NAGPUR MUNICIPAL CORPORATION

AUGMENTATION TO NAGPUR CITY WATER SUPPLY SCHEME PENCH – IV

DRAFT PROJECT REPORT – PART 1

LIFTING WATER FROM PENCH RESERVOIR AND CONVEYING UPTO MAHADULA

VOLUME - 1

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DRAFT PROJECT REPORT - PENCH IV
PART – 1

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VOLUME - I

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1.0 PREAMBLE

Nagpur Municipal Corporation (NMC) had invited proposals from reputed consultants for "Preparation of Detailed Project Report for Augmentation of Water Supply to Nagpur City Pench - III, Stage – II (now renamed as Pench – IV)".

Accordingly M/s. Shah Technical Consultants Pvt. Ltd., Mumbai (STC) had submitted their proposal which was adjudged to be the most responsive proposal, after techno-economic evaluation. STC was therefore entrusted with the assignment vide NMC's Work Order No. NMC / PPC.EE(PPC)/38/2004 Dated 2nd July 2004.

1.1 Background

As specified in the terms of Reference, Pench Phase – III, Stage – II (Pench-IV) is intended to augment the water supply of Nagpur City by 113 MLD which would largely meet the demand of Nagpur City upto the year 2011. Total reservation of 190 Mm^3 (520 MLD) per year has been made in Pench Dam Project for water supply to Nagpur city. Out of the total reservation of 190 Mm^3, approximately 127 Mm^3 has already been availed of by NMC in three phases as,

Pench – I	--	41.4 Mm^3 (113.5 MLD)
Pench – II	--	48.5 Mm^3 (133 MLD)
Pench – III, Stage – I	--	36.5 Mm^3 (100 MLD)

While designing the raw water intake facilities due consideration is to be given to total available reservation in Pench Dam.

Similarly while designing other components like Raw Water Transmission Main, Water Treatment Plant, Pure Water Transmission System, MBRs, ESR's, GSR's and distribution system additional due consideration is been given to the demand of water estimated for year 2031.

1.2 Scope of Consultancy Services:

The scope of consultancy services envisaged by NMC as per the Terms of Reference (ToR) is as follows:

1.2.1 Preparing Detailed Project Report (DPR)

The task of preparation of Detailed Project Report (DPR) covers;

i. Review of existing water supply scheme, data and reports available with NMC.

ii. Collection of data from various agencies, carrying out surveys, investigations, optimum designs and preparation of detailed plans and estimates for various components of the project.

iii. Updating the drawings available with NMC incorporating the additions/ deletions / revisions made subsequent to preparation of these drawing and also incorporating the works covered under present studies.

iv. Environmental and Social Assessment Report, Sustainability and Risk Management Plan, Institutional Reforms, Summary Project Analysis: Economics, Financial, Technical, Institutional, Environmental, Social, Safeguard Policies, Project Processing Schedule, etc.

v. Assist NMC in obtaining Technical and Administrative approval to the DPR.

vi. Extending support to NMC for getting loan from funding agencies like World Bank, ADB, NABARD, etc.

The major components to be covered by the DPR are as follows:

a) Surveys and soil investigation
b) Intake arrangement at Dam / Tapping Right Bank Canal
c) Pumping stations
d) Water Treatment Plant
e) Water Transmission System / feeder mains
f) Water Distribution System
g) SCADA system

1.2.2 Preparation Tender Documents and Bid Evaluation

This task covers the following:

i. Preparation of detailed design, drawing, BOQs and bid documents for all components of the proposed project.

ii. Assisting NMC I following pre-tender activities

a) Preparing criteria for short listing of contractors
b) Preparing tender notices
c) Preparing documents for pre-qualification of contractors
d) Evaluation of pre-qualification proposals received by NMC.
e) Preparing document for Request for Proposals (RFP) for project implementation.
f) Preparing documents for RFP for appointment and selection of Project Management Consultant.

iii. Assisting NMC in Bidding & Technical Evaluation

a) Participating in prebid meetings and preparing the minutes of pre-bid meeting.
b) Assisting NMC in replying to bidder queries and prepare necessary addendum.
c) Undertake the evaluation of bids received by NMC.
d) Assist NMC in negotiations with the selected bidders.
e) Assist NMC in finalization of documents after negotiation.

1.2.3 Technical Advisory Support / Clarifications / Correction in Design, Drawing during execution of Project

This task will cover, broadly the following:

i. Checking vendor drawings in respect of pumping station / ESR / GSR equipment, WTP equipment / structures and WTM specials and providing clarifications to the client in respect of drawings produced by the consultant.

ii. Review of vendor drawings for all accepted bids for mechanical and electrical equipment to ensure conformity with specifications and approval thereof when comments are incorporated by the bidder.

iii. Review vendor drawings in connection with fabrication of pipes and specials to be provided at various locations.

iv. Review of process, hydraulic, mechanical and electrical equipment designs, hydraulic flow diagrams and plant layout for water treatment plant, prepared by the successful bidder, to check conformity with specifications and approval thereof when comments are incorporated by the vendor / contractor.

v. Review of structural designs for water treatment plant to ensure correctness and comments to be forwarded to the consultant for compliance.

vi. Review of equipment vendor drawings to ensure conformity and comments offered for compliance by the vendor.

vii. Review of final structural drawings (WTP/ESR/GSR) prepared by the successful bidder and comments offered for compliance by the vendor.

2.0 STUDY METHODOLOGY

On award of assignment, the consultants (STC & DRA) commenced their project activity by immediately mobilizing their team of experts and senior engineers at Nagpur, who visited the project area for a first hand appraisal of assignment requirements and collection of basic primary data. The team carried out interactive discussions with the concerned officials of NMC and firmed up their assignment logistics.

An inception report was submitted to NMC containing the scope of work, design concepts for each project component and block estimates.

After submission of inception report and approval of the same the Consultants Team Member proceeded to the respective stations to take up subsequent tasks of work plan, while the Project Co-ordinator stationed at Nagpur itself to liaison with NMC officials and also to co-ordinate, monitor & manage our field related activities of the project.

All the team members had occasional discussions with NMC officials for each aspect of project.

Some revised guidelines were given by NMC officials for preparation of draft project report. This necessitated some amount of modifications in the work program, resulting in marginal modifications for the submission targets of deliverables.

Consultants had completed following activities planned for assignment :

- Data Collection
- Submission of Inception Report
- Field investigations, analysis and design.

Engineers of STC had further discussions and site visits with field level officials of NMC for verification and site specific assessment implications of those observations.

The Draft Project Report is now being submitted incorporating relevant effect of all exercises subsequent to submission of Inception Report. This draft project report comprises sections each dealing with various aspects and along with related tables, statements, drawings, design calculations and cost estimates.

2.1 Data Collection

2.1.1 Secondary Data

Secondary data were collected from Government Departments and Institutions, as mentioned below excluding Nagpur Municipal Corporation (NMC)

1 Survey of India
2 Census of India
3 Irrigation department, Maharashtra (Jalsampda)
4 Central Water Commission
5 Maharashtra State Electricity Board (MSEB)
6 District Land Record (DLR), etc.

Secondary data collected from above sources were complied, collated and analyzed for system planning, design and cost estimates.

2.1.2 Reconnaissance Survey

Under reconnaissance survey, consultants along with NMC officials visited the entire project area with an emphasis on alternative sites for intake work locations, WTP Locations, transmission alignments, ESR / GSR Locations, etc. Consultants through this reconnaissance assessed general physical and

functional status of existing system components, prepared preliminary alternate system planning and finalized arrangements.

2.1.3 Primary Data

Primary data collection activities comprised generally the following major categories.

- Topographical Survey
- Staking of pipeline route
- Soil Investigation
- Cadastral Survey
- Corrosion / Resistivity Survey
- Water Quality Survey
- Existing System Data

2.2 Data Compilation and Analysis

All the data collected were reviewed, scrutinised and cross -checked to assertion their consistency as well as authenticity. The data was then collated and analyzed to produce various outputs as mentioned below

1 Index Map
2 Base Map
3 Test Reports on Water Quality.
4 Soil strata along with it's corrosiveness properties
5 Existing System Data
6 Land Acquisition details
7 Longitudinal Sections along Transmission Main
8 Contour at Head Works, BPT and WTP Locations

3.0 EXISTING WATER SUPPLY SCENARIO

3.1 Existing Water Supply System - Background

Water supply to Nagpur City was drawn from five surface sources viz. Ambajhari tank, Gorewada Tank, Kanhan river, Wunna Irrigation Tank, and Pench canal. Out of these, Ambajhari Tank is presently supplying water to MIDC area and Wunna Irrigation Tank is used only to meet the needs of defence area and surroundings. Hence City gets water only from Gorewada Tank, Kanhan River, and Pench Canal. Gorewada Tank Source was developed in the year 1911. As city grew and the need for water increased, Gorewada Tank source became inadequate. As augmentation to Gorewada was not possible due to site constraints, surface water source from river Kanhan was developed. The irrigation department, Govt. of Maharashtra executed a storage dam across river Pench in 1976 for hydro-electric project at Totaladoh and pickup dam at Navegaon Khairy, wherein reservation of 190 Mm^3 was made for water supply to Nagpur City.

3.1.1 Old Gorewada Source

This was developed in the year 1911. It consists of an earthen bund across river Pili at a distance of about 8 km towards North-East of Nagpur City having gross and live storage capacities 8.82 Mm^3 and 7.92 Mm^3 respectively. On the downstream of Gorewada Tank, conventional Water Treatment Plant of 16.0 MLD capacity is constructed. Treated water is collected in pure water sump and then pumped to Seminary hills G.S.R for further distribution

3.1.2 Kanhan Water Source

Surface water intake located approximately 14 km from Nagpur City and 300 m. downstream of the confluence of the River Kolar and the River Kanhan was constructed in year 1940. In 1956 a barrage was constructed across Kanhan River about 500 m upstream of Kanhan head works with a storage capacity of 7.82 Mm^3. Kanhan Water Supply Scheme was commissioned in

four phases during the years 1940 - 1970. The first phase capacity in 1940 was 27.3 MLD which was augmented to 63.6 MLD in 1954. The capacity was further augmented to 86.3 MLD in 1966 and finally to 109 MLD in 1970.

Under this scheme, two intake wells in Kanhan river bed and two dry wells on the right bank of Kanhan River are constructed. Raw water is pumped to conventional treatment plant of 109 MLD capacity. Treated water from the Treatment Plant is pumped to G.S.R. of capacity 22.74 ML at Government House through 600 to 900 mm dia. M.S. parallel rising mains of length 15.24 km. which are interconnected to each other.

3.1.3 Pench Source

3.1.3.1 Pench Project - Phase I

In this scheme 113.5 MLD water is drawn from Pench right bank canal by gravity to the Mahadulla pumping station. The raw water is pumped to the B.P.T. of capacity 5.7 lakhs liters through 1606 mm dia M.S. Rising Main of length 5624 m. from B.P.T. water is taken to the Gorewada balancing tank through 700 mm dia duplicate C.I. gravity mains each of length 400 m. from Gorewada Tank it is drawn to the conventional treatment plant of capacity 113.5 MLD through 1200 mm dia M.S. gravity main. The filtered and chlorinated water from the treatment plant is pumped to Seminary Hills G.S.R. of capacity 20.43 ML and Gittikhadan G.S.R. of capacity 5.94 ML. Sitabuldi G.S.R. is fed from Seminary Hills G.S.R. through 700 mm dia M.S. Feeder Main of length 4000 m.

3.1.3.2 Pench Project - Phase II

Under Pench Phase - II a baby canal from Pench right bank canal to Mahadulla pumping station was constructed to draw additional 136 MLD of water. The raw water is pumped to the existing B.P.T. of capacity 5.70 lakh ltrs. through 1626mm dia M.S. Rising Main of length 5.60 km from B.P.T. water is conveyed to Gorewada tank through 1500 mm dia P.S.C. 8 $Kg.cm^2$

gravity main of length 400 m. from Gorewada Tank water is taken to conventional water treatment plant of capacity 145 MLD through 1100 mm and 1000 mm dia P.S.C. 4 Kg./Sq.cm. gravity mains of length 650 m and 325 m respectively. Pure water is pumped to Seminary Hills G.S.R. of capacity 20.43 ML through 1321mm dia M.S. Rising Main of length 3760 m. In this scheme two E.S.R.s at Jaripatka and Sharda Rolling Mill each of capacity 22.7 lakhs liters are constructed.

3.1.3.3 Pench project -Phase III, Stage - I

Under Pench III Phase – I, additional 100 MLD water drawn from PRBC to Mahadula pumping station through the baby canal. Additional pumps are provided at Mahadula for Raw Water Pumping. A new treatment plant is also constructed at Gorewada. The system is identical to Pench - I & Pench - II project.

3.2 Population / Demand

In year 2000, NMC had appointed M/s Tata Consulting Engineers Ltd. (TCE) for preparation of Master Plan for water supply to Nagpur city. Population projections were carried out during these studies, which are reproduced below:

Population Projection by Various Methods

Sr. No.	Method	Years			
		2001	2011	2011	2031
01.	Arithmetic Increase Method	18,36,145	20,47,538	22,58,931	24,70,325
02.	Geometric Increase Method	22,90,196	32,28,184	45,50,340	64,14,007
03.	Incremental Increase Method	18,92,434	21,60,122	24,27,808	26,95,493
04.	Migration-Birth / death Rate Method	19,97,397	24,90,808	32,05,884	42,08,420

Sr. No.	Method	Years			
		2001	2011	2011	2031
05.	Graphical Trend Method	21,50,000	28,30,000	36,90,000	47,50,000

The Master Plan report and the population projections made therein have already been accepted by NMC. Hence population projections by Graphical Trend Method adopted in Master Plan report form a basis for calculation of water demand in the present report.

Projected population of slum areas are as follows:

Year	2004	2011	2021	2031
Slum Population	8,23,900	9,90,500	12,91,500	16,62,500

It is estimated that at present, out of the total slum population approximately 40% habitants are served through public stand posts whereas balance 60% are served through house connection. NMC has drawn plans to encourage individual house connections in slum areas. It is estimated that there will be approximately 10% decrease per decade, in the population served through stand posts and corresponding increase in house connections.

Year wise population figures served through stand posts and house connections in slum areas are as follows:

Sl.	Description	Years			
		2004	2011	2021	2031
01.	Slum population with house connections	4,94,340	6,93,350	10,33,200	14,96,250
02.	Slum population on stand post supply	3,29,560	3,97,150	2,50,300	1,66,250
	Total Slum Population	**8,23,900**	**9,90,500**	**12,91,500**	**16,62,500**

Thus for the purpose of water supply, the total population is divided into two categories as follows:

Total Population	23,50,000	28,30,000	36,90,000	47,50,000
Population served through House Connection	20,20,440	25,32,850	34,31,700	45,83,700
Population served through stand post	3,29,560	2,97,150	2,58,300	1,66,250

3.2.1 Water Demand

3.2.1.1 Domestic Demand

As per CPHEEO manual on water supply and treatment (Third edition (May, 1999) revised and updated) the recommended 'Maximum' water supply in liter / capita / day (LPCD) is as follows:

Metropolitan & Mega Cities	**Recommendation**
Provided with piped water supply where sewerage system is existing / contemplated	150 LPCD

Note:

(i) In urban areas, where water provided through public stand posts, 40 lpcd should be considered.

(ii) Figures exclude "Unaccounted for Water (UfW)" which should be limited to 15%.

(iii) Figures include requirements of water for commercial, institutional and minor industries. However, the bulk supply to such establishments should be assessed separately with proper justification.

With the above recommendation, treated water demand has been considered with 150 lpcd for water supply through house service connection and 40 lpcd for the population, where water is provided through stand post.

3.2.1.2 Non-domestic (Bulk) Demand

Nagpur has many large institutions and organizations like NEERI, Railway, MES, VNIT, Govt. Medical College & Hospital Air Force maintenance command etc. which requires bulk water supply, hence institutions / establishment with 100 mm and above size service connections are treated as bulk consumer and its water demand based on NMC billing for 2004 has been considered separately and worked out as 37.95 MLD and further projected proportionate to population growth.

Sl. No.	Description	Years			
		2004	2011	2021	2031
1.	Non-Domestic Bulk Demand in MLD	37.95	45.70	59.59	76.71

3.2.1.3 Fire Demand

As per CPHEEO Page-12 recommendation fife demand is calculated in kilo liters/day on formula $100\sqrt{p}$ where, p = population in thousands. The 1/3 of the fire fighting requirements from the part of the service storage.

Sl. No.	Description	Years			
		2004	2011	2021	2031
1.	Fire Demand (ml)	4.85	5.32	6.07	6.89

3.2.1.4 Other Water Demands

It is intended that the Pench-IV water supply project, when implemented, will cater to the following apart from NMC area.

1. Village in fringe areas
2. CIDCO area

3. International Cargo Hub
4. Kamptee Cantonment

1. Villages in Fringe Areas

There are approximately 125 villages located within 5 km. area outside NMC limits. At present these villages are being served through various schemes implemented by Maharashtra Jeevan Pradhikaran and Zilla Parishad. The schemes so implemented have been designed for a supply of 40 lpcd. It is however intended that these villages be served at the rate of 100 lpcd. Thus the deficit of 60 lpcd (100-40) is proposed to be met with by the Pench-IV project, when implemented.

