PHILIPPINE NATIONAL STANDARD

PNS/BAFS PABES 289:2019
ICS 65.040.01

Agricultural Infrastructures – Farm-to-Market Roads – Concrete Roads

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Foreword

The Philippine National Standard (PNS) for Agricultural Infrastructures – Farm-to-Market Roads – Concrete Roads (PNS/BAFS PABES 2892019) has been prepared by the Bureau of Agriculture and Fisheries Standards (BAFS), in collaboration with the Technical Working Group (TWG) for Farm-to-Market Roads per approved Department of Agriculture Special Order (SO) No. 954 Series of 2016.

This Standard replaces the provisions for concrete roads specified by PAES 421:2009 Agricultural Structures – Farm-to-Market Roads.

This edition includes the following significant changes compared to the previous edition:

- Focus on the provisions for concrete roads only
- Modification in “Scope”
- Modification in the definition of “Farm-to-Market Road” and other terms in “Terms and Definitions”
- Revision of figure and provisions under “Typical location of Farm-to-Market Roads”
- Addition of clause on “General Components of Farm-to-Market Roads”
- Addition of terms and definitions related to bio-engineering slope protection and other terms in “Terms and Definitions”
- Modification in Clause on “Design Considerations”, including considerations for geometric, pavement, drainage, slope protection, and miscellaneous structures design
- Revision of minimum pavement thickness to 200mm
- Revision of minimum pavement width for two-lane roads to 5m
- Consolidation of applicable provisions under clause on “Materials and Construction Requirements”
- Addition of materials and construction requirements for structure excavation, other types of aggregate base courses, slope protection, drainage, and miscellaneous structures
- Deletion of clauses on “Method of Measurement” and “Basis of Payment”
- Addition of clause on “Operation and Maintenance of Farm-to-Market Roads”
- Addition of Annex A “Sample Plan, Profile, and Cross Section Plan of FMR”
- Addition of Annex B “Classification of Roads”
- Addition of Annex C “Minimum Stopping and Passing Sight Distances”
- Addition of Annex D “Recommended Permissible Velocities of Channels”
- Addition of Annex E “Typical Road Safety Signs”

Provisions of this standard are based on the DPWH Standard Specifications for Public Works and Highways, Volume II – Highways, Bridges and Airports, 2013 Edition and other sources.

This Standard has been technically prepared in accordance with International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) Directives Part 2, 8th edition – Principles and rules for the structure and drafting of ISO and IEC documents.

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

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

1 Scope

This standard specifies the minimum requirements for the design, construction, and operation and maintenance of one-lane and two-lane concrete Farm-to-Market Roads for the purpose of, but not limited to, the preparation of program of works, detailed engineering design, procurement, monitoring, inspection, and evaluation. It covers the construction of new roads and upgrading of existing roads with Average Daily Traffic (ADT) equal or less than 400.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Department of Public Works and Highways (DPWH) Design Guidelines, Criteria, and Standards Volume 4 (2015), *Highway Design*

American Association of State Highway and Transportation Officials (AASHTO) (2011), *A Policy on Geometric Design of Highways and Streets*, 6th Ed.

AASHTO (1993), *Guide for Design of Pavement Structures*

DPWH Standard Specifications for Highways, Bridges, and Airports, Volume II (2013)

PNS/BAFS/PAES 218:2017, *Open Channels – Design of Main Canals, Laterals and Farm Ditches*

DPWH Highway Safety Design Standards Part 2 (2012), *Road Signs and Pavement Marking Manual*

American Society for Testing and Materials (ATSM) A615/A615M, *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement*

AASHTO T 11, *Standard Method of Test for Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing*

AASHTO T 90, *Standard Method of Test for Determining the Plastic Limit and Plasticity Index of Soils*

AASHTO T 89, *Standard Method of Test for Determining Liquid Limits of Soil*

AASHTO T 99, *Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm Drop*

AASHTO T 191, *Standard Method of Test for Density of Soil In-Place by the Sand-Cone Method*

ASTM D2167, *Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method*

ASTM D4718/D4718M, *Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles*

AASHTO T 96, *Standard Method of Test for Resistance to Degradation of Small-size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*

AASHTO T 193, *Standard Method of Test for the California Bearing Ratio (CBR)*

AASHTO T 180, *Standard Method of Test for Moisture- Density Relations of Soils Using a 4.54 kg (10 lb) Rammer and a 457 mm (18 in) Drop*

ASTM D 1632, *Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory*

AASHTO T 134, *Standard Method of Test for Moisture – Density Relations of Soil – Cement Mixtures*

ASTM D 1633, *Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders*

AASHTO M 85, *Standard Specification for Portland Cement*

AASHTO M240M/M240 or ASTM C595/C595M, *Standard Specification for Blended Hydraulic Cement*

AASHTO R 71, *Standard Practice for Sampling and Amount of Testing of Hydraulic Cement*

AASHTO T 71, *Standard Method of Test for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar*

ASTM C 1602/C1602M, *Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete*

AASHTO M31M/M31, *Standard Specification for Deformed and Plain Carbon and Low-Alloy Steel Bars for Concrete Reinforcement*

AASHTO M42M/M42, *Standard Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement*

ASTM D 6690, *Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements*

AASHTO M 33 or ASTM D994/D994M, *Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)*

AASHTO M 213, *Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)*

ASTM D 2628, *Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements*

AASHTO M194M/M194, *Standard Specification for Chemical Admixtures for Concrete*

AASHTO M 144, *Standard Specification for Calcium Chloride*

ACI Standard 211.1, *Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete*
AASHTO T119M/T119, *Standard Method of Test for Slump of Hydraulic Cement Concrete*

AASHTO T 97, *Standard Method of Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)*

AASHTO T 177, *Standard Method of Test for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)*

AASHTO T24M/T24, *Standard Method of Test for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete*

AASHTO M 157, *Standards Specification for Ready-Mixed Concrete*

ASTM C685/C685M, *Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing*

AASHTO T 23, *Standard Method of Test for Making and Curing Concrete Test Specimens in the Field*

AASHTO T 148, *Standard Method of Test for Measuring Length of Drilled Concrete Cores*

ASTM C 171, *Standard Specification for Sheet Materials for Curing Concrete*

AASHTO M 248, *Standard Specification for Ready-Mixed White and Yellow Traffic Paints*

AASHTO M 249, *Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form)*

AASHTO T 250, *Standard Method of Test for Thermoplastic Traffic Line Material*

ASTM D 5167, *Standard Practice for Melting of Hot-Applied Joint and Crack Sealant and Filler for Evaluation*

ASTM D 5329, *Standard Test Method for Sealants and Filler, Hot-Applied, for Joints and Cracks in Asphalt Pavements and Portland Cement Concrete Pavements*

Philippine Rural Development Project (PRDP), *Operation and Maintenance Manual for Rural Infrastructure Sub-projects*

DPWH Department Order No. 41 series of 2016, *Amended Policy Guidelines on the Maintenance of National Roads and Bridges*

3 Terms and Definitions

For the purpose of this standard, the following terms shall apply.

3.1
access ramp
slope located at the side of the road carriageway that provides entrance from lower ground levels

3.2
aggregates
granular material of mineral composition such as sand, gravel, shell, crushed and uncrushed stone or lightweight materials

3.3
agriculture and fisheries
production of crops, livestock, and aquatic flora and fauna

3.4
backfill
suitable materials such as gravel, sand, and earth used to refill excavated materials during construction

3.5
backfilling
the act of refilling suitable materials or replacing unsuitable materials removed during construction

3.6
base course
layer of aggregate, soil-treated aggregate, treated soil, or soil aggregate of designed thickness that rests upon the Subbase or if no Subbase, upon the sub-grade, to support a surface course.

3.7
borrow
suitable material used for embankments

3.8
California Bearing Ratio (CBR)
ratio between a test load and an arbitrarily defined standard load, expressed as a percentage

3.9
clearing
removal and disposal of trees, vegetation or other unwanted materials from the ground surface

3.10
coco coir twine
string made of coconut coir strands twisted together

3.11
coco coir peat
natural and residual materials from coconut coir which serves as soil conditioner

3.12
coco-log
tubular structure of coconut coir fiber blankets of different diameter filled with coco coir, and/or coco peat

3.13
coconet
handspun coconut coir fiber twine woven into blankets of different density

3.14
coconut geonet
any coconut coir fiber-based material such as coconets, coco-logs, coco peat, placed in sloping lands and embankments to hold the vulnerable soil and permit vegetative growth to control surface erosion and conserve the productivity of the soil

3.15
compaction
application of pressure to soil materials to result in a dense mass free of excessive voids; minimizes settlement, decreases permeability and increases strength

3.16
concrete
hardened mixture of fine and coarse aggregate, water, cement, and admixtures

3.17
Contractor
entity having a Contract with a procurement agency and accredited by the Philippine Constructors Accreditation Board (PCAB)

3.18
course
structural component of specified thickness; it may consist of one layer or more

3.19
crossfall
cross slope
transverse slope that helps the carriageway to drain properly

3.20
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

3.21
drainage
removal of water from the road area by the use of culverts, ditches, channels and other several structures

3.22
earthwork
operations connected with excavating and placing embankments with soil, earth or rock

3.23
embankment
construction, usually of earth or stone, to raise the ground or formation level above the natural surface

3.24
Engineer
a person authorized by law and registered and licensed by the Professional Regulation Commission (PRC) to design and supervise the construction of Farm-to-Market Roads; refers to the engineer of the implementing agency

3.25
Equivalent Single Axle Load (ESAL)
load from the conversion of an expected axle load into an equivalent number of 18-kip single axle load

3.26
erosion control
protection of soil from disclosing by water, wind, or other agent

3.27
excavation
act of cutting, digging, or scooping to remove material

3.28
farm
place devoted for agricultural and fisheries production

3.29
Farm-to-Market Roads (FMR)
road within the agriculture and fisheries production areas, coastal landing points, and postharvest or processing facilities that links to local roads, national highways, and markets.

3.30
Field Density Test (FDT)
determination of the degree of compaction of the soil

3.31
fill
suitable embankment materials placed above natural ground line

3.32
geotextile
fabrics used in subsurface drainage, hydraulic filter, erosion control, sediment control, pavement structures and used as waterproofing and stress relieving membrane, and as a permeable separator to prevent mixing of dissimilar materials such as foundations and select fill materials

3.33
grade
slope of a roadway, channel, or natural ground

3.34
gradation
property of a soil which describes the distribution of size groups

3.35
gradient
rate of increase or decrease in the level of the land, the slope expressed in percentage

3.36
grading
preparation of the sub-grade, in line and elevation, for application of pavement materials including base and surfacing materials

3.37
grubbing
removal and disposal of trees, and other unwanted materials below the ground surface

3.38
intersection
general area where two or more roads, within which are included the roadway and roadside facilities for traffic movements in that area

3.39
lane roadway
roadway with single, two, or more clearly marked lanes for vehicular traffic

3.40
local roads
road that predominantly carries through traffic from one area to another, forming principal avenues of travel for traffic movements which include provincial, municipal, city, and barangay roads

3.41
market
a place, building, or structure where buyers and sellers meet for the sale or purchase of agriculture and fisheries products

3.42
masonry
form of stone, brick, concrete block, concrete, or other similar building materials that have been bonded together with mortar to form a structure

3.43
one-lane concrete road
concrete roadway, with clearly marked single or one lane for vehicular traffic

3.44
Plans
the contract drawings which show the locations, character, and dimension of the prescribed work, including layouts, profiles, cross sections, and other details

3.45
Right of Way (ROW)
a part or the entirety of the property, site, or location with defined physical boundaries used or required by a government project

3.46
riprap
quarried stone especially selected, graded and placed to prevent erosion and thereby preserve the shape of a surface, slope, or underlying structure

3.47
road carriageway
portion of a road intended for the movement of vehicles, exclusive of shoulders (see Figure 1)

3.48
road carriageway width
lateral design width for one lane or two lanes strip of roadway

3.49
road shoulder
portion of the roadway contiguous with the travelled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses (see Figure 1)

3.50
road upgrading
civil works covering removal, replacement, widening of pavement, and/or increase of thickness of pavement to ensure road safety and easier road safety

3.51
roadbed
graded portion of a road between top and side slopes, prepared as a foundation for the pavement structure and shoulders

3.52
roadway
space, location, or site intended to employ traffic consideration, preferably for the transport of agricultural and fisheries products (see Figure 1)

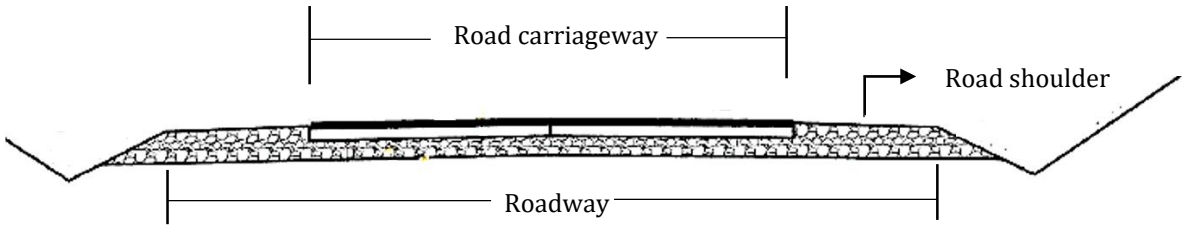


Figure 1 – Two-lane concrete roadway

3.53
salvage materials
saving of different existing materials from the projects which are removed and intended to be used in other construction

3.54
sidewalk
portion of the roadway primarily constructed for the use of pedestrians

3.55
sight distance
distance at which a driver of a vehicle can see an object of specified height on the road ahead, assuming adequate sight and visual acuity and clear atmospheric conditions

3.56
shoulder rollover
difference in crossfall between the pavement and its adjacent shoulder

3.57
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

3.58
structures
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

3.59
subbase layer
layer of the specified or selected materials, treated or untreated, of designated thickness in a pavement structure immediately above the sub-grade and below the pavement

3.60
subgrade
top surface of the roadbed upon which the pavement structure is placed

3.61
suitable materials
material which is acceptable in accordance with the contract and which can be compacted

3.62
superelevation
cross slope of the pavement at a horizontal curve, provided to partially counterbalance the centrifugal force on a vehicle going around that curve.

3.63
traffic
vehicular and non-vehicular movement along a route such as pedestrians, vehicles, animals, etc.

3.64
two-lane concrete pavement road
concrete pavement roadway, on which two lanes are marked for vehicular traffic

3.65
turnout
a widened, unobstructed shoulder area 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

3.66
unsuitable materials
materials not appropriate and safe for backfill and borrow which include garbage etc.

3.67
weep hole
an opening provided during construction in retaining walls, aprons, canal linings, foundation, etc., to permit drainage of water collecting behind and beneath such structures to reduce hydrostatic head.

4 Typical Location of Farm-to-Market Roads

4.1 FMRs shall be located within key production areas, marginal lands or new lands within the Strategic Agricultural and Fisheries Development Zones (SAFDZs), comprehensive land use (CLUP), and other convergence initiative areas of concerned agencies to provide easy and optimum access for the mobility of agriculture and fishery products. (See Figure 2)

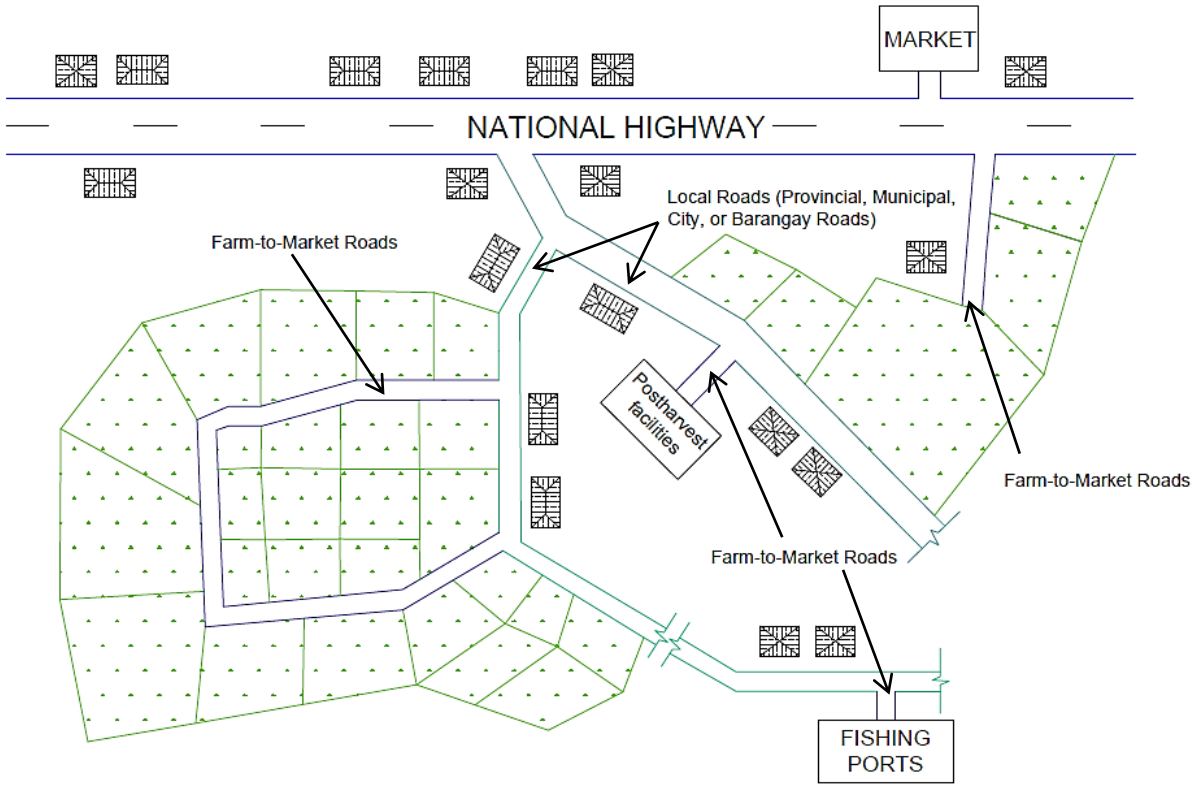


Figure 2 – Typical location of FMR

4.2 Roads shall prioritize the conveyance of goods and services within or to and from the production areas, primary assembly areas, major markets/trading posts, fishing ports, fishpond/fish cage areas, agricultural and maricultural zones, postharvest facilities and processing zones/industries.

5 General Components of Farm-to-Market Roads

The typical plan and profile of FMR, along with the required contents of a plan and profile, are shown in Annex A. The general components of a one-lane and two-lane roadway are shown in Figure 3 and 4, respectively.

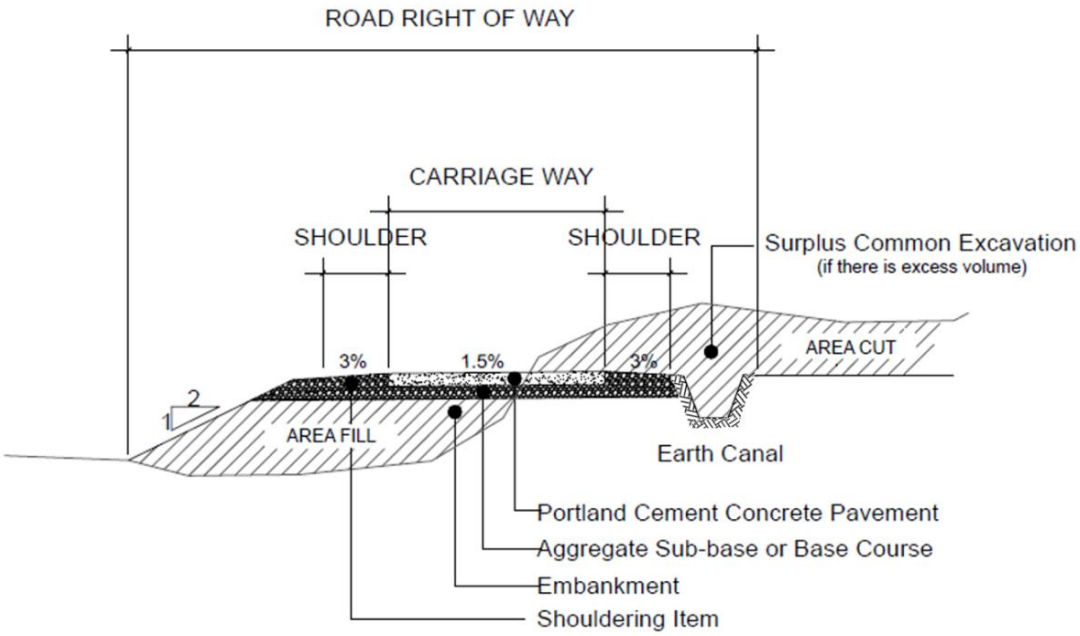


Figure 3 – General components of a one-lane FMR

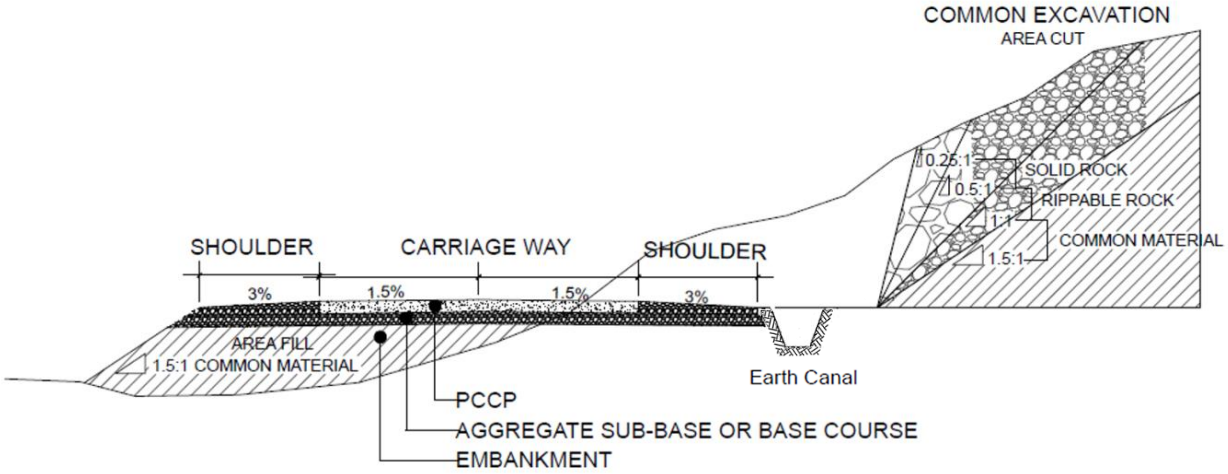


Figure 4 – General components of a two-lane FMR

6 Design Considerations

6.1 General

6.1.1 Farm-to-Market Roads shall be designed to ensure efficient movement of goods and services with utmost consideration for the convenience and safety of the motorists and pedestrians. Aesthetics and environmental impacts shall be taken to account in the most economical manner and consistent with the prescribed design standards.

