طرح نگهداشت و افزایش تولید ۲۷ مخزن

SPECIFICATION FOR ROAD & PAVING

نگهداشت و افزایش تولید میدان نفتی بینک

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1. INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

GENERAL DEFINITION

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields Company (NISOC)
PROJECT:	Binak Oilfield Development – General Facilities
EPD/EPC CONTRACTOR (GC):	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of : Hirgan Energy – Design & Inspection(D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	The firm appointed by EPD/EPC CONTRACTOR (GC) and approved by CLIENT (in writing) for the inspection of goods.
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
MAY:	Is used where a provision is completely discretionary.

2. SCOPE

This specification covers the minimum requirement for the design, material, construction and testing of Road and Paving issues for Binak Oil fields project.

3. OREDER OF PREFRENCES

CONTRACTOR/SUBCONTRACTOR shall notify the COMPANY of any apparent conflict between the project specifications and drawing. Resolution and/or interpretation shall be obtained from the COMPANY in writing before proceeding with the design or construction.

In case of conflict, the order of precedence shall be:

Drawing

Specification

Standard

4. NORMATIVE REFERENCES

The design shall be in accordance with this specification and with the requirement and recommendations of the latest editions and supplements of the following documents:

4.1. NATIONAL CODES AND STANDARD

- **PROJECT STANDARDS**

BK-GNRAL-PEDCO-000-CV-DW-0003	Standard Drawing for Roads
BK-GNRAL-PEDCO-000-CV-DW-0035	Standard Drawing for Paving
BK-GNRAL-PEDCO-000-CV-SP-0004	Specifications for Earth Works
BK-GNRAL-PEDCO-000-ST-SP-0001	Specification For Concrete Work

- **IPS (IRANIAN PETROLEUM STANDARD) & THE NATIONAL BUILDING REGULATIONS (LATEST EDITION)**

IPS-E-CE-500	Engineering Standard for loads
IPS-M-CE-105	Material Standard for Building Material
IPS-E-CE-160	Engineering Standard for Geometric design of Roads and Streets
IPS-G-CE-182	Engineering & Construction Standard for Roads Surfacing and Pavements
Iranian National Building code	Specification and public works (publication 55)
Iranian National code	General Specification of Road (publication 101)
Iranian National code	Highway Geometric Design (publication 415)
Iranian National code	Iran Asphalt Pavement Manual (publication 234)
NPCS-CS-GC-06	
MPORG	Planning and Budget Organization CODES

4.2. INTERNATIONAL CODES AND STANDARDS

- **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM):**

ASTM-A 616	Rail steel deformed and plain bars for reinforced concrete
ASTM-C 33	Concrete aggregates
ASTM-C 90	Hollow load-bearing concrete masonry units
ASTM-C 117	Test for materials finer than No. 200 sieve in mineral aggregates by washing
ASTM-C 127	Test for specific gravity and absorption coarse aggregate
ASTM-C 128	Test for specific gravity and absorption of fine aggregate
ASTM-C 94	Standard Specification for Ready Mixed Concrete

ASTM-C 136	Test for sieve or screen analysis of fine and coarse aggregates
ASTM-D 113	Test for ductility of bituminous materials
ASTM-D 242	Specification for material filler for bituminous paving
ASTM-D 1559	Specification for asphalt cement for use in pavement mixtures construction (including tentative revision) test for resistance to plastic flow of bituminous mixture using material apparatus
ASTM-D 1075	Stability of job-formula
ASTM-D 2027	Specification for liquid asphalt (medium-curing type)
ASTM-D 2397	Specification for cationic emulsified asphalt
ASTM-D 3515	Standard Specification for hot-mixed, hot-laid bituminous paving mixtures
AASHTO T180	Modified protector compaction tests
ASTM-D 1557	Test for moisture density relations of soils using 10-1b rammer and 18inch drop
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM-D 4	Standard Test Method for Bitumen Content
ASTM-D 2397	Standard Specification for Cationic Emulsified Asphalt
ASTM-D 3515	Standard Specification for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures (Withdrawn 2009)
ASTM-D 946	Standard Specification for Penetration-Graded Asphalt Binder for Use in Pavement Construction
ASTM D 3282	Standard Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
ASTM-D 421	Standard Practice for Dry Preparation of Soil Samples for Particle-Size (Standard Withdrawn)
ASTM-D 4125	Standard Test Methods for Asphalt Content of Asphalt Mixtures by the Nuclear Method
ASTM-D 977	Standard Specification for Emulsified Asphalt
ASTM-D 1241	Standard Specification for Materials for Soil-Aggregate Subbase, Base, and

- **AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)**

AASHTO M145	Standard Specification for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
AASHTO	Guide to design of pavement structure (1993)

- **AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI CODE)**

ANSI-A 58.1-82	minimum Design Loads for Buildings and Other Structures

- **AMERICAN CONCRETE INSTITUTE (ACI CODE)**

ACI-360 2010	Guide to Design of Slabs-on-Ground

- **BRITISH STANDARD INSTITUTED (BSI)**

BS 1377	Engineering Standard for loads

5. ROAD DESIGN

Access road shall be designed in accordance with the "AASHTO guide for the design of pavement structures" (1993), Part II - Chapter "Highway Pavement Structural Design".