Year wise water demand of these villages to be met from Pench- IV Project is summarized as follows:

Sl. No.	Description	Years			
		2004	2011	2021	2031
1.	Villages in East area	-	9.01	10.63	12.47
2.	Villages in West area	-	10.54	12.78	17.74
3.	Villages in North area	-	7.99	9.84	11.70
4.	Villages in South area	-	2.74	3.98	4.77
	Total	-	**30.28**	**37.23**	**46.68**

2. CIDCO Area

The year wise demands of CIDCO area, adopted in Master Plan are as follows:

Year	2004	2011	2021	2031
Demand in MLD	-	42.0	46.2	58.80

3. **International Cargo Hub**

The year wise demand of Cargo Hub as conveyed by their Superintending Engineers are as follows:

Year	2004	2011	2021	2031
Demand in MLD	40.50	43.60	64.20	107.50

4. **Kamptee Cantonment**

Kamptee cantonment area is being supplied with 10 MLD of treated water from Kanhan Water Works. This demand is expected to remain constant.

The year wise net demand of water, at consumers end, therefore works out as under:

Sl. No.	Description	Years			
		2004	2011	2021	2031
1.	Population served through house connection @ 150 lpcd.	303.07	379.93	514.76	687.56
2.	Population served through stand post @ 40 lpcd.	13.18	11.89	10.33	6.65
3.	Bulk-Non Domestic Demand	37.95	45.70	59.59	76.71
4.	Fire Demand	4.85	5.32	6.07	6.89
5.	Villages in Fringe Areas	-	30.28	37.23	46.68
6.	CIDCO Area	-	42.00	46.20	58.80
7.	Cargo Hub	40.50	43.60	64.20	107.50
8.	Kamptee Cantonment	10.00	10.00	10.00	10.00
	Subtotal	50.50	125.88	157.63	222.98
	Grand Total	**408.55**	**568.72**	**748.38**	**1000.79**

Annexure, Table No.(1)
STATEMENT OF WATER DEMAND

Sr. No.	Description	Year 2004			Year 2011			Year 2021			Year 2031		
		Within NMC limits	Outside NMC limits	Special Projects	Within NMC limits	Outside NMC limits	Special Projects	Within NMC limits	Outside NMC limits	Special Projects	Within NMC limits	Outside NMC limits	Special Projects
		Nagpur City	Fringe Area & CIDCO	MIHAN	Nagpur City	Fringe Area & CIDCO	MIHAN	Nagpur City	Fringe Area & CIDCO	MIHAN	Nagpur City	Fringe Area & CIDCO	MIHAN
1.0	**Total Population**	2,350,000			2,830,000			3,690,000			4,750,000		
1.1	**Total Slum Population**	823,900			990,500			1,291,500			1,662,500		
1.2	**Slum Population** (with House connection)	494340			693350			1033200			1496250		
1.3	**Slum Population** (on Stand post Supply)	329,560			297,150			258,300			166,250		
1.4	**Population Excluding Slum** (1.0 - 1.1)	1,526,100			1,839,500			2,398,500			3,087,500		
2.0	**Population of Fringe Area** (5.0 Km Circle)		428,785			504,700			620,500			728,200	
			N.A.										
3.0	**Treated Water Demand Breakup in mld**												
a	**Domestic demand**												
	HIG, MIG, LIG Slum with house connection	303.07	(74.51).		379.93			514.76			687.56		
	Slums with stand post supply	13.18			11.89			10.33			6.65		
b	**Non Domestic**												
	Commercial, Institutional & Minor industries with Bulk Supply	37.95			45.7			59.59			76.71		
c	**Fire Demand**	4.85			5.32			6.07			6.89		
d	**Fringe Area** (villages in 5.0 Km circle)		N.A.			30.28			37.23			43.69	
e	**CIDCO (Meghdoot)**		N.A.			42.00			46.20			58.80	
f	**Special Projects** (Multimodel Interna tional Hub Airport at Nagpur) MIHAN			40.50			43.60			64.20			107.50
4.0	**Treated Water Demand at consumer end In mld**	359.05	N.A	40.50	442.84	72.28	43.60	590.75	83.43	64.20	777.81	102.49	107.50
5.0	**Treated water demand in mld** (Within NMC limits, Outside NMC limits & Special Project)	399.55			558.72			738.38			987.80		
6.0	**Water Demand in mld**												
	% Losses in Distribution System	25	25	25	15	15	15	15	15	15	15	15	15
a	**Treated Water Demand (ESR's /Sump)**	478.73	N.A	54.00	520.99	85.04	51.29	695	98.15	75.53	915.07	120.58	126.47
	% Losses in P.W. Transmission	2	2	2	2	2	2	2	2	2	2	2	2
b	**Treated Water Demand for P.W.Transmission**	488.5	N.A	55.10	531.62	86.78	52.34	709.18	100.15	77.07	933.74	123.04	129.05
c	**Treated Water Demand @ WTP**	488.5	N.A	55.10	531.62	86.78	52.34	709.18	100.15	77.07	933.74	123.04	129.05
	% Losses in WTP	5	5	5	1	1	1	1	1	1	1	1	1
d	**Raw Water Demand @ WTP**	514.21	N.A	58	536.99	87.66	52.87	716.34	101.16	77.85	943.17	124.28	130.35
	% Losses in R.W. Transmission	2	2	2	2	2	2	2	2	2	2	2	2
e	**Raw Water Demand @ Intake**	524.70	N.A	59.18	547.95	89.45	53.95	730.96	103.22	79.44	962.42	126.82	133.01
7.0	**Raw water demand In mld** (Within NMC limits, Outside NMC limits & Special Project)	583.88			691.35			913.62			1222.25		

Table No. (2)

STATEMENT OF WATER SUPPLY (As per Master Plan upto 2031)

Sr. No.	Particulars		Year 2004			Year 2011		Year 2021		Year 2031	
		%	mld	$Mm^3/Yr.$	%	mld	$Mm^3/Yr.$	mld	$Mm^3/Yr.$	mld	$Mm^3/Yr.$
I)	**Source-I : Kanhan**										
1	**Raw water Supply as per Irrigation Demand based on Rated Capacity of Pump**		164.40	60.00							
2	Actual Intake as per Measurement		126.75	46.30							
3	NRW on Kanhan (Raw water)		37.65	13.70							
4	**Raw Water available @ Intake**		126.75	46.30		150.70	55.00	150.70	55.00	150.70	55.00
5	Less Raw Water Transmission losses	2	2.54		2	3.01		3.01		3.01	
6	Raw water @ WTP		124.21			147.69		147.69		147.69	
7	Less WTP losses =	5	6.21		1	1.48		1.48		1.48	
8	**Treated Water @ WTP**		118.00			146.21		146.21		146.21	
9	Water Supply to Kamthi-Cantonment		10.00			10.00		10.00		10.00	
10	**Treated Water Supply from WTP**		108.00			136.21		136.21		136.21	
II)	**Source-II: Pench & Gorewada**										
1	**Raw water from Pench as per Irrigation Demand**		460.30	168.00		520.60	190.00	520.60	190.00	520.60	190.00
2	Actual Intake As per Measurement		371.63	135.60							
3	NRW (Raw Water)		88.67	32.40							
4	**Raw water Supply to Gorewada lake for Pench WTP** (at Gorewada)		371.63			520.6	190.0	520.6	190.0	520.6	190.0
5	Raw Water of **Gorewada lake** for Gorewada Old WTP		17.20			17.20		17.20		17.20	
6	**Raw water available (4+5)**		388.83			537.80		537.80		537.80	
7	Less Raw Water Transmission losses	2	7.78		2	10.76		10.76		10.76	
8	Raw water @ WTP		381.05			527.04		527.04		527.04	
9	Less WTP losses =	5	19.05		1	5.27		5.27		5.27	
10	**Treated Water supply from WTP**		362.00			521.77		521.77		521.77	
III)	**Source-III : Rahari**										
1	**Raw water**		0.00			0.00		175.00		350.00	
2	Less Raw Water Transmission losses	2	0.00		2	0.00		3.50		7.00	
3	Raw water supply from WTP		0.00			0.00		171.50		343.00	
4	Less WTP losses =	5	0.00		1	0,00		1.72		3.43	
5	**Treated Water Supply from WTP**		0.00			0.00		169.78		339.57	
IV)	**Raw Water available from Source I, II & III**		515.58			688.50		863.50		1038.50	
	Less For Kamthi-Cantonment		10.74			10.31		10.31		10.31	
	Water Supply For Nagpur Water S.S.		504.84			678.19		853.19		1028.19	
V)	**Treated Water Supply from WTP**		480.00			667.98		837.76		1007.55	
	Less P. W. Supply to Kamthi-Cantonment		10.00			10.00		10.00		10.00	
VI)	**Treated water Supply From WTP for Nagpur**		470.00			657.98		827.76		997.55	

4.0 PROPOSED WATER SUPPLY PROJECT

Refer Annexure-1 Summery of proposed works (Part-1)

4.1 Need for Project

Pench Dam Project has provided for a reservation of 190 Mm^3 / year (520 MLD) for Nagpur city and 40 Mm^3 / year (110 MLD) for water supply to proposed International Cargo Hub. NMC will be supplying water to this cargo hub and hence in ultimate stage NMC has to plan for total of 230 Mm^3/year (190 +40) i.e. 630 MLD of water to be obtained from Pench Dam as source.

NMC has already constructed facilities at Gorewada for treatment of 346 MLD of water which amounts to drawl of 127 Mm^3/year of raw water from Pench Dam source. This present drawl is through the Pench Right Bank Canal.

Pench Right Bank Canal is in a bad state. The lining of canal is damaged at numerous points. Further number of head as well as cross regulators so also aqueducts are damaged and have heavy leakages. Dependability of the Pench Right Bank Canal is therefore in question. Since major water supply to Nagpur city is from Pench Dam, the canal is required to be run continuously. Irrigation Department is therefore not in a position to take canal closure for its repairs. Irrigation Authorities are therefore continuously pressing NMC authorities for making alternative arrangements for drawl of water from Pench Dam.

Under the circumstances, it will be prudent not to rely upon the canal and lift water from the dam itself and convey the same to existing as well as proposed facilities through a pipeline.

Raw water intake arrangements are therefore required to be design for 630 MLD representing their total quantum of water to be availed of from Pench Dam.

It is not advisable to rely upon a single pipeline for conveyance of raw water. Hence it is proposed to lay two pipelines each with a carrying capacity of 315 MLD each. Another advantage of laying two pipelines is that the capital expenditure can be spread over two stages.

Single pipeline of 315 MLD capacity will not however be able to cater to even the existing requirement of 346 MLD at Gorewada. It will therefore be necessary to partially continue with the existing system of drawl from PRBC. Hence out of 315

mld supply through proposed 1930 mm dia pipeline, 115 MLD will be supplied to a new water treatment plant at Godhani (through proposed 1422 mm dia pipeline) and 200 MLD to existing BPT at Gorewada (through one of the 1626 mm dia existing pipeline).

Balance requirement at Gorewada will have to be drawn from PRBC till second phase is completed and will be continued to pump from Mahadula to Gorewada BPT through second 1626mm dia exiting pipeline. (Refer Key Plan given in Annexure-1)

4.2 Proposed Scheme

The project components consist in:

1 The intake facilities at Pench (Navegaon Khairi) reservoir at pench river course. The units are designed for total intake capacity of 630 MLD. This will include pumping facility of 630MLD raw water up to Break Pressure tank having total head as 48 meters, in two phases, each of 315 MLD along with the necessary electrical sub-station of appropriate capacity.

2 60 meters long raw water pumping main from the pumping station to break pressure tank, located near Head Work Site comprising of 2032 mm (OD) M.S., pipeline of 20 mm shell thickness. The same line will cater for Phase-II flow of 315 MLD.

3 Construction of circular break pressure tank on hillock near H/W site with following features.

i)	Inner Diameter of Tank	=	10m
ii)	Bed level of Tank	=	353.000 m
iii)	Top level of Tank	=	363.000 m
iv)	Inlet to Tank	=	2032 mm (O.D.) M.S. pipe
v)	Outlet from tank	=	1930 mm (O.D.) M.S. pipe
vi)	Overflow	=	Combination of 1930 mm (MS) and 2000 mm (id) RCC NP-3 pipe

The unit is designed for 630 MLD flow

4 Raw Water Transmission Main from BPT to bifurcation point at Mahadula of 1930 mm (O.D.) mild steel with shell thickness of 10 mm, 20 mm CC outcoating and 12 mm CC inlining, for the length of about 27.5 km. For Phase I

Second line may be of same dia to be proposed in Phase – II

5 Bifurcation arrangement at Mahadula, to bifurcate the incoming 315 MLD of flow in two branches. One branch carrying 115 MLD of flow upto proposed WTP location at Godhani and second branch will get connected to existing raw water transmission main of 1626 mm (O.D.) MS pipeline feeding Gorewada.

In Phase II, tapping arrangement at Mahadula will be provided for cargo Hub (MIHAN) project for the flow of 115 MLD and remaining flow of 200 MLD will get carried (from Mahadula to Gorewada BPT) by existing transmission main of 1626 mm (O.D.) to Gorewada.

6 Raw water transmission main from bifurcation point at Mahadula to proposed WTP location of length approximately of 2600 m and 1422 mm (O.D.), 10 mm thick size carrying 115 MLD of discharge.

7 An ultra modern state of art water treatment plant of nominal capacity of 115 MLD capacity of Godhani.

8 Pure water rising main from WTP at Godhani to existing MBR at Governor House of size 1422 mm φ, MS 10 mm thick and length about 7500 m.

9 Strengthening & extension of existing distribution network including ESR's and distribution mains.

5.0 PROPOSED SYSTEM : CONCEPTS AND DESIGN

5.1 Head Works

5.1.1 Intake Arrangements

An Octagon shaped intake structure is proposed to be constructed in the bed of river itself ,considering (though very remote) the possibility of flow being restricted to the original river channel.

Salient levels at Pench Storage area

River Bed Level	-	304.000 MRL
Canal Bed Level	-	310.000 MRL
Lowest Bad Level	-	314.000 MRL
Full Reservoir Level	-	325.000 MRL
Highest Flood Level	-	327.000 MRL

Intake structure has been designed with following considerations

- Provision against failure to supply because of fluctuations in water level or channel instability
- Provision for water withdrawal at various depths where desirable and feasible.
- Protection against hydraulic surges, floods, floating debris, boats and barges.
- Location of the intake to provide water of the best available quality to avoid pollution and to provide structural stability
- Provision of racks and screens as required to prevent entry of objects that might damage pumps.

- Provision of adequate space for routine equipment cleaning and maintenance

- Provision of facilities for removing equipment when major repairs are necessary

- Location and design to minimize damage to aquatic life

The intake structure is designed to draw 630 x 1.5 = 945 MLD of water.

Actual drawal will be thorough ports 2.5 m x 1.6 m – 4 Nos. each at two levels.

Emergency / Desilting ports are provided with sill at 1 m above river bed level (RL 304.000 + 1.000) i.e. at RL 305.000 M

Thimble mounted sluice gates are provided to regulate the flow through these gates.

Two intake conduits each capable of conveying 472.5 MLD will be laid from intake tower to pump sump. The internal diameter of the conduit (RCC NP-IV) will be 2600 mm slope of the pipe line has adopted considering all the transient losses.

The length of the conduit will be 500 m. Since the diameter of the conduits is fairly large no intermediate inspection chambers or access shafts are proposed.

As the intake tower has to be accessible at all times. R.C.C. approach bridge of 4 m wide with rail and trolley arrangement, suitable for O & M facilities is proposed.

Hydraulic Design Summary Intake Works At Pench Reservoir

a) **Data**

Flow	630 MLD
Minimum Water Level (RL)	314.000 m
Maximum Water Level (RL)	325.000 m

Following references are considered for the design of Intake Works

1. AWWA Water Treatment Plant Design III rd Edition - 1998

2. Water Works Engineering Planning, Design and Operation, Syed R. Quasim, Edward M. Mothley & Guang Zhu., Prentice Hall Inc. 2000

3. IS 13349 : 1992 Specification for single faced Cast iron thimble mounted sluice gates, Bureau of Indian Standards

4. Water Supply - Fifth Edition

   Alan C. Twort, Don D. Ratnayaha & Malcum J. Brandt
   Fifth Edition - 2000
   IWA Publishing, London, UK

5. Manual on Water Supply & Treatment

   G.O.I. - 1999

b) **Intake Structure**

Proposed capacity = 945 MLD

No. of streams	=	2 each carrying 472.5 MLD flow
Sluice Gate	=	2.5 x 1.6 , Four Nos. At each level
Gate invert (Sill)	=	322.4 m - 4 Nos. & 311.4 m - 4 Nos.

c) Coarse Screen

13 mm spaced at 4 cm c/c

No. of bars	=	87 Nos.
Rack width	=	3.5 m
Water depth	=	3.4 m
Velocity through screen	=	0.34 m/s

d) Intake Conduit

No. of conduits	=	2 Nos.
Type of construction	=	Pipeline
Actual velocity	=	1.03 m/s
Slope of pipe required	=	0.20 / 1000 m

5.1.1.1 Design of Intake Ports

Design Discharge :- 630 MLD

Intake works to be designed for 1.5 x 630 = 945 MLD

Total four (4) No. of ports are proposed at a single level

Discharge through each port = $\frac{945}{4}$

= 236.25 MLD

= 2.7343 m^3 / S

The inlet port size proposed is = 2500 x 1600 mm

Actual velocity through port will be $= \frac{2.7343}{(2.5 \times 1.6)}$

$= 0.684$ m/s

When the water level is below the soffit, it will act as weir

And $Q = 1.705\ bh^{3/2}$

Considering the 2 end contractions and approximately "h" as 1.4

$b = 2.5 - (0.1 \times n \times h)$

$= 2.5 - (0.1 \times 2 \times 1.4)$

$= 2.22$ m

$\therefore\ h^{3/2} = \frac{2.7343}{1.705 \times 2.22}$

$= 0.722$

$\therefore$ Head loss $= 0.80$ m

LEVELS OF PORTS

S.No	LEVEL (m)	No. Of PORTS
1	Soffit - 324. 00	4 Nos.
	Sill - 322. 40	
2	Soffit - 313. 00	4 Nos.
	Sill - 311. 40	
3	Soffit – 306. 60	2 Nos.
	Sill - 305. 00	

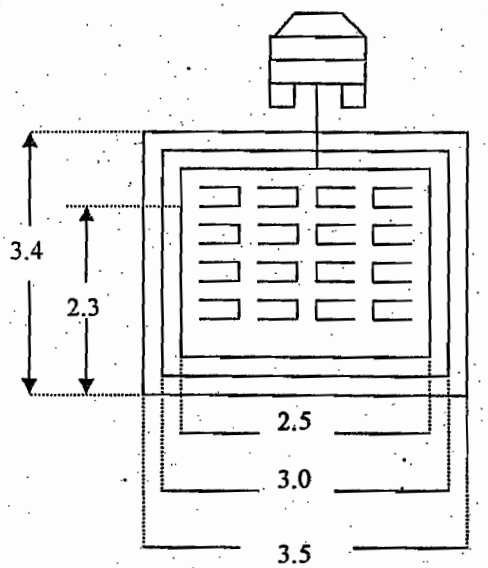
5.1.1.2 Design of Coarse Screen

Provide - 13 mm x 50 mm bars @ 4 cm c/c

Rack width = 3.5 m = 3500 mm

No. of opening = $\frac{3500}{40}$ =88 Nos.