6.1.2 The road shall be constructed on elevated portions and, if possible, should not pass through swampy, logged-over and flooded areas. The embankment height shall be at least 0.6 m higher than the flood level of the area.

6.1.3 Roads shall provide adequate and efficient route within the road influence area.

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

6.1.5 Roads shall be equipped with traffic signs, side rails, road markings, and other safety structures, as appropriate.

6.1.6 The design must be suitable for the anticipated traffic volume, design speed, and character of the vehicles that will use the facility.

6.1.7 Traffic analysis, field survey, and geotechnical investigation in accordance with the DPWH Design Guidelines, Criteria, and Standards (DGCS) (2015) shall be conducted prior to the preparation of Plans.

6.1.8 Road connections should follow the road hierarchy to avoid road usage beyond its design ADT.

6.2 Geometric Design

6.2.1 Design Speed

Design speed is a factor used as reference to various design features of the alignment such as radius, grade, superelevation, and sight distances. Geometric Design features should be consistent with the projected usage and environmental conditions of the terrain.

The prescribed minimum design speed based on the terrain type and projected ADT for the road is shown in Table 1.

Table 1 – Minimum design speed

Type of Terrain	Design Speed (kph) for Specific Design Volume		
	Under 50	50-250	250-400
Level	50	50	60
Rolling	30	50	50
Mountainous	30	30	30

[SOURCE: Table 5-1, *A Policy on Geometric Design of Highways and Streets*, 2011, by the American Association of State Highway and Transportation Officials, Washington, D.C., U.S.A. Used with permission.]

6.2.2 Horizontal Curves

Alignment should be as directional as possible and consistent with the topography. Generally, flatter curves should be used whenever applicable and curves of maximum degree should be avoided except for critical conditions.

The recommended minimum radius shall be 30 m. Where curves are superelevated, lower values may apply, but should not be less than 25 m for 30 kph design speed.

6.2.3 Gradient

The suggested maximum grades as a function of type of terrain and design speed are shown in Table 2.

Table 2 – Maximum grades

Type of Terrain	Maximum Grade (%) for a Specific Design Speed (kph)			
	30	40	50	60
Level	8	7	7	7
Rolling	11	11	10	10
Mountainous	16	15	14	13

[SOURCE: Table 5-2, *A Policy on Geometric Design of Highways and Streets*, 2011, by the American Association of State Highway and Transportation Officials, Washington, D.C., U.S.A. Used with permission.]

Minimum grade for paved surfaces shall be 0.30% to facilitate surface drainage on curbed and cut sections. The maximum design grade should be used only infrequently; in most cases, grades should be less than the maximum design grade.

6.2.4 Critical Lengths of Grade for Design

Based from 20-tonne truck which will affect a reduction in speed of 25 kph below the average running speed, the prescribed critical lengths of upgrades are shown in Table 3. For other design gross vehicle capacity, the critical lengths of upgrades shall be computed according to AASHTO A Policy on Geometric Design of Highways and Streets (2011).

Table 3 – Critical lengths of upgrades

Critical Length of Upgrade, m	Upgrade, %
500	3
340	4
240	5
200	6
170	7
150	8

[SOURCE: Table 3-33, DPWH Design Guidelines, Criteria, and Standards Volume 4 (2015)]

The above critical lengths of upgrade should not be used as a control but should be referred to as a guide. Climbing lane or turnouts on the uphill side should be provided for long upgrades.

6.2.5 Vertical Curves

Vertical curves shall be provided on grade breaks with algebraic difference in grade greater than 0.5%. Minimum length of curve shall be 40 m. Design controls based on sight distances for sag and crest are indicated in Table 4.

Table 4 – Design controls for vertical curves

Initial Speed (kph)	Stopping Sight Distance			Passing Sight Distance	
	Sight Distance	Rate of Vertical Curvature, *K** (m/%)		Sight Distance	Rate of Vertical Curvature, *K** (m/%)
		Crest	Sag		
30	35	2	6	120	17
40	50	4	9	140	23
50	65	7	13	160	30
60	85	11	18	180	38
70	105	17	23	210	51
80	130	26	30	245	69

*Rate of Vertical Curvature, K, is the length of curve per percent algebraic difference in intersecting grades (i.e., K=L/A).
[SOURCE: Table 5-3 and 5-4, *A Policy on Geometric Design of Highways and Streets*, 2011, by the American Association of State Highway and Transportation Officials, Washington, D.C., U.S.A. Used with permission.]

6.2.6 Superelevation

Superelevation (e) on horizontal curves shall be provided for FMR whenever practical. Minimum tangent of 30 m shall be provided for the runoff section. Maximum superelevation and maximum shoulder rollover of 8% shall be used.

The minimum radii within a range of superelevation rates are tabulated in Table 5.

Table 5 – Minimum radii and superelevation

e(%)	V_d=30 kph	V_d=40 kph	V_d=50 kph	V_d=60 kph
	R(m)	R(m)	R(m)	R(m)
-1.5	27	59	113	183
0	25	55	104	167
1.5	24	51	96	153
2.0	24	50	94	149
2.2	23	50	93	148
2.4	23	50	92	146
2.6	23	49	91	145
2.8	23	49	90	143
3.0	23	48	89	142
3.2	23	48	89	140

e(%)	V_d=30 kph	V_d=40 kph	V_d=50 kph	V_d=60 kph
	R(m)	R(m)	R(m)	R(m)
3.4	23	48	88	139
3.6	22	47	87	138
3.8	22	47	86	136
4.0	22	47	86	135
4.2	22	46	85	134
4.4	22	46	84	132
4.6	22	46	83	131
4.8	22	45	83	130
5.0	21	45	82	129
5.2	21	45	81	128
5.4	21	44	81	127
5.6	21	44	80	125
5.8	21	44	79	124
6.0	21	43	79	123
6.2	21	43	78	122
6.4	21	43	78	121
6.6	20	43	77	120
6.8	20	42	76	119
7.0	20	42	76	118
7.2	20	42	75	117
7.4	20	41	75	116
7.6	20	41	74	115
7.8	20	41	73	114
8.0	20	41	73	113

[SOURCE: Table 3-13a, *A Policy on Geometric Design of Highways and Streets*, 2011, by the American Association of State Highway and Transportation Officials, Washington, D.C., U.S.A. Used with permission.]

Minimum value for radius as discussed in Clause 6.2.2 shall govern. An illustration of superelevation is shown in Figure 5.

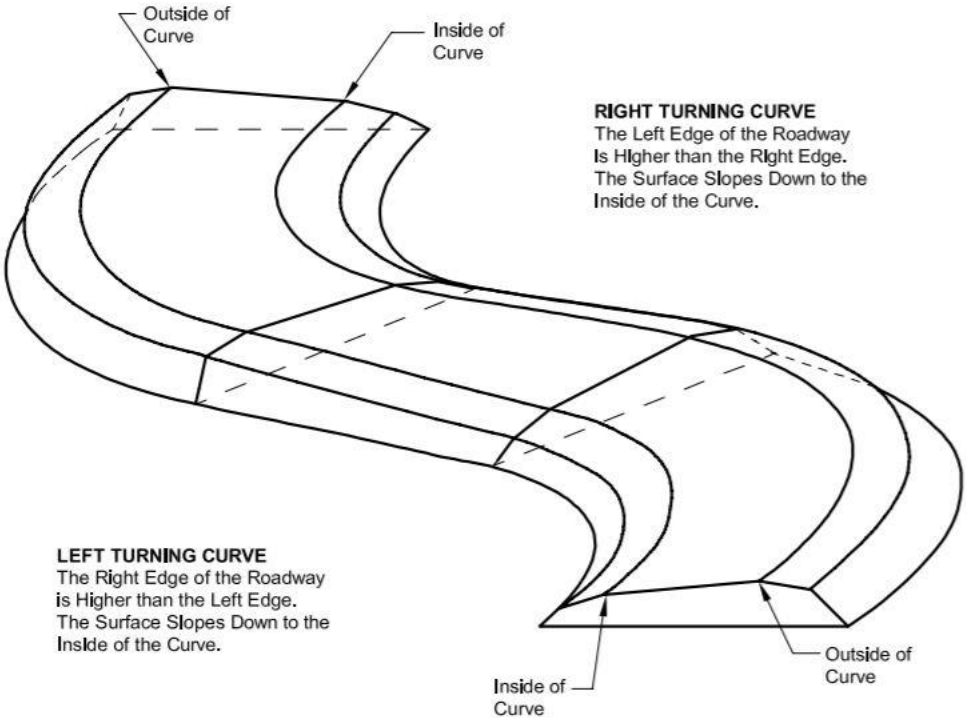


Figure 5 – Superelevation for left and right turning curves
[SOURCE: Massachusetts Department of Transportation (2006)]

6.2.7 Widening on Curves

Due to the fact that on curves the rear wheels of motor vehicles do not ordinarily travel in the same radius as the front wheels, the roadbed should be widened especially along sharp curves. A curve is considered a sharp curve when it is below the recommended minimum radius for a given design speed. The minimum widening recommended on curves should be 0.60 m and should depend on the degree of curvature, design speed, and design vehicle. The material of the widened section shall be made of the same material as the carriageway.

6.2.8 One-lane roadway

A one-lane roadway shall be constructed in places where only light vehicles pass through and with ADT less than 50.

There shall be provisions of turnout in strategic locations for maneuver of two vehicles traveling in opposite directions and in critical sections especially on steep grades along mountainous areas. Turnout shall be about 1 m wide and 60 m long as shown in Figure 6. The minimum distance of consecutive turnouts shall be 1000 m.

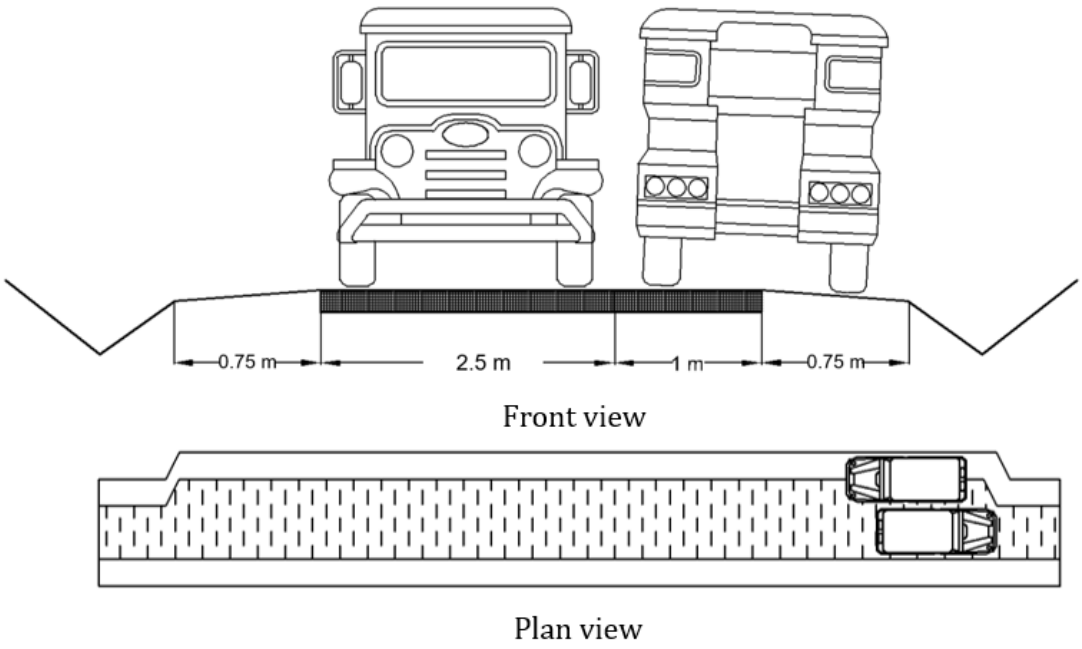


Figure 6 – One-lane roadway with turnout section

6.2.9 Site of road expansion for one-lane roadway

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

The design of the roadside ditch within the 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.

An illustration of a typical one-lane concrete road for expansion is shown in Figure 7.

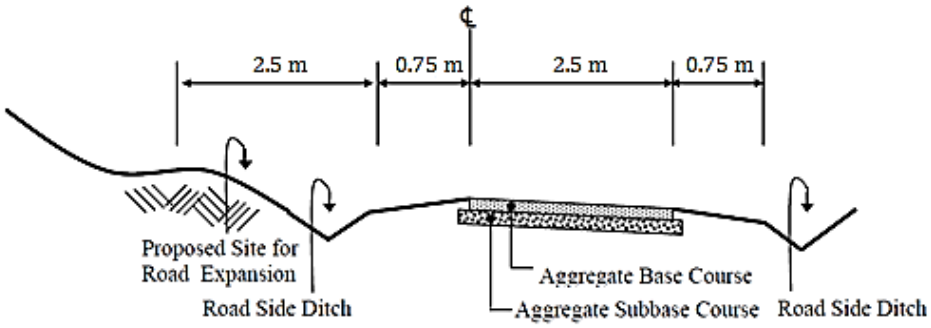


Figure 7 – Typical site for one-lane conrete road for expansion

6.2.10 Road carriageway

The road carriageway shall provide space for the safety and convenient movement of the vehicles. The minimum road carriageway width requirement for one-lane and two-lane roadway is summarized in Table 6.

Table 6 – Minimum road carriageway and road shoulder width requirement

Road lane	ADT	Minimum pavement width (m)	Minimum road shoulder width (m)
One lane	<50	2.5	0.75
Two lane	50-400	5	1.5

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

The minimum crossfall for the carriageway shall be 1.5 %. The typical cross-section for a two-lane concrete road is illustrated in Figure 8.

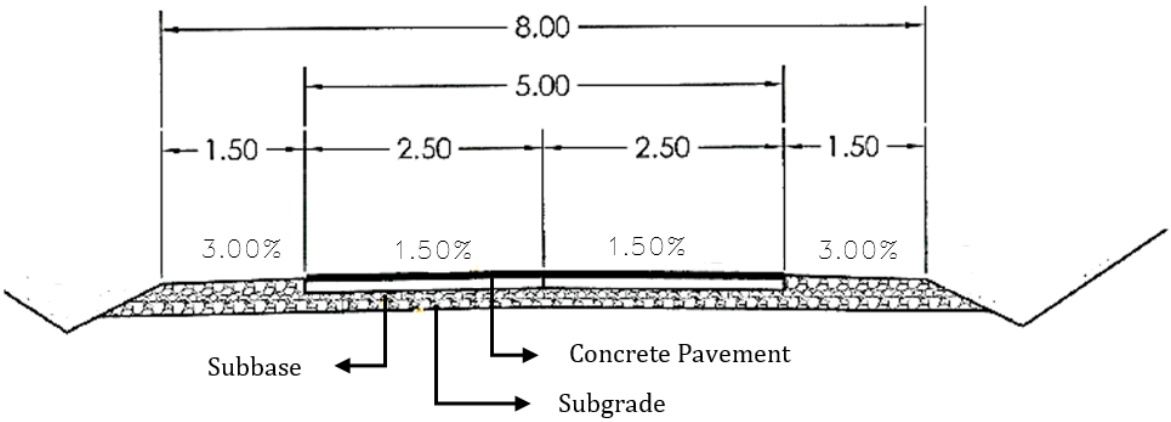


Figure 8 – Typical cross-section for two-lane concrete road

6.2.11 Road Shoulder

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 minimum road shoulder width requirement for one-lane and two-lane roadway is summarized in Table 1. In cases wherein roadway construction is limited such as in mountainous areas, the road shoulder width may be reduced to 0.6 m. It shall be filled with borrow and compacted to 100 % density, as certified by accredited laboratory.

The slope of road shoulder shall be 3 % from the edge of the road carriageway. The road shoulder shall be made of at least gravel surfacing.

6.2.12 Roadway on Irrigation Canals

If the roadway on irrigation canals will be used as FMR, minimum road carriageway and shoulder width shall conform to Clause 6.2.9. If the width of the existing roadbed is insufficient, the width shall be increased by providing additional embankment.

When lateral or sublateral runs parallel to an existing infrastructure road for an appreciable length, within a center to center distance of 200 m, and the size of the canal is fit for manual desilting, the roadway embankment can be deleted.

Careful consideration shall be given to the height of freeboard as basis for the height of embankment. At curves, there shall be provision for safety.

Stability of embankment shall be considered in the design. In cases where existing canals will be traversed by the proposed FMR, the canal shall be protected by an appropriate structure prior to construction. A typical FMR on irrigation canals is shown in Figure 9.

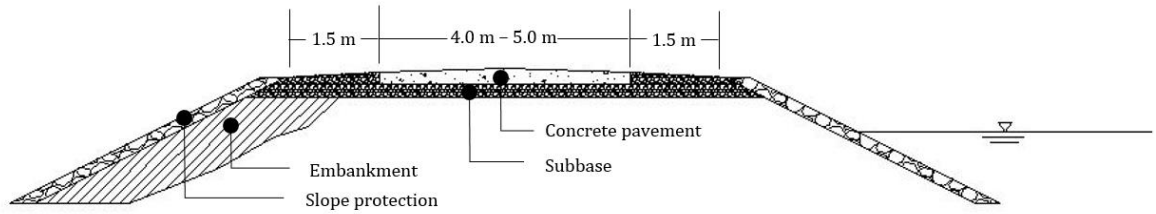


Figure 9 – Two-lane roadway on irrigation canals

6.2.13 Intersection

The intersection and approach areas where vehicles are stored while waiting to enter the intersection should be designed with a relatively flat grade; the maximum grade on the approach leg should not exceed 2% where practical and at least 30 m in length.

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 or other vegetation within the limit of the intersection area.

The angle of intersection, if possible, shall be at right angles (90°). However, the intersecting angles in the range of 45° to 65° are acceptable and may be used in special situations while intersections at angles of less than 45° are strongly discouraged.

Visibility shall range from 40 m for roadway with a speed not exceeding 30 kph.

6.2.14 Side Slope

The maximum side slope shall be 2:1. Normal slope shall be 4:1. Separate design slope for cut and fill should be provided. This depends on soil classification for cut and height of fill embankment. The cut slope for common materials shall be 1.5:1 to 1:1, 0.5:1 to 1:1 for rippable rock, and 0.25:1 to 0.5:1 for hard/solid rock. The minimum fill slope shall be 1.5:1. The side slopes are illustrated in Figure 4.

6.2.15 Crossfall

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.

The crossfall shall be 1.5 % for carriageway and 3.0 % for shoulder.

6.3 Pavement Design

Pavement Design is the process of determining the thickness and strength of a pavement laid on a soil foundation for the purpose of providing an even non-skid, stable and desirable surface, permitting efficient, rapid and safe flow of traffic in accordance with specified loads. For consistency, Portland cement concrete should be used as road pavement material.

6.3.1 Pavement Thickness

Pavement thickness shall be designed using AASHTO 1993 Guide Equation – Pavement Thickness Design. The minimum thickness of pavement shall be 200 mm.

6.3.2 Pavement Slab Length

Slab length refers to the joint spacing or distance between free transverse joints. In general, the spacing of both transverse and longitudinal contraction joints depends on local conditions of material and environment. As a rough guide, joint spacing (in feet) should not greatly exceed twice the slab thickness (in inches). Also, as a general guideline, the ratio of slab width to length should not exceed 1.25. Maximum slab length to be used shall be 4.5 m.

6.3.3 Subbase Layer

The classification of subgrade for concrete roads and minimum thickness of subbase required are shown in Table 7.

Table 7 – Minimum thickness of subbase

Type of subgrade	Definition	Minimum thickness of Subbase
Weak	All subgrade of CBR Value 2 percent or less as defined in the table for estimated laboratory CBR values for soils compacted at the natural moisture content	150 mm
Normal	Subgrades other than those defined by the other categories	80 mm
Very Stable	All subgrades of CBR value 15 percent or more as defined in the table for estimated laboratory CBR values for soils compacted at the natural moisture content	0

[SOURCE: DPWH Design Guidelines, Criteria, and Standards for Public Works and Highways, Volume II (1984)]

Based on the above, the subbase thickness could be 80 mm thick. This thickness of 80 mm is suitable for roads where no construction traffic is required to use the subbase. Where heavy construction vehicles (for example, loaded trucks) have to be operated on the prepared subbase laid on weak or normal subgrades, the subbase should be strengthened. On subgrade with CBR of 4 percent or less, an additional 150 mm of subbase is considered sufficient. On other normal subgrades an additional 80 mm should suffice.

On places where there are no available quarry areas to produce aggregates that will conform with the requirements of Item 200 and 201 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II, it is recommended to use stabilizers conforming to Items 203, 204, 205, and 207 of the same document.

