طرح نگهداشت و افزایش تولید 27 مخزن

CIVIL DESIGN CRITERIA

نگهداشت و افزایش تولید میدان نفتی بینک

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IFA: Issued For Approval
AFD: Approved For Design
AFC: Approved For Construction
AFP: Approved For Purchase
AFQ: Approved For Quotation
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REVISION RECORD SHEET

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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 design criteria document outlines the method of calculation and general requirements for civil engineering design. The civil design and construction work includes the following:

- Site facilities
- Surface drainage system
- Sewerage
- Pipe crossings
- Concrete basins
- Fencing & Gate
- Earth work activities

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

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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

4.1.1. PUBLICATION NO.101 GENERAL SPECIFICATION FOR ROADS AND HIGHWAYS

4.1.2. IPS - IRANIAN PETROLEUM STANDARDS:

IPS-E-PR-725	Engineering Standard for Process Design of Plant Waste Water Sewer System
IPS-E-CE-380	Engineering Standard for Drain and Sewer Systems Outside Buildings
IPS-E-CE-200	Engineering standard for Concrete structure (latest edition)
IPS-C-CE-200	Construction standard for Concrete structure
IPS-G-CE-182	Road Surfacing and Pavements
IPS-E-CE-140	Retaining Walls and Slope Protection
IPS-E-CE-400	Sanitary Sewage Treatment
IPS-G-CE-270	Fencing and Gates
IPS-C-CE-112	Earthworks Activities
IPS-E-CE-160	Engineering standard for Geometric design of roads and street
IPS-E-CE-170	Engineering and Construction Standard for Culvert Bridges and Related Structures.
IPS-E-PR-725	Engineering Standard for Process Design of plant waste water sewer system.
IPS-E-CE-342	Engineering Standard for Water Supply and Sewerage Systems
IPS-E-PR-850	Engineering Standard for Process Requirements of vessels, reactors and separators
IPS-C-CE-132	Engineering Standard for Foundations, Piles and retaining Walls.
IPS-M-CE-345	Engineering Standard for Water Supply and Sewerage Equipment
IPS-M-PI-190	Material and Equipment Standard for line Pipes.

4.1.3. NISOC STANDARDS - NATIONAL IRANIAN SOUTH OIL FIELDS COMPANY

4.1.4. NATIONAL IRANIAN BUILDING REGULATIONS: CHAPTER NINE, "DESIGN, FABRICATION AND ERECTION OF REINFORCED CONCRETE STRUCTURES. LATEST EDITION.

4.2. INTERNATIONAL CODES AND STANDARDS

4.2.1. ASTM-AMERICAN SOCIETY FOR TESTING AND MATERIALS:

ASTM 4595-11	Standard Test Method for Tensile Properties of Geotextile by the Wide-Width Strip Method
ASTM D4885-01	Standard Test Method for Detem1ining Performance Strength of Geomembrane by the Wide Strip Tensile Method.
ASTM D2261-11	Standard Test Method for Tearing Strength of Fabrics by tongue Procedure
ASTM D4533-11	Standard Test Method for Trapezoid Tearing Strength of Geotextile.
ASTM D556-10	Standard Test Method for Detennining Small-Strain Tensile Properties of Geogrids and Geotextiles by IN-Air Cyclic Tension Tests.
ASTM D5035-11	Standard Test Method for Breaking Force and Elongation of Textile Fabrics
ASTM A82	Standard Specification for steel welded wire Reinforcement, Deformed or Concrete
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

4.2.2. GRI- GLOBAL REPORTING INITIATIVE:

GRI-GCL3	Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners
GRI-GCL4	Gripping of Reinforced GCLs to End Platens During Direct Shear Testing
GRI Standard Practice CG4(a)	Determination of the Long-Term Design Strength of Stiff Geogrids
GRI Standard Practice CG4(b)	Determination of the Long-Term Design Strength of Flexible Geogrids
GRI test Methods GM9	Cold Weather Seaming of Geomembranes