∴ No. of bars = 87 Nos.



Flow at intake = 945 MLD at single level (i.e. through 4 No. of ports)

∴ Flow in each port = $\frac{945}{4}$ =237 MLD

= 2.75 m^3/s

Approximate velocity = $\frac{2.75}{2.5 \times 3.4}$

Va = 0.210 m/s

Area of bars = 87 x 0.013 x 3.4

= 3.85 m^2

Net area = (3.5 x 3.4) - 3.85

= 8.05 m^2

Velocity the screen = $\frac{2.75}{8.05}$

Vs = 0.34 m/s

Loss of Head through screen = $\frac{1}{0.70}(\frac{Vs^2-Va^2}{2g})=\frac{1}{0.7}\times(\frac{0.34^2-0.21^2}{2\times9.81})$

= 0.005 m

If the screen is clogged by 50 % , Vs will be doubled i.e. Vs = 0.34x 2

In this case Hf = $\frac{1}{0.70}(\frac{Vs^2-Va^2}{2g})=\frac{1}{0.7}\times(\frac{0.68^2-0.21^2}{2\times9.81})$

= 0.030 M

5.1.1.3 Hydraulic Design of Intake Conduit

H/W - Capacity = 630 MLD

Design capacity = 1.5 Times

= 1.5 x 630

= 945 MLD

Consider two streams for intake :

Each conduit will carry = $\frac{945}{2}$

= 472.50 MLD discharge

472.50 MLD = 5.47 m^3/s

With Ave. velocity of 0.9 m/s, the diameter required works out to @ 2780 mmφ

Adopting - 2600 mm, R.C.C. NP 4 Pipe, with barrel thickness = 215 mm

Velocity works to = 1.03 m/s

Calculation For Slope : -

Discharge = 472.5 MLD

= 5.47 m^3/S

C/S Area = $\frac{\pi}{4} x (2.6)^2$

= 5.3093 m^2

∴ Actual Velocity = 1.03 m/s (v)

Slope required can be calculated by,

$V = 4.567 \times 10^{-3} \times C \times d^{0.63} \times (S)^{0.54}$

$1.03 = 4.567 \times 10^{-3} \times 140 \times 2600^{0.63} \times (S)^{0.54}$

∴ S = 0.25 M / 1000 M

For 500 m length of conduit,

$$H_L = \frac{0.25}{2} = 0.125m \text{ - } [1]$$

H/L at entrance in conduit the Dell mouth

$$H_L = 0.04\frac{V^2}{2G} = 6.04\times\frac{(1.03)^2}{2\times9.81} = 2.16\times10^{-3}\text{m} - [2]$$

H/L at exit

$$H_L = 1\frac{V^2}{2G} = 1\times\frac{(1.03)^2}{2\times9.81} = 0.54\text{m} - [3]$$

$[1] + [2] + [3] = 0.125 + 2.16 \times 10^{-3} + 0.54$

$= 0.181$ m say 0.20 m

Invert of Intake conduit at Intake Tower = 306.500 M

Invert of Intake Conduit at sump well = 306.500 - 0.20

= 306.300 M

5.1.1.4 Structural Design Of Intake Conduit

Material = RCC (NP4)

Internal diameter = 2600 mm

Outer diameter = 2600 + 2(215)

= 3030 mm

Width of trench = 3030 + 500

= 3530 mm (B)

Depth of trench to pipe invert = 13 M (Max)

Unit wt of Fill material = 18 KN / m^3

Depth of fill material over top of pipe (H) = 13 - 3.030

≈ 10 M

Vehicle load on pipe due to fill material (W_C)

Wc = CtWB2 -As per clause - A-1, IS 783 : 1985

$$\frac{H}{B}=\frac{10}{3.530}=2.832, Ct=1.75$$

∴ Wc = $1.75 \times 18 \times (3.53)^2$

= 392.51 KN / M

For X=2/10, For X=3/10 - IS :783 - B1

Load factor F_t=2.6 F_t=3.6

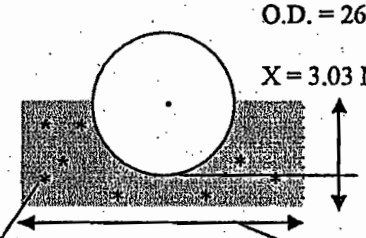
Minimum cracking load

= 392.51 / 2.6 = 392.51 / 3.6

= 150.96 KN / M = 109.030 KN /M

As per, IS - 458 : 2003, Load to produce 0.25 mm crack,= 166.70 KN/M

Hence Provide RCC NP4 Pipe with Bedding and support conditions as shown.



O.D. = 2600 + 2(215)

X = 3.03 M

$\frac{X}{D} = \frac{3}{10} \times 3.03 = 909 \simeq 1M$

100 MM

As per Clause B - 1
IS 785 : 1985

Width of cradle = D + 200
= 3.2300 Say 3.3 M Minimum

Reinforced Concrete where

$P = 0.4\% = \frac{\text{Area of steel}}{\text{Area of concrete at Invert}}$

As per WPCF Manual of practice No.: 9

Design and construction of sanitary & storm sewer (P.211)

5.1.2 Mechanical Works - Raw Water Pumping Station

5.1.2.1 Scope

The scope covers following:

(1) Providing 315 MLD pumping station at Navegaon Khairi with provision for future expansion i.e. providing 630 MLD pumping station (for immediate and future too).

(2) Providing, installing electrically operated penstocks at various levels

(A) Penstocks

(a) At intake structure
(b) in the distribution chamber at the end of the conduit.

(B) Screens

(a) Providing coarse screens (fixed)
(b) Providing installing, electrically operated removable screens in the distribution chamber near sump & pump house.

(3) Sump and pump house

(4) Vertical turbine pumps

(5) Lifting equipments

(6) Valves

(7) Delivery piping

(8) Sump Pumps

5.1.2.2 References:

Following references have been considered in the design of pumping station and equipments.

(i) Hydraulic design of pumps, sumps & intakes -MJ Prosser

(ii) Pump Handbook -Karasik, Messing, Cooper, Heald

(iii) Water Works Engineering (planning, design & operation) -Quasim, Motlay, Zhu.

(iv) CPHEEO Manual

(v) Hydraulic design of pump sumps and intake -IS -15310 -2003

(vi) Cast Iron single faced thimble mounted sluice gates -IS -13349 -1992

(vii) Pumping station design -Robert L. Sanks

(viii) Relevant B.I Standards

5.1.2.3 Pumping Station

Design considerations

(i) Size of sump to avoid vortex, starvation etc.
(ii) Adequate submergence to prevent cavitation at lowest water level
(iii) Keeping approach velocity within limits
(iv) Selection of pumps to suit maximum and minimum flow requirements of the system at better efficiency.

(v) Materials of construction to suit the quality of water pumped

(vi) Smooth operations, easy maintenance, control and monitoring.

(vii) Working space, loading, unloading facility, easy access to all equipments for operation & maintenance.

(viii) Noise and vibration level within permissible limits and safety

The G.A drawing covering all above points as proposed is enclosed.

The pumping station shall be near the road, in the area so that sub station of about 40 m x 30 m. shall be constructed exclusively for this and in the close vicinity of pump house, to prevent voltage drop.

The details are provided in the para 3 below:

5.1.2.4 Penstocks

Penstocks are considered for regulation of adequate flow at different levels of reservoir including emergency operation and also at the entrance of the distribution chamber and are for isolation of two compartments of the sump.

Thus two nos. of penstocks are provided at respective levels. All these penstocks are operated electrically. The levels and locations are as under:

(a) Location: Intake Tower

Sl.	Level	Qty.	Size in mm	Operating Head (mtrs.)	Type	IS
i	322.4 m.	4 Nos.	2500 x 1600	5	Flange Back Frame Sluice gate Wall mounted through CI wall thimble	IS-13349
Ii	311.4 m.	4 Nos.		15		
Iii	305 m.	2 Nos.		22		
iv	306.5 m.	2 Nos.		22		

(b) Location: Distribution Chambers

Sl.	Level	Qty.	Size in mm	Operating Head (mtrs.)	Type	IS
(i)	306.3	2 Nos.	2250 x 2500	22	Flange Back Frame sluice gate Wall mounted through CI wall thimble	IS-13349
(ii)	306.4	1 No.	2000 x 2000	22		

All these positions are shown in G.A Drawing. Design features are covered in intake structures.

The velocity at distribution chamber is 0.97 m/sec. (i.e. Q/ A = 5.46/(2.25 x 2.5) = 0.970).

The penstock shall be in cast iron construction with grade FG 200. The penstock shall be designed so as to ensure tight closure while maintaining freedom of door movement during operation so as to minimize sliding wear of sealing faces. The penstocks shall be suitable for seating and unseating head application and shall be upward opening type.

Non-ferrous metal sealing faces shall be made from accurately machined gunmetal or bronze strips beded and fixed in machined recesses by non-corrodible countersunk screws. The faces of the strip shall be hand scraped to watertight finish and operation of opening and closing. The spindle of penstock shall be rising type. The penstock shall be provided with suitable hand wheel of adequate diameter and bevel geared headstock suitably designed to ensure that operating force required at the rim of hand wheel does not exceed 200 N. Direction of opening and closing shall be marked on the hand wheel. The threads of rising spindle shall be suitably covered to protect from weather by means of weatherproof polycarbonate tube cover securely fitted. The head stocks shall be mounted on the floor as shown in drawing. Thrust tube with fixing bracket and spindle guide plates or alternatively technically equal arrangement shall be provided to absorb thrust in both direction of operation.

Adjustable type C.I wedging devices shall be provided to allow for future on site adjustment of wedges to enable appropriate wedging action and compensate for possible wear of sealing faces.

Gate position indicator shall be provided.

Material of construction of penstocks shall be as below:

Gate frame, shutter, wall thimble, headstock, stem guide bracket, wedging device, stop nut, yoke	CI FG 200 to IS 210
Wedges, sealing faces, operating nut	Gun metal L TB 2 to IS 318
Spindle and spindle coupling, fasteners, studs, anchor bolt.	Stainless steel AISI – 304/316

(c) Coarse Screen

10 number of coarse screens are provided in front of penstocks. These screens are fixed and installed vertically so as to prevent entry of wooden logs and similar objects into the intake structure. The sizes of the coarse screen are 3500 mm x 3500 mm. and shown in the drawing of intake structure. The design is also covered in the intake structure.

(d) Removable Screens

The intake conduits are terminated in the distribution chambers where the 2 no. of sliding and removable stainless steel screens 304 having 40 mm. spacing will be installed for each port. It shall be electrically operated with wire rope with hoist and will be lifted at 328 MRL so that one screen will always be in position to obstruct the debris leading to sump.

The size of the screens is;

2800 mm. x 3200 mm. and the velocity through screens is 0.609 m/sec. Four Numbers of such screens will be provided in each distribution chambers (ports).

5.1.2.5 Sump and Pump House

Present requirement	-	315 MLD
Future requirement	-	315 MLD
Total	-	630 MLD
Designed capacity	-	1.5 x 630 = 945 MLD
Hourly capacity	-	39375 m^3 (945 MLD)
	-	26250 m^3 (630 MLD)
	-	13125 m^3 (315 MLD)

Two compartments of the sump are provided with isolation for maintenance and desilting without affecting water supply and having the total capacity of sump with two compartments - 6750 cubic meters.

For effective water height of 15 meters, this is about 15 minutes capacity for 630 MLD and about 30 minutes for the present flow of 315 MLD (13125 m^3).

Width of sump:

(i)	Channel width	-	2000 mm
(ii)	Straight path to pump	-	5000 mm
(iii)	Centre of bell mouth of pump	-	1000 mm
(iv)	Back clearance	-	2000 mm
	Total	-	**10000 mm.**

Width of pump house:

(i)	Rear clearance between wall & panel	-	1000 mm.

(ii)	Width of3.3 kV panel	-	2000 mm.
(iii)	Draw out space required	-	2000 mm.
(iv)	Working space	-	2000 mm.
(v)	Pump bay	-	2000 mm.
(vi)	Dismantling joint, NRV, SV, BFV	-	4000 mm.
	Total	-	**13000,**
			Say 13500

However the pump house has to be spacious, well ventilated, space for movements of operations, engineers and same working space. As such the delivery header is proposed outside the pump house. The size of the pump house is 38 meters long and 10 mtrs. wide with two compartment. In order to have an approach from nearby road for loading, unloading bay at floor 328 R.L, 5.50 mtrs. Space is provided. One staircase is provided in each compartment.

Provisions in Pump House (Following provisions are made)

(i) Two compartments with isolation gate

Two compartment with isolating penstock to use any compartment at a time or both simultaneously.

(ii) Channel for streamline and uniform flow

2 meters wide, 3.5 m. deep channel

This arrangement is provided for uniform distribution of raw water to all pumps in required quantity. Further the silt accumulation will be done in channel for which a slope of about 5 degrees as shown in the drawing is provided with silt pocket of 1.5 m. x 1.5 m. x 0.6 m.

(iii) The bottom of the pump house shall have slope towards the pumps and the slope will be 7°, for 3 meters and thereafter flat floor for the remaining 5 meters.

(iv) Pump Floor (at 328 MRL)

The pump will be installed as shown in the drawing. The space between pumps, clearance and submergence is as per hydraulic institute standard and references. The discharge head shall be mounted on a base frame fabricated out of 400 x 200 mm. ICMC / suitable ISMB rigidly grouted to the RCC beam for which a slot of 1.5 meters x 1.5 meters is required. The R.L of this floor is 328 m. i.e. one meter above the high flood level. The delivery pipeline shall also be laid on this floor.

(v) Battery and Store Room, Retiring Room

The rear portion of this floor shall be used for battery 5m x 3m x 3 m. and a storage room of 3m. x 3m. x 3m. One room for operators 'off' duty or called as retiring room shall be provided at suitable place on the floor at 328 MRL.

(vi) Pump House & Header suitable for 630 MLD

Pump house & header is designed for 630 MLD as duplication after 10 to 15 years afterwards would involve huge expenditure about 3 to 4 times than the present besides disturbance in water supply. The reliability and sustainability is considered in this respect as the intake structure is designed for 630 MLD.

(vii) Vortex prevention cones

The cones below the pumps shall be provided upto 950 mm to prevent vortex formation.

(viii) Silting pockets & ports

1.5 m. x 1.5 m x 0.6 m. silt pockets - 4 Nos. are provided in the pump house.

a) One each in the 2m x 3.5 m. channel near the centre of the pump_house – 2 Nos.

b) One each in the left and right front corners of pump house – 2 Nos.

The M.S rigid grill of 1.5m. x 1.5m. may be provided at floors 328 m (4 No.) and 331 m (2 Nos) for disilting ports through a bucket of 1000 mm x 900 mm x 800 mm.

(ix) Loading unloading bay at 328 MRL

5.5 meter loading, unloading space is provided at with approach directly for tank / pumps from road.

(x) 1.2 meter walkway

1.2 meter walkway is provided around the 3 sides (sides and back) of pump house to have access to distribution ports for removal of debris and also for observation. The same shall be carried through wheel borrows of 0.9 m x 0.6 m.

(xi) Operating Floor (at 331 MRL)

The floor shall be at 331 m. and 7 meters wide upto pumps. The glass panels with doors shall be provided about 17.50 m. x 5 m. x 4m. on both sides of the H. T panels. The glass panels for the left hand side

shall be provided while the one on right hand side would be constructed afterwards.

(xii) Corbel level – 336.000 MRL suitable for 15 MT.

(xiii) Invert level of pump house roof – 338.500 MRL

(xiv) Adequate light & ventilation

Adequate light and ventilation has been provided with access to substation.

(xv) Toilet & Bathroom

The toilet and bathroom for operators, visitors is absolutely necessary but not accommodated in the pump house.