If the roadbed soils are of a quality equal to that of a subbase or in cases where design traffic is less than 1,000,000 18-kip Equivalent Single Axle Load (ESAL), a subbase layer may not be needed.

6.3.5 Joints

6.3.5.1 Load Transfer Device

Load transfer describes the transfer or distribution of load across discontinuities such as joints or cracks. This can be achieved through devices such as dowels, tie bars, etc. If dowel bars are used as load transfer device, the dowel diameter should be equal to the slab thickness multiplied by 1/8 and spaced at 300 mm on center with length

equal to 450 mm. The full range of prescribed diameter and spacing based on the pavement thickness is shown in Table 8.

Table 8 – Recommended diameter and spacing of dowels

T (mm)	Spacing (mm)						
	12Ø	**16Ø**	**20Ø**	**25Ø**	**28Ø**	**30Ø**	**32Ø**
150	120	220					
160	110	190	300				
170	100	170	270				
180		150	240				
190		140	210				
200		120	190	300			
210		110	170	270			
220		100	160	250	300		
230			150	230	280		
240			130	210	260	300	
250			120	190	240	280	300
260			110	180	220	260	290
270			110	160	210	240	270
280			100	150	190	220	250

The dowels should be plain, round bars equivalent to ASTM A615/A615M. Corrosion protection should be provided. Dowels should be able to move longitudinally in their slots to allow free joint movement from expansion or contraction of the concrete.

6.3.5.2 Contraction Joints

Contraction joints are used to control cracking by relieving stresses due to temperature, moisture, and friction. This type of joints may be provided both in transverse and longitudinal directions. For transverse joints, contraction joints are placed at the end of each slab (see Clause 6.3.2) by introducing a plane of weakness. For roads with design thickness exceeding 200 mm due to heavy traffic loadings, dowel bars should be installed on every contraction joint to improve the joint load transfer mechanism of the pavement, to prevent early pavement deterioration, and to minimize resulting design thickness.

6.3.5.3 Construction Joints

Construction joints allow for interruption during placement of concrete and should occur at planned joint locations. For new road construction, transverse construction joints should be planned and placed where contraction joints are located. When unplanned interruption of paving operations occurs for more than 30 min due to weather condition or equipment breakdown, transverse construction joint may be placed at the middle third of the slab provided that the adjacent slab shall be provided with contraction joint in anticipation of crack propagation from the construction joint.

For expansion/widening projects, transverse construction joints shall be placed only at locations adjacent to any existing transverse joints of the existing pavement. In no case shall construction joints be placed at locations not coinciding with the existing joints to avoid creating undue cracks/defect to the existing pavement.

All transverse construction joints shall be butt joints with dowel bars with spacing as prescribed in Clause 6.3.5.1. All longitudinal construction joints shall be keyed joint with tie bars. Spacing for tie bars at longitudinal construction joints is shown in Table 9.

Table 9 – Recommended spacing for 12 mm diameter tie bar

Thickness, mm	Spacing, mm
150	750
160	750
170	750
180	750
190	750
200	750
210	750
220	750
230	750
240	600
250	600
260	600
270	600
280	600

6.3.5.4 Isolation or Expansion Joints

Isolation or expansion joints are used to allow anticipated differential horizontal movement to occur between a pavement and another structure. These joints may be as much as 19 to 25 mm wide. These joints shall be located at transition joints (e.g. at intersections)

In transverse expansion joints, at least one end of each dowel should be equipped with an expansion cap. The cap should be long enough to cover at least 50 mm of the dowel and should provide a watertight fit. The cap should be equipped with a stop that prevents the cap from slipping off the dowel during placement. The capped end of the dowel should also be lubricated to prevent bond.

6.4 Drainage Design

6.4.1 Location of Drainage Facilities

Drainage facilities should be located parallel to the FMR with the exemption depending on the terrain, possible construction problems, or available routes with less excavation and other disadvantages.

Drainage shall be discharged into the natural or man-made drainage features capable of conveying flow in a safe and efficient manner. Sinkholes or other low-lying areas without a natural outlet shall be avoided. Drainage outfalls shall be checked for present and future adequacy and possible occurrence of downstream problems such as erosion and flooding.

In areas where there is no possible drainage outfall or the proposed location is far, the flow may be discharged in a retention reservoir with pumping facilities where it can be reused.

6.4.2 Design Storm Frequency

The design storm frequencies for different types of drainage shall conform to Table 9. The drainage structure should be designed for the design flood but should have sufficient freeboard to contain the check flood.

Table 9 – Minimum Design Flood Frequency in Farm-to-Market Roads

Type of Drainage	Minimum Design Flood	Check Flood
Culvert	20-yr	50-yr
Roadside Ditches and Inlets	5-yr	10-yr
Median Ditches and Inlets	5-yr	10-yr
Curb Drop Inlets	5-yr	10-yr

[SOURCE: Table 5-3, DPWH Design Guidelines, Criteria, and Standards Volume 4 (2015)]

6.4.3 Storm Drain Systems

6.4.3.1 Curb and Gutter

Curb and gutter form a triangular channel that may be used for conveying low rainfall intensity events without interruptions to traffic. The curb and gutter shall be designed to avoid the runoff to spread to the shoulder and carriageway.

6.4.3.2 Inlets

Inlets shall be provided for curb and gutter type of drainage to remove the storm water from the roadway area. Inlets shall be properly located and sized in order for the curb and gutter drainage to be efficient.

The location and size of inlets are interrelated. Drainage system with lower inlet capacities shall have more inlets while systems with higher inlet capacities may allow fewer inlets. The size of inlets shall be able to accommodate expected carryover rates.

6.4.3.3 Culverts

The minimum velocity for culverts is 0.8 m/s. During dry weather flows, a smaller channel in the bottom of the culvert may be constructed to confine these smaller flows to a smaller cross section to achieve the minimum velocity. The maximum velocity for piped drainage systems shall be 5 m/s to prevent damage to the culvert.

A minimum internal width and clear depth shall be 910 mm. Pipe culverts shall be laid at grades such that there will be a cushion of at least 0.60m of fill over the top of the pipe. Culverts under high fills shall be designed to safely support the imposed load.

Circular culverts are most commonly used due to the available structural options for various fill heights for this type of cross section. Pipe arch and elliptical shapes can be used in lieu of circular pipe where there is limited cover or overfill.

Rectangular culverts can be designed to fit nearly any site condition. It can cater to low allowable headwater situations since the height may be decreased and the total span increased to satisfy location requirement. Modified box shapes in the form of hexagons or octagons may be used where it can be proved economical under certain construction situations.

Arch culverts can be used in locations when less obstruction to a waterway is desired and where foundations are adequate for structural support. It can also be used when it is desired maintain the natural stream bottom for fish passage. In this case, potential for failure from scour shall be carefully evaluated.

6.4.3.4 Catch Basin

Catch basins shall serve as a collection point of storm water and its subsequent entrance to the storm drain system. It shall be located at junctions where there is a change in water flow to prevent scouring in the walls of the storm drain system. It should have a provision for capturing and extraction of sediments, debris, and other pollutants to prevent clogging in the storm drain system. An illustration of a catch basin is shown in Figure 10.

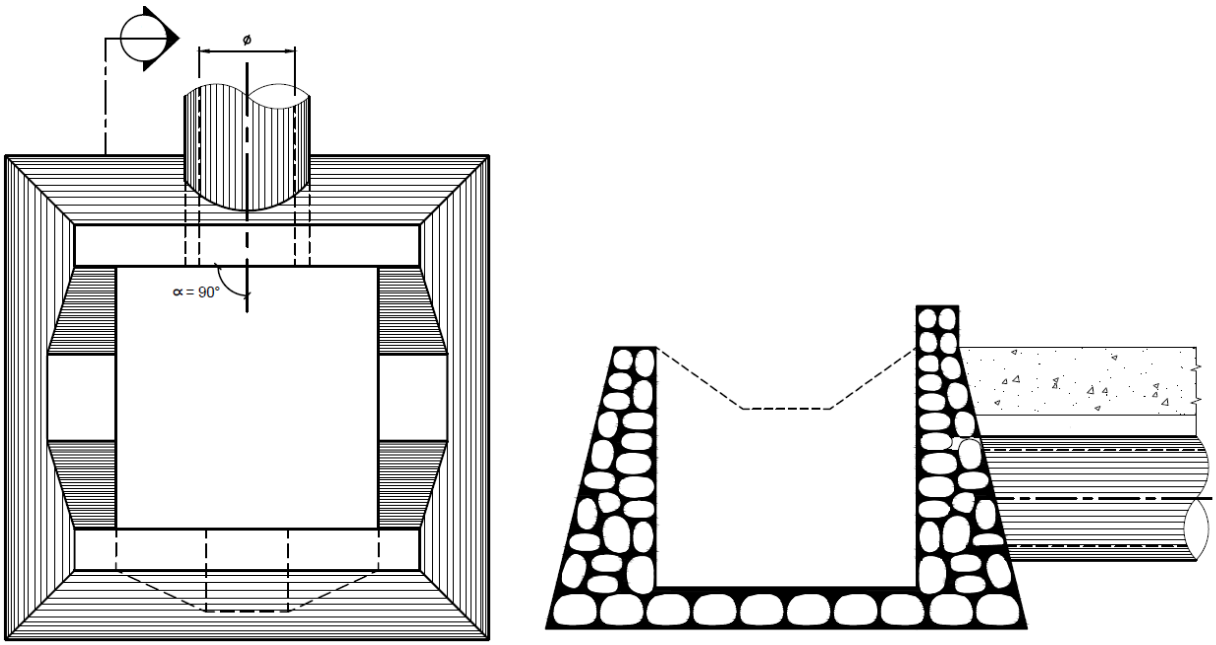


Figure 10 – Typical layout of catch basin
[SOURCE: DPWH Bureau of Design, Standard Drawings for Roads and Bridges]

6.4.3.5 Ditches

Roadside ditches are constructed to drain water from the subgrade and to collect surface water either from the roadway surface or adjacent. Hydrologic analysis and hydraulic design calculations shall be performed.

The depth shall be measured from the ditch bottom level to the subgrade level while the depth bottom width shall be measured from the base of the front side drain to the base of the backside drain.

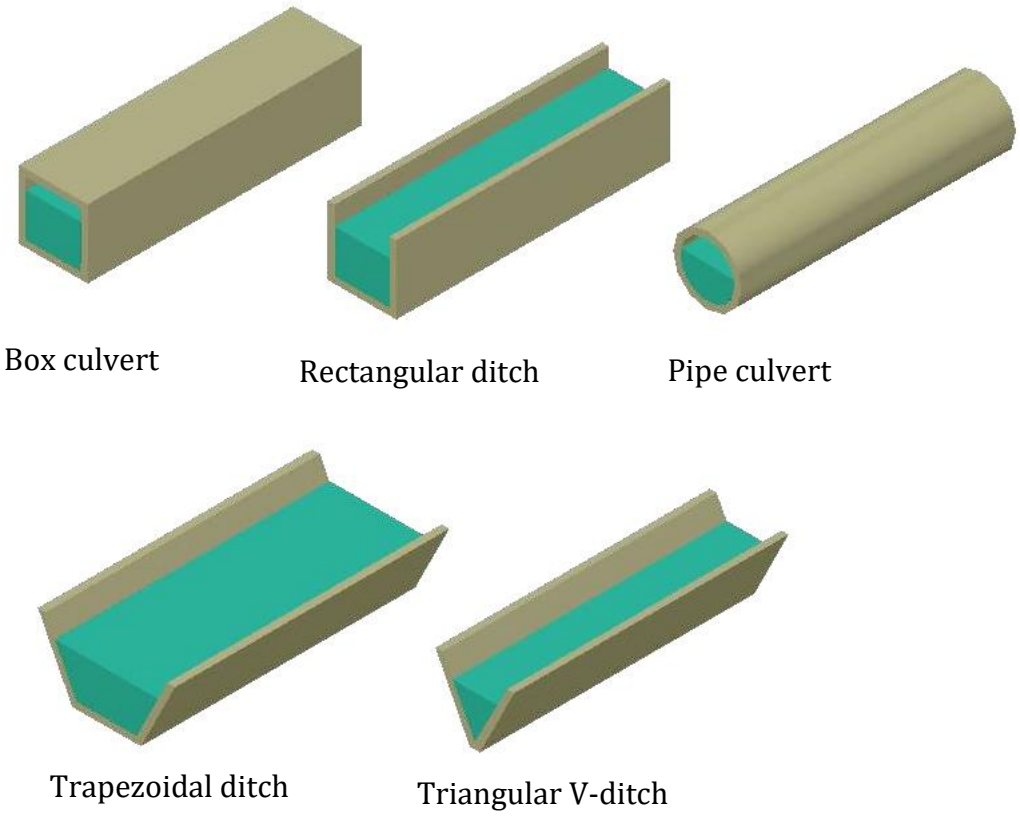


Figure 11 – Different types of culverts and lined canals

The formulas for area and other related parameters should be based on the Annex A of PNS/BAFS/PAES 218:2017.

6.4.3.5.1 Earth Trapezoidal Ditch

A ditch with a trapezoidal section (see Figure 12) can reduce the risk of erosion for a lower water velocity.

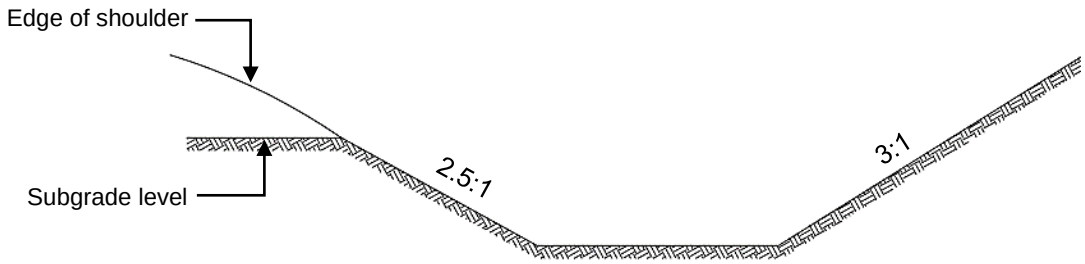


Figure 12 – Typical layout of an earth trapezoidal ditch

6.4.3.5.2 Earth Triangular V-Ditch

A ditch with a triangular section (see Figure 13) is intended primarily for low flow conditions such as in median and roadside ditches. This shape of channel is susceptible to erosion and shall require lining when flow velocities exceed the permissible velocities shown in the Annex C.

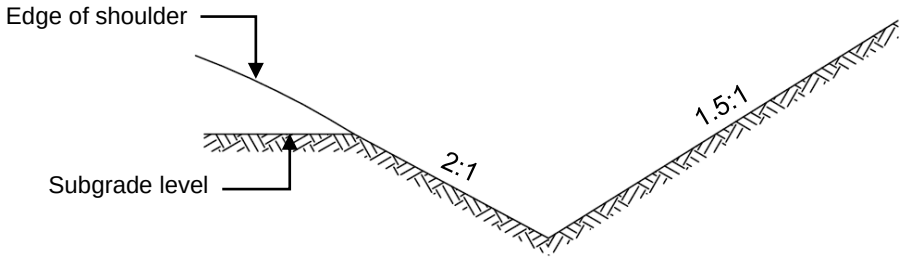


Figure 13 – Typical layout of an earth triangular V-ditch

6.4.3.6 Weep holes

All retaining walls and slope protection structures shall be provided with weep holes. Unless otherwise shown in the Plans or as directed by the Engineer, the weep holes shall be placed horizontally at the lowest points where free outlets for water can be obtained and shall be spaced at not more than 2 m center to center in a staggered manner. The length of the weep holes shall not be less than the thickness of the walls of the abutment and shall be at least 50 mm diameter PVC or other pipe materials accepted by the Engineer.

6.5 Slope Protection Design

The classification and applicability of slope protection measures should be according to Table 7-2 of the DPWH Design Guidelines, Criteria, and Standards Volume 4 – Highway Design. Selection of appropriate slope protection measures should conform to the flowchart shown in Figure 14.

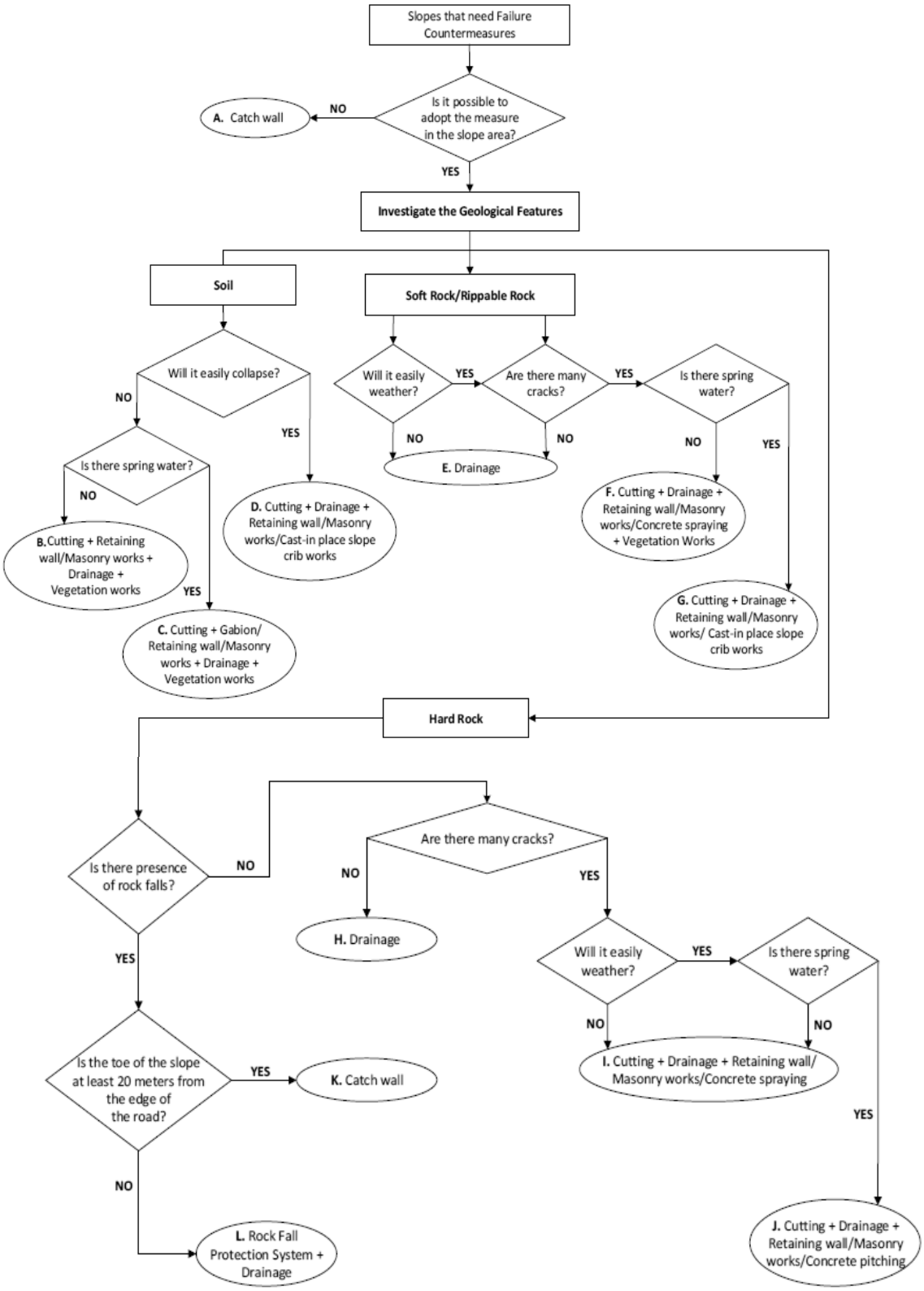


Figure 14 – Selection of Natural Slope Failure Countermeasures
[SOURCE: DPWH DGCS Vol. 4]

6.6 Miscellaneous Structures Design

6.6.1 Sidewalk

In pedestrian predominated areas, there shall be provisions for rumble strips, sidewalks and/or bike lanes, as applicable.

A sidewalk or a path suitable to the conditions should be generally provided wherever roadside and land development conditions affect regular pedestrian movement along a highway. Sidewalk locations are expected at points of community development, such as schools and local businesses.

Sidewalk widths in lower speed residential areas shall be from 1.2 m to 2.4 m. Sidewalks less than 1.5 m shall provide a passing section every 60 m for accessibility. For sidewalks designed to allow two people to pass, the minimum width shall be 1.8 m.

Sidewalks should have all weather surfaces to serve their intended use and discourage pedestrians from walking on the traveled way. Cross slope shall not exceed 2 % and shall be designed to accommodate persons with disabilities.

Consideration shall be given to the relative locations of inlets and sidewalks to ensure that neither grates or ponded water are encountered by pedestrians.

6.6.2 Longitudinal Roadside Barriers

Barriers shall be used to prevent vehicles that leave the traveled way from colliding with objects that have a greater crash severity potential than the barrier itself. Barriers can be classified into three types: flexible, semi-rigid, and rigid. Selection of barrier types shall be dependent on the acceptable amount of barrier deflection that will take place when the barrier is struck.

For flexible carrier systems, there shall be sufficient lateral clearance from fixed objects due to deflection during impact. Rigid barrier system should be used where shallow impact angles are expected such as along narrow shoulders and where deflection cannot be tolerated such as at a work zone.

Barriers should be located beyond the edge of the shoulder so that the full shoulder width may be used. The fill supporting the barrier should be sufficiently wide to provide lateral support. Examples of longitudinal roadside barriers are steel beam guardrail, wire rope guardrail, and concrete barriers.