GRI Specification GM10	The Stress Crack Resistance of HDPE Geomembrane Sheet
GRI test Methods, GM13	Test Methods, Test Properties and Testing Frequency for High Density Polyethylene Smooth and Textured Geomembranes.
GRI Test Method GM14	Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
GRI Test Method GM17	Test Methods, Test Properties and Testing Frequencies for linear low-Density Polyethylene (LLDPE) Smooth and Texture Geomembranes
GRI Test Method GM18	Test Methods, Test Properties and Testing Frequencies for Flexible Polypropylene Nonreinforced and Reinforced Geomembranes
GR Test Methods GM21	Test Methods, Properties and Frequencies for Ethylene Propylene Diene Terpolymer Nonreinforced and Scrim Reinforced Geomembranes.
GRI Test Methods GM22	Test Methods, Required Properties and Testing Frequencies from Scrim Reinforced Polyethylene Geomembranes Used in Exposed Temporary Applications.
GRI Test Method GM25	Test Methods Test Properties and Testing Frequency for Reinforced Linear Low Density Polyethylene Geomembranes.
GRI standard –G53	Selecting In-situ Monitoring Methods and Devices for the Elevation of Geosynthetic Performance.
GRI Test Method	
GRI Standard Practice GT7	Determination of the Long-Term Design Stress of Geotextiles.
GRI Test Method GT10	Test Methods, Properties and Frequencies for High Strength Geotextiles Tubes Used as Coastal and Riverine Structures.
GRI Test Method	Installation of Geotextile Tubes Used for Coastal and Riverine Structures.
GRI Test Method GT12a	Test Methods and Properties for Nonwoven Geotextiles Used as Protections Materials.
GRI Gt 13a	ASTM Version Test Methods Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate.

GRI GT13 (b)	ISO Version Test Method and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregates

4.2.3. AASHTO-AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

4.2.4. ACI -AMERICAN CONCRETE INSTITUTE

ACI-318	Building code Requirements for Reinforced Concrete
ACI 350 R	Environmental Engineering Concrete Structures

4.2.5. BS-BRITISH STANDARD

4.3. THE PROJECT DOCUMENTS

BK-GNRAL-PEDCO-000-CV-SP-0004	Specification for Earth Work
BK-GNRAL-PEDCO-000-CV-SP-0002	Specification for Road and Paving
BK-GNRAL-PEDCO-000-CV-SP-0005	Specification for Sewer and Drainage

5. SITE FACILITIES

5.1. AREA FILLS AND GRADING

In general, grading shall be performed to provide extensive, reasonably level areas of new and old facilities construction. The site shall be cutting (Minimum 300 mm) from un-suitable top soil However, All fill material shall be suitable for construction thereon, and all fills intended to carry loads shall be compacted to not less than 95% modified AASHTO density.

All areas which are to be excavated or filled shall be cleared of debris and vegetation and stripped to a depth of at least 30cm or as directed by the site engineer to remove all organic materials.

5.2. SLOPE PROTECTION (IPS-C-CE-132)

5.2.1. GENERAL (IPS-C-CE-132)

The areas to receive slope protection shall be dressed smooth according to the slopes or shapes called for on the drawings and shall be free from stumps, organic matter, or

waste material. A filter blanket should be provided where it is anticipated that there may be migration of fines through the protection layer.

5.2.2. RIP-RAP PROTECTION (IPS-C-CE-132)

Stone for rip-rap shall be placed on the prepared slope surface in a manner to produce a reasonably well graded mass of stone with the minimum practicable percentage of voids, and shall be constructed to the lines, grades, and thickness shown on the drawings or as directed by AR. Rip-rap protection shall be placed to its full course thickness at one operation and in such a manner as to avoid displacing the underlying material .

Unless otherwise authorized by the AR, the rip-rap protection shall be placed in conjunction with the construction of the embankment with only sufficient lag in construction of the rip-rap protection as may be necessary to prevent mixture of embankment and rip-rap material.

5.2.3. PRECAST CONCRETE ELEMENTS (IPS-C-CE-132)

Precast concrete elements may be manufactured on the job or at a regular masonry unit manufacturing plant. If reinforcement is required, it shall be furnished and placed as shown on the drawings. All blocks shall be of the limiting dimensions shown on the drawings .

Plant manufactured slabs shall be uniformed in texture with true sharp edges. Plant manufactured blocks shall comply with ASTM specification C 90. Blocks shall be laid in horizontal course and successive courses shall break joints with preceding courses. Weep holes shall be provided through the protection cover as shown on the working drawings or as directed by the AR.