The same shall be provided in the comer of sub station which will be close to operators from pump house and those from sub station

Raw Water Pumps

1. Governing Levels

a.	River bed level	304.0 MRL
b	Minimum water level in Pench Reservoir (FRL)	314.0 MRL
c	Full reservoir level of Pench Reservoir (FRL)	325.0 MRL
d	Highest Flood Level (HFL)	327.0 MRL
e	HGL required at Break Pressure Tank (BPT)	358.0 MRL
f	Floor Level	328.0 MRL
g.	Nearest ground level at proposed pump station	328.0 MRL

The levels at a to d above have been adopted from the data furnished by irrigation department whereas HGL at BPT has been calculated. Calculations for HGL at BPT are furnished subsequently in their report. The ground level at proposed intake work is adopted as per actual surveys carried out. The floor level is decided considering safety i.e. 1 meter above HFL.

2. Type of Pumps

The choice is between vertical turbine pumps and centrifugal pumps. The pumps will have to be located above HFL to avoid submergence in case of floods. The difference between HFL and minimum level is 13.0 M. Centrifugal pumps cannot work for such high suction lifts and hence are ruled out. Vertical turbine pumps is therefore an obvious choice.

Turbidity of water is less than 50 NTU since it is impounded and as such, self water lubricated vertical turbine pumps are always preferred over oil lubricated pumps for ease of maintenance and do not require any consumables for operation. Oil lubricated pumps are installed only when the raw water characteristics are adverse.

Hence self water lubricated V. T. Pumps are proposed.

3. Pump Nominal Speed

Pump size reduces with increase in the nominal speed, however higher speeds result in increased wear and tear and thus higher maintenance cost. High speed pumps are also susceptible to higher vibration and noise levels. Considering the above aspects, general engineering practice and size of pumps involved it is proposed to provide pumps with a nominal speed of 980 RPM (1000 RPM syn.).

4. Pump Specific Speed

Pump specific speed is the most important criterion for deciding the number of operating pumps and there number of stages for this pump. From maintenance point of view, minimum number of stages are preferred. Pumps with low specific speeds have unstable performance characteristics whereas pumps with very high specific speeds are sensitive to the variations in total head of pumps. The preferred range of specific speed is 3000 to 4000 in US units or 58 to 77 in SI units.

5. Duty Conditions

a. Total Head on Pumps

For calculation of static head on pumps mean water level [(325+314)/2 = 319.5] has been considered. Hence the static lift works out to 38.5 meters.

Frictional losses in 40 meter header of 2032 mm. M.S pipeline, 20 mm. thick and provided with 12 mm. thick mortar lining work out to 0.196 meters.

Hence the total head on pumps worked out as under:

Static head	=	38.5 m.
Frictional losses in pipeline, valve, Entrance and exits (station losses)	=	4.224 meters
Therefore Total head on pumps	=	42.72 meters

Say 43 mtrs.

b. Discharging capacity

Capacity of the scheme = 315 MLD

Normally to overcome the interruption in power supply due to low frequency, low voltage about 3% additional capacity is considered.

315 + 9.45 = 3245
say 325 MLD

The 4 nos. of duty pumps are proposed so that discharge of each pump would be 81.25 ml/day or 941 liters/second.

6. Pumps

6.1 Working Pumps

a. The total capacity of 315 MLD (325 MLD with 3% extra) will be pumped by operating 4 pumps in parallel.

b. stand-bye pumps -2 nos. of pumps will be provided as stand-bye. i.e.50% which is as per norms of CPHEEO.

c. Immediate + future pumps -The life of pumps being 15 years, 6 nos. of pumps are proposed and 6 nos. for future needs of additional 315 MLD and as such the pump house provided for the 12 nos. of pumping sets.

d. Single stage, VT Pump (self water lubricated)

Specific speed	-	3000 (U.S. units)
Nominal speed	-	1000 (syn)
Stage	-	Single stage

7. Horse Power

The 750 HP (560 kW) pumps are required.

8.	Column dia.	=	700 mm. for velocity 2.44 meters/sec. which is within permissible limits of 2.75m/secs. (CPHEEO page 673)
9.	Bell mouth dia.	=	950 mm. with velocity of 1.31 m/sec. <1.50 m/sec as per CPHEEO, P-415)
10.	Column thickness	=	12 mm. thick.
11.	Shaft dia.	=	100 mm.
Discharging capacity		=	941 lps
Total head		=	42.72 m
			Say 43 m
Submergence		=	2700 mm
Head range		=	31 m to 50 m
Shut off		=	Above 55 m
Efficiency		=	80%

5.1.2.6 Codes and Standards:

The design, manufacture and performance of the V. T. Pumps shall comply with all currently applicable statues, regulations and safety codes in the locality area where the equipment will be installed. The equipment shall also conform to the latest applicable Indian standards as under

IS 1710	Vertical turbine pump for clear cold, fresh water.
IS 5120	Technical requirements for roto-dynamic special purpose pumps.

Where the above standards are in conflict with the stipulation of this specification, this specification supersedes them.

5.1.2.7 Design Requirements

The equipment shall be capable of developing the required total head at rated capacity for continuous operation. The total head discharge curve shall be continuously rising towards the shut off with highest shut off point. Pumps shall be identical and shall be suitable for parallel operation with equal load division. Impellers shall preferably be of non over-loading type. Pumps shall run smooth without undue noise (85 db) and vibrations. The magnitude of peak to peak vibration at slip will be limited to 100 microns at the bearing housing.

5.1.2.8 Features of Constructions

Pumps shall be vertical Turbine type with required number of stages not exceeding the requirement given above and suitable for the service condition stipulated.

5.1.2.9 Bowl Assembly

A pump bowl/bowls shall be flanged with machined matching of faces. The suction bell mouth to bowl assembly, to column and to discharge head i.e. all joints shall be flange joints. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice the duty head or 1.5 times shut off head whichever is greater.

5.1.2.10 Suction Bell Mouth & Strainer

A cast iron/M.S. bell mouth not less than 950 mm dia. Shall be fitted to the suction nozzle to limit the velocity. The suction strainer shall be of S.S. Net opening area in strainer shall not be -less than 3 times of entrance area of bell mouth. The shape and curvature of the bell mouth shall be designed to

streamline the flow of bowl suction. The thickness of bell mouth shall not be less than 10 mm.

5.1.2.11 Impeller

The impeller/s shall be dynamically balanced so as not to cause any vibrations during operation. The impellers shall be closed type and shall be made in one piece and securely fixed to the stainless steel shaft, to assure accurate adjustment of each impeller. The water passage will be finished smooth by hand. Balancing holes / device for reducing hydraulic thrust shall not be provided.

5.1.2.12 Wearing Rings

Wearing rings shall be renewable type. These shall be held in place by screwing against rotation, press fit or locked with pins, flanged and screwed. Wearing rings shall be provided on both easing and impeller.

Hardness of wearing rings shall be less by atleast 50 BHN than the impeller.

5.1.2.13 Shaft

The shaft shall be of stainless steel and finished to the close tolerance at the impeller / bearing fixing sizes.

The design of the shaft shall also take into consideration the critical speed of the shaft, which shall be at least 20% abovelbelow the operating speed.

The shaft shall be properly balanced so as not to cause any vibrations during operation and shall have bush bearings of stainless steel, water lubricated. Extra long bearing shall be provided for suction and discharge bowls. The hardness of bush bearing shall be less by atleast 50 BHN than that of shaft.

5.1.2.14 Column Pipe Assembly

Column pipes shall be of M.S. Fabricated heavy weight, flanged type each in 1.5 m length or less so that after complete erection of the pump/s the bottom of stainer shall be at RL 308 m and length of strainer shall be adjusted accordingly. The total length of column assembly, bowl assembly, bell mouth and strainer shall be 20 mtrs. for each pump.

The column assembly length (including column pipes, bowl, assembly, bell mouth and stainer) shall be adjusted considering, the pump floor, levels, as given above. A matching piece shall be provided if required. The stiffeners shall be provided to all pipe flanges. The discharge head/tee and column pipe dia shall be same. The discharge head/tee incorporate full diameter elbow.

5.1.2.15 Line Shafts

These shafts shall be of solid circular section, prepared from stainless steel machined and ground thoroughly and coupled with screwed or muff couplings. The shaft sections shall be provided with non-corrosive and abrasion resisting wearing surfaces particularly at the location ot" each guide bearing. Length of line shaft shall not be more than 1.5 m. each.

5.1.2.16 Line Shaft Bearings

These shall be designed to be water lubricated by the pumped water and shall be placed in bearing holders located in position at the joint of columns. Line shaft bearing shall be of cutless hard rubber designed for efficient water lubrication. Composite design of line shaft material and it's diameter and bearing centres shall ensure that the entire rotating assembly is brought from *stand-still* to full speed without any vibrations and shaft deflection and to ensure that first critical speed is not within 80% to 120% of full speed.

Reverse Rotation -

The unit shall be suitable for reserve operation during power tripping of adequate or provision to prevent non reversible ratchet shall be provided.

5.1.2.17 Discharge Head & Motor Stool

The discharge head shall be fabricated from M.S. and shall incorporate mounting flange for motor stool for solid shaft motor, shuffling box with renewable gland packings and tapping for pressure gauge mounting etc. The discharge head shall be of robust construction and shall be designed to support entire load of pump assembly, water column and motor etc. and shall withstand all static and dynamic, torsional loads, hydraulic thrust imposed during operation from shut off to stipulated operating conditions and thrust due to change in direction of flow, without any vibrations. The discharge head shall be installed on sole plate with ISMB / ISMC frame and entire load of motor and pump shall be on the lower floor as given below:

Pump floor level	328 MRL
Operating floor level	331 MRL

Drain arrangement for gland leakage water shall be provided at bottom of discharge head with G.I. Pipe. The base of the discharge head shall not be less than 1500 mm x 1500 mm. The power shall be transmitted from motor to vertical shafting through a flexible coupling. Both halves of the coupling shall *be* machined all over, securely keyed to their respective shafts. The pins shall be of stainless steels. The arrangement of two halves shall be suitable to check alignment and parallelism. A self aligning thrust bearing shall be housed in the head gear adequately designed to accommodate entire weight of rotating parts and hydraulic thrust and shall be suitable for reserved rotation up to atleast 150% normal forward speed. Bearing shall be designed for 30,000 hours life. The bearing shall be of oil lubricated type and shall be provided with oil level gauges and suitably positioned temperature probes. Two sets of adjustable contacts shall be provided one for an alarm and other for tripping the Raw

water pump motor. This shall be connected to scanner panel so that digital temperature can be read with alarm and tripping.

Motor stool shall be provided for mounting the electric motor. The motor stool shall accommodate the pump thrust bearing and pump motor coupling. The motor stool shall be robust construction and of fabricated mild steel and adequately sized with opening to work on the flexible coupling. Height of pump supporting girder/channel, discharge head and motor stool shall be adjusted to have motor base at or marginally above panel floor level.

5.1.2.18 Miscellaneous

The pump shall be provided with non reversible ratchet or similar mechanism to prevent them from rotation in reverse direction. Pressure gauge to each pump and manifold pipe shall be provided. Pressure gauge shall be 150 m~ dia. 0 -15 kgicm2 and least count shall be 0.05. Each pressure gauge shall be fitted with restrictor nozzle of brass and G.!. Pipe and U tube. Pressure gauge on manifold shall also be provided. All pressure gauges shall be installed in pump house on wall with necessary G.I. pipe connections from manifold to pump house. The pressure gauges shall be installed at suitable height so that the reading can be taken accurately.

5.1.2.19 Sole Plate

The M.S. Sole plate arrangement as shown in the drawing shall be provided under the discharge head for precise horizontal and vertical alignment. Thickness of sole plate shall not be less than 40 mm. It shall be independent of base plate integral with the discharge head. The contact surfaces of the sole plate arrangement as under shall be machined for precise leveling and shall ensure vibration free operation of the pump.

i) Corner plates and sole frame
ii) Sole frame and sole plate
iii) Sole plate and discharge head

All joints between machined contact surfaces shall be with nut bolts /tapped studs / bolts. All contact surfaces shall be blue-matched to ensure proper contact to the extent of 60% of contact area after necessary site finish if required. The opening in the sole-plate/frame shall be of adequate size to pass the bowl assembly etc. very easily. M.S. base frame shall be anchored in the floor ensuring complete rigidity. Entire structural fabrication and foundation arrangement shall be designed and submitted for approval. M.S. Plates shall be grouted on pump supporting R.C.C. beams provided in structure. The fixing of M.S. Plates on the R.C.C. beams and subsequent anchoring of M.S. sole frame in proper level shall. The minimum size of sole plate shall be 1.5 mx 1.5mx 0.04 m.

5.1.2.20 Air Release Arrangement

An air valve of dia 100 mm shall be provided on M. S. Tee or for the discharge head. For expelling the while starting and admitting air

5.1.2.21 Water Lubrication Tank and other Accessories

In order to lubricate line shaft bearing of the pump, lubrication arrangement comprising the following shall be provided.

i) Lubrication tanks 2 Nos. interconnected with each other and common for all pumps fabricated from sheet metal of thickness not less than 5 mm and of capacity not less than 2 M^3. The tank shall be cylindrical and shall be installed on panel mounting floor with at least 6 concrete saddles at a suitable place.

ii) Each lubrication tank shall be equipped with the following:-

a) W L sight gauge
b) Overflow lead to sump
c) Drain valve lead to sump

d) G.I. pipe connection with isolating valve and non-return valve to each pump column assembly for lubrication. The valve shall be located near the tank. The size of individual pipe and valve to pump shall be 40 mm. dia

e) Inlet connection with solenoid operated valve and suitable removable strainer by suitable tapping from common header.

f) Float valve in the tank for control of overflow.

g) Any other item necessarily required for proper functioning.

5.1.2.22 Materials of Construction

a)	Discharge and suction case, Bowls	C.I.I.S. 210 Gr. FG 200
b)	Discharge head, Bell mouth and motor stool.	M.S. Fabricated.
c)	Impeller	Stainless Steel of CF 8M.
d)	Impeller Shaft	High grade carbon steel/stainless steel AISI 410/416
e)	Column Pipes	ERW Heavy Duty / MS Fabricator
f)	Shaft Sleeve	Stainless steel AISI 410/416
g)	Line shaft	Stainless steel AISI 410/416
h)	Nut bolt and washer	Stainless Steel AISI 410
i)	Wearing ring	Bronze
j)	Line shaft bearing	Cutless hard rubber.

Minimum Sizes

a)	Column Pipe diameter	700 mm
b)	Thickness of column pipe and bell mouth	12 mm
c)	Impeller and line shaft dia. commercial size	100 mm or nearest
d)	Bell mouth diameter	950 mm
e)	Thickness of sole plate	40 mm
f)	Length of each column pipe (flanged)	1.5 mtrs. For 20 mtrs length excluding bowl assembly, bellmouth and strainer
g)	Flanges of columns	Conforming to 1538 not less than 25 mm thick
h)	Discharge head	Flat bottom
i)	Discharge Elbow	700 mm dia
j)	Noise level	Not more than 85 db
k)	Vibration	below 100 microns

5.1.2.23 Non-Return Valve

i. The non-return valve will be swing reflux valve type with multiple doors. The valve will be generally conform to IS 5312 Part 2.

ii. The valve will be suitable for mounting on a horizontal pipeline and flow direction will be clearly embossed on the valve body.

iii. Valves will possess high speed closing characteristics and be designed for minimum slam when closing.

iv. PN Rating shall be 1

v. Material of construction will be as follows :-

Body and door	:	CI grade FG 260 conforming to IS 210 / S.G. Iron grade 400/12 to IS 1865 / Cast steel grade B conforming to IS 1030
Hinge pin & Face and seat rings	:	Stainless steel 04 Cr17 Ni 12 Mo2 / 04 Cr 18 Ni 10 to IS 6603
Bearing bushes	:	Leaded Lin Bronze grade, LTB 2 to Is 318

5.1.2.24 Sluice Valve

5.1.2.24.1 Design requirements

a. Sluice valves are generally conforms to IS 14846. Additionally they should also meet specific requirements as stated.

b. Spindle thrust collar and operating arrangement including hand wheel should be designed in such a way that one man is able to operate the valve against full different pressure by exerting not more than 40KGF.

5.1.2.24.2 Feature of construction

a) Valve shall have non-rising spindle.

b) Valve shall be with bushing arrangement for replacement of packing without leakage.

c) Valves sizes 450mm and above shall be provided with renewable CI channel & shoe arrangement and clearance being controlled between 2 to 3 mm throughout the travel.

d) Valves size 450mm and above shall be provided with grease packed enclosed spur/worm gearboxes.

e) All valve doors when fully closed would ensure door faces are riding on body seat ring by at least 50% of the width seat rings and there is sufficient room for wear travel.

f) All face and seat rings will be force/ press fitted and rivetcd to the recess in the CI casting

g) Nominal size of the valve, make, pressure rating shall be cast on the body of the valve.

Data

1. Size	:	700 mm dia
2. Design rating	:	PN 1
3. Drilling	:	IS 1538 PART IV & VI
4. Material of construction	:	
Body	:	CI IS 210 GR FG 260
Disc	:	CI IS 210 GR FG 260
Spindle	:	St. Steel IS 6603 GR 12 CR 12

Seat & Face Rings	: Bronze IS 318 LTBII
Channel & Shoe	: Cast Iron
Drain & Plugs	: Bronze IS 318 LTB II
Gear Box Housing	: CI
Gears	: SG IRON IS 1865 GR 500/7
Ball Thrust Bearing	: Bronze
Bushing Arngmt	: Bronze.
Rivets	: Soft Annealed Brass
Gland Packing	: Grease Hemp
Fastners	: MS.