6.6.3 Monuments, Markers, and Guide Posts

Monuments or markers to be used for indicating the start and end of the roadway (see Figure 15) shall be placed at the right side of the roadway. It shall be located beyond the shoulders at both ends of the roadway. The markings on the monument or markers shall be weather resistant. It shall not fade, discolor, peel, crack, or blister and shall remain clear.

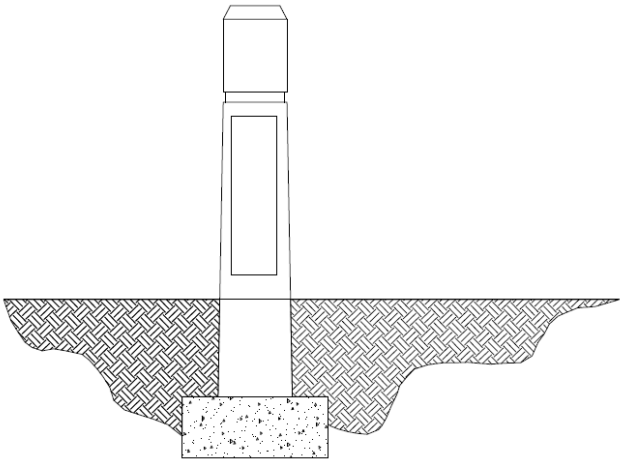


Figure 15 – Typical layout of a monument

Guide posts which outline the roadway may be used in place of longitudinal barriers at low volume and less hazardous locations. Guide posts may be used to delineate curves, mark abrupt changes in shoulder width, at approaches to structure, at drop inlets, and at cut sections to provide warning. They shall be fitted with retro-reflective elements on a white post.

6.6.4 Road Signs

The road signs shall comply in all respects with the DPWH Highway Safety Design Standards Part 2: Road Signs and Pavement Marking Manual. Typical road safety signs that are used in FMRs are shown in Annex D.

6.6.5 Chevron Signs

The chevron signs shall be used to guide drivers through a change in horizontal alignment of the road such as curves and less than sharp turns. Chevron signs shall also be used to supplement any of the advance warning signs, the horizontal alignment signs (W-types) or the standard guide posts and delineators.

The chevron sign shall be a vertical rectangle. No border shall be used on the chevron sign.

The point of the arrow or chevron shall indicate the direction of travel. They shall be visible for at least 150 m to provide the road user with adequate time to react to the change in alignment. The minimum lateral offset of the chevron sign shall be 1.8 m from the edge of pavement.

The chevron signs shall be installed on the outside of the curve, set up aligned with the approaching traffic at right angle to a driver’s line of sight. Two sided chevron signs may be used on two-lane, two-way roads to guide drivers travelling in both directions.

The spacing of the chevron signs should allow the driver to see at least three (3) signs in view while negotiating the curve, until the change in alignment eliminates the need for the signs.

Chevron signs shall be mounted clear of roadside vegetation and clearly visible under headlight illumination by night. Chevrons should be installed 1.5m above the ground in the rural areas and 2.2m in the urban areas. The recommended spacing for the chevrons within a curve is shown in Table 13.

Table 13 – Recommended Spacing for Chevron Signs

Advisory Speed Limit (kph)	Radius (m)	Chevron Spacing (m)
≤20	≤60	12
30-50	60-120	24
60-70	120-210	36

The above spacing distances shall apply to points within the curve. Approach and departure spacing distances shall be twice those shown above.

6.6.6 Pavement Markings

6.6.6.1 Color

The color of pavement markings shall be white except for the following cases where yellow may be used:

- unbroken portion of no-passing lines
- curb marking for prohibition of parking
- on islands in line of traffic
- Keep Intersection Open markings

Black and white stripes may be used in hazard markers to warn road users at locations where the protruding objects such as bridge piers, traffic islands, and other permanent objects on or near the roadway.

6.6.6.2 Types of Lines

Lines may be longitudinal, transverse, or oblique. Depending on the use and meaning of such lines, they are either broken and solid lines.

For broken lines, the speed of vehicles on the section of road or in the area in question should be taken into account in determining the length of the line strokes and the gaps between them. A solid unbroken line shall be used where crossing of the line is either discouraged or prohibited.

6.6.6.3 Width of Lines and Tolerance

The width of solid or broken lines shall be from 100 mm to 300mm depending on the usage of a specified line. Transverse lines shall be generally wider because of the angle at which the road user sees pavement markings on the carriageway. Width of line markings shall conform to the following tolerances:

Length	Tolerance
Under 500 mm	+20 % or –10 %
Greater or equal to 500 mm but less than 5m	+10 %
Greater or equal to 5m	+5 %

6.6.7 Access Facilities

Access facilities shall be constructed for the use of pedestrians, animals and pathways for machinery. These facilities may be constructed in strategic portions of the roadway as needed and may be parallel or perpendicular to the roadway.

6.6.7.1 Access Ramps

Access ramps shall have a maximum of 8 % slope and a minimum width of 1 m. It shall be designed in consideration for persons with disabilities.

6.6.7.2 Stairs

The width shall not be less than 90 cm. The tread of the stairs shall not be less than 25 cm in width exclusive of nosing and projections and the riser shall not be more than 20 cm. There shall be no variation in the width of the treads and the height of the risers in any flight. The top and bottom of any flight of stairs shall be clearly distinguished.

6.6.7.3 Access Roads

Access roads shall be rough finished with a minimum width of 2.5 m and a maximum of 10% gradient. Roads crossings over irrigation canals may be considered as access roads.

7 Materials and Construction Requirements

7.1 Clearing and Grubbing

This clause consists of clearing, grubbing, removing and disposing all vegetation and debris as designated in the Contract except those object that are designated to remain in place or are to be removed in consonance with other provisions of this Standard. The work shall also include the preservation from injury or defacement of all objects designated to remain.

Before the work starts, the limits of work and designation of all trees, shrubs, plants and other things to remain shall be established by the Engineer. All objects designated to remain shall be preserved by the Contractor. The Contractor shall be allowed to remove only trees and bushes that are absolutely necessary for the construction operation and shall save as many trees as possible.

Removal of all trees and bushes, 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 mowed as required, except as provided below:

a. Removal of undisturbed stumps and roots and nonperishable solid objects with a minimum depth of 1 m below sub-grade for slope of embankments will not be required.
b. 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 above the ground line or low water level.
c. 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.
d. Grubbing of pits, channel changes and ditches will be required only to a depth necessitated by the proposed excavation within such areas.
e. In areas covered by wild grass and other vegetation, top soil shall be cut to a maximum depth of 150 mm below the original ground surface or as designated by the Engineer, and disposed outside the clearing and grubbing limits as indicated in the typical roadway section.

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 or cutting of trees within the road ROW is permitted unless otherwise done in accordance with applicable laws, ordinances and regulations.

Materials and debris which cannot be burned and perishable materials may be disposed by methods and at locations approved by the Engineer.

No stumps, roots, bush 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 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, necessary arrangements shall be made by the Contractor with the property owners in writing for obtaining suitable disposal locations which are outside the limits of view from the project.

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 and faces not exceeding 3900 mm^2 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 loose thickness. Diseased trees shall be buried or disposed of as directed by the Engineer.

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 m above the roadbed surface. All trimmings shall be done by skilled workmen and in accordance with good surgery practices.

7.2 Excavation

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

7.2.1 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.

7.2.1.1 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.

7.2.1.2 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 cubic meter or more as determined by physical measurements or visually by the Engineer.

7.2.1.3 Common Excavation

It shall consist of all excavations not included in the Bill of Quantities under “rock excavation” or other items.

7.2.1.4 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.

7.2.2 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.

7.2.3 Construction Requirements

7.2.3.1 General

When there is evidence of discrepancies between the actual elevations and that shown in 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 and 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 Clause 7.1.

7.2.3.2 Conservation of Topsoil

Where provided for in the Plans or in the Special Provisions, all suitable topsoil encountered in excavation and on areas where embankments are 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**.**

7.2.3.3 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 in the Plans or as directed by the Engineer.

Soil that cannot be properly compacted in the embankments shall be designated by the Engineer as unsuitable soil. All unsuitable materials shall be disposed 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 as shown in the Plans or as directed by the Engineer.

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

7.2.3.4 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.

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

A drilling equipment capable of suitably checking the moisture penetration to the full depth of the excavation shall be provided by the Contractor.

7.2.3.5 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:

- **a.** Drilling holes at uniform intervals along the slope lines,
- **b.** Loading and stemming the holes with appropriate explosives and stemming material
- **c.** Detonating the holes simultaneously.

Prior to starting drilling operations for presplitting, a plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern, and sequence of firing shall be furnished by the Contractor to the Engineer. 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 is satisfactory. Discontinuance of the presplitting may be ordered by the Engineer 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 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; 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 will be permitted for construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern.

7.2.3.6 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 Clause 7.2.3.3.

Ditches shall conform to the slope, grade, and shape of the required cross-section, with no projections of roots, stumps, rock or similar matter. All ditches dug shall be maintained and kept open and clean until final acceptance of the work by the Contractor.

Furrow ditches shall be formed along the line staked by the Engineer. The ditches shall be cleaned out by suitable method, throwing all loose materials on the downhill side so that the bottom of the finished ditch shall be approximately 450 mm below the crest of the loose material piled on the downhill side. The low lines shall be in satisfactory shape to provide drainage without overflow.

7.2.3.7 Excavation of Roadbed Level

Rock shall be excavated to a depth of 150 mm 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, such depressions shall be properly drained or, when permitted by the Engineer, be filled with approved impermeable material by the Contractor.

Material below subgrade, other than solid rock shall be thoroughly scarified to a depth of 150 mm 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.

7.2.3.8 Borrow Areas

Opening of any borrow areas shall be notified to the Engineer sufficiently in advance by the Contractor, 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.

7.2.3.9 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, removal of unsuitable material and backfilling with approved material to the finished graded section may be required by the Engineer to the Contractor. 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 in the Plans or approved by the Engineer.

7.3 Structure Excavation

This clause shall consist of the necessary excavation for foundation of culverts and other structures not otherwise provided for in the Standard. Except as otherwise provided for pipe culverts, the backfilling of completed structures and the disposal of all excavated surplus materials, shall be in accordance with this Standard and in reasonably close conformity with the Plans or as established by the Engineer.

This clause shall include necessary diverting of live streams, bailing, pumping, draining, sheeting, bracing, and the necessary construction of cribs and cofferdams, and furnishing the materials therefore, and the subsequent removal of cribs and cofferdams and the placing of all necessary backfill.

It shall also include the furnishing and placing of approved foundation fill material to replace unsuitable material encountered below the foundation elevation of structures. No allowance shall be made for classification of different types of material encountered.

7.3.1 Clearing and Grubbing

Prior to starting excavation operations in any area, all necessary clearing and grubbing in that area shall have been performed in accordance with Clause 7.1.

7.3.2 Excavation

7.3.2.1 General

The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross-sectional elevations and measurements may be taken on the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the Engineer. Trenches or foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the
Plans or as staked by the Engineer. They shall be of sufficient size to permit the placing of structures or structure footings of the full width and length shown. The elevations of the bottoms of footings, as shown on the Plans, shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary, to secure a satisfactory foundation.

Boulders, logs, and other objectionable materials encountered in excavation shall be removed.

After each excavation is completed, the Contractor shall notify the Engineer to that effect and no footing, bedding material or pipe culvert shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

7.3.2.2 Structures other than pipe culverts

All rock or other hard foundation materials shall be cleaned of all loose materials, and cut to a firm surface, either level, stepped, or serrated as directed by the Engineer. All seams or crevices shall be cleaned and grouted. All loose and disintegrated rocks and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be made until just before the footing is to be placed. When the foundation material is soft or mucky or otherwise unsuitable, as determined by the Engineer, the Contractor shall remove the unsuitable material and backfill with approved granular material. This foundation fill shall be placed and compacted in 150 mm layers up to the foundation elevation.

When foundation piles are used, the excavation of each pit shall be completed before the piles are driven and any placing of foundation fill shall be done after the piles are driven. After the driving is completed, all loose and displaced materials shall be removed, leaving a smooth, solid bed to receive the footing.

7.3.2.3 Pipe Culverts

The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe.

Where rock, hardpan, or other unyielding material is encountered, it shall be removed below the foundation grade for a depth of at least 300 mm or 4 mm for each 100 mm of fill over the top of pipe, whichever is greater, but not to exceed three-quarters of the vertical inside diameter of the pipe. The width of the excavation shall be at least 300 mm greater than the horizontal outside diameter of the pipe. The excavation below grade shall be backfilled with selected fine compressible material, such as silty clay or loam, and lightly compacted in layers not over 150 mm in uncompacted depth to form a uniform but yielding foundation.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed to the depth directed by the Engineer and replaced with approved granular foundation fill material properly compacted to provide adequate support for the pipe, unless other special construction methods are called for on the Plans.

The foundation surface shall provide a firm foundation of uniform density throughout the length of the culvert and, if directed by the Engineer, shall be cambered in the direction parallel to the pipe centerline.

Where pipe culverts are to be placed in trenches excavated in embankments, the excavation of each trench shall be performed after the embankment has been constructed to a plane parallel to the proposed profile grade and to such height above the bottom of the pipe as shown on the Plans or directed by the Engineer.

7.3.3 Utilization of Excavated Materials

All excavated materials, so far as suitable, shall be utilized as backfill or embankment. The surplus materials shall be disposed of in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure. No excavated materials shall be deposited at any time so as to endanger the partly finished structure.

7.3.4 Cofferdams

Suitable and practically watertight cofferdams shall be used wherever water-bearing strata are encountered above the elevation of the bottom of the excavation. If requested, drawings showing the proposed method of cofferdam construction shall be submitted by the Contractor, as directed by the Engineer.

Cofferdams shall in general, be carried well below the bottoms of the footings and shall be well braced and as nearly watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

When conditions are encountered which, as determined by the Engineer, render it impracticable to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as shown on the Plans or directed by the Engineer. The foundation shall then be dewatered and the footing placed. When weighted cribs are employed and the mass is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire mass of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdams shall be vented or ported at low water level as directed.

Cofferdams shall be constructed so as to protect green concrete against damage from sudden rising of the stream and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams in such a way as to extend into substructure masonry, without written permission from the Engineer.

Any pumping that may be permitted from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete material being carried away. Any pumping required during the placing of concrete, or for a period of at least 24 hr thereafter, shall be done from a suitable sump located outside the concrete forms. Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

Unless otherwise provided, cofferdams, with all sheeting and bracing involved therewith, shall be removed by the Contractor after the completion of the substructure. Removal shall be effected in such manner as not to disturb or mar finished masonry.

7.3.5 Preservation of Channel

Unless otherwise permitted, no excavation shall be made outside of caissons, cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the side of the structure before caissons, cribs, or cofferdams are sunk in place, the Contractor shall, after the foundation base is in place, backfill all such excavations to the original ground surface or stream bed with material satisfactory to the Engineer.

7.3.6 Backfill and Embankment for Structures Other Than Pipe Culverts

Excavated areas around structures shall be backfilled with free draining granular material approved by the Engineer and placed in horizontal layers not over 150 mm in thickness, to the level of the original ground surface. Each layer shall be moistened or dried as required and thoroughly compacted with mechanical tampers.

In placing backfills or embankment, the material shall be placed simultaneously in so far as possible to approximately the same elevation on both sides of an abutment, pier, or wall. If conditions require placing backfill or embankment appreciably higher on one side than on the opposite side, the additional material on the higher side shall

not be placed until the masonry has been in place for 14 days, or until tests made by the laboratory under the supervision of the Engineer establishes that the masonry has attained sufficient
strength to withstand any pressure created by the methods used and materials placed without damage or strain beyond a safe factor.

Backfill or embankment shall not be placed behind the walls of concrete culverts or abutments or rigid frame structures until the top slab is placed and cured. Backfill and embankment behind abutments held at the top by the superstructure, and behind the sidewalls of culverts, shall be carried up simultaneously behind opposite abutments or sidewalls.

All embankments adjacent to structures shall be constructed in horizontal layers and compacted as prescribed in Clause 7.4.3.3 except that mechanical tampers may be used for the required compaction. Special care shall be taken to prevent any wedging action against the structure, and slopes bounding or within the areas to be filled shall be benched or serrated to prevent wedge action. The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled against except insofar as undisturbed material obtrudes upon the area.
Broken rock or coarse sand and gravel shall be provided for a drainage filter at weep holes as shown on the Plans.

7.3.7 Bedding, Backfill, and Embankment for Pipe Culverts

Bedding, Backfill and Embankment for pipe culverts shall be done in accordance with Clause 7.16.1.

7.4 Embankment

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

7.4.1 Material Requirements

Embankment shall be constructed of suitable materials. It can be a common material or rock.

7.4.1.1 Selected Borrow for Topping

7.4.1.1.1 Gradation

Soil of such gradation shows that all particles will pass a sieve with 75 mm square openings and not more than 15 % of the mass will pass the 0.075 mm (No. 200) sieve, as determined by AASHTO T 11.

7.4.1.1.2 Plasticity Index

The material shall have a plasticity index of not more than 6 as determined by AASHTO T 90.

7.4.1.1.3 Liquid Limit

The material shall have a liquid limit of not more than 30 as determined by AASHTO T 89.

7.4.1.2 Unsuitable materials

Unsuitable materials shall include the detrimental quantities of organic material such as grass, root and sewerage; highly organic soils such 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; and soils that cannot be properly compacted as determined by the Engineer.

7.4.2 Construction Requirements

7.4.2.1 General

Prior to construction of embankment, all necessary clearing and grubbing in the area shall have been performed in conformity with the requirements of Clause 7.1.

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 not contain unsuitable materials. 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 in the Plans or directed by the Engineer, the surface of the existing ground shall be compacted to a depth of 150 mm and the specified requirements of this section
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.

7.4.2.2 Methods of Construction

When there is evidence of discrepancies on the actual elevations and as shown in 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 m 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 Clause 7.2.3. This area shall then be compacted in conformity with the requirements of Clause 7.4.2.3. 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 of the sub-grade, such old road surface shall be scarified to a depth of at least 150 mm wherever directed by the Engineer. This scarified material shall then be compacted as provided in conformity to the requirements of Clause 7.4.2.3.

When shoulder excavation is specified, the roadway shoulders shall be excavated to the depth and width shown in 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 Clause 7.2.3.3. 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, 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 % 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.

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 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 % of rock larger than 150 mm in greatest dimension shall not be constructed above an elevation of 300 mm 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 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 Clause 7.4.2.3.

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.

7.4.2.3 Compaction

7.4.2.3.1 Compaction Trials

Before commencing the formation of embankments, proposals for the compaction of each type of fill material, types of compaction equipment, number of passes required, and the method of adjusting moisture content to be used in the Works shall be submitted by the Contractor to the Engineer for approval.

Full scale compaction trials on areas as required by the Engineer shall be carried out by the Contractor using appropriate procedures necessary to satisfy the specified requirements regarding compaction. 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.

7.4.2.3.2 Earth

Material placed in all embankment layer and the material scarified to the designated depth below sub-grade in cut sections shall be compacted by the Contractor until uniform density of not less than 95 % 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, DPWH Standard Specifications for Highways, Bridges, and Airports, Volume II, 2013.

During progress of the Work, density tests of compacted material shall be made by the Engineer in accordance with AASHTO T 191, ASTM D 2167, 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 ASTM D4718/D4718M. If, by such test, the Engineer determines that the specified density and moisture conditions have not been attained, additional work as may be necessary shall be performed by the Contractor 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.

7.4.2.3.3 Rock

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, DPWH Standard Specification for Bridges and Airports, Volume II, 2013 shall compact the embankment full width with a minimum of three complete passes for each layer of embankment.

7.4.3.3 Protection of Roadbed During Construction

During the construction of the roadway, the roadbed shall 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.

7.4.3.4 Rounding Slopes

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.

7.4.3.5 Warping Slopes

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.

7.4.3.6 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 in 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 reasonably close conformity with the Plans or other surfaces indicated on the Plans or as staked by the Engineer, with no variations wherefrom nor readily discernible as viewed from the road.

7.5 Subgrade Preparation

This clause shall consist of the preparation of subgrade for the support of overlying structural layers, as authorized by the Engineer. It shall extend to the full width of the roadway.

7.5.1 Material Requirements

All materials below subgrade level to a depth of 150 mm or to such greater depth as may be specified shall meet the requirements in Clause 7.4.1.1 except when the subgrade is in rock cut.

7.5.2 Construction Requirements

7.5.2.1 Subgrade Level Tolerances

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

Permitted variation from Design LEVEL OF SURFACE	+ 20 mm -30 mm
Permitted SURFACE IRREGULARITY MEASURED BY 3-m STRAIGHT EDGE	30 mm
Permitted variation from design CROSSFALL OR CAMBER	± 0.5 %
Permitted variation from Design LONGITUDINAL GRADE over 25 m length	± 0.1 %

7.5.2.2 Subgrade in Common Excavation

All materials below subgrade level in earth cuts to a depth 150 mm or other depth shown in the Plans or as directed by the Engineer shall be excavated. Suitable materials shall be set aside for future use. Unsuitable materials shall be disposed in designated areas as shown in the Plans or as approved by the Engineer.

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 Clause 7.4.2.3.

7.5.2.3 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 Clause 7.4.2.3.

7.5.2.4 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 Clause 7.4.2.3. 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 in the Plans.

7.5.2.5 Subgrade on Existing Pavement

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 Clause 7.4.2.3. The resulting subgrade level shall conform to the allowable tolerances of Clause 7.5.2.1.

7.6 Overhaul

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

7.7 Aggregate Subbase Course

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

7.7.1 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 14.

Table 14 – Grading requirements for subbase materials

Sieve Designation		Mass Percent Passing
Standard, mm	Alternate US Standard	
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 2/3 of the fraction passing the 0.425 mm (No. 40) sieve.