No design shall be carried out for the tracks. The following parameters shall be used for the design of road based on chapter 2 of the mentioned reference:

Road Type	R % Reliability	W_{18} $\times 10^6$(Total)	W_{18} $\times$ 10^6(Construction)	S° Standard deviation	M_R Ksi	P_O	P_t	Drainage Coefficient
all roads	80	1.50	0.80	0.50	40	4.20	2.50	1.00

The following minimum thickness shall be taken into account for the various layers:

- Road sub-base:200mm
- Road base: 150mm
- Surfacing:
- surfacing base course 60mm
- wearing course 40mm

5.1. TRANSVERSE SLOPES

Roads mostly shall be provided with a crown at the center line. Or may have one side slope in some situation. Streets shall be provided with one/two slope.

Transverse slope shall be a minimum of 2.0 percent.

5.2. LONGITUDINAL SLOPE

The maximum slope in the longitudinal direction for roads shall be 5 %. In some cases, this slope may be increased to 9 %, provided alternative access is available. For Streets, the maximum slope shall be 9 %.

5.3. ROAD DRAINAGE

Water collected on roads, streets and car parks shall run off to the non-contaminated water ditches.

5.4. DIMENSIONAL CHARACTERISTICS OF ROADS

The width of roads, Streets and shoulders shall be as follows:

Road Type	Width (m)	Width of shoulder (each side) (m)
Main access road	6.00	1.00
Road (To Flare Area)	6.00	No shoulder
Patrol road	6.00	No shoulder

5.5. ROAD MATERIALS

5.5.1. Subgrade:

The strength of the prepared subgrade shall be evaluated from the results of CBR tests.

5.5.2. Sub Base and Road Base

The sub base (maximum aggregate size 50mm) and road base granular material (maximum aggregate size 25 mm) shall be as follows:

- The sub base shall consist of granular, free-draining materials such as clinker, natural or crushed gravel, with the following properties:
- Granulometry: Type I, gradations A or B in accordance with ASTM D 1241 (or AASHTO M 147)
- Plasticity characteristics (ASTM D 2940):
  - Liquid limit: < 25
  - Plasticity index: < 6

The road base shall consist of crushed stone or natural graded granular material with the following properties:

- Granulometry: Type I, gradations C or D or Type II, gradations E or F in accordance with ASTM D 1241 (or ASHTO M 147)
- Plasticity characteristics (ASTM D 2940):
  - Liquid limit: <25
  - Plasticity index: NP

5.5.3. Surfacing

5.5.3.1. General:

Surfacing shall consist of bitumen bound materials. Coarse and fine aggregates for bituminous mixes shall be in accordance with the following tables:

Coarse aggregate for bituminous mixes (> 2 mm)		
Property	**Test**	**Specification**
Cleanliness	Sedimentation or decantation	< 5 % passing 0.075 sieve
Particle shape	Flakiness index	< 45 %
Strength	Los Angeles Abrasion Value (LAV)	< 30 (wearing coarse) < 35 (Other)

Abrasion	Aggregate Abrasion Value	(AAV) < 15
Polishing (wearing course only)	Polished Stone Value	Not less than 50 – 75
Water absorption	Water absorption	< 2 %
Fine Aggregate for bituminous mixes (< 2 mm)		
Property	**Test**	**Specification**
Cleanliness	Sedimentation or decantation	Percent passing 0.075 mm sieve: - Wearing courses < 8 % for sand fines < 17 % for crushed rock fines other layers: 22 %
Cleanliness	Sand Equivalent (Material passing 4.75 mm sieve)	Wearing course> 40 % Base Course > 50 %
Cleanliness	Plasticity Index (Material passing 0.425 mm sieve)	< 4

The material and mix components shall be as per the AASHTO designations.

5.5.3.2. Surfacing Courses

The surfacing base course shall be as per AASHTO designation as follows:

Sieve mm	**Percentage by mass of total aggregate passing test sieve**
28	100
20	95 – 100
14	65 – 85
10	52 – 72
6.30	39 – 55
3.35	32 – 46
1.18	-
0.30	7 – 21
0.075	2 – 8
Bitumen grade (pen) Bitumen content (per cent by mass of total mix)	60/70 5.00 ± 0.60

Minimum Stability KN at 60º	9.00
Flow mm	2 – 4

The surface wearing course shall be “rolled asphalt” as follows:

Sieve mm	**Percentage by mass of total aggregate passing test sieve**
28	100
20	100
14	90 – 100
10	50 – 85
2.36*	50 – 62
0.60*	35 – 62
0.212	10 – 40
0.075	6 – 10
Types of fines	Natural sand
Bitumen grade (pen) Bitumen content (percent by mass of total mix)	60/70 (as per ASTM D4) Minimum target value 6.00 ± 0.50**

***A maximum of 12 % should be retained between 0.60- and 2.36-mm sieves.**

****With 50 % coarse aggregate.**

The asphalt shall be in accordance with the AASHTO Standards. The preferred target for coarse aggregate is 50 %.

5.5.3.3. Prime and Tack Coats

Prime coat and tack coats shall be used respectively between:

- Road base and surfacing base course
- Surfacing base course and wearing course

The prime coat shall consist of a sprayed-on low viscosity (Max 500/min 250 mm^2/s) medium curing cutback bitumen MC-250. (In accordance with the ASTM D2170)

Tack coat shall be dilute bitumen emulsion type CSS 1h cationic (as per AASHTO M-208) or SS 1h anionic (as per AASHTO M-140).

