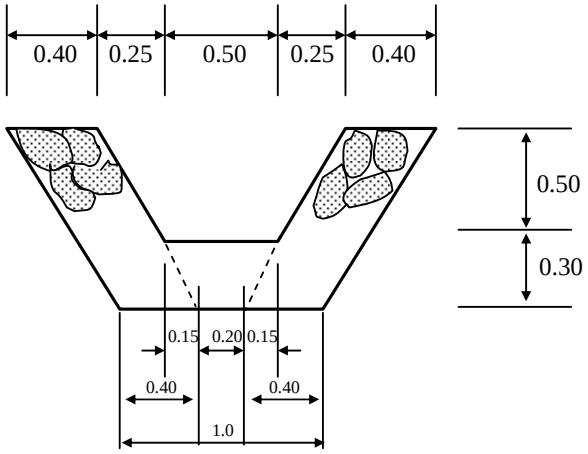



**Figure 18- Grouted Riprap Trapezoidal Ditch Canal**

**Construction Requirements**

Trapezoidal ditch design shall be constructed with grouted ripraps or with concrete lining.

It shall have a minimum thickness of 0.25 meters.

**Slope**

Minimal steep slopes shall be considered to minimize abrupt flow of water and relatively control erosion.

**Front Side slope**

For low traffic volume roads and unusual local conditions, it shall be as steep as 2:1.

The desirable front slope that should extend outward to provide enough side ditch flow line elevation is at least 0.80 m. below the elevation of the finished shoulder.

**Back Slope**

This shall be designed at a minimum steep slope of 2:1.

Steepening of the back slopes to a maximum of 2:1 shall be considered depending on the depth of cut and the class of roads.

**Depths**

Ditch depth shall be designed to a minimum of 0.50 m below subgrade level.

**Ditch bottom width**

This shall be measured from the base of the front slope to the base of the back slope.

Maximum bottom width shall be 1.2 meters at the base with the side batters of a 2:1 ratio. However, bottom width of at least 0.5 meters shall be considered depending on the availability of the right-of-way and class of roads constructed.

**Ditch Velocity**

Ditch shall be designed at a sufficient velocity that will minimize the potentials of erosion for road edges and will prevent siltation.

If the slope exceeds 4%, concrete-lined or masonry-lined ditch should be provided.

**b. Roadside Triangular V-Ditch**

This type of ditch shall easily be constructed and requires less right-of-way.

This shall be determined by considering the intended purpose, terrain, flow velocity and quantity of flow to be conveyed.

This is intended primarily for low flow conditions such as in median and roadside ditches

**Road Ditches**

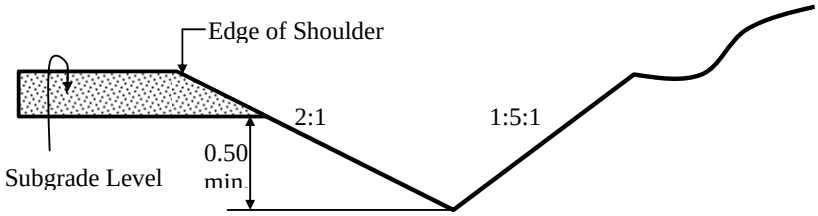



**Figure 19 - Earth Ditch**

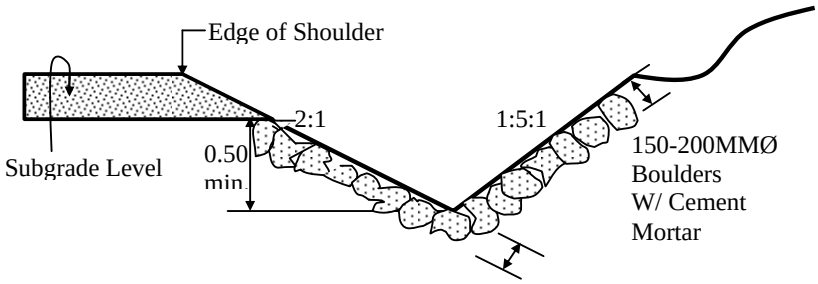



**Figure 20 - Masonry Lining Ditch**

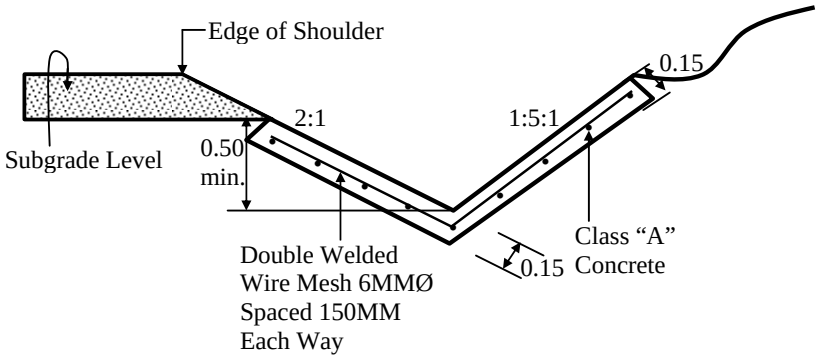



**Figure 21 - Concrete Lining Ditch**

**Construction Requirement**

Triangular V-ditch design shall be constructed with Earth Ditch, Masonry Lined Ditch, and Concrete Lined Ditch.