5.2.4. MASONRY (MORTAR RIP-RAP FOR SLOPES) (IPS-C-CE-132)

Stone for this purpose shall, as far as practicable, be selected as to size and shape in order to secure fairly large, flat surfaced stone which will lay up with a true and even surface and a minimum of voids. Spaces between the larger stones shall be filled with stones of suitable size, leaving the surface smooth, reasonably tight, and conforming to the contour required .

As each of the larger stones is placed, it shall be surrounded by fresh mortar and adjacent stones shall be shoved into contact. After the larger stones are in place all of the spaces or openings between them shall be filled with mortar and the smaller stones then placed by shoving them into position, forcing excess mortar to the surface and ensuring that each stone is carefully and firmly bedded laterally. After the work has been completed all excess mortar forced up shall be spread uniformly

to completely fill all surface voids. All surface joints shall then be roughly pointed .

Weep holes shall be provided through the protection cover as shown on the drawings or as directed by the AR .

Mortar shall not be placed in freezing weather. During hot, dry weather the work shall be protected from the sun and kept moist for a minimum of 3 days after placement. Rock shall be kept wet during placing of the mortar .

5.2.5. GEOSYNTHETIC DESIGN

5.2.5.1 MATERIALS

- **Geomembranes**

Required Geomembrane thickness shall not be less than 1.5 mm. the EPC contractor is responsible to submit certificates of full compliance to the owner before manufacturer selection .

- **Geotextiles**

Required Geotextile grade shall not be less than 542 gr/m2. The EPC contractor is responsible to submit certificates of full compliance to the owner before manufacturer selection .

All Geotextiles used as separation between subgrade soil and aggregate. The EPC contractor is responsible to submit certificates of full compliance to the owner before manufacturer selection .

- **Other Geosynthetics**

Material specification shall be proposed by EPC contractor and approved by the Owner.

5.2.5.2 DESIGN

For engineering calculation and design for geosynthetic materials reference shall be made to “DESIGNING WITH GEOSYNTHETICS” by R.M.Koerner or any other internationally-accepted reference subject to the owner’s approval .

5.2.5.3 INSTALLATION AND CONSTRUCTION

Installation and construction of geosynthetic materials shall be according to manufacturer’s standard .

5.2.5.4 INSPECTION AND QUALITY CONTROL

Testing, Inspection, quality control and quality assurance of geosynthetic materials shall be according to manufacturer's standard.

5.3. PAVING

5.3.1. TYPES OF PAVEMENTS (IPS-G-CE-182- CLAUSE 6)

Pavements can be classified into two groups, i.e. flexible and rigid

5.2.5.5 FLEXIBLE PAVEMENTS (SUB BASE, BASE, BINDER, AND SURFACE COURSES) (IPS-G-CE-182- CLAUSE 6.1)

Flexible pavement is made up of a series of layers, with the highest-quality materials at or near the surface. Sub bases are generally composed of inexpensive, locally available materials, while the base courses contain high-quality processed materials. In most cases the base course consists of crushed stone or gravel.

- **Asphalt Paving**

Design for flexible paving shall be based on local conditions at the individual plant sites because of the varying soil conditions and availability of base materials.

Road ways shall be sloped min.2% on the crown. Subgrade shall be shaped and rolled to provide a uniform compacted surface for application of base course material.

If fill is necessary, the engineer shall specify the removal of all top soil, organic material, or other soil incapable of supporting intended loads. In general, the minimum of fills will be 200mm. Following the removal of unsuitable soils the Subgrade shall be scarified to a depth of 150mm and compacted to 95% of the maximum density obtainable by the ASTM P1557 method of compaction.

If borrow is required, the engineer shall specify suitable material. Fill shall be compacted to 95% unless otherwise required by soil report.

Suitability of borrow shall be confirmed by the Engineer based upon inspection of the source by certified laboratory tests of samples for plasticity index, sieve analysis, compaction, CBR, swell and etc. Design thickness shall be based upon the design CBR or the subgrade given in soil report or estimated from classification data.

5.2.5.6 RIGID PAVEMENTS (IPS-G-CE-182- CLAUSE 6.2)

A rigid pavement is designed primarily on the basis of its resistance to bending, and essentially, Portland cement concrete is the sole type of pavement in this category .

The application of mechanics to concrete-pavement design requires a knowledge of the behaviour of the pavement, among which are included sub grade soils, sub base materials, concrete aggregates, cement, reinforcing steel, dowel and tie bars, etc. Likewise the external forces which act on the pavement must be thoroughly considered. As this type of pavement has very limited use in the Oil Industries' roads, therefore only reference is made to relevant publications of important organizations, i.e. AASHTO, etc.