5.5.3.4. Road Shoulders

Granular material for road shoulders shall be as for the road sub-base or road base material.

Surfacing is not applicable for road shoulders.

5.5.3.5. Approval of Materials and Bitumen Mix Formula

At least, one month prior to commencement of the work EPC Contractor shall submit to Client the characteristics of granular materials and bitumen mix formula, which shall be used on site.

The granular materials (either unbound, or bitumen bound) shall meet all quality requirements indicated in the above tables. EPC Contractor shall transmit these values to Client.

All materials shall be tested and approved before use. EPC Contractor shall notify Client the sources of materials and Client shall approve the sources prior to delivery of materials to the Site. Where the source of material does not meet the specification requirements, EPC Contractor shall furnish material from other sources. Delivery of materials produced from commercial manufacturing processes shall be accompanied by the manufacturer's certification and test report showing the materials comply with the specification requirements. For bitumen mix formula, EPC Contractor shall supply

- Type of bitumen (grade)
- Bitumen content (percent by mass of total mix) Stability (KN at 60 °C)
- Flow mm
- Compaction level (number of blows)
- Air voids.

The corresponding tests shall be repeated for each material delivery on site of:

- 5.00 m3 for granular materials
- 12.50 t of bitumen - bound materials

5.5.3.6. Storage and Handling of Materials

Materials shall be stored and handled to assure the preservation of their quality and fitness for the Works. Materials, even though approved before storage or handling, may again be inspected and tested prior to use in the Work. Stored materials shall be located to facilitate their prompt construction and Inspection.

Handling and stockpiling of aggregates shall always be such as to eliminate

integration or contamination of the various sizes. Stockpiles shall be kept flat and the formation of high cone shaped piles shall not be permitted.

Client may require the use of baffle-chutes or perforated chimneys, when trucks are used to construct stockpiles, the stockpiles shall be constructed one layer at a time with trucks depositing their loads as close to the previous load as possible. The use of tractors or loaders to push material deposited at one location to another location in the stockpile shall not be allowed during the construction of the stockpile, and their use shall be limited to levelling the deposited material only. Bin walls shall separate stockpile of aggregate located at permanent asphalt plant sites. Sand shall be stockpiled on asphalt or concrete floors. Client shall approve procedures at temporary asphalt plant sites.

Intermediate storage of hydrated lime and commercial mineral filler for equipment feeding the asphalt plant shall be in silos of adequate size to ensure a minimum of one day's continuous operation.

5.5.3.7. Inspection, Testing and Control of Materials

For verification of weights and measures, character of materials and determination of temperatures used in the preparation of the asphalt mixes, Client shall at all times have access to all portions of the mixing plant, aggregate plant, storage yards, crushers and other facilities used for producing and processing the materials of construction. Client will have authority to take samples and perform tests thereon of any material supplied to the site from any source whatsoever in order to establish their compliance with this specification and to accept or reject, as he deems necessary. Samples may also be taken by Client from completed work to determine compliance with this specification. The frequency of all sampling and testing shall be in accordance with this specification and/or as directed by Client.

5.5.3.8. Unacceptable Materials

Materials that do not comply with the requirements of this specification shall be rejected and removed immediately from the site of the works unless otherwise instructed by Client.

No rejected material or defects of which have been corrected, shall be used until Client has given prior approval.

5.6. ROAD CONSTRUCTION

Road construction shall be in accordance with the following criteria:

5.6.1. Horizontal Alignments, Surface Levels and Surface Regularity of Pavement Courses

The horizontal alignment, surface levels and surface regularity of pavement courses shall all be in accordance with the "AASHTO guide for the design of pavement structures" (1993), Part II - Chapter "Highway Pavement Structural Design".

5.6.2. Preparation of Subgrade

Immediately prior to placement of sub-base materials, the subgrade shall be scarified, moistened to its optimum moisture content and compacted to 95 % of Max. Dry density obtained when compacted as described in ASTM D 1557. The finished surface of the subgrade shall be smooth and shall be followed the true profile and elevation shown on the drawings.

Where unsuitable material is encountered, it shall be removed and replaced in accordance with “BK-GNRAL-PEDCO-000-CV-SP-0004 Specifications for Earth Works".

The subgrade, whether in cut or fill, shall be compacted in accordance with “BK-GNRAL-PEDCO-000-CV-DW-0003 Standard Drawing for Roads ".

The finished formation shall be to the levels, falls and shape required, be kept free of surface water wherever practicable and be free of ruts and ridges and all deleterious matter.

5.6.3. Construction of Sub-Base and Base Layer of Road

The transporting, laying, compacting and protection of sub-base and road base shall be in accordance with the "AASHTO guide for the design of pavement structures" (1993), Part II - Chapter "Highway Pavement Structural Design".

The material shall be placed in layers not exceeding 150 mm compacted thicknesses and within 1 % above and 2 % below optimum moisture content.