7.7.1.1 Plasticity

The fraction passing the 0.425 mm (No. 40) sieve shall have a plasticity index not greater than 12 as determined by AASHTO T 90.

7.7.1.2 Liquid Limit

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 as determined by AASHTO T 89.

7.7.1.3 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.

7.7.1.4 California Bearing Ratio (CBR)

The material shall have a soaked CBR value of not less than thirty percent (30%) as determined by AASHTO T 193. The CBR shall be obtained at the maximum dry density and determined by AASHTO T 180, Method D.

7.7.2 Construction Requirements

7.7.2.1 Preparation of Existing Surface

The existing surface shall be graded and finished in conformity to the requirements of Clause 7.5, before placing the subbase material.

7.7.2.2 Placing

The aggregate Subbase material shall be placed as a uniform mixture on a prepared quantity that will provide the required compacted thickness based on the Plans. When more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.

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.

7.7.2.3 Spreading and Compacting

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

The moisture content of Subbase material shall 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. Compacting 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 compacted. Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. Along curbs, headers and walls, and at all places not accessible to the roller, the subbase material shall be compacted thoroughly with approved tampers or compactors.
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.

7.7.2.4 Trial Section

One trial section of about 500 m^2 shall be set by the Contractor for every type of material and/or construction equipment/procedure for use, before subbase construction is started.

Before subbase construction is started, trial sections shall be spread and compacted by the Contractor 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.

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 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.

7.7.2.5 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 in the Plans. The allowable tolerances shall be specified hereunder:

Permitted variation from design THICKNESS OF LAYER	+20 mm
Permitted variation from design LEVEL OF SURFACE	+ 10 mm - 20 mm
Permitted SURFACE IRREGULARITY MEASURED by 3 m straight-edge	-20 mm
Permitted variation from design CROSSFALL OR CAMBER	± 0.3 %
Permitted variation from design LONGITUDINAL GRADE over 25 m length	± 0.1 %

7.8 Aggregate Base Course

This clause shall consist of furnishing, placing and compacting an aggregate base course on a prepared subgrade/subbase in accordance with this Standard and the lines, grades and cross sections shown in the Plans, or as approved by the Engineer.

7.8.1 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 biomass matter and lumps or balls of clay and other deleterious substances, 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 Standard.

The base course material shall conform to Table 15 whichever is specified in the Bill of Quantities.

Table 15 – Grading requirements for base course materials

Sieve Designation		Mass Percent Passing	
Standard	Alternate US Standard	Grading	Grading
(mm)		A	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 portion of the material passing the 0.075 mm (No. 200) sieve shall not be greater than 2/3 of the fraction passing the 0.425 mm (No.40) sieve.

7.8.1.1 Plasticity

The fraction passing the 0.425 mm (No. 40) sieve shall have a plasticity index not greater than 6 as determined by AASHTO T 90.

7.8.1.2 Liquid Limit

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 25 as determined by AASHTO T 89.

7.8.1.3 Abrasion

The coarse portion, retained on a 2.00 mm (No. 10) sieve shall have a mass percent of wear not exceeding 45 by the Los Angeles Abrasion test determined by AASHTO T 96, and not less than 50 % shall have at least one fractured face.

7.8.1.4 California Bearing Ratio

The material passing the 19 mm 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 shall be taken from sources approved by the Engineer, shall be free from hard lumps and shall not contain more than 15 % of material retained on the 4.75 mm (No. 4) sieve.

7.8.2 Construction Requirements

7.8.2.1 Preparation of Existing Surface

The existing Surface shall conform to the requirements of Clause 7.5.

7.8.2.2 Placing

Placing shall be in accordance with all the requirements of Clause 7.7.2.2.

7.8.2.3 Spreading and compacting

It shall be in accordance with all the requirements of Clause 7.7.2.3, except that the field density required of each layer is not less than 100 % 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.

7.8.2.4 Trial Sections

Trial Section shall conform to all the requirements specified in Clause 7.7.2.4.

7.8.2.5 Tolerances

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

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

7.9 Lime Stabilized Road Mix Base Course

This clause shall consist of a foundation for surface course composed of soil aggregate, lime and water in proper proportions, road-mixed and constructed on a prepared subgrade/subbase in accordance with this Standard and the lines, grades and typical cross-sections shown on the Plans or established by the Engineer.

7.9.1 Material Requirements

7.9.1.1 Soil Aggregate

It shall consist of any combination of gravel, sand, silt and clay or other approved combination of materials free from vegetable or other objectionable matter. It may be materials encountered in the construction site or materials obtained from approved sources. The crushed or 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. It is the intent of this Standard to utilize soils existing on the roadbed if the quality is satisfactory. If the quality and/or quantity is deficient, the soil aggregate shall be obtained wholly or partly from approved outside sources.

The soil-aggregate shall conform to the grading requirements of Table 16.

Table 16 – Grading Requirements

Sieve Designation		Mass Percent Passing	
Standard (mm)	**Alternate US Standard**	**Grading A**	**Grading B**
50	2”	100	100
4.75	No. 4	45-100	55-100
2.00	No. 10	37-80	45-100
0.425	No. 40	15-20	25-80
0.075	No. 200	0-25	11-35

The materials passing the 4.75 mm (No. 4) sieve produced in the crushing operation of either 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.

The aggregate shall have a mass percent of wear not exceeding 50 as determined by AASHTO Method T 96.

7.9.1.1.1 New Soil-Aggregate

It shall conform to the applicable requirements of Clause 7.9.1.1.

7.9.1.1.2 Salvaged Soil-Aggregate

Where soil-aggregate required is already in place, the Contractor shall not be responsible for its grading or quality except for removal of oversized materials as directed by the Engineer. In general, salvaged soil-aggregate to be used for lime stabilized road mix base course will consist of material meeting the requirements given in Clause 7.9.1.1.

7.9.1.2 Hydrated Lime

It shall conform to the requirements of Item 701 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.9.1.3 Water

It shall conform to the requirements of Clause 7.14.1.4.

7.9.1.4 Proportioning of Mixture

The amount of lime to be added to the soil-aggregate shall be from 3 to 12 mass percent of the dry soil. The exact percentage to be added shall be fixed by the Engineer on the basis of preliminary laboratory tests and trial mixes of materials furnished.

7.9.1.5 Strength Requirements

7.9.1.5.1 CBR Test for Gravelly Soils

The mixture passing the 19 mm sieve shall have a minimum soaked CBR-value of 100% tested according to AASHTO T 193. The CBR-value shall be obtained at the maximum dry density determined according to AASHTO T 180, Method D.

7.9.1.5.2 Unconfined Compression Test for Finer Textured Soils

The 7-day compressive strength of laboratory specimen molded and compacted in accordance with ASTM D 1632 to a density of 100% of maximum dry density determined according to AASHTO T 134, Method B, shall not be less than 2.1 MPa when tested in accordance with ASTM D 1633.

7.9.2 Construction Requirements

7.9.2.1 Weather Limitations

Lime shall not be applied during windy, rainy or impending bad weather. In the event rain occurs during the operations, work shall be promptly stopped and the entire section shall be reconstructed in accordance with this Standard.

7.9.2.2 Preparation of Soil-Aggregate

7.9.2.2.1 Case 1 (New Soil-Aggregate)

When new soil-aggregate is to be used, the existing roadbed shall be scarified lightly and bladed to uniform grade and to the cross-section shown on the Plans and shall when be rolled or watered and rolled, as directed. If so ordered by the Engineer, depressions shall first be filled and weak portions of the roadbed strengthened with new soil-aggregate. At least one day shall then be allowed for measuring, sampling and testing for approval of quantity and gradation before the windrow is spread for application of hydrated lime.

If the surface moisture of the soil-aggregate is more than 2 mass percent of the dry aggregate, the soil aggregate shall be turned by blades or disc harrows or otherwise aerated until the moisture content is reduced to 2 percent or less. The soil-aggregate shall then be spread smoothly and uniformly over half the road or other convenient width of the surface ready for the application of hydrated lime.

8.9.2.2.2 Case 2 (Salvaged Soil-Aggregate)

When material in the existing roadbed is to be used for mixing, the surface shall be scarified lightly and bladed to uniform grade and to the cross-section shown on the Plans. The reshaped surface shall then be scarified again to the depth ordered by the Engineer and in such manner as to leave a foundation of undisturbed material parallel, both in profile and cross-section, the proposed finished surface. The loosened materials shall be bladed aside into a windrow at the side of the road, and the undisturbed material roiled, or watered and rolled, as directed.

7.9.2.3 Application of Lime

The hydrated lime shall be uniformly spread at specified percent using either the dry or slurry (wet) methods. It shall be distributed in successive applications, in such amount and at such intervals as directed. The mixing equipment shall follow immediately behind the distributor, after each application to partially mix the lime with the soil-aggregate.

Dry lime should not be spread under windy conditions to avoid excessive dustings. It shall be applied only to such areas as can be mixed into the soil aggregate during the day of application. Dry application encompasses either spotting bags of lime in equal predetermined transverse and longitudinal intervals or applying bulk lime from suitably equipped self-unloading trucks. An approved spreader is preferable for uniform distribution.

If lime slurry is employed, the preparation facilities should be approved by the Engineer. A typical slurry ratio is 1 ton lime to 2 m^3 water. The actual mixing proportion depends upon the percent of lime, specified type of soil and its moisture condition.

The slurry is distributed by one or more passes over a measured area until the specified percentage (based on lime solids content) is obtained. To prevent run-off and consequent non-uniformity of lime distribution, the slurry is mixed in immediately after each spreading pass.

7.9.2.4 Mixing

After the last lime application and partial mixing, the entire mass of the mixture shall be windrowed on the road surface and then mixed by blading the mixture from side to side of the road or by manipulation producing equivalent results until the whole mass has a uniform color and the mixture is free from fat or lean spots or balls of unmixed particles. During the mixing operations, care shall be taken to avoid cutting into the underlying course. When directed, the mixing process shall be confined to part of the width or area of the road so as to allow traffic to pass.

Should the mixture show an excess, deficiency or uneven distribution of lime, the condition shall be corrected by the addition of soil-aggregate or lime as required and then remix. If the mixture contains excessive amounts of moisture or volatile matter, as may be encountered in slurry application method, it shall be bladed, aerated or otherwise manipulated until the moisture and volatile content are satisfactory. The spreading of the mix shall not be done when the surface to be covered is in an unsatisfactory condition. At the end of each day's work, or when the work is interrupted by weather conditions or otherwise, all loose materials shall be bladed into a windrow, whether mixing is completed or not, and shall be retained in a windrow until operations are resumed. When the mixing operations have been satisfactorily completed, the mixture shall be formed into a windrow of uniform cross-section.

7.9.2.5 Spreading, Compacting and Finishing

The material shall be spread by a self-propelled pneumatic-tire blade grader or a mechanical spreader of approved type. In spreading from the windrow, care shall be taken to avoid cutting into the underlying course. After the material is spread, the surface shall be rolled. Rolling shall be parallel to the road center line and shall commence at the outer edges of the road, overlapping the shoulders and progress toward the center, overlapping on successive passes by at least one-half the width of the roller, except that on superelevated curves rolling shall progress from the lower to the upper edge. Each pass shall terminate at least 910 mm in advance or to the rear of the end of the preceding pass. During compaction, the surface shall be dragged or bladed as necessary to fill ruts and to remove incipient corrugation or other irregularities. Rolling shall continue until the surface is of uniform texture and satisfactory compaction is obtained. Initial rolling shall be performed with a pneumatic tire roller and final rolling with a 3-wheel or tandem-type steel wheel roller. Rolling shall be discontinued whenever it begins to produce excessive pulverizing of the aggregate or displacement of the mixture.

When the compacted thickness of the road mix lime stabilized base course is to be more than 150 mm, the mixture shall be spread from the windrow and compacted in two (2) approximately equal layers. The first layer shall be bladed and rolled before the second layer is spread.

Compaction shall continue until a field density of not less than 100% of the compacted maximum dry density determined in accordance with AASHTO T 180, Method D has been attained. Field Density test shall be in accordance with AASHTO T 191.

7.9.2.6 Protection, Curing and Maintenance

After the lime-stabilized base course has been finished as specified herein, the surface shall be protected against rapid drying for a period of at least five (5) days by either of the following curing methods:

1. Maintain in a thorough and continuously moist condition by sprinkling with water.
2. Cover the completed surface with a 50 mm layer of earth or sand and maintain in moist condition.

3. Apply on the surface an asphalt membrane of the type and quantity approved by the Engineer.
4. Apply on the surface a liquid membrane curing compound of the type and quantity approved by the Engineer.

The Contractor shall be required to maintain the entire work within the limits of his Contract in good condition satisfactory to the Engineer from the time he first started work until all work shall have been completed. Maintenance shall include immediate repairs of any defects that may occur before and after the lime-stabilized base course has been compacted and finished, which work shall be done by the Contractor at his own expense and repeated as may be necessary to keep the base continuously intact.

7.9.2.7 Trial Sections

Trial sections of the stabilized base shall be constructed at least 2 weeks before actual base construction. These shall conform to the applicable requirements of Clause 7.7.2.4.

7.9.2.8 Tolerances

The stabilized base course shall be laid to the designed level and transverse slopes shown on the Plans. The allowable tolerances shall be in accordance with Clause 7.8.2.5.

7.9.2.9 Traffic

The Contractor will not be permitted to drive heavy equipment over completed portions prior to the end of five (5) days curing period except pneumatic-tired equipment required for constructing adjoining sections. Turning areas on completed portions of the base shall be protected by a layer of stable granular materials of not less than 50 mm of compacted depth.

7.10 Portland Cement Stabilized Road Mix Base Course

This clause shall consist of a foundation for surface course composed of soil aggregate, Portland Cement and water in proper proportions, road-mixed and constructed on a prepared subgrade/subbase in accordance with this Standard and the lines, grades and typical cross-sections shown on the Plans or as established by the Engineer.

7.10.1 Material Requirements

7.10.1.1 Soil Aggregate

It shall conform to the grading and quality requirements of Clause 7.9.1.1.

7.10.1.2 Portland Cement

It shall conform to the requirements of Item 700 of the DPWH Standard Specifications for Highways, Bridges, and Airports, Volume II, 2013.

7.10.1.3 Water

It shall conform to the requirements of Clause 7.14.1.4.

7.10.1.4 Proportioning of Mixture

The amount of cement to be added to the soil-aggregate shall be from 6 to 10 mass percent of the dry soil. The exact percentage to be added shall be fixed by the Engineer on the basis of preliminary laboratory tests and trial mixes of the materials furnished by the Contractor.

7.10.1.5 Strength Requirements

Strength requirements shall conform in all respects to those specified in Clause 7.9.1.5.

7.10.2 Construction Requirements

Construction requirements and procedures shall be as prescribed under Clause 7.9.2. In all cases, the world “lime” shall be deleted and replaced with “Portland Cement”.

7.11 Asphalt Stabilized Road Mix Base Course

This clause shall consist of a foundation for surface course, composed of soil-aggregate and asphaltic material in proper proportions, road mixed and constructed on a prepared subgrade/subbase in accordance with this Standard and the lines, grades and typical cross-sections shown on the Plans or established by the Engineer.

7.11.1 Material Requirements

7.11.1.1 Soil-Aggregates

It shall conform to the applicable requirements of Item 703, DPWH Standard Specifications for Highways, Bridges, and Airports, Volume II, 2013. Gradation A or B shall be used.

7.11.1.2 Asphaltic Material

Asphaltic material shall be Anionic or Cationic Emulsified Asphalt of the slow setting type meeting the requirements of Item 702, DPWH Standard Specifications for Highways, Bridges, and Airports, Volume II, 2013.

7.11.1.3 Proportioning of Mixture

The amount of asphaltic material to be added to the soil-aggregate shall be from 4 to 7 mass percent of the dry soil-aggregate. The exact percentage to be used shall be fixed by the Engineer on the basis of preliminary laboratory tests and trial mixes of the materials furnished by the Contractor.

7.11.1.4 Strength Requirements

Strength requirements shall conform in all respects to those specified in 7.9.1.5.

7.11.2 Construction Requirements

Construction requirements and procedures shall be as prescribed under Item 306.3.1 to 306.3.7, DPWH Standard Specifications for Highways, Bridges, and Airports, Volume II, 2013. In all cases the word “aggregate” shall be deleted and replaced by “soil-aggregate”.

Trial Sections shall conform to the applicable requirements of Clause 7.7.2.4.

The allowable tolerances shall be in accordance with Clause 7.8.2.5.

7.12 Portland Cement Treated Plant Mix Base Course

This clause shall consist of a foundation for surface course composed of aggregate, Portland Cement and water in proper proportions, mixed by a travel plant or in a central plant, spread and compacted on a prepared subgrade/subbase in one or more layers, in accordance with this Standard and the lines, grades, thickness and typical cross-sections shown on the Plans or as established by the Engineer.

7.12.1 Material Requirements

It shall conform to the requirements of Clause 7.10.1.

7.12.2 Construction Requirements

7.12.2.1 Weather Limitations

Portland Cement shall not be applied during windy, rainy or impending bad weather. In the event rain occurs, work shall be promptly stopped and the entire section shall be reconstructed in accordance with this Standard.

7.12.2.2 Travel Plant Method

The salvaged or new soil-aggregate shall be pulverized until at least 80 mass percent of all material other than stone or gravel will pass a 4.75 mm (No. 4) sieve.

Any material retained on a 50 mm sieve and other unsuitable material shall be removed. If additional material is specified, it shall be blended with the existing material. All butt joints at existing pavements or other structures shall be cleaned prior to mixing.

The subgrade/subbase shall support all equipment required in the construction of the base course. Soft or yielding areas shall be corrected prior to mixing.

The soil-aggregate to be treated shall be placed in a uniform windrow and spread to a uniform thickness to the required width. The specified quantity of Portland Cement

shall be applied uniformly in a trench on top of the windrows or spread uniformly over the soil-aggregate. Spread cement that has been lost shall be replaced, , before mixing is started.

Mixing shall be accomplished by means of a mixer that will thoroughly blend the cement with the soil-aggregate. The mixer shall be equipped with a water metering device that will introduce the required quantity of water during the mixing cycle. The cement soil-aggregate mixture shall be sufficiently blended to prevent the formation of cement balls when water is applied.

A maximum time of 2 hr shall be permitted for wet mixing, laydown, and finishing when this method is used.

7.12.2.3 Central Plant Method

The soil-aggregate shall be proportioned and mixed with cement and water in a central mixing plant. The plant shall be equipped with feeding and metering devices which will introduce the cement, soil-aggregate and water into the mixer in the quantities specified. Mixing shall continue until a uniform mixture has been obtained.

7.12.2.4 Spreading, Compacting and Finishing

The mixture shall be spread on a prepared and moistened subgrade/subbase in a uniform layer by an approved equipment. Not more than 60 minutes shall elapse between the start of mixing and the time of starting compaction of the spread mixture.

After spreading, the mixture shall be compacted and finished conforming to the procedures/requirements specified under Clause 7.9.2.5.

The compaction and finishing shall be completed within 2 hr of the time water is added to the mixture.

7.12.2.5 Protection, Curing and Maintenance

The completed cement treated base shall be cured with a bituminous curing seal applied as soon as possible after the completion of final rolling. The surface shall be kept moist until the seal is applied.

The rate of application shall be between 0.5 L/m^2 to 1.00 L/m^2 of surface. The exact rate will be determined by the Engineer. Curing seal will be applied in sufficient quantity to provide a continuous film over the base. The film shall be maintained at least 5 days unless the treated base is protected by a subsequent course.

The Contractor shall be responsible for adequate maintenance of the base at all times as specified under Clause 7.9.2.6.

7.12.2.6 Trial Sections

It shall conform to the requirements of Clause 7.9.2.7.

7.12.2.7 Tolerances

It shall conform to the requirements of Clause 7.9.2.8.

7.12.2.8 Traffic

It shall conform to the requirements of Clause 7.9.2.9.

7.13 Portland Cement Concrete Pavement (PCCP)

This clause shall consist of pavement of Portland Cement Concrete, with or without reinforcement, constructed on the prepared base in accordance with this Standard and in conformity with the lines, grades, thickness and typical cross-sections shown in the Plans. A typical plan of PCCP is shown in Figure 16.

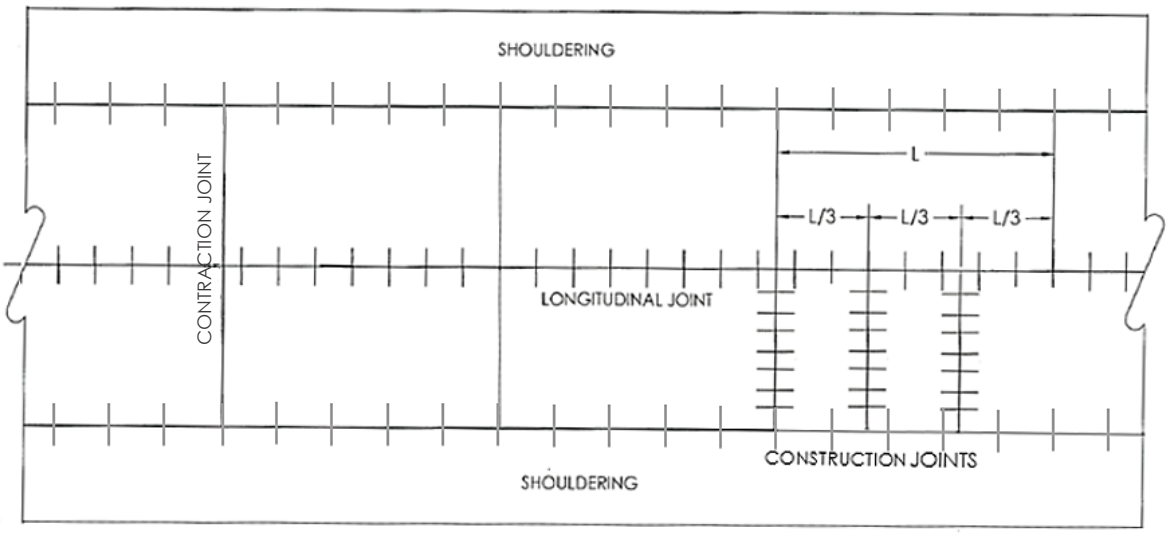


Figure 16 – Typical Plan of PCCP with concrete shoulders

7.13.1 Material Requirements

7.13.1.1 Portland Cement

Portland cement shall conform to the requirement of the AASHTO M 85. The types of cement are summarized in Table 17.