All roads and paved areas shall be designed for the loads as specified in design criteria for loads and forces and the required thickness calculated. The designed thickness or the following minimum values shall be used for all roads and paved areas, whichever is greater:

5.2.5.7 PAVING THICKNESS:

All Plant Roads and Paved Areas subjected to vehicular loading shall have the following minimum thicknesses:

a) **Asphalted Roads and Paved Areas**

- Wearing Course, 40mm asphaltic concrete.
- Binder Course, 60mm asphaltic concrete.
- Base Course, 150mm granular materials.
- Sub Base Course, 200 mm.

b) **Concrete Pavements**

- 250mm thick concrete slab, reinforced with 200 mesh □200□8 mm r
- 150mm thick base course of granular materials.

Walkways and Paved Areas not subjected to vehicular loading shall have the following minimum thicknesses:

- 100mm thick concrete slab, reinforced with 150 mesh , □150□8 reinforcin

- 150mm thick base course of granular materials

5.2.5.8 PAVING ELEVATION

High point of the paving shall be near the centre of the process operations areas and it shall be sloped a minimum of 0.5% to drain. Paving shall slope away from all equipment foundations to prevent water damage to foundation and preserve bearing capacity.

5.2.5.9 PAVING DESIGN

Final design thickness of pavements shall be appropriate to vehicular or other acted loadings. Paving slabs adjacent to foundation pedestals columns, etc. shall be separated by remoulded joint filler and sealer.

In the case of large areas covered by pavement slabs, the slabs shall be subdivided into square, rectangle or other convenient shapes by use of expansion joints. Such expansion joint should be placed at the high points of the slab in order to discourage infiltration of water below the slab. Other kinds of joints such as contraction, construction, control and etc. should be used as necessary.

Reinforced concrete paving shall be foreseen in areas in which may be hydrocarbon/polluted spillage. Paving in areas liable to the spillage of either caustic or acid solutions shall be curbed and shall prove according to project specifications.

Medium and heavy paving may support minor equipment, like small pumps, and staircase, light skid mounted packages, Pipe Supports with Max weight of 20kN on each support .

Concrete paved areas shall be parted into rectangular sections limited by expansion joints. These joints shall not be more than 16-20m apart and shall extend to the full depth of concrete paving. Expansion joints shall be 20mm width and shall be filled with hot bitumen or with suitable material hydrocarbon resistant. Higher part of joint shall be sealed with polystyrene or with suitable non-extruding material.

In correspondence of expansion joints shall be foreseen dowel bars for transferring at least 20% of the load across the joint. Dowel bars shall consist of smooth steel bar 25mm diameter, 1000mm long with at a spacing of 500mm. Half-dowel bars shall be coated to prevent bond between two sections of R.C. slab.

Contraction joints shall not be more than 6m apart. They shall be 10mm wide and 10mm deep sealed with suitable material non-extruding. The cut in concrete shall be made after casting.

Isolation joints shall be foreseen between paving and foundations projecting above grade.

5.4. ROADS

5.4.1. GENERAL

Roads in and around process areas shall be for movement of the mobile equipment planned for the facilities.

All roads shall be min. 6 meters wide. Shoulder should be used as necessary.

Shoulder width shall be as shown on drawings.

5.4.2. CLASSIFICATION OF ROADS AND STREETS (IPS-E-CE-160)

Roads and Streets of Iranian Petroleum Industries are classified by location and function as follows:

5.4.3. LOCATION (IPS-E-CE-160)

-Roads are traffic arteries outside of built-up areas .

-Streets are traffic arteries within built-up areas.

5.4.4. FUNCTION (IPS-E-CE-160)

a) Major streets or primary roads

The function of these roads or main traffic arteries is to serve or connect the main functional areas of a petroleum installation .

They are capable of carrying the largest volume of traffic and the heaviest types of vehicles anticipated .

b) Secondary streets or secondary roads

These streets or roads supplement the main system by providing access within each functional area. Secondary streets and roads are capable of carrying a moderate volume of medium-weight traffic with the occasional passage of maximum weight vehicles.

c) Lesser streets or tertiary roads

These streets and roads provide for traffic to individual buildings or groups of

buildings or patrolling road within functional areas .