Fill compaction controls shall be carried out as follows:

- Three measures of density, moisture content and sieve per each 150 m3 of compacted fill with at least one measure per layer for materials on which these tests are convenient (soils with less than 25 % of weight due to grains > 20 mm). In the opposite, only plate loading tests shall be carried out

- One plate loading test per each 1,000 m3 of compacted fill with at least one measure per layer, for all types of soils
- Density shall be:
  - For the sub-base: > 95 % of Maximum Dry Density (4.50 kg Rammer) for all layers for at least 95 % of measures (all measures being > 90 % of Maximum Dry Density (as per ASTM D 1557);
  - For the road base: > 100 % of Maximum Dry Density (4.50 kg Rammer) for all layers for at least 97 % of measures (all measures being > 97 % of Maximum Dry Density (as per ASTM D 1557).
- coefficient of compressibility shall be at least:
  - 50 MN/m2 for sub-base and 80 MN/m2 (or road base under an increase in average pressure under the plate from 0 to 0.30 MN/m2.

Any soft spots, irregularities or depressions that develop in the surface of any layer shall either be corrected by loosening the surface of such areas and adding further material, or by removing the material in such areas and replacing with further approved material, as Client may decide, and re compacting so that the surface is smooth and uniform and follows the profile of the finished formation.

In the event of "heave" occurring during compaction, caused either by excessive build-up of pore water pressure or the ground water table being sufficiently high to affect construction techniques, either of the following procedures shall be adopted subject to the approval of Client.

- Sufficient time shall be allowed to elapse enabling the excess pore water to dissipate prior to further construction or compaction being carried out.
- The affected material shall be removed and approved alternative construction layers substituted. Any surface area of the layer, which is too high, shall be graded off, scarified and re-compacted to the full depth of the affected layer.

Any surface area of the layer, which is too low, shall be scarified and corrected by the addition of suitable material of the same classification and moisture content or other approved material laid and compacted in accordance with above.

EPC Contractor shall carry out additional testing if required by Client to ensure that the standard of compaction is satisfactory through the full depth of layer.

The area treated shall not be less than 30 m long and 2 m wide or such area determined by Client as necessary to obtain compliance with this specification.

5.6.4. Construction of Surfacing (base course and wearing course)

5.6.4.1. Transportation and Delivery of the Mixture

- The bituminous mixture, heated and prepared as specified, shall be transported from the mixing plant to the site of the work in vehicles cleaned of all foreign material and having tight, clean, smooth and bodies. Each truckload shall be tarpaulin covered, whenever the weather conditions

necessitate the use of such cover.

- Suitable means shall be taken to protect the material so it will arrive at the site of work in good condition and at a temperature between 120 °C and 165 °C.

5.6.4.2. Construction Methods

- All surfaces to be paved shall be completed for the full width of the roadway and shoulder prior to the application of the mixture.
- Before spraying the prime coat, the road base surface shall be completely cleaned by means of compressed air spray to surface.
- Before constructing the base course, a prime coat of MC-250 cut-back asphalt shall be applied to the surface over the full area to be paved at a rate of 2.00 liters per square meter of the surface and permitted to remain undisturbed for a period of not less than 24 hours. The cutback shall be applied at temperatures between 40 °C and 80 °C and applied by a mechanical sprayer.
- Before placing the wearing course, a tack coat of cutback asphalt shall be applied on the base course over the full area to be paved.
- The paving courses shall not be applied until the prime or tack coat is dry and will not "pick up" under traffic. In the event of road works being opened to traffic before or after compaction and receiving a coating of mud prior to priming operations, the mud shall be removed in order to restore the surface to an acceptable condition to receive the primer.
- The bituminous mixture and materials shall not be applied on a wet base, or when weather is foggy or rainy. Application shall not take place when the temperature in the shade is below 5 °C and descending. Approval for scheduling must be obtained from the Client.
- Spreading and finishing: upon arrival at the point of use, the mixture shall be spread and struck off to the profile grade, elevation, and cross-section indicated on the plans for each course. For this purpose, self-powered spreading and finishing equipment provided with a screed or strike off assembly shall be used distributing the material to the width practicable. Blade graders or drags shall not be permitted. The material shall be laid to give the proper cross section, and the spreading machine shall be capable of placing the weight per square meter of surfacing material required.
- Compaction: As soon after spreading as the mixture can bear the roller without undue displacement or hair cracking it shall be rolled in two stages, first with a 6-tones roller and then With a 10-tones roller until no further movement can be observed. The period between rolling of base course and wearing course shall be between 0 to 4 hours (when applied at the same period) depending on site temperature at the time of placement. Roller wheels shall be equipped with scraping and sprinkling devices and shall be kept properly moistened without excess oil or water. Rolling shall start at the sides and proceed toward the center. Each trip of the roller shall overlap the previous trip by at least 300 mm. Alternate trips of the roller shall be of slightly

different lengths.
The speed of the roller shall not exceed 5 Km/h. Rolling shall be continued until no further compaction can be achieved. Mechanical tampers shall be used for compaction in locations inaccessible to the roller.

- Construction joints: the placing of the mixture shall be as nearly continuous as possible and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is discontinued for such a length of time as to permit the mixture to be chilled.
  In such cases, when the work is resumed, the previously laid material shall be cut back so as to produce a slightly bevelled edge for the full thickness of the course. After removal of the old material thus disturbed, the edge shall be coated with tack coat and the mixture laid against the fresh cut. Hot smoothing irons shall be used for sealing the joints.
- Forms: The use of forms will not be required. However, the edges of the Pavement shall be accurately aligned by the use of string or wire lines or by any other suitable approved method.
- Protection of pavement: Sections of the pavement shall be protected from traffic until properly cooled and all new traffic shall be excluded from the newly (laid mixture until 12 hours after completion of the rolling.