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 1P meeting the requirements of AASHTO M240M/M240 or ASTM C595/C595M 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.

When types IV and V (AASHTO M 85) cements are used, proper recognition shall be given to the effects of slower strength gain on concrete proportioning and construction

practices. Types S and SA cements will be permitted only when blended only with Portland Cement in proportions approved by the Engineer.

Suitable means of storing and protecting the cement against dampness shall be provided by the Contractor. 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.

The compressive strength of mortar samples tested at 7 days can be considered for acceptance of cement quality provided that the strength of the samples at 7 days is not less than 23.46 MPa which is 85 % of the compressive strength requirement for 28 days (27.6 MPa)

Samples of Cement shall be obtained in accordance with AASHTO R 71.

Table 17 – Types of cement

TYPE	CLASSIFICATION	CHARACTERISTICS	APPLICATIONS
I	General Purpose	Fairly high C_3S content for good early strength development	General construction (Most buildings, bridges, pavements, precast unit, etc.)
II	Moderate Sulfate Resistance	Low C_3A Content (<8%)	Structure exposed to soil or water containing sulfate ions
III	High Early Strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
IV	Low Heat of Hydration	Low content of C_3S (<50%) and C_3A	Massive structures such as dams
V	High Sulfate Resistance	Very low C_3A Content (<5%)	Structures exposed to high levels of sulfate ions

7.13.1.2 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 mass percent (3 %) of material passing the 0.075 mm (No. 200 sieve) by washing nor more than one mass percent (1 %) 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 cycles of the sodium sulfate soundness test, the weighted loss shall not exceed 10 %.

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 %.

The fine aggregate shall be well-graded from coarse to fine and shall conform to Table 18.

Table 18 – Grading requirements for fine aggregate

Sieve Designation	Mass Percent Passing
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

7.13.1.3 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 no more than one mass percent (1 %) of material passing the 0.075 mm (No. 200) sieve, not more than 0.25 % of clay lumps, nor more than 3.5 % of soft fragments.

If the coarse aggregate is subjected to five cycles of the sodium sulfate soundness test, the weighted loss shall not exceed 12 %.

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/m^3. The gradation of the coarse aggregate shall conform to Table 19.

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

Table 19 – Grading requirement for coarse aggregate

Sieve Designation		Mass Percent Passing		
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

Sieve Designation		Mass Percent Passing		
19.00	¾ in.	0 – 10	–	–
12.50	½ in.	0 – 5	0 – 5	10 – 30
4.75	No. 4	–	–	0 – 5

7.13.1.4 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, or as approved by the Engineer. For questionable sources, it shall conform with Table 20.

Table 20 – Acceptance Criteria for Questionable Water Supplies

Physical Properties	Limits
Compressive strength, min. % Control at 7 days	90
Time of Setting deviation from control Time of Setting (Gillmore Test)	From 1:00 earlier to 1:30 later
Initial	No marked change
Final Set	No marked change
Appearance	Clear
Color	Colorless
Odor	Odorless
Total Solids	500 parts/million max.
pH	4.5 to 8.5

Where the source of water is shallow, the intake shall be enclosed as to exclude silt, mud, grass or other foreign materials.

Water will be tested in accordance with, and shall meet the suggested requirements of AASHTO T 26.

7.13.1.5 Reinforcing Steel

It shall conform to the requirements of Item 404, Reinforcing Steel of the DPWH Standard Specifications for Highways, Bridges, and Airports, Volume II, 2013. Dowel and tie bars shall conform to the requirements of AASHTO M31M/M31 or AASHTO M42M/M42, 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 ± 5 mm of the dowel, with a closed end, and with a suitable stop to hold the end of the sleeve at least 25 mm from the end of the dowel so that they will not collapse during construction.

7.13.1.6 Joint Fillers

Poured filler for joints shall conform to the requirements of ASTM D 6690.

Preformed fillers for joints shall conform to the requirements of AASHTO M 33 or ASTM D994/D994M, AASHTO M 213, ASTM D 2628, as specified, and shall be punched to admit the dowels where called for on the Plans. The filler for each joint shall be furnished in a single piece for the depth and width required for the joint unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely and held accurately to shape, by stapling or other positive fastening satisfactory to the Engineer.

7.13.1.7 Admixtures

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

7.13.1.8 Curing Covers

Laminated sacks, sheeting films, or any equivalent material that protects the concrete during curing shall be used as covers.

7.13.1.9 Calcium Chloride/Calcium Nitrate

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

7.13.1.10 Storage of Cement, Reinforcing Steel, and Aggregate

There shall be a provision for weatherproof storage for cement, reinforcing steel, and aggregates.

7.13.1.11 Proportioning, Consistency and Strength of Concrete

The Contractor shall prepare the design mix based on the absolute volume method as outlined in the ACI Standard 211.1.

It is the intent of this Standard to require approximately nine (9) bags of cement per cubic meter of concrete based on a 40 kg per bag of cement to meet the minimum strength requirement. The materials to be used, the cement content and the proportions of aggregate and water that will produce a workable concrete shall be determined by the Engineer from laboratory tests. The requirements and the tests for the workable concrete is summarized in Table 21.

Table 21 – Workable Concrete Requirements

Parameter	Value	Test Method
Slump	40 mm to 75 mm if not vibrated 10 mm to 44 mm if vibrated	AASHTO T119M/T119
Flexural Strength	Not less than 3.8 MPa Not less than 4.5 MPa	AASHTO T 97 AASHTO T 177
Compressive Strength	24.1 MPa	AASHTO T 24M/T 24

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.

7.13.2 Construction Requirements

Construction of the pavement shall be immediately started by the Contractor upon completion of subgrade to avoid preparing the subgrade again when its condition was altered over time.

7.13.2.1 Quality Control of Concrete

7.13.2.1.1 General

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

7.13.2.1.2 Quality Control Plan

A Quality Control Plan detailing his production control procedures and the type and frequency of sampling and testing to ensure that the concrete produced complies with the Standard shall be furnished to the Engineer by the Contractor. Free access to recent plant production records, and if requested, copies of mix design, materials certifications and sampling and testing reports shall be provided to the Engineer.

7.13.2.1.3 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. The batcher 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 this Standard. 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.

7.13.2.1.4 Quality Control Testing

All sampling, testing and inspection necessary to assure quality control of the component materials and the concrete shall be performed by the Contractor witnessed by a qualified government technical personnel.
The determination of the gradation of fine and coarse aggregates and for testing the concrete mixture for slump and temperature shall be done by the Contractor witnessed by a qualified government technical personnel.

7.13.2.2 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.

7.13.2.3 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.

7.13.2.4 Setting Forms

7.13.2.4.1 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 3 cm or less, and thoroughly rerolled or tamped. Imperfections or variations above grade shall be corrected by tamping or by cutting as necessary.

7.13.2.4.2 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 1 cm at any point.

7.13.2.4.3 Grade and Alignment

The alignment and grade elevations of the forms shall be checked and corrections shall be made by the Contractor immediately before placing the concrete. This should be attested by a qualified government technical personnel. 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.

7.13.2.5 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.

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.

7.13.2.6 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 1 m 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 12 hr 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, a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer shall be provided by the Contractor, with chute, boot or other approved device. This is 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 one and half 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 1 % for the cement and 2 % 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 1 %. 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.

A qualified government technical personnel shall check, with the Contractor, that provision provided for batching plants are met.

7.13.2.7 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 in the serial plate.

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

The operation and mixing time for pan, twinshaft and other type of central mixers shall be based on the mixer manufacturer’s specifications.

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 in 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. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meter, as shown in the manufacturer's standard rating plate on the mixer, except that an overload up to 10 % 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 s 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 Item 311.3.2 of the DPWH Standard Specifications for Highways, Bridges, and Airports, Volume II, 2013. 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 min when the concrete is hauled in non-agitating trucks, 90 min 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.

In exceptional cases and when volumetric measurements are authorized for small projects requiring less than 75 m^3 of concrete per day of pouring, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregate. Batching and mixing shall be in accordance with ASTM C685/C685M*,* Section 6 through 9.

Concrete mixing by chute is allowed provided that a weighing scale for determining the batch weight will be used.

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 min 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.

7.13.2.8 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 32 °C.
Concrete not in place within 90 min 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.

7.13.2.9 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 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 s 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.

7.13.2.10 Test Specimens

As work progresses, at least one set consisting of three concrete beam test specimens, 150mm x 150mm x 525mm or 900mm shall be taken from each 75 cm^3 of pavement or fraction thereof placed each day. Test specimens shall be made under the supervision of the Engineer, and all concrete and other facilities necessary in making the test specimens shall be provided and protected from damage due to construction operations by the Contractor. Cylinder samples shall not be used as substitute for determining the adequacy of the strength of concrete.

The beams shall be made, cured, and tested in accordance with AASHTO T 23 and T 97.

7.13.2.11 Strike-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 in 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 in the Plans. When reinforced concrete pavement is placed in two 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 min without being covered with the top layer shall be removed and replaced with freshly mixed concrete. 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 in 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.

7.13.2.12 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.

7.13.2.12.1 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 in 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 in 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.

7.13.2.12.2 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.

7.13.2.12.3 Transverse Contraction Joint/Weakened Joint

When shown in 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.

7.13.2.12.3.1 Transverse Strip Contraction Joint

It shall be formed by installing a parting strip to be left in place as shown in the Plans.

7.13.2.12.3.2 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.

7.13.2.12.3.3 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 in 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 hr to 24 hr. 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.

7.13.2.12.4 Transverse Construction Joint

It shall be constructed when there is an interruption of more than 30 min in the concreting operations. No transverse joint shall be constructed within 1.5 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.

7.13.2.12.5 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 conformance with the requirements of Clause 7.13.1.5, shall be thoroughly coated with approved bituminous materials, e.g. MC-70, or an approved lubricant, to prevent the concrete from binding to that portion of the dowel. The sleeves for dowels shall be metal designed to cover 50 mm ± 5, of the dowel, with a watertight closed end and with a suitable stop to hold the end of the sleeves at least 25 mm from the 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.

7.13.2.13 Final Strike-off (Consolidation and Finishing)

7.13.2.13.1 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.

7.13.2.13.2 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 Clause 7.13.2.9.

After the concrete has been placed and vibrated adjacent to the joints as required in Clause 7.13.2.9, 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 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.

7.13.2.13.3 Machine Finishing

7.13.2.13.3.1 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.

7.13.2.13.3.2 Vibratory Method

When vibration is required, vibrators for full width complete of concrete paving slabs, shall operate at a frequency of 8,300 to 9,600 impulses per minute under load at a maximum spacing of 60 cm. 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 Clause 7.13.2.13.3.1 not in conflict with the provisions of the vibratory method shall govern.

7.13.2.13.4 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 operation 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 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 combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross-section, and free from porous areas.

7.13.2.13.5 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.

7.13.2.13.5.1 Hand Method

The hand-operated longitudinal float shall be not less than 365 cm in length and 15 cm 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.

7.13.2.13.5.2 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.

7.13.2.13.5.3 Alternative Mechanical Method

As an alternative, a machine composed of a cutting and smoothing float or floats suspended from and guided by a rigid frame may be used by the Contractor. 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 in length and 15 cm 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.

7.13.2.13.6 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, an accurate 300-cm straight-edge swung from handles 100 cm longer than one-half the width of the slab shall be furnished and used by the Contractor. 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.

7.13.2.13.7 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 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 two 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 to provide the required coefficient of friction.

7.13.2.13.8 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.

7.13.2.14 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 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.

7.13.2.15 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 using laminated sacks, sheeting films or any equivalent materials that serve the same purposes. 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 0.5 hr between stages of curing or during the curing period.

7.13.2.16 Removal of Forms

All forms for concrete shall remain in place undisturbed for not less than 24 hr 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. 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.

7.13.2.17 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 in 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 in 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.

7.13.2.18 Protection of Pavement

The pavement and its appurtenances shall be protected by the Contractor 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.

All boreholes after thickness and/or strength determinations of newly constructed concrete pavements shall be immediately filled/restored with the prescribed concrete mix after completion of the drilling works.

Any damage to the pavement, occurring prior to final acceptance, shall be repaired or the pavement replaced.

7.13.2.19 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.

7.13.2.19.1 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.

7.13.2.19.2 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. 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.

7.13.2.19.3 Finishing

The surface smoothness and texture shall meet the requirements of Clause 7.13.2.13 and 7.13.2.14.

7.13.2.19.4 Curing

Unless otherwise specified, curing shall be done in accordance with Clause 7.13.2.15. 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.

7.13.2.19.5 Joints

All joints shall be constructed in accordance with Clause 7.13.2.12.

7.13.2.19.6 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 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 laminated sacks, sheeting materials or any equivalent materials that serve the same purpose 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.

7.13.2.20 Acceptance of Concrete

The strength level of the concrete will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, f_c' and no individual strength test result is deficient by more than 15 % of the specified strength, f_c'.

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 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 24M/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_c'.

7.13.2.21 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 Clause 7.13.1.11. 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.

7.13.2.22 Tolerance and Pavement Thickness

7.13.2.22.1 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 one-half of the normal lot length. If the length of the last unit is shorter than one-half 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 equal segments and one core will be obtained from each segment in accordance with AASHTO T 24M/T 24.

7.13.2.22.2 Pavement Thickness

It is the intent of this Standard 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.

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.

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.

7.14 Slope Protection

7.14.1 Riprap and Grouted Riprap

This clause shall consist of the furnishing and placing of riprap with or without grout as the case may be, with or without filter backing furnished and constructed in accordance with this Standard and to the lines and grades and dimensions shown in the Plans.

7.14.1.1 Material Requirements

7.14.1.1.1 Stones

Stones for riprap shall consist of rock as nearly as rectangular in section as is practical, except that riprap of Class A may consist of round natural stones. The stones shall be sound, tough, durable, dense, resistant to the action the purpose intended.

Stones for riprap shall be one of the following classes as shown in the Plans or determined by the Engineer:

Class A Stones ranging from a minimum of 15kg to a maximum of 25kg with at least 50 percent of the stones weighing more than 20kg

Class B Stones ranging from minimum of 30kg to a maximum of 70kg with at least 50 percent of the stones weighing more than 50kg

Class C Stones ranging from minimum of 60kg to a maximum of 100kg with at
least 50 percent of the stones weighing more than 80kg

Class D Stones ranging from minimum of 100kg to a maximum of 200kg with at least 50 percent of the stones weighing more than 150kg

Sound pieces of broken concrete obtained from the removal of bridges, culverts and other structures may be substituted for stone with the approval of the Engineer.

7.14.1.1.2 Filter Materials

When required, the riprap shall be placed on a filter layer to prevent fine embankment materials to be washed out through the voids of the face stones. The grading of the filter material shall be as specified on the Plans, or in the Special Provisions, if not so specified, it will be required that D_{15} of the filter is at least 4 times the size D_{85} for the embankment material, where D_{15} percent and 85 percent, respectively, passing (by mass) in a grain size analysis, Fine aggregate passing grading requirements on Clause 7.13.1.2 will satisfy foregoing requirements.

7.14.1.1.3 Mortar

Mortar for grouted riprap shall consist of sand, cement and water conforming to the requirements given under Clause 7.13.1, mixed in the proportion of one part cement to three parts and by volume, and sufficient water to obtain the required consistency.

The horizontal and vertical contact surface between stones shall be embedded by cement mortar having a minimum thickness of 20 mm. Sufficient mortar shall be used to completely fill all voids leaving the face of the stones exposed.

7.14.1.2 Construction Requirements

7.14.1.2.1 Excavation

The bed for riprap shall be excavated to the required depths and properly compacted, trimmed and shaped.

The riprap shall be founded in a toe trench dug below the depth of scour as shown in the Plans or as ordered by the Engineer. The toe trench shall be filled with stone of the same class as that specified for the riprap, unless otherwise specified

7.14.1.2.2 Placing

Stones placed below the water line shall be distributed so that the minimum thickness of the riprap is not less than that specified.

Stones above the water line shall be placed by hand or individually by machines. They shall be laid with close, broken joints and shall be firmly bedded into the slope and against the adjoining stones. Each stone shall be laid with its longest axis perpendicular to the slope in close contact with each adjacent stone. The riprap shall be thoroughly rammed into place as construction progresses and the finished surface shall present an even, tight surface. Interstices between stones shall be filled with small broken fragments firmly rammed into place.

Unless otherwise provided, riprap shall have the following minimum thickness, measured perpendicular to the slope:

Class A	300 mm
Class B	500 mm
Class C	600 mm
Class D	800 mm

The surface of riprap shall not vary from the theoretical surface by more than 100 mm at any point.

7.14.1.2.3 Grouting

When grouted riprap is specified, stones shall be placed by hand or individually by machine as specified for riprap placed above the water line. The spaces between the stones shall then be filled with cement mortar throughout the thickness of the riprap as specified in Clause 7.14.1.1.3.

Grout shall be placed from bottom to top of the surface swept with a stiff broom. After grouting is completed, the surface shall be cured based on the requirements specified in the following for a period of at least three days:

Sheeting (film) materials	ASTM C 171
Cotton mats and water- proof paper can be used	

The stones shall also be laid in a manner that the vertical and horizontal alignments of the exposed face shall, as possible be maintained in a straight line.

7.14.1.2.4 Weep holes

Unless otherwise indicated on the Plans, weepholes shall be provided with filtering materials composed of graded gravel with larger stone placed adjacent to weephole. The materials shall be wrapped with filter cloth and securely tied at the inner end of the PVC pipe.

7.14.2 Stone Masonry

This Section shall consist of stone masonry in minor structures, in headwalls for culverts, in retaining walls at the toes of slopes, and at other places called for on the Plans, constructed on the prepared foundation bed, in accordance with this Standard and in conformity with the lines, grades, sections, and dimensions shown in the Plans or as ordered in writing by the Engineer.

7.14.2.1 Material Requirements

7.14.2.1.1 Stone

The stone shall be clean, hard, and durable and shall be subject to the Engineer's approval. Adobe stone shall not be used unless otherwise specified.

7.14.2.1.1.1 Sizes and Shapes

Unless other sizes are shown in the Plans, stones shall have a thickness of not less than 150 mm, and widths of not less than one and one-half times their respective thickness, and lengths of not less than one and a half times their respective widths. Each stone shall be of good shape and be free of depressions and projections that might weaken or prevent it from being properly bedded.

7.14.2.1.1.2 Dressing

The stone shall be dressed to remove any thin or weak portions. Face stones shall be dressed to provide bed and joint lines that do not vary more than 20 mm from the true lines and to ensure the meeting of bed and joint lines without the rounding of corners of the stones in excess of 30 mm in radius. Bed surfaces of the face stones shall be approximately normal to the face of the stones for about 80 mm and from this point may depart from a normal plane not to 50 mm in 300 mm

7.14.2.1.1.3 Finish for Exposed Faces

Face stones shall be pitched to the line along the beds and joints. The maximum projection of rock faces beyond the pitch lines shall not be more than 50 mm

7.14.2.1.2 Mortar

Cement, fine aggregate, and water shall conform to the respective requirements for those materials as specified in Clause 7.13.1.

The mortar for the masonry shall be composed of one part of Portland Cement and two parts of fine aggregate by volume and sufficient water to make the mortar of such consistency that it can be handled easily and spread with a trowel. Mortar shall be mixed only in those quantities required for immediate use. Unless an approved mortar mixing machine is used, the fine aggregate and cement shall be mixed dry in a tight box until the mixture assumes a uniform color, after which water shall be added as the mixing continues until the mortar attains the proper consistency. Mortar that is not used within 90 minutes after the water has been added shall be discarded. Retempering of mortar will not be permitted.

7.14.2.2 Construction Requirement

7.14.2.2.1 Selection and Placing

When the masonry is to be placed on a prepared foundation bed the bed shall be firm and normal to, or in steps normal to, the face of the wall, and shall have been approved by the Engineer before any stone is placed.

Care shall be taken to prevent the bunching of small stone on stones of the same size. Large stones shall be used in the corners.

All stones shall be cleaned thoroughly and wetted immediately before being set, and the bed which is to receive them shall be cleaned and moistened before the and moistened before the mortar is spread. They shall be laid with their longest faces horizontal in full beds of mortar, and the joints shall be flushed with mortar.

The exposed faces of individual stones shall be parallel to the faces of the walls in which the stones are set.
The stones shall be so handled as not to jar or displace the stones already set. Suitable equipment shall be provided for setting stones larger than those that can be handled by two men. The rolling or turning of stones on the walls will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone re-laid with fresh mortar.

7.14.2.2.2 Bed and Joints

Beds for face stones may vary from 20 mm to 50 mm in thickness. They shall not extend in an unbroken line through more than 5 stones. Joints may vary from 20 mm to 50 mm in thickness. They shall not extend in an unbroken line through more than two stones. They may be at angles with the vertical from 0° to 45°. Face stone shall bond at least 150 mm longitudinally and 50 mm vertically. At no place shall corners of four stones be adjacent to each other
Cross beds for vertical faced walls shall be level, and for battered walls may vary from level to normal to the batter line of the face of the wall.