5.1.2.25 Butterfly Valve

- The butterfly valve will be double flanged long body rated for PN 1.0 conforming to IS 13095 of 700 mm dia. The valve will be suitable for horizontal mounting. Bypass is not required.

- Resilient seat will be provided as per IS 13095.

- The face to face dimensions of the butterfly valve will be as per IS 13095 for double flanged long body BFV.

- Material of construction will be as follows :-

- Body & Disc.	:	CI grade FG 260 conforming to IS 210 / S.G. Iron grade 400 / 12 conforming IS 1865 / carbon steel as per class / grade in IS 13095
- Shaft	:	Stainless steel 12 Cr 13 / 15 Cr 16 Ni2 / 04 Cr 18 Ni10 / 04 Cr 17 Ni 12 Mo2
- Sealing ring / seal retaining ring	:	Stainless steel 04 Cr 18 Ni 10 / 04 Cr 17 Ni 12 Mo2

- Elastomers : Nitrile / Neoprene / EPDM rubber

- Internal fasteners : Stainless steel

5.1.2.26 Electric Actuator

5.1.2.26.1 Components / Accessories

The Electro mechanical actuator for sluice valve will be suitable to comprise motorized gear train to transmit drive to the valve stem. The actuator will be supplied with the following accessories.

a. A.C. electric motor.

b. Reduction gear unit.

c. Torque switch mechanism complete with set of torque switches.

d. Limit switch mechanism complete with set of limit switches.

e. Handwheel for manual operation.

f. Hand-auto changeover lever with suitable locking arrangement.

g. Local control switch / push buttons

h. 415 V / 240 V AC control transformer

5.1.2.27 Kinetic Air Valve

- The air valve of 100 mm and 200 mm diameter will be designed for PN 1.0 rating

- The valve will be capable of exhausting air from column assembly automatically when the pipeline is being filled and air being released at a sufficiently higher rate to prevent the restriction to Inflow. Similarly the valve will be capable of ventilating column assembly automatically when being emptied. The air inflow rate will be sufficiently high to prevent the development of a vacuum in pipeline. The valve will be automatically release air accumulated in pipe line work during normal working condition.

- Air valve will be of kinetic double orifice type with a large orifice for ventilation and exhausting air from the pipeline and small orifice for release of air under working pressure. The valve will be suitable for maximum working pressure in the system. The air valve will be provided with isolating valve and flanged end connection.

- A separate sluice valve of 100 mm diameter and PN 1.0 rating will be provided for isolation of air valve.

- Air Valve shall confirm to IS 14845

5.1.2.28 Pipe work and Fabricated Platform

5.1.2.28.1 General Requirements

Material of steel pipes and fittings will conform to IS:2062. Fabrication and testing will be in accordance with IS:3589 for pipes and IS:6392. The thickness shall be 20 mm and dia shall be of 2032 mm. The individual delivery pipe of pump shall also be 15 mm thick and 700 mm dia and supported by suitable MS/ RCC support and connected to common header with readial tee with pressure gauge. The header shall also have 200 mm dia sluice valves for scovering the pipeline during maintenance. Two 1200 mm

dia NRV shall also be installed on this header to prevent back flow of water. The thickness of pipeline is suitable to withstand water hammer pressure.

All the piping will be suitably supported by RCC chairs.

5.1.2.29 Dismantling Joint

Dismantling joint one for each pump will be provided in delivery side to facilitate removing valves.

The dismantling joint will be designed for hydro static test pressure of 1.6 kg/m^2. The dismantling joint will be in MS/ SS construction.

5.1.2.30 Supports, Thrust Blocks, Pads

Designed RCC/CC/structural steel support will be provided underneath pipeline in the pump house, wherever required and pads/ fabricated platforms to operate the valves

5.1.2.31 Lifting Equipment

5.1.2.31.1 Electrically Operated Traveling Crane

The crane will be electrically operated, single girder bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and will conform to IS:3177.

- Safe working load : 15.0 MT
- Class : 2
- Lift : 10 meters
- Suitable for : lifting, lowering, long travel, cross travel

5.1.2.31.2 Lifting equipments for Penstocks and Screens

2 No 10 MT lifting equipments and 3 MT Electric Hoist 4 numbers for screens with necessary monorails comprising traveling trolley, hoisting arrangements with ISMB 500 x 210 fixed to RCC beams or mounted on ISMB shall be provided. The lift shall be about 22 meters. This will be electrically operated.

5.1.2.31.3 Sump Pumps

Two numbers of sump pumps are proposed with piping and panel for disilting muddy, turbid water and shall be lowered at any place (4 places) provided in the pump house as and when required. The capacity of each pump would 1,10,000 ltrs/hr. at a total head of 30 mtrs. These pumps shall be portable.

5.1.2.32 Calculations

1. Specific speed (Ref. Pump Hand Book By Igor J. Karassik)

325 ml capacity by 4 pumps each with 81.25 ml.

Specific speed = $N_s = \frac{N\sqrt{Q}}{H^{.75}}$

Where;

N = Speed of pump

Q = US gallons / minute

H = Total head in feet

Assuming single stage pump and speed as 980 rpm

Q = 941 litrs./sec.

H = 141.04 feet (43 mtrs.)

$$= 980 \times \frac{\sqrt{\frac{941 \times 60}{3.782}}}{141.04^{0.75}}$$

$$= \frac{980 \times 122.18}{40.92}$$

= 2927,

Say 3000 O.K

4 working, 2 standbys sets are therefore adopted as found suitable

2. Column pipe dia.

Flow, Q = 0.941 m^3/sec.

Q = A x V

V = 2.75 m/sec.
(permissible limit CPHEEO page –673))

$$A = \frac{\pi}{4} \times d^2 = \frac{Q}{u} = \frac{0.941}{2.75}$$

$$d^2 = \frac{0.941 \times 4}{3.14 \times 2.75}$$

= 0.4359

d = 660 mm.

Adopt 700 mm. dia.

$$v = \frac{Q}{A} = \frac{0.941}{.7854 \times .7 \times .7}$$

= 2.445 m/sec. is within acceptable limits.

3. Bell Mouth Dia., D

D = About 1.5 d.

Say 700 x 1.5 = 1050 mm.

With 1000 mm. dia bellmouth

$$v = \frac{0.941}{.7854 \times 1 \times 1}$$

$$= 1.19 \text{ m/sec.}$$

With 950mm dia bellmouth

$$V = 1.32 \text{ m/sec. which is OK}$$

$$\text{Hence } D = 950 \text{ mm. O.K}$$

$$D/d = \frac{950}{700} = 1.35 \text{ O.K}$$

4. Column thickness

$$P = \frac{2st}{D} \quad \text{(Ref.: IS 3589-2001)}$$

Where,

s = Yield stress = 235 M Pa.

P = 42 m. = 4.2 kg/cm^2 = 0.42 N/mm^2

$$0.42 = \frac{2 \times 0.6 \times 235 \times t}{700}$$

$$t = 1.04 \text{ mm.}$$

Provide 1.50 mm for corrosion allowance

$$t = 6.3 \text{ mm. (Min As per IS 3589:2001)}$$

HEAD LOSS IN;

(i) Bell mouth, $Hf = \frac{k \times v^2}{2g}$

$k = 0.05$ (Pump Hand book)

$= \frac{0.05 \times 1.7424}{2 \times 9.81}$

$= 4.44^{-03}$

$= 0.00437$

Say 0.005 mtrs.

(ii) Column pipe 700 mm dia $= \frac{10.676 \times 1.}{(.7)^{4.87}} \times \left(\frac{0.941}{130}\right)^{1.852} \times 20 \times 1.2$

$= 0.1665,$

Say 0.170 m.

(iii) Discharge Head $= \frac{kV^2}{2g}$

(K= 0.5, As per CPHEEO, P-115)

$= \frac{0.5 \times (2.75)^2}{2 \times 9.81}$

$= 0.192$ m.

(iv) Non return valve (700 mm dia) (Check Valve)

$k = 2.5$ (As per CPHEEO, P-115)

$$h_f = \frac{kV^2}{2g}$$

$$= \frac{2.5\times(2.44)^2}{2\times9.81}$$

$= 0.758$ mtrs.

(v) Sluice valve (700 mm dia)

$k = 0.19$ (Pump Hand book)

$$h_f = \frac{0.19\times(2.44)^2}{2\times9.81}$$

$= 0.115$ mm.

(vi) Butterfly valve (700 mm dia)

$k = 3.00$ (Enquiry from vendor)

$h_f = 3 \times 0.606$

$= 1.8204$ mtrs.

(vii) Radial Tee (Bend)

$k = 0.38$ (As per CPHEEO, P-115)

h_f = 0.38 x 0.606

= 0.230 mm.

(viii) Head loss through (40 mtrs) header and rising main (60 mtrs) of 2032 mm dia as Hazen and Williams formula

20 mm. thick and 12 mm. mortar lining

hf = 0.196 mtrs.

(xi) 1200 mm NRV = 0.758 mtrs.

Total head = Static head + frictional losses

= 38.5 + 0. 005 + 0.170 + 0.192 + 0.758 + 0.115 + 1.8204 +0.230 + 0.196 + 0.758

= 42.74 mtrs. Say 43 mtrs.

Driving head is not required as there is enough margin.

$$BHP = \frac{Q \times H}{75 \times n}$$

Q in literes/ second = 941 l/s.

H = 43 mtrs.

Efficiency 80%

$$= \frac{941 \times 43}{75 \times 0.80} \times 1.1$$

(80% efficiency and 10 % margin)

= 741.82, Say 750

(ix) Shaft dia.

N = 980

HP = 750

HP = $2\pi \times NT$

750 = $2 \times \pi \times 980 \times T$

T = $\frac{750}{2 \times \pi \times 980} = 0.1218$

F = 630 kg/cm^2

= $\frac{\pi}{16} d^3 \times fs = 0.1218$

d^3 = $\frac{0.1218 \times 16}{\pi \times 630}$

= 9.85^{-04}

d = 0.0995 m.

= 99.5 mm.

Say d = 100 mm

Cross check

$$HP = \frac{fNd^3}{321000}$$

$$f = 7000 \text{ lb/in}^2$$

$$d = \sqrt[3]{\frac{750 \times 321000}{7000 \times 980}} = 3.27 \text{ in.}$$

$$= 83.15 \text{ mm}$$

Say adopt 100 mm which is higher and safe.

Dynamic Weight of Pump

1.	Weight of bowl assembly (900 mm)	=	1747 kg
2	Weight of strainer	=	150 kg
3	Weight of 950 mm dia bellmouth	=	112 kg
4	Weight of 700 mm dia 18 mtrs. Long column pipes	=	3726 kg
5.	Weight of Flanges – 20 numbers (900 mm dia OD 25 mm thick)	=	1180 kg
6	Weight of Water	=	6920 kg.
	Total (1 to 6)	=	**13838** kg
	Capacity of EOT Crane	=	15000 kg.
		=	15 MT
	Weight of discharge head + motor	=	4000 kg.

Dynamic weight = 3 x Pump weight + 2 x Motor weight (as per IS 2974 Part 4)

3 x 15 + 2 x 4 = 53 Tones

Maximum and minimum head on pumps

Minimum head = Discharge level in BPT – Level at HFL + h_f

= 358 – 327 + 4.24 = 35.24 mtrs.

Say 31 mtrs. (with margin)

Maximum head = Discharge level in BPT – lowest water level of the reservoir + h_f

= 358 – 314 + 4.24 = 48.24 mtrs.

Say 50 mtrs.

5.1.3 Electrical Works for Raw Water Intake Pumping Station

5.1.3.1 HT Panel Design

Electrical power will be supplied by MSEB at 33 kV through two separate substations by express feeders for reliability of supply.

1. Fault level is 191.46 MVA (3.35 kA for 3 sec) for three phase fault and 172 MVA for single phase fault as per MSEB.

2. System Voltage

Nominal	-	33 KV
Highest	-	36 KV (1.1 times nominal voltage)

5.1.3.1.1 Design Basis

At present 4 Nos. river intake pumps will be run to deliver the required capacity and two pump will be standby. This along with the aux. load for the pumping station will be the total load of the pumping station. In emergency it may be necessary to run 5 Nos. of pumps. Incomer is sized based on this philosophy.

Sr.	Description	Rating Kw	kVA rating kW/PF	Qty No. working+ stand by	Total connected Load KVA	Working Load in kVA	Diversity Factor	Total demand KVA
1	2	3	4	5	6	7	8	9
			a	b	a x b = c		d	c x d
1	Raw water pumps	580	683	4 + 2	4098	3415	0.9	3073.5
2	Aux. Load	81	102.25	Lot	102.25	101.25	1	101.25
						Total		3174.75

					20% design margin	**634.95**
					Grand Total	**3809.70**

Note:

** For details of auxiliary load, Item No : 2 shall be referred.

Total load = 3174.75 KVA

Load Current = 3174.75 / 33 x 1.732 x 0.9

= 61.72 Amps

33 KV intake pumping station receives power supply from MSEB at 33 KV. We have considered one 33 KV SF6 circuit breaker switchboard to receive the power supply and feed the intake pump motors and auxiliary load through suitable step down transformers. The switchboard shall consist of 2 incomers each rated for 100 % capacity with bus coupler and suitable outgoing feeders. Both the feeders can operate independently with the bus section breaker open. When one of the feeders trips on under voltage the other incomer feeder caters for the total pumping station load by closing the bus-section breaker automatically. Suitable auto changeover scheme is employed to implement this. Bus-section breaker shall close automatically after a time delay to allow for momentary voltage dip. Auto change over scheme shall ensure that the residual voltage is within safe value, before closing & voltage is less than 20 % (no volt condition) on the faulty feeder / bus for tripping and voltage available on the healthy bus/feeder shall be more than 80 %. For this suitable under voltage relays are used.

It is proposed to provide transformers at 4000 kVA, 33/3.6 kV capacity each so that single transformer can take full load in case of one transformer taken out for maintenance or repair.

The outgoing feeders comprise two main transformers. SF6 circuit breaker of suitable rating are considered with necessary protection for the transformer for both the outgoing feeders.

5.1.3.2 Breaker Design

5.1.3.2.1 33 kV Switch Board

Maximum load Current at 33kV breaker = $\frac{4000}{1.732 \times 33}$

= 69.98 Amp

Rated continuous current of Breaker chosen = 630 Amp.

Maximum Fault Current = symmetrical breaking current

Fault Level/($\sqrt{3}$ x Line Voltage) = 3.75 kA (Actual) for 3 secs.

Considering Line Voltage = 33 kV

Rated interrupting current rating = 16 kA

Making current = 1.8 x $\sqrt{2}$ x symmetrical breaking current

= 9.66 kA (Actual)

Chosen making capacity (peak) = 50 kA

Bus bars = 600 Amps, AI

Conclusion:

The maximum sinusoidal r.m.s. current, symmetrical making current and making current are within the rating of chosen breaker.

5.1.3.2.2 Current Transformer for 33 kV Circuit Breaker

Current rating at 33 kV side	=	69.98 Amp.
Nearest standard C.T. Rating available	=	100 Amp.
Secondary current rating for protection and metering	=	1 Amp.
The fault current at 192 MVA fault level is	=	3.5 kA
Accuracy class for metering C.T. core I	=	Class 1
Accuracy class for protection C.T. core II	=	5 P20

VA Burden of Core I

VA Burden of Digital power Meter	=	<5 VA
VA Burden of Ammeter	=	5 VA
Total VA Burden	=	10 VA
VA Burden chosen	=	15 VA

VA Burden of Core II = Over Current & Earth Fault Relay Element

= 10 VA

Rated burden chosen for both core = 15 VA

5.1.3.2.3 Voltage Transformer for 33 kV Circuit Breaker

Transformer Ratio is (33/ √3 kv) / (110/ √3)/ (110/ √3)

VA rating = 50 VA /phase ,Accuracy Class :1

VA Burden of Digital power monitor meter	=	10 VA
VA Burden of voltmeter	=	5 VA
VA Burden of under-voltage relay	=	5 VA
VA Burden of Indicating Lamps	=	15 VA
Total Burden in VA	=	35 VA

5.1.3.2.4 3.3 kV Switchboard

Main electrical load is of 6 Nos., 580 kW (778 HP) pumps motor sets. Considering the ratings of motor, it is proposed to use 3.3 kV motor with DOL starter.

The switchboard shall include the following:

(1)	Incomers (2 Nos.)	=	1250 A, withdrawal vacuum circuit breaker, Relays
(2)	Bus complex (1 No.)	=	1250 A, withdrawal vacuum circui t breaker, Relays
(3)	3.3 kV motor feeders (6 Nos.) with DOL starters for 560 kW motor	=	630 A, with drawl vacuum circuit breaker, Relays
(4)	Transformer feeders (2 Nos.)	=	400A, withdrawal vacuum contactor with fuse, Relays

		Incomer & Bus ampler	3.3 kV	Aux. Trans
a)	Maximum Load Current	700	128	40
b)	Rated continuous current of breaker chosen	1250	630	400
c)	Fault level in kA at 3.3 kV Bus as per MSEB for 3 secs.	10.96	10.96	10.96
d)	Rated interrupting current rating in kA	25.0	25.0	25.0
e)	Making current (2.55 x Breaking current)	27.95	27.95	27.95
f)	Chosen making current capacity	63.0	63.0	63.0
g)	Bus bar shall be Aluminum for 2500 Amps.			