5.6.5. Construction of Tracks

Tracks shall be constructed in two layers; base and sub-base layers.

5.6.6. Construction of Shoulders

Shoulders shall be compacted in the same manner as the sub base and the wearing course.

5.6.7. Control and Tests

A qualified independent laboratory at EPC Contractor's expense shall perform all controls and tests .
This laboratory shall be proposed by EPC Contractor and must be agreed by Client .
The laboratory shall send results of controls and tests simultaneously to Client and to EPC Contractor. No layer shall be covered before results of tests are transmitted to and approved by Client.

5.6.8. Road and Car Park Areas at the Construction Phase

Additional roads to be built at the construction phase shall be shown on the project drawings. At the construction phase, only the sub-bas and road base courses shall be installed.

At the completion of the construction phase and for all permanent roads, the surface shall be cleaned and re-shaped, and the wearing course shall be installed. Holes in the existing base course shall be filled with base course material.

5.6.9. Crash Barriers

Crash barriers shall be provided where considered essential to protect personnel and/or equipment and piping, i.e. at road crossings over and under pipe racks and pipe tracks, roads adjacent to pipe tracks, roads adjacent to steep slopes, T-junctions and sharp bends, along bridge. They shall also be provided where roads run along deep ditches or slopes. The crash barrier system shall consist of 1-beam steel supports, embedded in the soil at 3 m centers, to carry a guardrail of 0.75 m minimum height. All steelwork shall be galvanized. The system shall be able to absorb impact energy by deformation without collapse the impact energy shall be determined considering a vehicle of 5000 kg, traveling at a velocity of 50 km/h at an angle of incidence of 20°C. They shall be located in the road shoulder with the centerline of the barriers at 0.15 m from the limit between the road and the shoulder.

6. CONCRETE PAVING

6.1. DESCRIPTION OF PAVING

Paving for process trains and utilities areas shall be provided with elementary drainage areas. Areas shall be of square configuration as far as possible-Each drainage area shall have a catch basin located at low point. The drainage areas should be determined and surveyed. The relevant drainage authority shall be specified.

The difference of levels between high point and low point of paving shall be 150 mm. Slope of paving shall be between 0.50 % and 4 %.

No paving shall be required between roads and paving for process trains and utilities areas.

6.2. GENERAL

All concrete mixes for paving shall conform to the requirements of "BK-GNRAL-PEDCO-000-ST-SP-0001 Specification For Concrete Work ". Concrete kerbs shall be constructed where necessary to confine oily or chemical spills. Kerbs, when used in conjunction with a concrete slab, shall have dowels inserted into the slab, and shall have a construction joint between the slab and the kerb.

Concrete paving shall be constructed with expansion and contraction joints. All

expansion joints shall be made up with maximum 20 mm thick pre-molded joint filler, (non-extruded type) with an elastomeric oil resistant sealer. Joints shall be provided at a maximum spacing of 18m and shall be constructed using smooth dowels passing through the joint with a bond breaker on one side to allow for sliding of the dowel within the slab during expansion and contraction-

Transverse and longitudinal construction joints shall be 6 mm thick and shall be placed at maximum of 6.00 m and 4.50 m respectively and constructed with the reinforcement passing through the joints, pre-molded joint filler and elastomeric oil resistant sealer.

Either an expansion joint or a construction joint shall be provided at all locations where a change in plan dimension occurs.

Foundation plinths penetrating the paving shall be isolated from the paving by "Flexcell" or similar joint filler material and sealed with an elastomeric oil (or chemical at certain locations) resistant sealer such as "Aerolastic 1614" or similar as follows:

25 mm thick joints shall be used around foundations supporting structures and static or vibrating equipment.

6.3. SUPER HEAVY DUTY PAVING

Concrete paving for areas subject to very heavy vehicular traffic shall have a minimum thickness of 250 mm, reinforced with a double layer of welded wire fabric, and provided with a stable, well compacted base. The minimum size of reinforcement shall be 10mm steel wire fabric 200×200 mm, in accordance with ASTM A 185. All concrete pavements for super heavy-duty service shall be constructed using a thickened slab at all edges and joints where reinforcing or dowels are not continuous through the joints.

6.4. HEAVY DUTY PAVING

Concrete paving for areas subject to heavy vehicular traffic shall have a minimum thickness of 200 mm, reinforced with a double layer of welded wire fabric, and provided with a stable, well compacted base. The minimum size of reinforcement shall be 10mm steel wire fabric 200×200 mm, in accordance with ASTM A 185. All concrete pavements for heavy-duty service shall be constructed using a thickened slab at all edges and joints where reinforcing or dowels are not continuous through the joints.

6.5. MEDIUM DUTY PAVING

Concrete paving used in areas subject to vehicular traffic shall be constructed with a minimum thickness of 150 mm, reinforced with single layer welded wire fabric, and provided with a stable, well-compacted base. The minimum size of reinforcement shall be 10mm steel wire fabric 150×150 mm material in accordance with ASTM A 185.