They are capable of carrying a moderate volume of light-weight traffic .

Patrol road will be classified as C type and other road will be classified as A and B .

5.4.5. PRELIMINARY CONSIDERATIONS (IPS-E-CE-160)

Before designing roads and streets of any classification the following factors should be considered .

5.2.5.10 GENERAL FACTORS (IPS-E-CE-160)

a) Coordination with the master development plan .

b) Funds available .

c) Topography and physical features of the area. (For more detailed information refer to IPS E-CE-110, "Soil Engineering").

d) Cost of alternative road designs .

e) Climatic conditions .

Special consideration shall be given to design for protection of sub grades and shoulders in typhoon areas .

f) Required life expectancy .

The expectancy must be comparable to the useful life of a served facility. Usually the design year is about 25 years from the date of completion of construction but may range from the current year to 25 years depending on the nature of the improvement.

5.2.5.11 SPECIFIC REQUIREMENTS (IPS-E-CE-160)

In addition to the above general factors, the following surveys, studies, and explorations should be conducted, as required :

- Reconnaissance survey
- Preliminary survey
- Location survey
- Traffic estimate

- Weight and size considerations
- Subsurface conditions.

5.4.6. TRAFFIC LOADS

Traffic loads shall be in accordance with Iranian bridge loading code (Pub. No 139 of Planning and Budget Organization). Designing of roads will be in accordance with “Specification for Road & Paving”, (BK-GNRAL-PEDCO-000-CV-SP-0002)

5.5. SURFACE DRAINAGE SYSTEM

5.5.1. GENERAL

For all cited areas, it is essential that surface water be carried away promptly, other by surface runoff resulting from a suitable cross section, or by separate storm drains. Adequate subgrade drainage is provided by either elevating the section, ditching, nullah drains or sub drains.

The surface drainage system of the PLANT shall be based mainly on open drainage ditches. The use of catch basins, storm drains and culverts shall be minimized. The surface drainage system wil be designed according to “Specification for Sewerage & Drainage”, (BK-GNRAL-PEDCO-000-CV-SP-0005)

5.5.2. STORM WATER

Amount of storm water and its gathering network should be based on the various Intensity-duration foundations of rainfall, depends on the region as reported by the meteorological authorities. (For more information see specification for sewer & drainage).

The surface storm water runoff shall be determined by rational method from the following equation:

$Q = 2.778\ C.I.A.$

Where

Q = Rate of Runoff (litters/sec)

C = Runoff Coefficient

I = Design Rainfall Intensity

A = Area of the Drained Surface (hectares)

The run off coefficient C shall be taken as follows :

-Paved areas and roof surfaces: 1.0

-Roads and Roads shoulders: 1.0

-Gravelled and unpaved areas: 0.5

-Landscaped areas (sandy soil): 0.1

-Landscaped areas (clayey soil): 0.5

The surface storm water is discharged directly to a nearby natural watercourse.

For the calculation of each gathering line “time of concentration” shall be considered for using the intensity rainfall equation.

5.5.3. DRAINAGE AREA

Paved process areas shall be divided into individual drainage areas having a maximum surface of 400 m2.

The paving slope towards relevant catch basin or drain shall be within 1% to 4%.

Unpaved areas upstream of any plant area road or yard may drain into ditches or catch basins.

5.5.4. CLEARANCE BETWEEN LINES

Minimum clear space between underground sewer lines shall be 300mm .

5.5.5. VELOCITY

Flow velocities within 0.9 m/s and 1.2 m/s are recommended in gravity pipe systems.

Minimum velocity for lines flowing full shall be 0.6 m/s. This shall be increased to 0.9 m/s where water should carry solid particles such as sand or etc.

Maximum velocity shall be 1.5 m/s, higher velocity may be reached for short runs (5m) only.

5.5.6. STORM WATER DESIGN

5.2.5.12 CROSS SECTION SIZING

Pipes and ditches shall be calculated according to Manning Formula:

$V = Q/S = (1/n) \times R^{2/3} \times s^{1/2}$ Velocity (m/s)

Q = Flow Rate (m^3/s)

A = Cross Section Wet Area (m^2)

P = Perimeter Wet Area (m)

R = A/P = Hydraulic Radius (m)

n = Manning Roughness Coefficient (s/m1/3)

Cast and Ductile Iron: 0.013

Carbon Steel: 0.013

Concrete: 0.013

Asbestos Cement: 0.011

Concrete Ditches: 0.014

s = Bottom slope

5.2.5.13 MINIMUM SLOPE IN DITCHES

Minimum slopes in ditches shall be as follows:

-Trapezoidal ditches: 0.001

-Rectangular ditches: 0.0015

Any change in slopes may be evaluated properly for a minimum and maximum flows expected in the ditch.