Current Transformers for 3.3 kV breakers:

(1) Incomers

C.T ratio:

1500/1 Amps, 5P10 for over current protection

C.T ratio 1500/1 Amp, Clear PS for restricted earth fault protection

(2) Motor feeders

C.T Ratio = 150/1 Amps Class 1

(3) Aux. Transformer feeder

C. T ratio = 100/1 Amps 5P20

5.1.3.3 Protection

5.1.3.3.1 Protection For Transformers

Protection of the Incomer feeder shall be provided by means of IDMT relay with two elements having range 50 to 200 % of 1 Amps. With definite minimum time of 1.3 Sec. at 10 times the current setting. Earth fault shall be IDMT with 10 to 40% setting range.

1.3 Sec relays have been chosen since the VCB/SF6 are provided at the downstream and hence operating time would be less than 100 milli sec. Hence to provide time grading between 33 kV incomer and outgoing feeders operating time of 1.3 sec is sufficient.

Instantaneous short circuit protection on HV side and back up over current protection for the transformer is considered for the Transformer outgoing feeder by means of IDMT relay with two elements having range 50 to 200 % of 1 Amps. With definite minimum time of 1.3 Sec. at 10 times the current setting and instantaneous high setting over current range (500-2000%).

Earth fault protection on HV side for primary winding and protection against LV through fault current is achieved by means of instantaneous Earth fault element with external resistance for stability against magnetizing current inrush having range as 10-40%.Back up ground fault relay for the LV system by means of IDMT element having range 10-40% is also provided.

Suitable instantaneous under voltage relays (2nos)with adjustable setting range and adjustable time delay shall be provided on each incomer and bus-section for the auto change over scheme.

Type of relays shall be as follows:

Under voltage relays with 1 No. timer, GEC ALSTOM type VAGM22. with a range (40-80%) to check the healthiness of the voltage.

Under voltage relays with 1 No. timer, GEC ALSTOM type VAG21 with a 20% fixed setting to check the no voltage condition.

5.1.3.3.2 Protection for motor

A solid state motor protection relay is proposed for protection of the pump motor (560 kW). Motor protection relay shall provide the following protection as a minimum:

1) Thermal overload

2) Instantaneous over current

3) Stalling protection

4) Phase unbalance

5) Earth fault

To protect the motors from operating at lower than desired voltage two nos. instantaneous under voltage relays with adjustable setting range of 20 to 80% of 110 Volts shall be provided in the starter pads. The under voltage relay even though instantaneous shall act through time delay relay and trip the contactors.

5.1.3.3.3 Capacitors are not envisaged at 33 kV, since the operating power factor at the bus section is expected to be greater than 0.95.

Capacitor for power factor improvement of motor

Assume motor power factor to be improved from 0.85 to 0.95

Calculations:

kVA at 0.85 p.f = 580/0.85 x 0.88

= 775.40 kVA

kVA of motor at 0.95 p.f. = 693.78 kVA

kVAs of capacitor required

$$=\sqrt{(\text{sq(kVA at 0.85)} - \text{sq(kW)}} - \sqrt{\text{sq(kVA at 0.95)} - \text{sq(kW)}}$$

= 133.93 kVAs Say 135 kVAr

Capacitor current at 3.3 kV = $135/\sqrt{1.732 \times 3.3} = 23.62$ Amps

Magnetizing current at the motor I, normally 90% at no load current. From manufacturer's data for 3.3 kV, 580 kW motor I no. load/I full load = 0.3

Therefore I no. load = 0.3 x 128

= 38.0 Amps.

Hence magnetizing current of motor = 0.9 x 38

= 34.5 Amps.

Capacitor current is less than motor magnetizing current hence power factor can not be improved to 0.95.

5.1.3.4 HT Cable Design

33 kV cables are sized for a fault current of 16.00 kA (Actual fault current is 3.79 kA) for 1 sec. based on this minimum size of the cable shall be 185 sq.mm.

For all the HV feeders, 3C X 185 sq.mm XLPE ,33kV(UE) is selected. Since the load current is very less, current carrying capacity will be sufficient.

H.T Cables:

- 0.75 for 6 cables in a tray touching each other
- 0.90 for 45°C ambient temperature
- Overall derating factor = 0.675

Sr.	Road Description	Rating	Full load Current Amps.	Current/ Derating factor Amps.	Cable size (sq.mm)	Cable runs	Cable Type
1.	33kV switchboard to transformers	4000 kVA	70	104.00	3 x 185	1 x 2	AYFY
2.	Transformer to 3.3kV switchboard	4000 kVA	700	1037.00	4x3x240	3x2	AYFY
3.	3.3 kV switchboard to 580 kW motors	580 kW	128	190	3x120	1x6	AYFY
4.	3.3kV switchboard to 200 kVA Aux.	200 kVA	39	58	3x35	1x2	AYFY

	Trans.						
5.	3.3 kV p.f. Imp. Motor Capacitors	130 kVA	24	34	3x35	1x6	AYFY

5.1.3.5 **DC Battery Sizing Philosophy**

110V DC system shall feed following loads in the pumping station:

Closing coils, trip coils, protective relays, auxiliary relays, timers, indicating lamps, annunciator, etc. on 33 kV circuit breaker feeders, 3.3 kV C.B.feeders.

Considerations for the Battery Sizing

- Battery capacity has been sized to feed continuous load for 2 hour duration and in addition, momentary load for 1 minute duration.
- Lead acid maintenance free Battery bank of 110V DC has been considered.

Estimation of Continuous and Momentary Loads of Battery

- Following loads have been considered for calculation of battery capacity:

a. LED Indication lamps : 1W
b. Aux relay : 3W as per GEC ALSTOM type VAA11
c. Trip supervision relay : 6W as per GEC ALSTOM type VAX.
d. Trip relay : 5W as per GEC ALSTOM type VAJH13 [low burden].
e. Tripping coil of 33 KV VCB : 200W
f. Tripping coil of 415V CB : 250W as per GE ALSTOM type M-Pact.

- Continuous Load

(i) LED indication for 2 I/C. 1 B/C, 2-O/G in SWGR = 33 kV

a. In 33 kV switchboard .[On and spring charged]
b. Aux. Relay 1 No. in each panel [Assumed]= 12 W
c. Trip supervision relay for 33 KV incomers = 12 W
d. Trip relay operated [2 nos] = 10 W
e) Annunciation facia [2 nos]

(ii) In 3.3 kV switchboard

a) Aux. Relay 1 no. in each panel (Assumed) = 10 W
b) Trip supervising relay for 3.3 kV incomers = 12 W
c) Trip relay operated (10 nos.) = 50 W
d) Annunciation facia (10 nos.)

CONTINUOUS LOAD CURRENT: 8 AMP FOR 2 HOURS

- Momentary Loads

a) Tripping of 1-I/C & 2-O/G CB at 33 kV

b) Hooter [1 for all system]

c) Improving of 2 I/C & 8 O/G CB at 3.3 kV

MOMENTARY LOAD CURRENT: 45 AMP FOR 1 MIN

Type of cell = Lead Acid Maintenance free

End cell voltage considered = 1.75 V/cell

Discharge rate considered = 10 hrs.

Based on above, Lead-Acid maintenance free battery of 130 AH at 10 hrs. discharge rate of is calculated. This sizing is arrived taking into consideration ageing factor, design margin, temperature correction factor etc., by the manufacturer. However, the battery manufacturer shall confirm the battery sizing based on the discharge performance characteristics of the batteries offered.

5.1.3.6 Transformer Capacity for auxiliary load

The load on auxiliary transformer is as below:

Sr.	Description	Rating Kw	Qty No. working + stand by	Total connected Load in KW	Worki-ng load in kw	Diversity factor	Demand in kw
		a	b	a x b = c	d	e	f
1.	Compressor	7.5	1W + 1S	15	7.5	1.0	7.5
2.	EOT Crain	15	1	15	15	0.4	6.0
3.	Valve actuators (only one working at a time)	3.0	6	18	3	1.0	3
4.	Desludging pumps	15.0	2W	30	30	1.0	30
5.	Ventilation system	20	1 (lot)	20	20	1.0	20
6.	Telemetry & Instrumentation	1	1 (lot)	1	1	1	1
7.	Lighting & power	10	1(lot)	10	10	1.0	10
8.	Other unaccounted load	5	1(lot)	5	5	0.7	3.5
	Total			**114**	**91.5**		**81**

Hence the demand in kW = 81 kW

Demand in KVA @ 0.8 power factor = 101.25 kVA

Add 20% extra capacity hence transformer capacity = 121.5 kVA

Considering 97% transformer efficiency final = 125.26 kVA
Transformer capacity

Taking into consideration further expansion of pumping station.

200 KVA transformer would be adequate to take full load when one transformer will be out for maintenance.

Voltage Regulation:

A. H.T. Side

All 33 kV motors are 580 kW in rating. With Direct-on-line starters, voltages at 3.3 kV motor terminal and 3.3 kV bus are within limits i.e. Vm ≥ 0.85 Vs, Vbus ≥ 0.9 Vs.

B. L.T. Side

All motors are small in rating, hence there is no severe current demand on transformer hence voltage regulation is not a concern.

The primary current of the transformer will be (200 / (1.732 * 3.3)) = 34.99 amps.

For 200 KVA transformer we earlier suggested contactor with 3.3 KV HRC fuse of 100 amps rating with overload and short circuit protection.

5.1.3.7 430 Volts AC Distribution Panel

The secondary current of 200 KVA transformer is

= (200/1.732*0.415)) = **278.25 Amps**

The fault MVA at 33 kV is 16 kA. Other system parameters are not known but max. fault current a 200 KVA transformer with 4.5% impedance can supply is (309 x (100 / 4.5)) = 6867 AMPS ≅ 7 KA. Fault current on L.T side will not exceed 7.5 kA for 191.46 MVA fault level at 33 kV.

Hence we recommended 25 KA rating for LV panel components and LV panel bus bar as that is minimum KA rating available. For cables even 10 KA rating for 1 second shall be adequate considering fuse protection.

It is recommended to have 400 amps, 25 KA rating MCCB with microprocessor based release as incomer the micro processor based release shall have following protections:

1. Overload protection
2. Short circuit protection (with short time delay)
3. Short circuit protection (instantaneous)
4. Earth fault protection

The bus bar shall be rated for 600 A, 25 KA for 1 second.

All out going distribution feeders shall be SDFs of appropriate rating.

All motor starter feeders for motors upto and including 7.5 kw shall have DOL starters and motors above 7.5 KW shall have star delta starters.

The selection of SDFs, HRC back-up protection, contactor rating and over load relay range shall be as per type – II co-ordination chart recommended by

manufacturer. The contactors shall be one size higher than that recommended for normal life by the manufacturer to have long trouble free operation.

5.1.3.8 LT Side Power Factor Improving Capacitor

The total working load on any one of the two transformers at a time is 81 kw at 0.8 power factor (assumed).

The calculation can be worked out as below:

KVA of load at 0.8 p.f. = 81/0.8 = 101.25 KVA

KVA at 0.95 p.f. = 81/0.95 = 85.26 KVA

KVAR of Capacitor required

= $\sqrt{}$(sq.(KVA 0.80) –sq.(KW))– $\sqrt{}$ sq.(KVA 0.95)-sq.(KW)

= 39.13 KVAR

Considering maximum demand, it is recommended to connect two no. 20 KVAR capacitor with manually controlled SDF on each bus section.

5.1.3.9 LT Cables

Derating factors : 0.75 for 6 cables in a tray touching each other.
: 0.90 for 45°C ambient temperature.
: Overall derating factor = **0.675.**

Sr.	Load Description	Rating Kw	Full load current IL	Current/ derating factor	Cable size	Cable runs	Cable type
1.	Transformer Secondary	200 KVA	309	458	2 x 3.5 x 185	2	AYFY
2.	Air compressor	7.5	16 IL	24	3 x 2.5	1	YWY

Sr.	Load Description	Rating Kw	Full load current IL	Current/ derating factor	Cable size	Cable runs	Cable type
3.	EOT	15	30	44.4	4x25	1	AYFY
4.	Valve actuators	3	6.0 IL	8.9	3 x 2.5	1	YWY
5.	Sump pumps	15.0	30	45	3 x 25	2	AYFY
6.	Ventilation Load	20	35	51.5	4 x 25	1	AYFY
7.	Lighting DB	10	15	23	4 x 25	1	AYFY
8.	Other unaccounted load.	5.0	11.2	16.6	4 x 25	1	YWY
9.	Capacitor 20 kVAR	25 kVAR	31	46	3x25	4	AYFY
10.	Telemetry	1	1.39	2.06	3 x 3.5	1	AYFY

5.1.3.10 Earthing Design

Design Basis

Max fault current at 415 V = 25 KA [Actual calculated 6.49 KA]

Duration of fault current = 0.5 Sec

Max earth resistivity = 18 Ω m [assumed].

Mat. at earth electrode = Galvanised Iron for Pipe & Copper for Plate

Type at joint = Bolted.

Reference = IS 3043-1987

If required, calculations will be revised based on actual measurement of soil Resistivity figure during the installation stage.

Determination of Size of Earth Grid Conductor [MEL]

The size of earth grid conductor is decided as per IS 3043 formula [Pg. 29].

$$\frac{I}{S} = k\frac{1}{\sqrt{t}}$$

Where,

S = Cross Sectional area of grid in mm^2

I = Value of a. c. rms. fault current in Amperes.

t = Duration of fault in Secs. [operating time of disconnecting device]

k = Factor dependent on the material of the protective conductor , the insulation & other parts ; initial & final temperatures.

k = 80 for steel material [table 6A of IS 3043] [Pg.31]

I = 25 KA

t = 0.5 Sec.

$$S = \frac{I\sqrt{t}}{k}$$

$$S = \frac{2000\sqrt{0.5}}{80}$$

$$S = 220.97\ mm^2$$

Since two no earth connections are given for each & every equipment, considering two parallel paths,

$$S = \frac{220.97}{2} = 110.48\ mm^2$$

GI strip Conductor of size 50 x 6 sq.mm can be used which has cross-sectional area of 300 mm^2 as MEL. Strip between Transformer Neutral & Neutral Earth Pit shall be same but insulated.

Determination of no. of Earth Electrodes [EP]

As per IS 3043 [pg 27] dissipation of fault current of electrode surface is:-

$$I = \frac{7.57x10^3}{\sqrt{\delta t}} \text{ Amp/m}^2$$

Where,

I = Current density in AMP / m^2

t = Duration of fault current is 0.5 Sec.

δ = Resistivity of soil in Ω m. is 50 Ω -m.

$$I = \frac{7.57x10^3}{\sqrt{18x0.5}} Amp/m^2$$

$$I = 2524 Amp/m^2$$

In order to dissipate fault current of 15kA the total area of electrode required is

$$Area = \frac{25\times10^3}{2524} = 9.91m^2$$

Area of 1no. Plate earth electrode[both sides of plate]

$A_E = 2[L \times B]$ m^2

Where

L = Length of plate electrode in mtr. [600 mm.]

B = Width of plate electrode in mtr. [600 mm.]

$A_E = 2[0.6 \times 0.6] = 0.72$ m^2

Total Area for 10 nos. of plate Electrode = 10 x 0.72 = **7.2 m^2**
[For Transformer Neutral]

Area of 1no. Pipe earth electrode

$A_E = \pi \times D \times L \ m^2$

$A_E = \pi \times 0.04 \times 3$

$= 0.377 \ m^2$

Where

D = Diam of pipe electrode in mtr. is 40 mm.
L = Length of pipe electrode in mtr. is 3mtr.

Allowing 5% reduction in area due to perforation

$A_E = 0.377 \times 0.95 = 0.36 \ m^2$

Total Area for 6nos. of pipe Electrode= 6 x 0.36 = **2.16m^2**

Area of 300mtrs of 50 x 6 mm GI strip [main earth loop] which is buried directly underground [both sides of strip]

$A_E = 2 \times (300 \times 0.05) =$ **30 m^2**

Total Area of Electrodes = 7.2+2.16+30 = **39.36 m^2** which is more than required Area of 9.91 m^2 as calculated in clause 3.1 above. Hence no. of Electrodes provided are adequate.

Calculation of Earth Resistance

Pipe Electrodes --- 6 nos. provided [Ref. Overall Earthing layout]

The earth resistance of pipe electrode is calculated as per formula given in IS 3043 - [page 20]

$$R = \frac{100\delta}{2\pi L}\log_e \frac{4L}{D} \quad \Omega$$

Where L = Length pipe electrode in cm [300]

D = Diam of pipe electrode in cm [4cm]

δ = resistivity of soil in Ω m. [50 Ω -m].

$$R = \frac{100\times 18}{2\pi 300}\log_e \frac{4\times 300}{4}\Omega$$

$= 5.449\ \Omega$

Hence Effective resistance[Re1] for 6 nos. pipe electrodes provided will be,

$$1/\mathrm{Re}_1 = 6/R$$
$$1/\mathrm{Re}_1 = 6/5.449$$
$$\mathrm{Re}_1 = 5.449/6$$
$$\mathrm{Re}_1 = 0.9082\Omega$$

Plate Electrodes - 10 nos. for Transformer Neutral as required by CEIG [Ref. Overall Earthing layout]

The earth resistance of copper plate electrode [600mm X 600mm] is calculated as Per formula given in IS 3043 - [page 19]

$$R = \frac{\delta}{4}\sqrt{\frac{\pi}{A}} \quad \Omega$$

Where, A = Area of both sides of plate in sq.m. [0.72 sq.m]

δ = resistivity of soil in Ω m. [50 Ω -m].

$$R = \frac{18}{4}\sqrt{\frac{3.14}{0.72}}\Omega$$

$$R = 18.795\Omega$$

Hence Effective resistance [Re2] for 10 nos. plate electrodes provided will be,

$$1/\mathrm{Re}_2 = 10/R$$

$$1/\mathrm{Re}_2 = 10/18.795$$

$$\mathrm{Re}_2 = 18.795/10$$

$$\mathrm{Re}_2 = 1.8795\Omega$$

Main Earth loop Resistance - 300mtr length.