6.6. LIGHT-DUTY PAVING

Concrete paving used in areas not subject to vehicular traffic or other heavy loading shall be constructed with a minimum thickness of 100 mm, reinforced with single layer welded wire fabric, and provided with a stable, well-compacted base. The minimum size of reinforcement shall be 8 mm steel wire fabric 150×150 mm material in accordance with ASTM A 185.

6.7. PAVING FINISH

Concrete paving shall be laid with a wood float finish.

6.8. BASE

In areas where the paving is light-duty type and the sub-grade is a well-compacted granular material achieving a minimum CBR value of 25 %, a base course is not required under the paving.

For all other areas concrete paving shall be constructed on a prepared base course. The base course construction shall be as for the road base for roads described in this specification. Thickness of base shall be 150 mm. All concrete paving shall be installed on a 500 (0.125 mm) gauge polyethylene sheet laid over the base or finished sub-grade.

6.9. PAVING CONCRETE

Concrete for concrete paving construction shall conform to the requirements of "BK-GNRAL-PEDCO-000-ST-SP-0001 Specification for Concrete Works", particularly for tests and QA/QC.

7. ASPHALTIC CONCRETE PAVING

7.1. MATERIAL

7.1.1. Aggregates

Aggregates shall consist of crushed stone, crushed or uncrushed gravel, screenings, sand, and mineral filler. Aggregates shall have a satisfactory local service record in bituminous pavement construction within the last five years. The source selected shall be approved by the Engineer. If the source selected is not approved because of inadequate quality and quantity, the EPC Contractor shall provide alternate source or sources of material. Material passing the No.200 sieve shall be designated as mineral filler. Mineral filler shall conform to ASTM D242.

7.1.2. Bituminous Material

The Bituminous material to be mixed the material aggregates shall be asphalt cement conforming to ASTM D946. The penetration grade (P.G.) shall be selected in accordance with the following:

- Parking and open storage area : 60-70 P.G.
- Roads : 60-70 or 85-100 P.G.

In addition, asphalt cement shall conform to the following requirements:

- After exposure in thin films in accordance with the requirements of AASHTO T 179, the penetration shall be not less than 45 % for range 85-100, and not less than 50 % for range 6070 penetration grades.
- After exposure in thin films in accordance with AASHTO T 179, the ductility of the asphalt residue, when tested in accordance with ASTM D113, shall be not less than 100 centimeters.

7.1.3. Aggregate Gradation

The aggregate gradation as determined by ASTM C 117 and ASTM C 136 and as selected by the Engineer shall conform to one of the following:

Sieve	**Percentage by Weight passing (square-mesh sieve)**		
Designation	Type 1	Type 2	Type3
25 mm (1 in)	100	--	--

Sieve	**Percentage by Weight passing (square-mesh sieve)**		
19 mm (3/4 in)	90	100	--

12.50 mm (1/2 in)	--	90-100	100
9.50 mm (3/8 in)	70-85	80-95	80-95
No. 4	50-65	55-72	55-73
No. 8	38-53	40-55	45-60
No.50	12-26	14-27	17-30
No-200	4-8	4-8	4-9

7.1.4. Composition of Mixture

- Job-mix formula

The Job-mix formula shall be submitted by the EPC Contractor and no bituminous mixture shall be manufactured until the mix has been approved by the Engineer. The formula shall indicate the percentage or each sieve fraction of aggregate, percentage of bituminous (by Weight) in the job-mix formula shall be accordance within limits for dense mixtures indicated in ASTM D 3515.

The asphalt mixture shall be prepared and tested in accordance with ASTM D 1559.

- Test Properties of Bituminous Mixtures

The apparent specific gravity, as determined by ASTM C 127 and ASTM C 128, with bitumen, and the mixture shall meet the following requirements as determined by ASTM D1559:

Test Property	**50-Blow Compaction**
Stability, minimum, pounds	500
Flow, maximum, 0,25 mm (1/100-in)	20
Voids total mix, %	3-5
Voids filled with bitumen, %	75-85

- Stripping of Aggregates

If the index of retained stability of the job-mix formula is less than 75 when tested in accordance with ASTM D1075, the aggregates shall be rejected or treated by one of the following procedures:

- Addition of heat-stable additives to bitumen.
- Addition of hydrated lime, or other cementitious material containing free lime, as a portion of the mineral filler.

7.2. EQUIPMENT

7.2.1. Mixing Plant

The mixing plant shall be a weigh-batch or continuous-mix type approved by the Engineer and operated as required to produce a mixture within the job-mix formula.

7.2.2. Bituminous Material Spreaders

Bituminous material spreaders shall be self-propelled, capable of producing a finished surface conforming to the smoothness requirements specified hereinafter. The use of a spreader that leaves indentations or other objectionable irregularities in the freshly laid mix will not permitted.

7.2.3. Blowers and Brooms

Blowers and brooms shall be the power type suitable for cleaning the surface to be paved.

7.3. SAWS

Saws shall be the power type, capable of rapidly cutting pavement and trimming joints and edges of pavement.

7.3.1. Small Tools

Small tools available for the work shall consist of the following:

Rakes, lutes, shovels, tampers, smoothing irons, pavement cutter, portable heater for heating small tools, wood sandals of standard type, and other small tools as required. A sufficient number shall be available at all times. The lutes shall be constructed of metal and shall consist of a plate or sheet 90 cm × 10 cm attached to a handle properly branched. Hand tampers shall weigh not less than 10 Kg and have a tamping face not larger than 320 square centimetres.