5.2.5.14 FREE BOARD

Free boards of ditches shall be added to above calculated water level of drainage as follows:

- 0.15m for drainage ditches with capacities up to 0.5 m^3/s.
- 0.30m for drainage ditches with capacities up to 1.4 m^3/s.
- 0.45m for drainage ditches with capacities 1.4 m^3/s and above.

5.6. SEWAGE SYSTEM

5.6.1. SOURCE

Sanitary sewer will collect waste from lavatories, toiles, shower, urinals, drinking fountains, kitchen facilities, sinks and may include building floor drains where hydrocarbon is not present.

Drains where hydrocarbon, rain water, etc. should not be discharged into this sewer. Designing of sewage system will be designed according to “Specification for Sewerage & Drainage”, (BK-GNRAL-PEDCO-000-CV-SP-0005)

5.6.2. FLOW OF SEWER

The rate of flow for the sanitary sewer shall be estimated based on following consideration.

a) Person/day/shift to be considered.

b) Average daily consumption of water per capital.

c) Any exceptional peak discharge due to simultaneous to fixtures in a building like shower building.

Generally 90% of the total water supply is converted to waste water and considering delivered to sewers.

5.6.3. SANITARY WASTE COLLECTION

Sanitary waste shall be collected from lavatories, showers, toilets, urinals, kitchen facilities, sinks, building floor drains, drinking fountains by underground/above ground pipes.

Each building shall have a sewer connection which shall be connected to main sewer/lateral sewer lines through manholes.

All building sewers are collected from a group of buildings and finally join with main sewer of the plant.

Main sewer shall carry the total waste to treatment plant. It is preferred to discharge by gravity system, in the treatment plant based on available level. However if levels do not permit, then intermediate pumping shall be provided.

5.6.4. SEWER DESIGN

Sanitary sewer shall be designed based on following considerations. The velocity in sewer should not be less than 0.6 m/s when running 1/2 full. Normally this velocity may be kept as

0.90m/s at design flow. So that slope of sewer can be designed accordingly which shall be minimum slope.

The maximum velocity in the sewer is recommended as 1.5m/s when running $^{3}/_{4}$ full at a slope which shall be maximum slope.

5.2.5.15 SIZE OF SEWER PIPE

The minimum size from a building shall be of diameter 150mm, however the minimum size will be 200mm in case of serving more than one building.

5.2.5.16 HYDRAULIC FORMULA

Manning's formula shall be used for sizing the sewer links.

5.2.5.17 SEWER APPEARANCES

Manholes shall be provided on sanitary sewer (gravity system). The location of manhole shall be as given below:

a) Where main sewer header direction changes.

b) Where there are abrupt changes of gradient or invert level of sewer.

c) Where there is change in pipe diameter.

d) Where there is an interconnection of main sewer headers with lateral headers.

Manholes spacing shall be as given below.

Sewer diameter	**Recommend max spacing of manhole**
Up to 300 (12”)	40 m
350(14”)and above	60 m

All manholes shall be liquid-tight and of reinforced concrete construction.

5.6.5. MATERIAL

Pipe Material of sanitary sewer that commonly used is given as below:

a) Concrete pipes.

b) Cast Iron pipes.

c) HDPE, PVC pipes.

d) GRP pipes.

Material of sewers shall be selected based on type of soil, practice and strength of pipes required as per the requirements of designer and owner. Pipe material of sanitary sewer will be finalized according to “piping material specification”, (BK-GCS-PEDCO-120-PI-SP-000).

5.6.6. PIPE CROSSINGS

Piping below roads shall be run in sleeves or culverts, as applicable. Direct burial for non- process lines is usually the rule. Pipe crossings shall be installed so that the angle between the road way axis and the axis of the crossing is as near 90 degrees as is practicable. After pipe has been installed the trench shall be backfield with approved material and compacted. The base course and surface coat shall be installed according to the original road specifications.