The resistance of earth grid will be further reduced due to burial of 50 x 6 mm GI strip.

The earth resistance of Main Earth Loop is calculated as per formula given in IS 3043 - [page 21]

$$R_g = \frac{100\delta}{2\pi L}\log_e \frac{2L^2}{wt} ohms$$

Where L	=	Length of strip in cm	[30000cm]
w	=	Depth of burial of strip in cm	[60cm]
t	=	Width of conductor in cm.	[5cm]
δ	=	resistivity of soil in Ω m.	[18 Ω -m].

$$R_g = \frac{100\times 18}{2\pi 30000}\log_e\left(\frac{2\times(30000)^2}{60\times 5}\right)$$

$$R_g = 0.00955\times 15.607 = 0.149\Omega$$

Combined resistance of 16 nos. electrodes & main earth loop is

$$1/Rcomb = 1/\mathrm{Re}_1 + 1/\mathrm{Re}_2 + 1/R_g$$

$$\frac{1}{Rcomb} = \frac{1}{0.9082} + \frac{1}{1.8795} + \frac{1}{0.149}$$

$$\frac{1}{Rcomb} = 1.018 + 0.532 + 6.7064 = 8.2567$$

$$Rcomb = 0.1211\Omega$$

Thus quantity of 40mm Φ, GI pipe Earth Electrodes provided = 6nos & 600mm x 600mm copper plate Earth Electrodes provided = 10 nos. for Transformer Neutral, that is **total 16no. Earth Electrodes** provided, are adequate for achieving Earth Resistance less than 1Ω as stipulated by IS 3043.

5.1.3.11 LIGHTING DESIGN

For indoor areas like Sub-station with Mounting height upto 5mtrs., 2x36W, Industrial, Lighting Fittings with vitreous enameled reflector shall be used.

For indoor areas like Pump Room with mounting height 6mtrs. or more, Highbay fittings with 400W HPMV lamps & integral control gear box shall be used. HPMV lamps are proposed with a view of having illumination near to natural day light for the comfort of operator. Also HPMV lamps have better colour rendering index than HPSV.

For Periphery Lighting, Street light fittings with 70W HPSV lamps shall be used to match with Road Lighting.

5.1.3.11.1 Building Services

The Contract shall include the design supply, delivery to Site, off-loading, storage, erection, testing and setting to work the complete building services installation including but not limited to:

(a) Internal main and emergency lighting;
(b) External walkways and floodlighting;
(c) Roadway lighting;
(d) Small power;
(e) Air conditioning;
(f) Ventilation;
(g) Fire Detection System.

The building services installation shall comply with Standard Specification and the following clauses herein.

5.1.3.11.2 Internal Lighting

Internal main lighting

Internal lighting shall be designed to provide the following minimum service illuminance, measured at floor level:-

(a)	Process plant/pump hall areas	:	200 lux
(b)	Chemical preparation areas	:	300 lux
(c)	Switch rooms	:	300 lux
(d)	Control room	:	350 lux
(e)	Workshop areas	:	300 lux
(f)	Laboratory	:	500 lux
(g)	Offices	:	350 lux
(h)	Staff rooms and reception areas	:	150 lux
(i)	Toilets, washrooms, mess rooms corridors and staircases	:	100 lux

Luminaires shall be fixed directly to, or suspended from, the underside of roof slabs, ceilings or fixed to walls as appropriate.

Pump halls and other high bay areas shall be provided with high or low bay energy efficient lighting. Where special provision would have to be made for accessing luminaires supported from the underside of the roof slab for maintenance, luminaires shall be wall mounted.

Luminaires for the control room and offices shall be designed to minimise glare.

Light switches shall be located adjacent to doorways. Multi-way switching shall be provided for rooms and areas with more than one point of access. For large area light switching or high/low bay lighting, contactors shall be provided to switch lighting in blocks from each entry point.

Internal emergency lighting

Emergency lighting shall be provided and shall comprise exit and escape route luminaries to facilitate safe movement of personnel in or from any building or major dry structure in the event of a mains supply failure. Exit luminaries shall be provided above all doors leading to or accessible to an outdoor area.

Emergency lighting shall also be provided in areas where essential operations may be required during a mains supply failure, for example, switch room and control rooms.

5.1.3.11.3 External lighting

Luminaries shall be provided to illuminate all external personnel walkway areas around buildings and structures. The lighting shall be designed to provide an even minimum service illuminance measured at ground level of 15 lux.

Lighting shall be switched at personnel access doors. Multi-way switching shall be provided where there is more than one point of access.

Floodlighting

Floodlighting shall be provided for the entrance to the site, raw water intake, outdoor substation area, all site pumping stations and wet wells, loading/unloading areas. Floodlighting shall also be provided at all locations requiring inspection.

Floodlights shall be mounted on galvanized steel poles or on structure walls as appropriate.

Floodlighting shall provide a minimum service illuminance of 50 lux measured at the working plane.

Floodlighting shall be locally switched.

Roadway lighting

Roadway lighting shall comprise tubular steel columns with semi cut-off high pressure sodium type luminaires complete with control gear. The roadway lighting shall provide a minimum illuminance at ground level of 25 lux.

Minimum 4c x 6sq mm, 1.1 kV, Cu., PVC, Annoured cables shall be used for power supply from distribution board up to the individual junction boxes of each street light pole. From the junction boxes up to the luminaries 2.5sq mm Cu flexible wire shall be used.

Roadway lighting shall be solar time switch controlled. The time switch shall be located adjacent to the point of supply. An over-ride switch shall be provided to manually over- ride the solar time switch controller. This shall be located at the low voltage switch room for the raw water pumping station.

Small power

Industrial switched type 230Vac socket outlets with residual current devices for the connection of electric tools shall be installed in convenient pla6es in all plant and workshop areas.

Suitable rated 400Vac/230Vac socket outlets with residual current device shall be provided for intake structure and raw water pumping station. The socket outlets shall be located in an IP65 weatherproof enclosure fixed to the structure wall.

Commercial type 230V 15A and SA socket outlets shall be installed throughout all administrative office areas including the associated corridor areas. A minimum of two socket outlets shall be provided in each room to allow each desk to be serviced with a power supply without the need for extension leads.

Low voltage and extra low voltage supply transformers shall be provided for hand held power tools and lights adjacent to all below ground structures which require maintenance access.

5.1.3.11.4 Ventilation

Mechanical ventilation shall be provided as follows:-

Location: Air changes/hour (ACH):

- Monitoring room : 6
- Pump room : 36

Miscellaneous:

- Toilets and washrooms : 6

- Electrical switch rooms : 10

For further details of ventilation requirements refer to the mechanical specification.

Ceiling Fans

All administrative areas such as the control room, all offices and building entrance areas at raw water pumping station shall be provided with ceiling fans to provide 4 ACH. The fans shall be provided with local speed controllers and switches adjacent to each individual unit.

5.1.3.11.5 Air conditioning

As a minimum control room shall be air conditioned.

The air conditioning shall be designed to maintain a dry bulb temperature of 22 °c and relative humidity of 500/0 under the outside mean monthly maximum shade temperature and humidity specified elsewhere.

5.1.3.11.6 Fire detection system

A fire detection system shall be provided in accordance with BS 5839: Fire detection and alarm systems for buildings, the local fire regulations and the following requirements:

(a) Fire detectors

Optical smoke type detectors shall be installed in switchrooms, stores containing flammable materials and the control rooms.

The Detectors shall be locally resettable and shall be detachable from their installation position to facilitate maintenance and replacement.

Detectors shall have light-emitting type operation indication and shall be suitable for fixing direct to circular conduit boxes.

(b) Manual call points

Manual call points shall be located strategically throughout the plant. A call point shall be located adjacent to each external door and at personnel doors to switch rooms, chemical areas and stores of flammable materials. For multi-storey buildings, call points shall additionally be located at stairwell landings on each floor.

(c) Control panel

Wall mounted addressable type control panels shall be located in the low voltage switch room at the raw water pumping station.

A system-test facility and a power supply failure indication shall be provided.

Each control panel shall be provided with voltage-free changeover contacts to be monitored by the DCS for the following conditions:

(i) system fault
(ii) normal supply failed
(iii) system operated.

The contacts shall be wired to cable terminations.

A correctly-oriented plan of the premises showing the locations of the fire zones and exits, and instructions for the actions to be taken in the event of fire or fault indication, shall be positioned adjacent to the control and indicating equipment. They shall be in an approved durable form.

(d) Fire alarm devices

Sounder and visual fire alarm devices shall be installed in switch room and on each floor of multi-storey buildings. The fife alarm sounder/strobe device locations shall be audible or easily observed from all parts of the water treatment works and raw water pumping station.

(e) Power supplies

The normal supply for each control panel shall be derived from the normal site power supplies. A standby supply shall be provided by an integral sealed-type battery complete with an automatic charger. The battery shall be of the nickel- alkaline or lead-acid type and shall have a life of not less than 4 years and shall be capable of automatically maintaining the system operational for a minimum period of 24 hours.

The battery charger shall be fitted with a milli-amp meter to indicate the rate of charge.

The normal site power supply for each control panel shall be from a dedicated outgoing MCB. The outgoing unit shall be coloured red and shall be fitted with a label inscribed 'Fire alarm -do not switch off.

(f) Wiring

Wiring shall be carried out using the red covered fire resistant cabling in accordance with the local fire regulations.

5.1.3.11.7 Telephone facilities

A complete telephone system shall be provided for the raw water pumping station. The system shall comprise a site EP ABX located in the control room.

The site telephone system shall be connected to the telephone company network to provide off-site communications.

Telephone handsets shall be provided in the control room, each electrical switch room and each office.

The EP ABX shall be sized to provide 50% spare capacity for additional telephone handsets and external telephone lines.

Site Intercom

The Contractor shall provide a site intercom system comprising of a externally mounted call- point at the site entrance gates for the raw water pumping station.

The external call-point shall be provided with in-built call button, a microphone and speak push-button, and a speaker all located in a weather proof enclosure adjacent to each site entrance.

The control room shall be provided with a desk mounted microphone and speak push- button. An audible call alarm shall be provided which is audible in all parts of the administration area of the filter building.

5.1.3.11.8 Distribution boards

A distribution board shall be installed on each floor of each building and shall provide distribution to lighting, socket outlets, heating, ventilation and air conditioning. Circuits shall be arranged to provide a balanced load on each phase of the supply.

The fire detection system shall be supplied from a dedicated feeder unit on the appropriate 415V motor control centre.

5.1.3.11.9 Wiring

Internal wiring on concrete and block work surface shall be carried out using single core PVC insulated non-sheathed cables installed in surface mounted heavy duty galvanized steel conduit and / or trunking. Wiring in plastered and tiled areas shall be installed in concealed steel conduit.

External wiring shall be carried out using single core PVC insulated non-sheathed cables installed in heavy duty galvanized steel conduit or PVC covered mineral insulated copper sheathed cables.

5.1.3.12. Ventilation System Design

Introduction

In any industrial building where industrial processes are carried out a large amount of heat is evolved. If such heat is not removed from industrial building, it will affect efficiency of the workers working therein and it will also affect the life of the machinery especially electrical one. Similar is the case of Nag pur Water Supply and Sewerage Project wherein following pumping station will be installed & commissioned.

1. Raw Water Intake

Method of Ventilation

Ventilation can either be carried out by natural or mechanical way.

In the present cases of all four installations the natural ventilation is neither practicable nor adequate enough to remove the heat generated during pumping operation. Natural ventilation also depends upon pressure exerted by the wind outside, stack action generated in the building, cross ventilation through the building configuration and roof of the building and hence airflow cannot be controlled consistently thorough out all the seasons.

In view of above, it is essential to adopt mechanical ventilation. Mechanical ventilation may be either (a) by exhaust ventilation whereby air is removed from a building by means of fan while fresh air is introduced from windows and other openings, or (b) by positive ventilation whereby air is supplied by means of a fan or blower from outside or (c) by combination of both exhaust and positive ventilation. In case of positive ventilation, it is possible, where necessary, to cool the air before being brought into the building either by way of evaporation cooling or by air conditioning.

a. Exhaust ventilation

Ventilation by this method can be effected in case of narrow buildings. Exhaust fans are provided in walls on one side of the building and roofs to draw large volumes of air through the building from the opposite side. Adequate inlet openings for air are provided so as to minimise draughts caused by high inlet velocities. In this case short circuiting of air should be avoided.

b. Positive Ventilation

Positive ventilation affords better control of atmospheric conditions inside the factory building. It is useful where exhaust ventilation cannot be used due to wider processing area. In positive ventilation method, air is forced into the building by means of centrally located supply fans and distributed air through the duct. The duct may carry cooled or conditioned air. Unit ventilators may be provided for individual roofs and may be placed against outside wall. The air supply outlets are many times more than what is possible by exhaust.

c. Combined System

In this system the air is forced into the area of working at lower level and hot air which takes natural upward path is removed by roof

extractors provided preferably over the heat producing machines or processes.

d. Selected Method

The method of Exhaust Ventilation mentioned above amongst the offer, it is found to be useful in the installation taking into account the number of air charges required at the installation are less.

5.1.3.12.1 Data

General

Ambient temperature (max.)	=	450 C
Humidity (max.)	=	77 %
Altitude	=	< 1000 m.

Raw Water Intake

i. Raw water intake pump room

No. of pumps	=	6
Motor capacity	=	580 kW
Motor efficiency	=	94.5 %
Lighting fittings	=	8 Nos. + 20 Nos.
Wattage of fitting	=	400 Watts each + 80 Watts each
Pump room size (LxWxH)	=	25.5 m x 13.00m x(EL338.50-EL328.00) including sub floor below motor

ii. Raw water intake -Cable tray room

Size (L x W x H)	=	20 m x 7.0 m x 2.5m

Design Criteria and Assumptions

It is essential to find out total quantity of air required for ventilation for maintaining temperature in the area of ventilation within a limit.

For this purpose following assumptions are taken into account.

i. Maximum temperature difference between outside air and inside air should not exceed 5°C as the maximum ambient temperature is given as 45° C.

ii. Temperature of outlet air should not exceed 50° C for more than one hour, as it will be injurious to the worker.

iii. Wet bulb temperature during 45° C dry bulb temperature shall not exceed 27°C.

iv. Sufficient elevation level difference between intake air and outlet air is present.

v. It is assumed that the roof top of the building is painted with heat reflecting paint and wherever possible it is insulated.

vi. Heat from the Sun affects comparatively less as inside the building heat developed due to the electrical motors is more and temperature inside the building is more than outside temperature.

vii. During high ambient temperature, the electrical lighting heat load will be nil in the pump rooms. However, for safer side it is considered in the calculations.

viii. Electrical loads viz. auxiliary pumps are not considered for heat load calculations, as these pumps will not be operated continuously.

ix. Doors and windows provided to the building are shielded with sunglass film etc. so as to reduce heat entering inside the building due to sun rays.

x. Formula used for requirement of air for ventilation is,

$$Q = \frac{3.462 \times Ks}{t}$$

Where Ks = Sensible heat gained in kcal/hr.

t = Allowable temperature difference in °C

Q = Quantity of air in m^3/hrs.

1 KWH = 860 Kcal/Hr.

Detailed Design for Ventilation

Raw Water Intake

A. Pump Room

i. Volume of room = 25.5 x 13.0 x 10.5 – 20m x 7.0 m x 2.5m.

= 3480.75 – 350.00

= 3130.75 m^3

ii. Heat loss due to motor kcal/hr.= Rating of motor x No. of motors x (1-efficiency)

iii. Heat loss due to lighting = No. of fittings x wattage x 0.86

= 8 x 400 x 0.86 + 12 x 80 x 0.86

= 2752.0 + 825.60

= 3577.60 kcal/hr.

iv. Total heat loss in Kcal/hr. = 162110.0 + 3577.60

= 165687.6 kcal/hr.

v. Air requirement for ventilation in m^3/hr = $Q = \frac{3.462 \times Ks}{t}$

Ks = 165687.6 kcal/hr.

t = 5°C

= $\frac{3.462 \times 165687.6}{5}$

= 114722.09 m^3/hr.

vi. Air changes per hour = $\frac{114722.09}{3130.75}$

= 36.00

vii. No. of exhaust fans required = $\frac{114722.09}{10400}$

= 11.03, Say 11 Nos.

Each of size 600 mm, 3 phase, capacity of 10400 m^3/hr. and db level not exceeding 65.

viii. Power requirement of fans,
Power of each fan is 550 W.

	Total Power	=	550 x 11
		=	6050 Watts
		=	6.05 kW
B.	Cable Tray Room		
i.	Volume of room	=	20 m x 7 m x 2.5 m.
		=	350 m^3.
ii.	Heat due to lighting load	=	No. of fittings x wattage x 0.86
		=	8 x 80 x 0.86
		=	550.4 kcal/hr.
iii.	Air requirement for ventilation= in m^3/hr.		It is required on the basis of air changes per hour which should be at least 6 changes per hour.
			Therefore, 350 x 6 m^3/hr. air has to be displaced i.e. 2100.00.
iv.	No. of exhaust fan required	=	$\frac{2100}{1250}$
		=	1.68, Say 2 Nos.