7.3.2. Steel-Wheeled Rollers

Steel-wheeled rollers shall be self-propelled, three-wheel or tandem type, weighing not less than 10 tons. The rollers shall have adjustable wheel scrapers, water tanks, and sprinkling devices to keep the wheels sufficiently wet to prevent the bituminous mixture from sticking to the wheels. The rollers shall be capable of reversing without backlash and free from worn parts.

The rollers wheels shall not have flat or pitted areas or projections that leave marks in the pavement.

7.3.3. Rubber Wheeled Rollers

Rubber wheeled rollers must be of a self-propelled type and weight of which as well as the tire inflation pressure shall be adjustable. The wheels of the roller shall be so spaced that one pass will accomplish one complete coverage equal to the rolling width of the machine. There shall be a minimum of 1 cm overlap of the tracking wheels. During compaction, the rollers shall be operated at a low and constant speed and shall not exceed 8 Km/hr for rubber wheeled rollers.

Furthermore, they shall reverse directions of travel gradually and gently without undue shock.

7.4. CONTROL TESTS

7.4.1. General

Prior to laying a bituminous course, the underlying surface of prepared subgrade, base course, or pavement shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, and hand brooms, as directed. The surface shall be inspected by the Engineer to determine its fitness to receive treatment. The surface to be paved shall receive a prime coat or a tack coat as per specification.

- No greater shall be treated in any one day than is planned to be covered by asphalt concrete during the same day, unless otherwise authorized by the Engineer.
- A prime coat according to article 4.5.3.3. shall be applied.
- before the asphalt concrete pavement is placed upon an existing hard surface pavement, a tack coat of either 200-300 paving asphalt at an approximate rate of 1kg per square meter or grade SS-TH emulsified asphalt (per ASTM D2397) at an approximate rate of 0.23 to 0.45 liter per square meter shall be uniformly applied upon the existing pavement.

7.4.2. Transportation of Bituminous Mixture

The bituminous mixture shall be transported from the mixing plant to the site in trucks having tight, clean, smooth bodies with a minimum coating of concentrated solution of hydrated lime and water to prevent adhesion of the mixture. Each load of mixture shall be covered with canvas or other suitable material to protect the mixture from the weather and to prevent loss of heat. Mixture having temperature will be greater than 175 °C, or less than 115 °C, or which foam or show indications of moisture will be rejected. Hauling over freshly laid material will not be permitted.

7.4.3. Placing Bituminous Mixture

Contact surface of previously constructed pavement, curbs, manholes, and other structures shall be sprayed with a tack coat of asphalt. The mechanical spreader shall be adjusted and its speed regulated so that the course being placed shall be smooth and continuous without tears or pulls. The course shall be of such depth that after compaction the cross-section grade and contour shall be as shown on the drawings. In areas where the use of machine spreading is impractical, the mixture shall be spread by hand. Spreading by hand shall be performed carefully to avoid segregation of the mix. Broadcasting of the material will not be permitted.

Lumps that do not break down readily shall be removed. Wood or steel forms may be used to assure correct grade and cross section. Unless otherwise directed, placing shall being on the high side of areas with a one-way slope or along the centerline of areas with a crowned section and shall be in the direction of the main traffic flow. Placing of mixture shall be as continuous as possible, and the speed of placing shall be adjusted, as directed to permit proper rolling.

7.4.4. Compaction of Bituminous Mixture

The compaction of mixture shall be accomplished by steel-wheeled rollers. Rolling shall be as soon after placing, as the mixture will support the roller without undue displacement. Rolling of the course shall be continued until all roller marks are eliminated and at least 97 % of the density of a course shall be continued until all roller marks are eliminated and at least 97 % of the density of a laboratory specimen of the same mixture subjected to 50 blows of a standard

Marshall Hammer (per ASTM 1559) on each side of the specimen is obtained. The speed of the rollers shall not exceed 50 m/min, and at all times be slow enough to avoid displacement of the hot mixture. The initial pass of roller shall be with the driving wheel loading- The wheels of the roller shall be moistened to prevent adhesion of the mixture. In areas accessible to the roller, the mixture shall be compacted with hot hand tampers.

7.4.5. Joint of Pavement

The joints between old and new pavements or between lanes of new work shall be constructed so as to ensure uniform bond, texture, density, and smoothness as in other sections of the course. Edges of existing pavement shall be cut to straight, vertical surfaces. All content surfaces of existing pavement shall be sprayed or painted with a uniform tack coat of asphalt.

7.4.6. Protection of Pavements

After final rolling, no vehicular traffic shall be permitted on the pavement for at least 6 hours after rolling.

7.4.7. Finishing Surface Requirements

The finished surface shall not vary more than 6.50 mm from a 3 meters straightedge. The straightedge shall be furnished by the EPC Contractor- Defective areas shall be corrected by and at the expense of the EPC Contractor.

7.4.8. Grading

The grade shall be properly shaped to the required elevations and parallel to the required surface. The elevation of any point and the line of any edge or center of the paving shall conform to that shown on the drawings within the tolerances stated below.