7.14.2.2.3 Headers

Headers shall be distributed uniformly throughout the walls of the structures so as to form at least one-fifth of the exposed faces. They shall be of such lengths as to extend from the front face of the wall into the backing of at least 300 mm. When a wall is 450 mm or less in thickness, the headers shall extend entirely from front to back face.

7.14.2.2.4 Backing

Backing shall be built mostly of large stones as shown in the approved Plans or as directed by the Engineer. The individual stones composing the backing and hearting shall be well bonded with the stones in the face wall and with each other. All openings and interstices in the backing shall be filled completely with mortar or with spalls surrounded completely by mortar.

7.14.2.2.5 Pointing

Both bed and vertical joints shall be finished as shown in the Plans or as directed by the Engineer. The mortar in joints on top of surface of masonry shall be crowned slightly at the center of the masonry to provide drainage.

7.14.2.2.6 Coping

Copings, if called for, shall be finished as shown in the Plans. Where copings are not called for, the top of the wall shall be finished with stones wide enough to cover the top of the wall from 450 mm to 1000 mm in length, and of random heights, with a minimum height of 150 mm. Stone shall be laid in such a manner that the top course is an integral part of the wall. The tops of top course of stone shall be pitched to line, in both vertical and horizontal planes.

7.14.2.2.7 Weep holes

It shall conform to the requirements of Clause 7.14.1.2.4.

7.14.2.2.8 Cleaning Exposed Faces

Immediately after being laid, and while the mortar is fresh, all face stones shall be thoroughly cleaned of mortar stains and shall be kept clean until the work is completed.

7.14.2.2.9 Curing

In hot or dry weather, the masonry shall be satisfactory protected from the sun and shall be kept wet for a period of at least three days after completion.

7.14.3 Coconet Bio-Engineering Solutions

This clause covers installation of coconut coir fiber made into geonets such as coconets, coco-logs, coco twines and coco peat as bioengineering materials for controlling soil erosion and slope stabilization in accordance with the cross section shown in the Plans or as directed by the Engineer.

7.14.3.1 Material Requirements

7.14.3.1.1 Coconut Coir

Coconut coir fiber materials for use in fabrication of coconut geonets shall be a multi-cellular fiber with 12 to 24 microns in diameter and the ratio of length to diameter shall be 35. The fiber shall also be hygroscopic, with moisture content of 10% to 12% at 65% humidity and 22% to 55% at 95% relative humidity.

7.14.3.1.2 Coco-net and Coco-log/Fascine

Coco-net and Coco-log shall conform to Table 22 and Table 23, respectively.

Table 22 – Physical Properties of Coco-net

Properties		COCONET 400	COCONET 700	COCONET 900
Thickness, minimum		10.0 mm		
Width, minimum		1.0 mm		
Length, minimum		25.0 mm		
Unit Weight, g/m^2		400±20	700±30	900±45
Diameter of Twine, Hand and Machine Spuns		5.0mm±0.50mm		
No. of Twines/m (Hand &Machine Spuns), minimum	Crosswise Direction	40	40	70
	Lengthwise Direction	40	70	70
Material		Woven Netting made from High Strength 100% Coconut fiber twine		
Color		Natural Earth Tone		
Tensile Strength, minimum		150 N/twine		
Elongation, minimum	Machine Direction, %	26	34	42
	Cross Machine Direction, %	32	38	32
Water Velocity, minimum		2.7 m/sec	3.35 m/sec	4.26 m/sec
Water absorption, minimum		163 %	146 %	132 %
Slope Inclination, H:V		≤ 1:1	1:1 to 60°	75°

Table 23 – Physical Properties of Coco-log

Type of Coco-log/Fascine	Diameter (mm)	Weight (min.) (Kg/m)
Cocolog 100	100	2.0
Cocolog 200	200	4.5
Cocolog 300	300	10
Cocolog 400	400	20
Cocolog 500	500	30

7.14.3.1.3 Backfill

Backfill shall be in accordance with the approved Plan and shall conform to the requirements of Clause 7.4.

7.14.3.1.4 Bamboo Stakes

Bamboo stakes shall be mature and shall be 30 to 40 mm in width and 300 mm long.

7.14.3.1.5 Live Plant Stakes (Live *Gliricidia sepium* (*Kakawate*) or *Leucaena leucocephala* (*Ipil-ipil)* or Equivalent Species)

Live plant stakes shall be kept moist and installed the same day they were prepared and shall be 50 to 150 mm in diameter and 500 mm to 1000 mm in length.

7.14.3.2 Construction Requirements

7.14.3.2.1 Quality Control

The coconut geonets manufacturer shall be responsible for establishing and maintaining a quality control program to assure compliance with the requirements of this Standard.

7.14.3.2.2 Equipment

Equipment and tools necessary for handling materials and performing all parts of the works shall be approved by the Engineer as to design, capacity and mechanical condition. The equipment shall be at the jobsite sufficiently ahead of the start of construction operations.

7.14.3.2.3 Site Measurement

Site measurements shall be done to prepare specific lengths of the coco-nets to conform the necessary area requirements and the necessary length for coco-logs to be installed/ placed.

7.14.3.2.4 Preparation of Bed

Site for net installation shall be graded and sloped to the approved design and any runoff control such as diversions, dikes and berms shall be completed prior to installation. All depression/gullies and eroded portions shall be backfilled for the coco-nets to snugly come in contact with the soil surface. The face of the slope shall be smoothened. Rocks, clods, vegetation (deemed detrimental to the erosion control system to be installed), and other obstructions shall be removed from tip to toe of the slope to ensure complete contact of the coco-nets with the soil.

Existing vegetation that is considered not detrimental shall be retained, but shall be trimmed down to facilitate the installation of the coconut geonets.

7.14.3.2.5 Anchoring

1. Common Soil – The coconut geonets shall be secured to the ground using bamboo pegs. An average of 3 pegs per square meter shall be used to ensure uniform contact of coco-net to the ground surface. For loose soils, longer pegs shall be used to have sufficient ground penetration to resist pullout.

2. Compacted Soil – A combination of bamboo pegs and U-shaped wire staples may be used for compacted, hard to penetrate soil. An average of 3

pegs/staples per square meter shall be used to ensure uniform contact of coco-net to the ground surface.

3. Hard Rock – The coconut geonets shall be anchored to solid rock surfaces using metal stake pins with a minimum diameter of 8.0 mm and length of 200 to 300 mm.

7.14.3.2.6 Installation/Placing of Coconut Geonets

The coconut geonets shall be used on critical cut slopes, embankments and disturbed soils generally steeper than 3:1, where water velocities are likely to wash out soils and new vegetation. Coco-nets shall be placed and anchored on the graded surface of the slope to maximize net contact with the slope surface. Installation shall begin at the top of the slope with the coco-net laid down and securely anchored 1.0 meter from the edge of the slope by folding underneath the leading edges of the coco-net to ensure that no twines would come loose. After which the coco-nets shall then be unrolled downslope in the direction of the water flow. Adjacent coco-nets shall be installed side-by-side and shall be sewn together using coco coir twine. The coco-nets shall be laid loosely (not stretched) on the ground. Coco-net shall then be fastened and secured firmly to the ground in accordance to Clause 7.14.3.2.5. Anchoring shall be at right angle to the ground surface.

When necessary, coco-log/fascines shall be used in conjunction with coconets installation to reduce long slopes and as major stopper of downward movement of soil as rainwater carries them downslope. It shall be placed across the slope on contour and shall be pegged with lives stakes to the ground at 1.0 m intervals. For slopes with loose soil, the coco-logs/fascines shall be installed on trenches. The trench shall be deep enough to accommodate half the diameter of the coco-logs. Contour interval shall be 1.0 m to 8.0 m depending on the steepness of the slope and the erodibility of the soil.

7.14.3.2.7 Placing of Coco Coir Peat (Soil Conditioner)

After the installation of coconut geonets, coco coir peat-soil mixture shall be distributed evenly on the net protected slope. Thumping and raking shall follow to make the mix settle underneath to ensure appropriate soil moisture and nutrient release as grasses and other planting materials shall be planted.

7.14.3.2.8 Vegetation

1. Vetiver Grass Hedgerow – Live hedgerow of vetiver grass (or any local suitable species) slips shall be planted on the slopes at 150 mm plant interval depending on the erosivity of the soil, the steepness of the slope, and the design waterflow.

   Row distance shall likewise depend on the steepness of the slope, and shall range from 1.0 to 4.0 m.

2. Grass cover – Fast growing leguminous creeping/twining grass cover shall be used for slope faces requiring immediate vegetative cover. It shall be applied

to the soil at a rate depending on the desired plant density and the calculated onsite mortality rate of the plants.

3. Trees – If trees shall be used to stabilize a slope, species that have sturdy, long, and deep-penetrating roots shall be selected.

Whereas, in water channels or rivers, appropriate plants that can thrive in water or water saturated condition, while functioning to prevent bank erosion shall be used. Numerous other considerations shall be taken into account in choosing the proper planting materials. These plant properties shall include, drought resistance, effect on local ecology, aesthetics, etc.

7.14.3.2.9 Performance Monitoring

Post project monitoring shall include checking on any breaks of the installed coconut geonets especially at the point of junctions, the growth of grasses and the manifestation of any failure of germination of plants and the sudden outburst of rain that might have inflicted damaged to some sections. Repair works shall be done on damaged sections of the slope and replacement shall be done in case of plant mortality.

Watering, weeding and fertilization may be done subject to the discretion of the Contractor's Bio-Engineer or Plant Specialist. Maintenance activities shall be terminated upon the recommendation of the bioengineer and approval of the owner.

7.14.4 Other Slope Protection Structures

If other types of slope protection will be used, it shall conform to the requirements specified in Part G – Drainage and Slope Protection of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15 Drainage

7.15.1 Pipe Culverts and Storm Drains

This clause shall consist of the construction or reconstruction of pipe culverts and storm drains in accordance with this Standard and in conformity with the lines and grades shown in the Plans or as established by the Engineer.

7.15.1.1 Material Requirements

Materials for pipe culverts and storm drains construction shall conform to the requirements specified in Item 500.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15.1.2 Construction Requirements

Construction of pipe culverts and storm drains shall conform to the requirements of Item 500.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15.3 Inlets and Catch Basins

This clause shall consist of the construction, reconstruction or adjustment of inlets and catch basins in accordance with this Standard and in reasonably close conformity with the lines and grades shown in the Plans or as established by the Engineer.

7.15.3.1 Material Requirements

Materials for manholes, inlets and catch basins construction shall conform to the requirements specified in Item 502.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15.3.2 Construction Requirements

Construction of manholes, inlets and catch basins shall conform to the requirements of Item 502.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15.4 Drainage Steel Grating with Frame

This clause shall consist of furnishing all materials, tools, and equipment including labor required in undertaking the proper application of steel grating with frame as shown in the approved Plans and in accordance with this Standard.

7.15.4.1 Classes and Uses of Road Gates and Frames

Classes of grates that are commonly used in drainage work are sump, trench and box.

Sump grates shall be used to create a trafficable ground level entry area for surface rainwater to flow into the underground storm water drainage system. Sump grates shall be used in paved or grassed areas that are graded to direct the surface water to a single pit or to a series of pits. Sump grates shall be plain or hinged.

Trench grates shall be used to collect surface rainwater run off from areas that cannot be graded to direct flow into a single pit.

Box grates or road drainage shall be used to transfer road surface storm water into an underground drainage system. Normally used in conjunction with kerb entry, the addition of the grate significantly increases the hydraulic capacity of the inlet, particularly on steep slopes.

7.15.4.2 Strength Classifications and the Loading Conditions for Sump, Trench and Box Grates

Class	Test Load	Description
Class A	10 kN	For locations trafficked only by pedestrians, wheelchairs and cyclists – inaccessible to motor vehicles by virtue of barriers, narrow passages or stepped or unpaved approaches.

Class	Test Load	Description
Class B	80 kN	For locations normally trafficked by pedestrians and slow moving passenger cars or light agricultural tractors. These locations include areas accessible to infrequent slow moving heavy trucks.Typical locations include footpaths, ground level and multistoried car parks, suburban driveways and back yards.
Class C	150 kN	For locations trafficked by slow moving fully laden trucks such as pedestrians, malls and industrial or commercial areas.
Class D	210 kN	For locations trafficked by fast moving fully laden trucks and forklifts with wheel loads to 5.0T. This includes all public roads from residential to freeway.
Class E, F, G	400 kN, 600 kN or 900 kN	For locations subject to vehicles such as large forklifts, earthmoving or container handling equipment and aircraft.Typical locations include wharves, container storage areas, heavy industry or construction sites and domestic or international airports.

All loading conditions specified above are applicable to the three classes of grates depending on their specific uses and locations.

7.15.4.3 Material Requirements

Materials for drainage steel grating with frame shall conform to the requirements specified in Item 503.4 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15.4.4 Construction Requirements

Construction of drainage steel grating with frame shall conform to the requirements of Item 503.5 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15.6 Ditches

This clause shall consist of the construction or reconstruction of roadside ditches in accordance with this Standard and in conformity with the lines and grades shown in the Plans or as established by the Engineer.

Materials and construction requirements for roadside ditches shall conform to the requirements specified in Clause 7.14.1 and 7.14.2.

7.15.7 Cleaning and Reconditioning Existing Drainage Structures

This clause shall consist of cleaning and reconditioning existing pipes and appurtenant structures in reasonably close conformity with this Standard and as shown in the Plans.

7.15.7.1 Material Requirements

Materials used for repair or replacement under the various Pay Items shall conform to the requirements of the applicable Items of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15.7.2 Construction Requirements

7.15.7.2.1 Pipe Removed and Cleaned

The pipe shall be carefully removed and cleaned of foreign material both within the barrel and at the jointed ends.

7.15.7.2.2 Pipe Cleaned in Place

All foreign materials within the barrel shall be removed and disposed by methods which will prevent damage to the pipe.

If approved by the Engineer, all or part of the pipe designated to be cleaned in place may be removed, cleaned, and relaid in accordance with the applicable clauses. In such cases, the Contractor shall furnish all materials required to replace damaged pipes and joints, perform all excavation and backfill, and relay the pipe, all at the contract bid price for this Item.

7.15.7.2.3 Relaying or Stockpiling Salvaged Pipe

Re-laying of pipe selected by the Engineer to be removed and cleaned shall be done as shown in the Plans, in accordance with the appropriate Item for the kind of pipe involved. The Contractor shall furnish all jointing materials and shall replace the pipe broken by him, in sufficient lengths to complete the designated length to be relaid without added compensation. Salvaged pipe to be stockpiled shall be placed as shown in the Plans and as directed by the Engineer. No pipe which has sustained structural damage shall be placed in stockpiles. The Contractor shall dispose of such damaged pipes at approved locations.

7.15.7.2.4 Reconditioning Drainage Structures

Structures such as manholes, inlets, and the likes, designated on the Plans or as directed by the Engineer to be reconditioned shall have all debris removed, leaks repaired, missing or broken metalwork replaced, and each structure left in operating condition.

7.15.8 Curb and/or Gutter

This clause shall consist of the construction of curb and gutter either Precast or Cast in place, made of concrete in accordance with this Standard at the location, and in conformity with the lines, grades, dimensions and design, shown in the Plans or as required by the Engineer.

7.15.8.1 Material Requirements

Materials for curb and/or gutter construction shall conform to the requirements specified in Item 600.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.15.8.2 Construction Requirements

Construction of curb and/or gutter shall conform to the requirements of Item 600.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16 Miscellaneous Structures

7.16.1 Sidewalk

This clause shall consist of the construction of asphalt or portland cement concrete sidewalk in accordance with this Standard and to the lines, grades, levels and dimensions shown in the Plans, or as required by the Engineer.

Shoulders and area above canals may be used for sidewalks and/ or bike lanes.

7.16.1.1 Material Requirements

Materials for sidewalk construction shall conform to the requirements specified in Item 601.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.1.2 Construction Requirements

Construction of sidewalk shall conform to the requirements of Item 601.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.2 Monuments, Markers and Guide Posts

This clause shall consist of project markers, right-of-way monuments, and/or guide posts, furnished and installed in accordance with this Standard at the locations, and in conformity with the sizes, dimensions and design, shown in the Plans, or as required by the Engineer.

7.16.2.1 Material Requirements

Materials for monuments, markers and guide posts construction shall conform to the requirements specified in Item 602.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.2.2 Construction Requirements

Construction of monuments, markers and guide posts shall conform to the requirements of Item 602.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.3 Guardrail

This clause shall consist of furnishing and constructing posts and guardrails of the types called for in the contract and in accordance with this Standard, at the locations, and in conformity with the lines and grades shown in the Plans, or as required by the Engineer.

7.16.3.1 Material Requirements

Materials for guardrail construction shall conform to the requirements specified in Item 603.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.3.2 Construction Requirements

Construction of guardrail shall conform to the requirements of Item 603.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.4 Fencing

This clause shall consist of furnishing and constructing posts and barbed wire or chain link fences in accordance with the details, and at the locations, shown in the Plans, or as required by the Engineer.

7.16.4.1 Material Requirements

Materials for fencing shall conform to the requirements specified in Item 604.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.4.2 Construction Requirements

Construction of fences shall conform to the requirements of Item 604.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.5 Road Sign

This clause shall consist of furnishing and installing road signs in accordance with this Standard and to the details shown in the Plans, or as required by the Engineer.

7.16.5.1 Material Requirements

Materials for road signs shall conform to the requirements specified in Item 605.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.5.2 Construction Requirements

Construction of road signs shall conform to the requirements of Item 605.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.6 Pavement Markings

This clause shall consist of placing markings on the finished pavement. The work shall include the furnishing of premixed reflectorized traffic paint or reflectorized pavement marking paint conforming to the requirements of AASHTO M 248, whichever is called for in the Contract, sampling and packing, preparing the surface, and applying the paint to the pavement surface, all in accordance with this Standard.

The paint shall be applied to the size, shape and location of the markings shown in the Plans, or as required by the Engineer.

7.16.6.1 Premixed Reflectorized Traffic Paints

Premixed reflectorized traffic paint is a paint in which the glass beads are mixed in the paint during the process of manufacture, so that upon application and drying, the paint line is capable of retroreflection of the light beams.

Premixed reflectorized traffic paints which are available in both white and yellow are paints that provide reflective marking for concrete, bituminous, bricks or stone surface of highways, bridges, tunnels, streets, parking lots and airports.

7.16.6.2 Classification

Premixed reflectorized traffic paint shall be classified according to the following types based on the vehicles used:

Type I	Alkyd
Type II	Chlorinated Rubber Alkyd

7.16.6.3 Material Requirements

Materials for pavement markings shall conform to the requirements specified in Item 606.2.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.6.4 Construction Requirements

Construction of pavement markings shall conform to the requirements of Item 606.2.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.7 Concrete Joint Sealant (Hot- Poured Elastic and Cold- Applied Types)

This clause shall consist of furnishing and placing joint sealant, composed of a mixture of materials that will form a resilient and adhesive compound capable of effectively sealing joints and cracks applied either hot or cold in concrete pavements, bridges and other structures, in accordance with this Standard and to the details shown in the Plans, or as directed by the Engineer.

7.16.7.1 Classification

This Standard applies to the following types of concrete joint sealant:

a. Concrete Joint Sealant Hot-Poured Elastic Type
b. Concrete Joint Sealant Cold-Applied Type

7.16.7.2 Material Requirements

Concrete joint sealants shall conform to the requirements specified in Item 613.2 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.7.3 Construction Requirements

Construction of concrete joint sealant shall conform to the requirements of Item 613.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.7.4 Delivery and Storage

Joint sealer shall be delivered in manufacturer's original unopened containers and packaging, with labels clearly identifying product name and manufacturer. The joint sealer shall be stored in dry and shaded area in accordance with manufacturer's instructions. Containers shall be sealed until it is ready for use. Expired joint sealer shall be removed from the site.

7.16.7.5 Sampling and Testing

Sampling shall be taken at the plant or warehouse prior to delivery or at the time of delivery. If sampling is done prior to shipment, the Engineer shall have the access to the materials to be sampled. The Engineer shall be provided all reasonable facilities for inspection and sampling shall be conducted so as not to interfere unnecessarily with the operation of the works.

Samples shall consist of one of the manufacturer's original sealed containers selected at random from the lot or batch of finished material that was manufactured simultaneously or continuously, as a unit between the time of compounding and the time of packaging or placing in shipping containers.

Obtain the hot-poured type sealant portion for testing from the selected manufacturer's original sealed container in accordance with ASTM D 5167. The sample portion added to and heated in the melter shall weigh 800 g ± 50 g.
Heat the material in accordance with ASTM D 5167.

Testing for hot-poured type sealant shall be in accordance with ASTM D 5329.

7.16.8 Chevron Signs

This clause shall consist of furnishing and installing chevron signs in accordance with this Standard and to the details shown in the Plans, or as required by the Engineer.