Masonry V-ditch shall have a minimum thickness of 0.25 meters composed of boulders with diameter of 0.15-0.20 meter and cement mortar.

Concrete lining ditch shall have a minimum thickness of 0.15 meters class “A” concrete with double welded wire mesh diameter of 0.06 meters at 0.15 meters apart.

**Slope**

Minimal steep slopes shall be considered to minimize abrupt flow of water and relatively, control erosion.

**Front Side slope**

For low traffic volume roads and unusual local conditions, it shall be as steep as 2:1.

The desirable front slope that should extend outward to provide enough side ditch flow line elevation is at least 0.80 m. below the elevation of the finished shoulder.

**Back Slope**

This shall be designed at a minimum steep slope of 1:1.5.

**Depths**

This shall be measured from the subgrade level to the traversable bottom level of the design.

Minimum Depth of triangular V-ditch design shall be 0.50 meters from the subgrade level.

**Ditch Velocity**

Ditch shall be designed at sufficient velocity that will minimize the potentials of erosion for road edges and will prevent siltation. If the slope exceeds 4%, concrete-lined or masonry-lined ditch should be provided.

This shape of channel is susceptible to erosion and shall require lining when flow velocities exceed the permissible velocities shown in the table.

**Table 29 Recommended Permissible Velocities for Unlined Channels**

| Type of Material in Excavation Section | Permissible Velocity (m/s) | |
|---|---|---|
| | Intermittent Flow | Sustained Flow |
| Fine Sand (Noncolloidal) | 0.8 | 0.8 |
| Sandy Loam (Noncolloidal) | 0.8 | 0.8 |
| Silt Loam (Noncolloidal) | 0.9 | 0.9 |
| Fine Loam | 1.1 | 1.1 |
| Volcanic Ash | 1.2 | 1.1 |
| Fine Gravel | 1.2 | 1.1 |
| Stiff Clay (Colloidal) | 1.5 | 1.2 |
| Graded Material (Noncolloidal) | | |
| Loam to Gravel | 2.0 | 1.5 |
| Silt to Gravel | 2.1 | 1.7 |
| Gravel | 2.3 | 1.8 |
| Coarse Gravel | 2.4 | 2.0 |
| Gravel to Cobbles (Under 150 mm) | 2.7 | 2.1 |
| Gravel and Cobbles (Over 200 mm) | 3.0 | 2.4 |

## C. Roadside Rectangular Ditch

This shall be often used to convey large flows in areas with limited right-of-way.

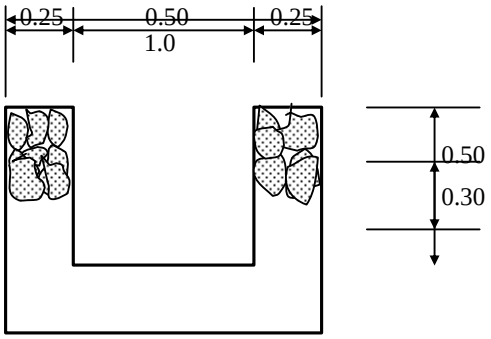



**Figure 22 - Rectangular Road Side Ditch with Grouted Riprap**

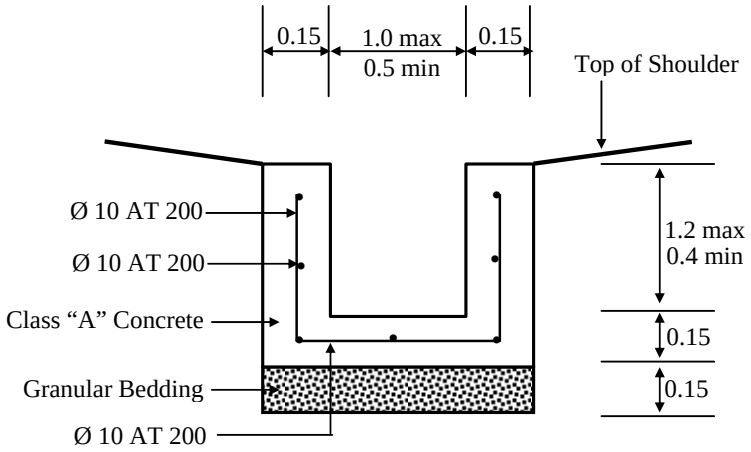



**Figure 23 - Concrete Lined Canal**

* **CHB-lined Canal may also be recommended**

**Construction Requirement**

Rectangular ditch design shall be constructed with grouted ripraps or with concrete lining ditch.

It shall be made of either concrete pavement or masonry materials.

It shall have a minimum thickness of 0.15 meters for concrete materials.

It shall have a minimum thickness of 0.25 meters for masonry with grouted ripraps.

**Depths**

Rectangular ditch depth shall be designed to place ditch bottom below a normal pavement box allowing any moisture trapped under the pavement to travel through the porous Subbase into the ditch.

It shall be measured from the ditch bottom level to the subgrade level.

Minimum depth shall be 0.5 meters and maximum of 1.2 meters.

**Ditch Bottom Width**

This shall be measured from the base of the front side drain to the base of the backside drain.

Minimum bottom width shall be 0.5 meters and a maximum of1.0 meters.

**Ditch Velocity**

Ditch shall be designed at a slow flow velocity to minimize the potentials of erosion for road edges.