	Tolerances from True Level
General Grading	+ 25/-5 mm
Tank Foundation	+5 /-5 mm
Foundations	+25/-25 mm

7.5. TRAFFIC PAINT

7.5.1. Traffic Paint shall be of Acrylic Thermoplastic Type:

Materials-acrylic / thermoplastic paint shall be rapid hardening (less than one hour hardening in 200C dry), resistance to abrasion and water. It shall have high degree of bonding to asphalt or concrete surfaces. Color of such paints shall be white unless noted otherwise on drawings.

Specific gravity of paint shall be 1.40 to 1.60 grams per cubic centimetres. Solid shall comprise 60 to 66 percent V/V. Other requirements of the paint - not specified above - shall be as per latest revision of BS-3662 Specifications for hot applied thermoplastic road marking materials",

" Workmanship - surfaces to receive paint, shall be dry, free from grease, salt, dust, chips, and any other deleterious materials. Any old paint shall be made rough by scouring with abrasives.

Thickness of dry film shall be 0.20 to 0.30 mm paint shall be well mixed before application, but mixing with solvents shall be minimized. Specified expiry dates marked on tins shall be strictly adhered to.

7.5.2. Sampling and Testing

The EPC Contractor at locations directed shall perform sampling for the determination of thickness and density of the completed pavements. One sample shall be taken for each 1000 square meters of the completed pavement with a minimum of 2 samples. All tests necessary to determine conformance with the specified requirements will be performed by the laboratory. The EPC Contractor is responsible to deliver the samples to the laboratory.

The EPC Contractor shall replace the pavement where samples are removed at his expense. No payment will be made for areas of pavement deficient in composition, density, or thickness until they are removed and replaced by the EPC Contractor as directed by the Engineer.

7.6. KERBS

Inverted kerbs shall be provided at the external edges of paving which are not adjacent to foundations.

The kerb shall extend from the top of paving to 150mm below grade and shall be cast integrally with the paving.

7.7. PLINTHS AND SUPPORTS

Minor equipment, steel platforms and pipe supports may be supported directly on paving. The allowable loading on the paving due to vertical load and applied moments, will depend on the soil conditions, the sub-base, thickness of paving, reinforcement and distance from the edge of paving. Allowable loading shall be determined by the EPC CONTRACTOR.

Where minor equipment, steel platforms and pipe supports are supported directly on the paving, the design of the plinths shall allow for their construction after the paving has been laid. Details of pipe support plinths shall be shown on standard detail drawings and located in the field by referring to the relevant piping drawings.

8. GRAVEL PAVING

8.1. MATERIAL

8.1.1. General

Gravel shall be composed of particle that shows evidence of mechanical crushing. The principal constituents of this material may be granular fragments of quartz and feldspar.

It may also contain fragments of granite rock. Gravel shall be free from vegetable matter and other deleterious substances. Gravel shall consist of material passing through 3/4inch sieve and retained on No. 4 sieve. Gravel conforming to the requirement specified above shall have a percentage of wear not to exceed 50 percent after 500 revolutions.

8.1.2. Graduation Requirement

Material used for gravel paving shall be clean and particle size should be between 4.75 and 19 mm and minimum compacted thickness must be at least 100 mm.

8.1.3. Sample

The sample of proposed material (one cubic meter) shall be delivered to the job site for sampling and approval of the Engineer before additional deliveries are made.

8.2. INSTALLATION

8.2.1. Subgrade

During construction, embankments and excavations shall be kept shaped and drained. Ditches and drains above subgrade shall be maintained in such a manner as to drain effectively at all times. The finished subgrade shall not be disturbed by traffic or other operations and shall be protected and maintained by the EPC Contractor in a satisfactory condition until surfacing id placed. No surfacing shall be laid until the subgrade has been checked and approved. Surfacing shall not be placed on a muddy, spongy, or frozen subgrade. Just before placing gravel surfacing, the EPC Contractor shall recheck subgrade, fill and compact holes and swales, and perform all grading to shape the subgrade to the grade lines and elevations shown on the drawing.

• Following the approval of the subgrade, it shall be rolled with a approved roller weighing not less than 10 tons, until compacted to Min, 100 % to modified AASHTO density.

This operation shall include any reshaping, scarifying of native soil, and wetting or aeration required to obtain the specified compact density. All soft or otherwise unsuitable material shall be removed and replaced with suitable material from excavation or borrow as approved. All large stones encountered in the excavation shall be removed or broken off to a depth of not less than 150 mm below the subgrade. The resulting area and all other low section, holes or depressions shall be brought to the required grade with suitable material and the entire subgrade shaped to line, and cross section and compacted to the specified density. Subgrade compaction shall be extended to include the shoulders with less than 100 % percent modified AASHTO density.

8.2.1.1. SUBGRADE DRAINAGE

Water-Bearing strata should be intercepted some distance away from the roadway section. Ditches should be constructed to such a depth as to ensure that free water in the ditch will always be below base-course level. In dealing with the problems of subgrade drainage, due consideration should be given to both ground-water and surface infiltration.

8.2.2. Clean-Up

The EPC Contractor shall remove from the site and dispose of ail excess and unsuitable material as directed by the Engineer. The EPC Contractor shall leave the site clean of any debris or other foreign materials, leaving the work area clean and suitable for final acceptance.