7.16.8.1 Material Requirements

Materials for chevron signs shall conform to the requirements specified in Item 620.3 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

7.16.8.2 Construction Requirements

Construction of chevron signs shall conform to the requirements specified in Item 620.4 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

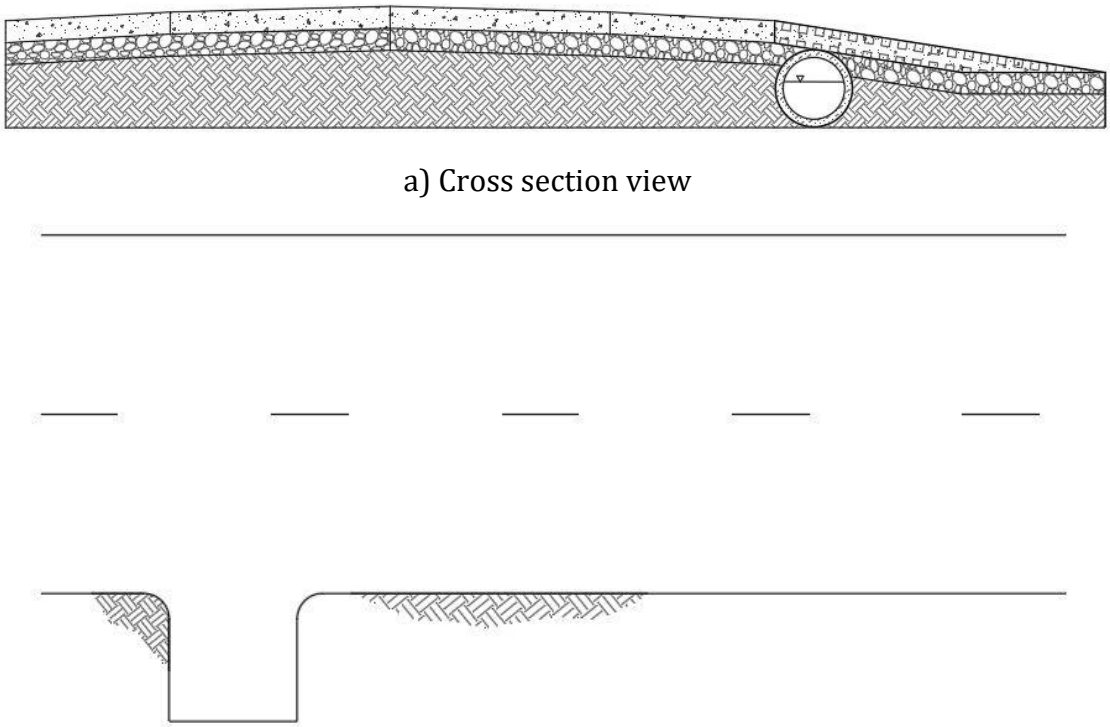
7.16.9 Access Facilities

This clause shall consist of furnishing and installing access facilities in accordance with this Standard and to the details shown in the Plans, or as required by the Engineer.

Access ramps shall be made of concrete with appropriate slope protection which shall conform to the requirements specified in Clause 7.14. Materials and construction for access ramps shall conform to the requirements in Item 404 and Item 405 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

Materials and construction for stairs shall conform to Clause 7.14.1, Clause 7.14.2, and Item 404 and Item 405 of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

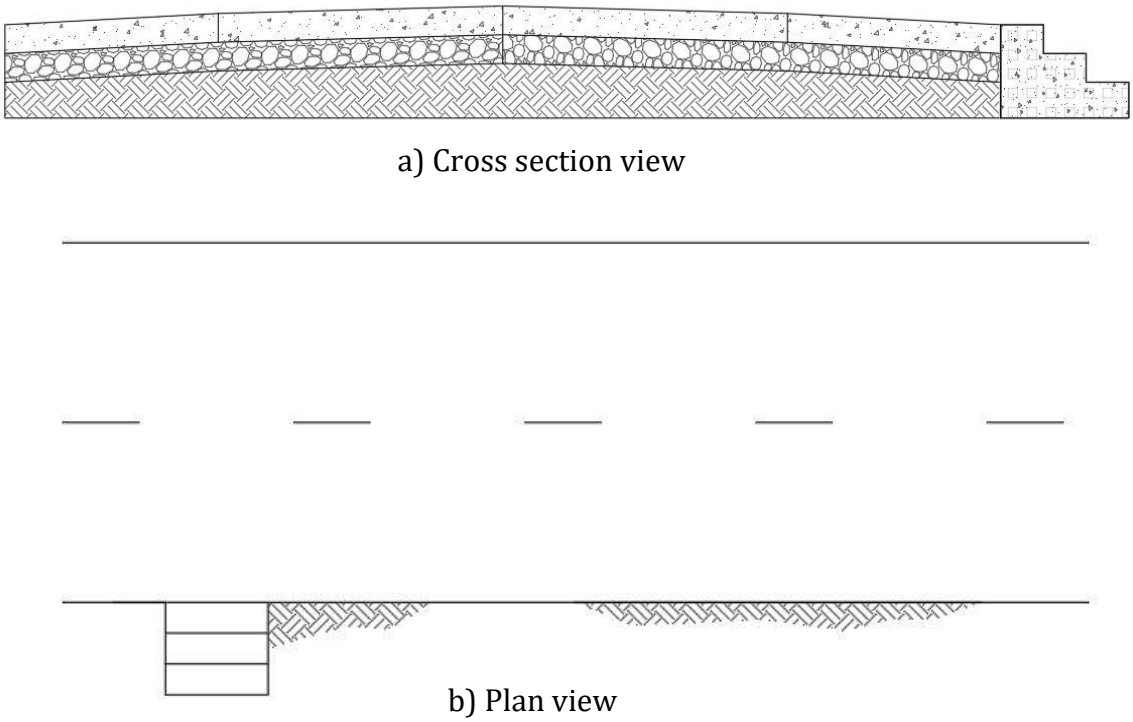
Access roads shall conform to the requirements specified in Clause 7.13. Examples of different access facilities are shown in Figures 17 to 19.



a) Cross section view

b) Plan view

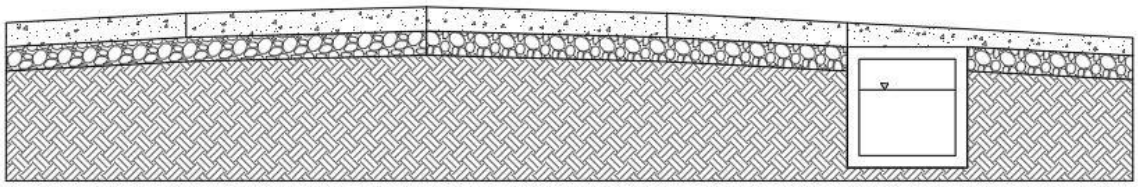
Figure 17 – Access ramp perpendicular to carriageway



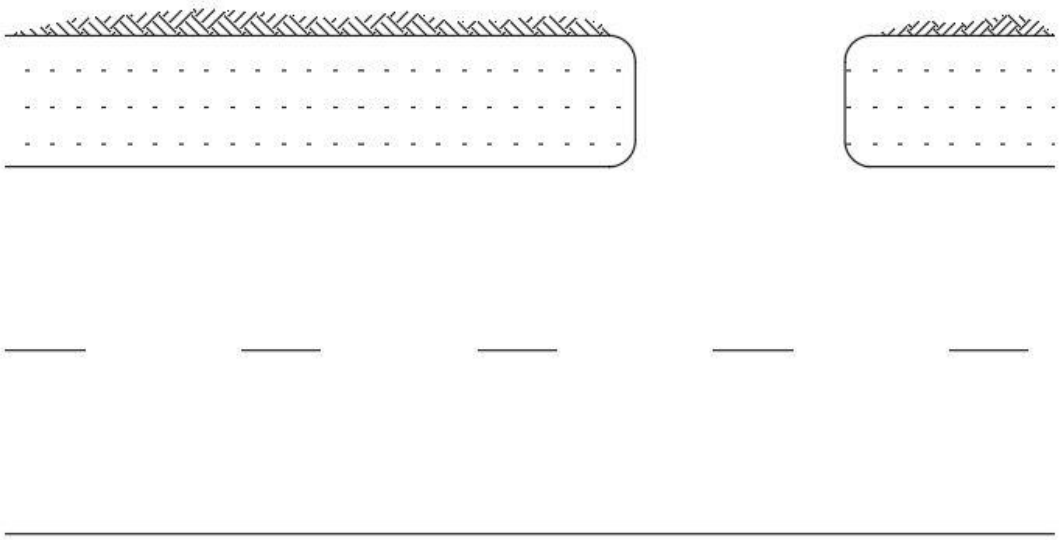
a) Cross section view

b) Plan view

Figure 18 – Reinforced concrete stairs as road access facility



a) Cross section view



b) Plan view

Figure 19 – Access road over irrigation canal

8 Operation and Maintenance of Farm-to-Market Roads

The operation and maintenance of FMRs shall be in accordance with the applicable provisions of the Operation and Maintenance Manual for Rural Infrastructure Sub-projects of the Philippine Rural Development Project. Defects and their corresponding corrective measure may be referred to the Annex 2A of the DPWH Department Order (DO) No. 41, series of 2016.

Annex A
(informative)

Sample Plan, Profile, and Cross section Plan of FMR

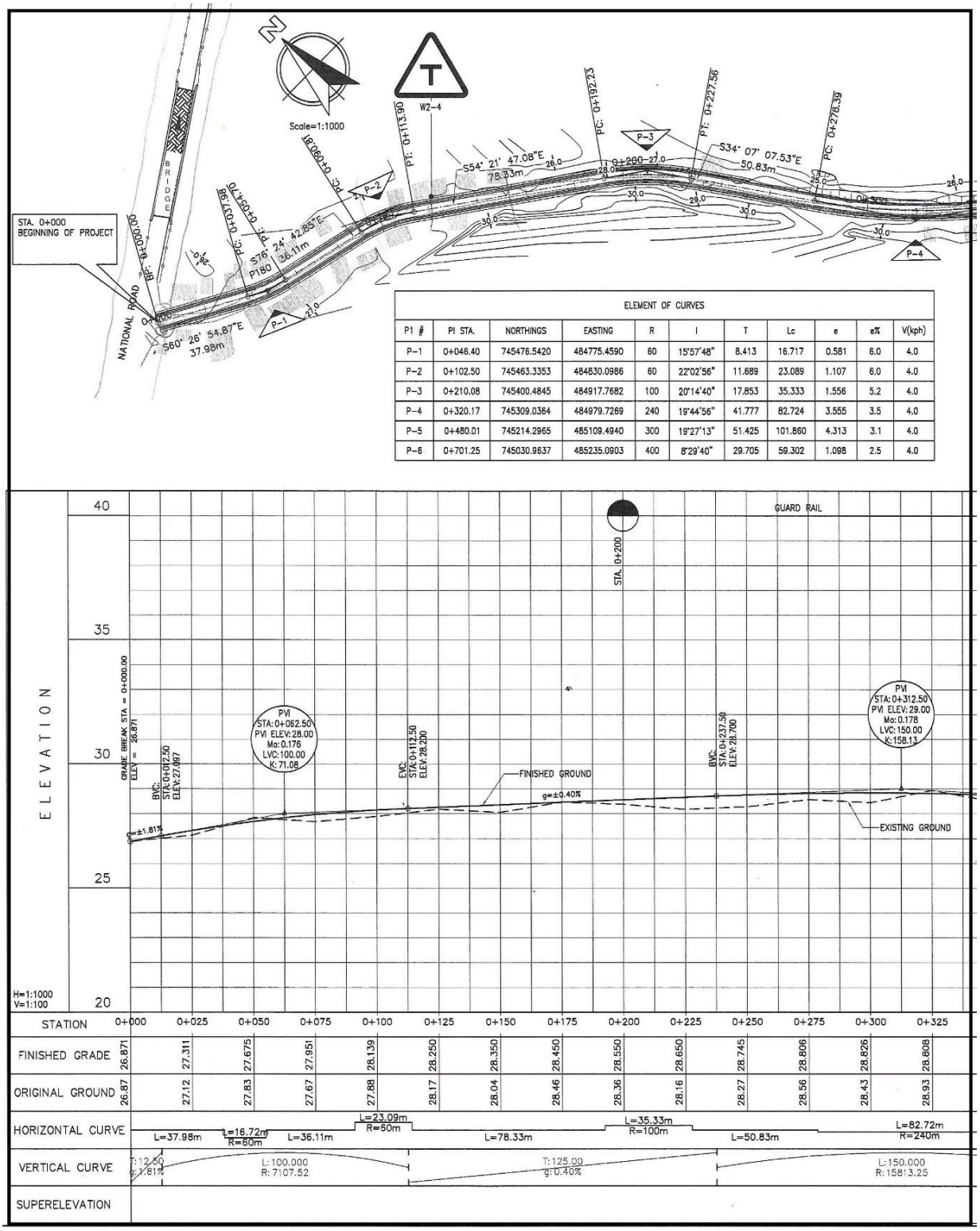


Figure 20 – Sample Plan and Profile of FMR

The following contents should be indicated in the Plan and Profile Sheets, as based in the DPWH DO No. 32, Series of 2011.

Plan:

1. The centerline, edge of pavement, shoulder edge, and road Right-of-Way limits
2. The stations at the centerline
3. The drainage structures (existing and proposed) are drawn indicating the direction of flow and the description/dimension;
4. The Azimuths, Distances and PI No. and check the orientation of the azimuth and its accuracy
5. The contour lines with the standard intervals
6. The Standard Reference and Control Points
7. The elements of horizontal curves including its limit and check if they are accurately indicated on the Plans
8. The North Arrow indicator
9. Description and type and limits of slope protection works and other roadside facilities/structures (existing or proposed)
10. Matchline at every sheet

Profile:

1. The elements of vertical curve including its limit
2. The gradient and finished grade elevation and verify if the natural or original ground elevation and the finished grade elevation plotted at every 20m interval as indicated on the plans is the same as indicated and template in the detailed roadway cross-sections
3. The matchline at every sheet
4. The existing and proposed drainage structures including its description properly drawn and indicated as per drainage schedule/cross-sections
5. The profile of the proposed side drainage indicating its slope gradient
6. The original and finished designed grade elevation at every 20m interval
7. The ordinary and maximum flood elevation for drainage structures including the flooded areas/sections
8. The superelevation and widening diagrams and check its application if they are properly indicated on the Plans
9. Pavement/subgrade data based on test pit/borehole where logged

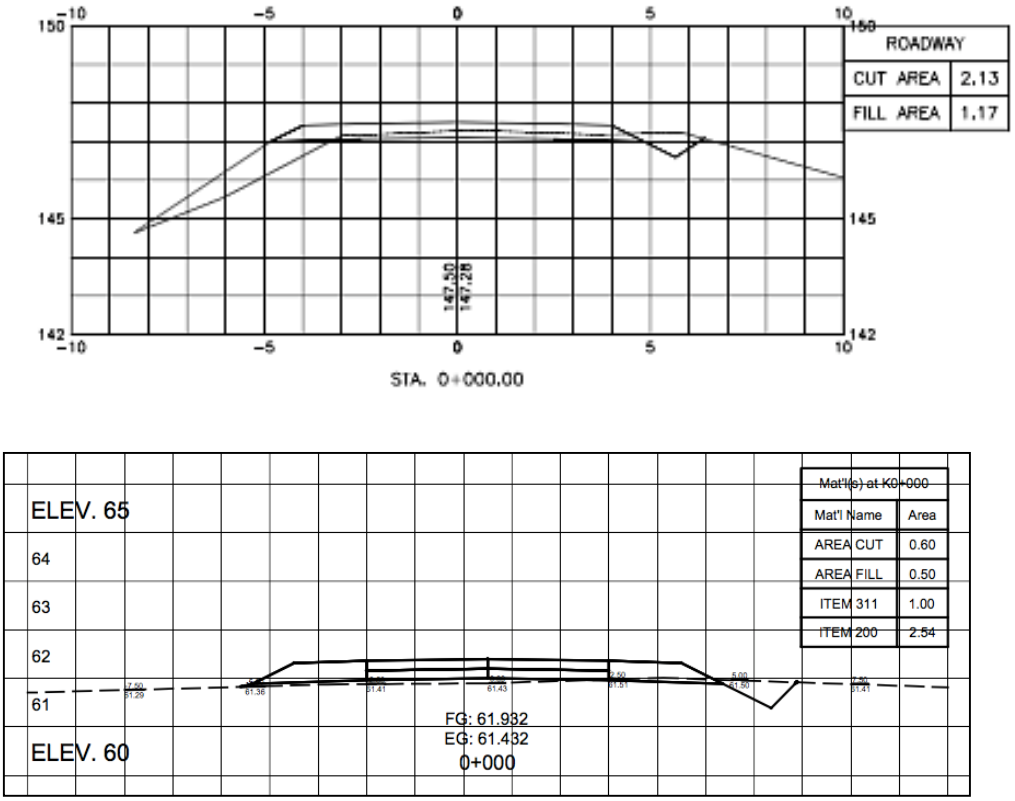


Figure 21 – Sample Cross-section Plan of FMR

Cross-section Plan should show:

1. The gridlines scaled at 1:100
2. The cross-section centerline
3. The station limit
4. The elevations
5. The end areas for cut and fill. Indicate soil classification of cut whether common earth (CE), unclassified Soil (US) or solid rock (SR).

Annex B
(informative)

Classification of Roads

Table 24 – Classification of roads based on jurisdiction

Classification	Description
National Roads[1]	National roads are classified as primary and secondary roads. The former forms the part of the main highway trunk-line system which is continuous in extent; the latter includes all access roads forming a secondary trunk-line system.
Provincial Roads[1]	Roads connecting one municipality to another, with the terminal to be the public plaza; plus roads extending from one municipality or from a provincial or national road to a public wharf or railway station.
City Roads[1]	Roads/streets within the urban area of a city not classified as provincial or national roads
Municipal Roads[1]	Roads/streets within the poblacion area of a municipality not classified as provincial or national roads
Barangay Roads[1]	Roads located outside the poblacion area of a municipality or urban area of a city and those outside industrial, commercial or residential subdivision (access roads to subdivisions are not barangay roads), and are not otherwise classified as national, provincial, city or municipal roads.

Table 25 – Classification of roads based on function

Classification	Description
Tourism Roads[1]	Tourism road is a road which marketed as particularly suited for tourist. Tourism road may be formed when existing road are promoted with traffic sign and advertising material. Others may be roadways enjoyed by local citizen in areas of unique or exceptional natural beauty. It is often developed because it promises to generate employment, enhance community infrastructure and assist in revitalizing the flagging economies in rural areas.
Farm to Mill Roads[2]	Roads connecting the sugarcane farms to any sugarcane processing facilities such as sugar mills, ethanol distilleries, biomass powerplants and other production facilities using sugarcane as raw material with specifications that can handle truckloads of sugarcane

Farm-to-Market Roads	See Clause 3.29
Expressways[1]	Divided arterial highways for through traffic, with full or partial control of access and generally with grade separations at major intersections.

[1]DPWH DGCS Volume 4 (2015)
[2]Implementing Rules and Regulations, Sugar Industry Development Act of 2015

Annex C
(normative)

Minimum Stopping and Passing Sight Distances

Table 26 – Design stopping sight distance on grades and level roadways

Design Speed (kph)	Downgrade			Upgrade			Level
	3%	6%	9%	3%	6%	9%	
20	20	20	20	19	18	18	20
30	32	35	35	31	30	29	35
40	50	50	53	45	44	43	50
50	66	70	74	61	59	58	65
60	87	92	97	80	77	75	85

[SOURCE: Table 3-8 and Table 3-9, DPWH Design Guidelines, Criteria, and Standards Volume 4, 2015]

Table 27 – Passing sight distance for design of two-lane roads

Design Speed (kph)	Assumed Speed (kph)		Passing Sight Distance (m)
	Passed Vehicle	Passing Vehicle	
30	11	30	120
40	21	40	140
50	31	50	160
60	41	60	180

[SOURCE: Table 3-11 DPWH Design Guidelines, Criteria, and Standards Volume 4, 2015]

Annex D
(normative)

Recommended Permissible Velocities for Channels

Table 28 – Permissible range of velocities for channels of different materials

Material	Range of Mean Velocity (m/s)
Concrete	0.6-3.0
Asphalt	0.6-1.5
Stone or block masonry	06-1.8
Dry Compact gravel or clay	0.6-1.0

[SOURCE: DPWH Design Guidelines, Criteria, and Standards for Public Works and Highways, Volume II (1984)]

Table 29 – Permissible velocities for channels of different materials at different mean depths

Soil Type (grain size, mm)	Mean Depth (m)			
	0.4	**1.0**	**2.0**	**3.0**
Boulders (<256)	4.6	5.1	5.8	6.2
Large Cobbles (256-128)	3.6	4.5	4.7	5.0
Small Cobbles (128-64)	2.3	2.7	3.2	3.4
Very Coarse Gravel (64-32)	1.6	1.9	2.2	2.5
Coarse Gravel (32-16)	1.3	1.4	1.6	1.9
Medium Gravel (16-8)	1.2	1.1	1.2	1.4
Fine Gravel (8-4)	1.0	0.9	1.0	1.2
Very Fine Gravel (4-2)	0.8	0.8	0.9	0.9
Very Coarse Sand(2-1)	0.5	0.6	0.7	0.8
Coarse Sand(1-0.5)	0.5	0.5	0.6	0.7
Medium Sand(0.5-0.25)	0.4	0.5	0.5	0.6
Fine Sand (0.25-0.125)	0.3	0.4	0.5	0.5
Sandy Loam (heavy)	1.0	1.2	1.4	1.5
Sandy Loam (light)	0.9	1.2	1.4	1.5
Loess (settled)	0.8	1.0	1.2	1.3

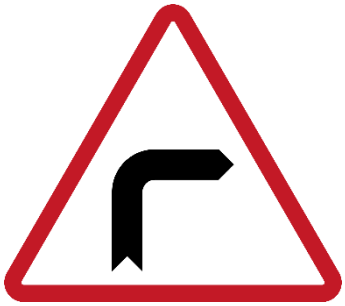
[SOURCE: DPWH Design Guidelines, Criteria, and Standards, Volume 3 (2015)]

Annex E
(informative)

Typical Road Safety Signs

Stop sign (R1-1)

Speed restriction sign at 60 kph (R4-1)



Sharp turn sign (W1-1)

Curve sign (W1-3)

Reverse curve sign (W1-4)

Stop and give way sign (W3-2)

Animal crossing sign (W5-10)

No through road sign (S2-8)

Chevron sign (HM1A)

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