It is essential to provide 2 Nos. of fans for replacement of air and put them on before carrying out in the area. Size of the fan 300 mm, 3 phase, capacity 1250 m3/hr. db level maximum 54.

v. Power requirement of fans:

Power of each fan is 55 W.

Total Power = 55 x 2

= 110 Watts.

= 0.11 kW

Installation Details

Typical sizes of exhaust fans (refer sketch) are as follows (all dimensions are in mm):

Size (Dia.)	A	B	C	D	E	F	G
600 mm.	720	598	635	11.5	405	162	600
300 mm.	385	317	327	9.5	300	125	300

Exhaust fan shall be protected with wire guard and provided with louvers.

Marking of Exhaust Fan locations are provided in the following drawings.

1. Ventilation system for Intake Works

5.1.3.13 Summary

1. MSEB Power Supply with two independent 33 kV Express Lines. Fault Level is 191.6 mVA as per MSEB.

2. Indoor 33 kV switch board with two nos. Incomers, one Bus-Coupler and two outgoing Transformer Feeders is proposed. 6304 SF6 circuit

breakers with 16 kA breaking capacity are proposed (Minimum standard rating).

3. Two transformers of 4000 kVA, 33/3.6 kV, Dyn 11, ONAN, O.L.T.C are proposed considering D.O.L starting of 580 kW motors and 5 Nos. pumps running with one transformer in service (worst condition).

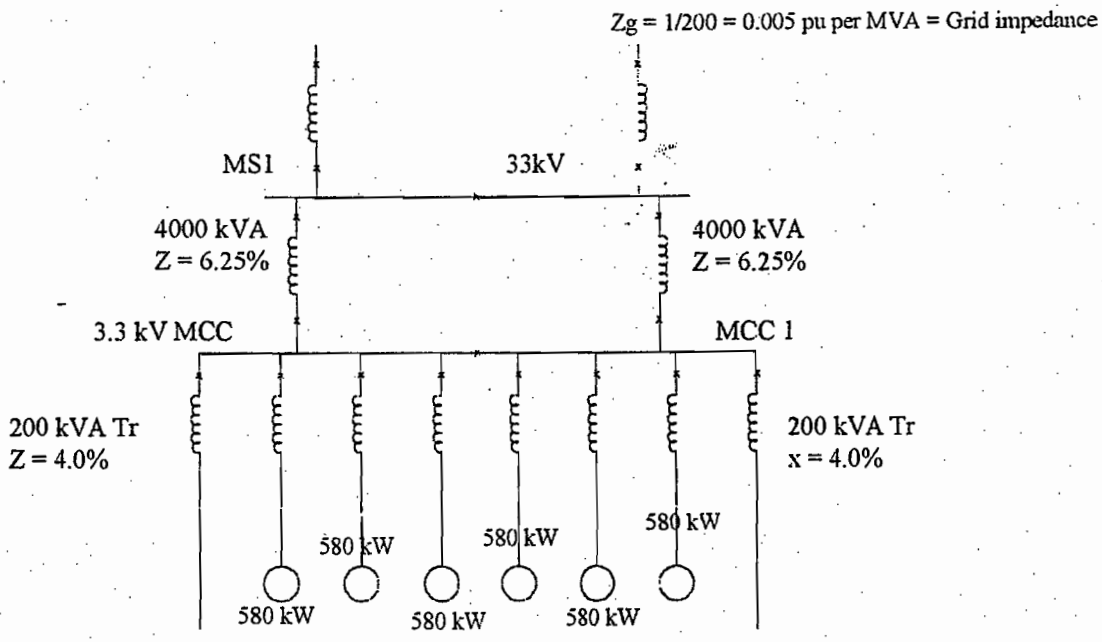
4. 3.3 kV, 580 kW, squired cage Inductor Motor, CACA/JETV with D.O.L starters are proposed. Programmable Logic Control (PLC) is proposed for monitoring and controlling motor operations.

5. Power factor improvement is by providing individual capacitors for 3.3 kV motors and bulk capacitors for 415 V, L. T Load, Power Manager is proposed for monitoring power consumption.

6. Two Auxiliary Transformers of 200 kVA, 3.3 /0.433 kV, Dyn 11, ONAN, Off-Load-Tap charger are proposed for L. T Load.

7. Ventilation, Earthing, Lighting protection, Fire Alarm, Intercom System are provided. Telemetry and SCADA systems are proposed separately.

Short Circuit Calculations



$Zg = 0.005$ p.u.per MVA $= Xg$

$Z_T = 0.0625$ p.u. $= \frac{0.0625}{4} = 0.015625$ p.u. per MVA $= X_T$

580 kw motor $= 1.33 \times 580 = 771.4$ kvA

$\therefore$ X"d $=$ Zm $= 0.16$ p.u. $= \frac{0.16}{0.7714} = 0.2074 =$ Xm

Circuit Element	Reactance on it's input X" d or actual Ohm	Reactance p.u. per MVA	First cycle Reactance p.u. per MVA	Interruption cycle reactance p.u. per MVA
X grid		0.005	0.005	0.005
H.V. Cable to MS - 1 HV Cable to MCC - 1	Negligible hence not taken			
X_{Tr} 4000 kvA	0.0625 p.u.	0.015625	0.015625	0.015625
H.V. Cable to Motor	Negligible hence not taken			
580 kw motors	0.16 p.u.	0.2074	0.2074	1.5 x 0.2074

Considering worst condition of only one transformer supplying full load from single 33 kv supply line and 3.3 kv Buscopler closed.

$$\frac{1}{X_{mars}}=\frac{1}{X_g+X_T}+\frac{1}{X_m}=\frac{1}{0.005+0.015625}+\frac{5}{0.2074}$$

$$= \quad 48.485 + 24.11 = 72.593 \text{ MVA}$$

$\therefore$ Ish $= \frac{72.593}{1.732\times 8.3}=12.7$ kA (First Cycle)

Interruption cycle $= \frac{1}{0.020625}+\frac{5}{1.5\times 0.2074}=48.485+16.07=64.555=$MVA

$\therefore$ $Ish_2 = \frac{64.555}{1.732\times 3.3}=11.29$kA

For 415 V Bus

$$\frac{1}{X_{mas\text{-}2}}=\frac{1}{X_{T1}+X_g}+\frac{1}{X_{m0}}=72.593$$

$\therefore$ $X_{mas\ 2} = 0.013775$

Aux. Transformer = 200 kVa Z = 4.0 %

$\therefore$ Zp.u. = 0.04

$\therefore$ Zp.u. per MVA= $\frac{0.04}{0.2}=0.2$

$$\therefore \frac{1}{X_{Total}}=\frac{1}{X_{Mas\text{-}2}+X_{Taux}}=\frac{1}{0.013775+0.2}=\frac{1}{0.213775}=\text{MVA}$$

$\therefore$ Fault MVA = 4.68

$\therefore$ Ish $= \frac{4.68}{1.732\times 0.415}=6.51$ kA

AT 33 kv Bus

$$\frac{1}{X_{Mas\text{-}3}}=\frac{1}{X_a}+\frac{1}{X_{Tr}+X_m}=\frac{1}{0.005}+\frac{1}{0.015625+\frac{0.2074}{5}}$$

$$= \quad 200 + 17.11 \quad - \quad 217.51 \text{ MVA}$$

$\therefore$ Ish = 3.8 kA for 3 Secs

TRANSFORMER CAPACITY CALCULATIONS

1 Fault level at 33 kV Bus - 191.46 MVA ≈ 2.35 kA

2 System voltage for motors - $V_1 = 3.3$ kV = 1905.3 Volts

3 Motor terminal voltage during starting = 0.85 V_1 = 1619.5 Volts Assumed = Vm

4 3.3 kV Bus Voltage during motor starting = 0.9 x V_1= 1715 Volts (Requirements during starting condition) = V_{bus}

5 Power factor during starting - $\cos\phi = 0.15$ ∴ $\sin\phi$ = 0.988

6 Starting currents of motor - 6 times full load current ∴ K = 6

Full load current of water - $\frac{580 \times 1.33}{1.732 \times 3.3} \simeq 135$ Amps

Cable size - 3.5 x 120 sq.mm - Xc = 0.977 Ω / km, Rc = 0.324 Ω / km

Length of cable - 50 mtrs (Max)

∴ Xc = 0.0049 Ω , Rc = 0.0162 Ω

$$(Vbus)^2 = \left[VmCos\phi + \frac{K \times Ifl \times Vm \times Rc}{V_1}\right]^2 + \left[VmSin\phi + \frac{K \times Ifl \times Vm \times Xc}{V_1}\right]^2$$

$$\therefore (1715)^2 = \left[0.15 \times Vm + \frac{6 \times 135 \times Vm \times 0.0162}{1905.3}\right]^2 + \left[0.988 \times Vm + \frac{6 \times 135 \times Vm \times 0.0049}{1905.3}\right]^2$$

$$= [0.15Vm + 0.00689Vm]^2 + [0.988Vm + 0.002083Vm]^2$$

$$= 0.0246\ V^2m + 0.99\ V^2m = 1.0147\ V^2m$$

$$= 1702.55 \text{ Volts} \quad \therefore \quad \frac{Vm}{V_1} = 0.8936$$

Putting this value of Vm in

$$V_1^2 = \left[VmCos\phi + \frac{K \times Ifl \times Vm \times R_{CT}}{V_1} \right]^2 + \left[VmSin\phi + \frac{K \times Ifl \times Vm \times Xs}{V_1} \right]^2$$

Xs = Total Reactance upto motor terminals

$Xs = Xg + X_T + X_{CT}$

$R_{CT} = Rc_{240} + Rc_{120} = \frac{0.161 \times 150}{1000 \times 4} + 0.0162 = 0.2224\Omega$

$X_{CT} = Xc_{240} + Xc_{120} = \frac{0.0902 \times 150}{1000 \times 4} + 0.0049 = 0.00338 + 0.0049 = 0.0083$

$$\therefore (1905.3)^2 = \left[1702.55 \times 0.15 + \frac{6 \times 135 \times 1702.55 \times 0.02224}{1905.3} \right]^2 + \left[1702.55 \times 0.988 + \frac{6 \times 135 \times 1702.55 \times Xs}{1905.3} \right.$$

$= [255.383 + 16.0956]^2 + [1682.119 + 723.805Xs]^2$

$= 73700.359 + [2829524.33 + 2435052.286Xs + X^2s \times 523893.552]$

$3630168.09 = 523893.552\ X^2_S + 2435052.286\ Xs + 2903224.689$

$0 = 523893.552\ X^2_S + 2435052.286\ Xs - 726946.401$ (÷ 523893.552)

$0 = X^2_S + 4.648\ Xs - 1.3876$

$\therefore Xs = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ a=1, b= 4.648, c= -1.3876

$b^2 = 21.60382$

$= \frac{-4.648 \pm 5.21097}{2 \times 1} = 0.281486$

$4ac = 5.5504$

$\therefore \sqrt{b^2 - 4ac} = \sqrt{27.154} = 5.21097$

$Xs = Xg + X_T + Xc_T$

$\therefore X_T = 0.281486 - 0.0083 - Xg$

$= 0.273186 - Xg$

$Xg = \frac{1}{191.46} = 0.005223$ pu per MVA

$XsP.u = \frac{0.273186}{E^2} = \frac{0.273186}{(3.3)^2} = 0.025086$

$\therefore X_T = 0.025086 - 0.005223 = 0.019863$

Reactance of Transformer is 6.25 % $\therefore$ 0.0625 p.u.

$\therefore$ MVA rating of Transformer required $= \frac{0.0625}{0.019863}$

$= 3.14656$

$\therefore$ KVA rating of Transformer $= 3146.56$ kVA minimum

$\therefore$ Transformer capacity proposed is 4000 KVA / 3500 KVA

Check for Fourth pump starting:-

Load before starting 4th Pump = 3 x 580 + Avg. load 50 kw

= 1790 kw

$\therefore$ $\text{Current} = \frac{1790 \times 0.9}{1.732 \times 3.3 \times 0.9} \simeq 313 \text{Amps}$

Starting current of 4th pump = 6 x 135 = 810 Amps

$\therefore$ Total Current = 810 + 313 = 1123 Amps

Full load current of 4000 kva Transformer

$= \frac{4000}{1.732 \times 3.3} \simeq 700 \text{Amps}$

$\therefore$ 1.5 times full load current = 700 x 1.5 = 1050 Amps

$\therefore$ % current at starting 4th Pump= $\frac{1123}{700} \simeq 1.60 \times 100 = 160\%$

In emergency if 5th pump is started.

Load - 4 x 580 + 50 = 2370

$\therefore$ Current = $\frac{2370 \times 0.9}{1.732 \times 3.3 \times 09} = 414.65 = 415.00$

Starting current of 5th motor = 6 x 135 = 810 Amps

$\therefore$ % current = $\frac{2370 \times 0.9}{1.732 \times 3.3 \times 09} = 414.65 = 415.00$

Starting current of 5th motor = 6 x 135 = 810 Amps

$\therefore$ Total current = 810 + 415 = 1225 Amps

$\therefore$ % current = $\frac{1225}{700} = 1.75$

$\therefore$ 75% overload

$\therefore$ 4000 kVA Transformer can take starting current load when 4th motor is started with auxiliary load off. However 5th motor can not be started with one transformer in service. 5th motor can be operated with both the transformers in service.

5.2 Raw Water Rising Main From Pumping Station To B.P.T.

Discharge (Phase I + Phase II) = 630 MLD

Hours of pumping = 24 Hours

Design Assumptions

1. Single Main carrying all the discharge of 630 MLD
2. Flow = 7.2917 m^3/s
3. Steel pipe confirming to IS 3589: 2001
4. Grade of steel = Fe 410
5. Ultimate Tensile Stress = 410 MPa
6. Yield stress Min = 235 MPa
7. Inlining = 12 mm Thick C.C.
8. Out coating = 20 mm Thick C.C.

2032 mm dia, Mild steel pipe with shell thickness = 20 mm is adopted conforming to IS 3589: 2001

5.2.1 Calculation of Frictional Losses

Hazen Williams Formula, with C=130 has been adopted for working out frictional losses.

$$Q = 7.436 \times 10^{-9} \times C \times D^{2.63} \times Hf^{0.54}$$

Where

Q = Discharge in MLD

C = 130

D = Internal Diameter = (2032 - (7 x 20) - (2x12))

= 1968 mm

Hf = m / km

i.e. $630 = 7.436 \times 10^{-9} \times 130 \times 1968^{2.63} \times Hf^{0.54}$

$$Hf = \left[\frac{630}{7.436\times10^{-9}\times130\times1968^{2.63}}\right]^{\frac{1}{0.54}} = 1.90 \text{ m / } 1000 \text{ m}$$

The length of the pipe is approximately 100 m.

It works out the frictional head loss (hf) to 0.19 m

Velocity in the pipe is calculated using following equation.

$V = 4.567 \times 10^{-3} \times C \times d^{0.63} \times Hf^{0.54}$

Where

V = Velocity in m/s

C = 130

d = Diameter of pipe in mm = 1968 mm

Hf = Head loss in m/1000 m

i.e. $V = 4.567 \times 10^{-3} \times 130 \times 1968^{0.63} \times (1.90/1000)^{0.54}$

$= 2.395$ m/s

5.2.2 Calculation For Water Hammer

For calculation of maximum water hammer pressure, following formula is used

$$H_{MAX} = a.\frac{Vo}{g}$$

Where

H_{MAX} = Max. water hammer head in m.

Vo = Normal velocity of water - m/s

g = Acceleration due to gravity in m/s^2

$$a = \frac{1425}{\sqrt{1+\frac{KD}{Ect}}}$$

Where

K = Bulk modulus of water = 2.07×10^8 kg/m^2

D = Nominal Diameter in mm = 2032-2x20 = 1992 mm

E = Modulus of elasticity of pipe material in Kg/cm^2 = 2.1×10^{10}

ct = Shell thickness in mm = 20 mm

$$a = \frac{1425}{\sqrt{1+\frac{KD}{Ect}}}$$

$$= \boxed{\frac{1425}{\sqrt{1+\frac{2.07 \times 10^8 \times 1992}{2.1 \times 10^{10} \times 20}}}}$$

$= 1425 / 1.408$

$= 1012$

$\therefore H_{MAX} = a.\frac{V}{g}$

$= 1012 \times 2.395 / 9.81$

$H_{MAX} = 247.09$ m

5.2.3 Checking Shell Thickness Against Field Test Pressure

Field Test Pressure = Static Head+ Max. Water Hammer Head + Frictional loss

$P = (358.000 - 328.000) + 247.09 + (0.19 \times 1.1)$

$= 30 + 247.09 + 0.2068$

$= 277.29$ m $\approx$ 2.77 MPa

As per IS 3589: 2001

$$P=\frac{2St}{D}$$

Where

P = Hydraulic Test Pressure in MPa =2.77

S = 0.6 x Specified minimum yield stress

T = Shell thickness in mm

D = Outside diameter in mm

$$2.77 = \frac{2 \times 0.6 \times 235 \times t}{2032}$$

= 19.96 < 20 mm O.K.

Check Against collapsing pressure

$$Ct = d \times 3\sqrt{\frac{S_F}{C}(P_{atm} - P_V)}$$

Where

S_F = Factor of safety (Adopted - 1.5)

Patm = Atmospheric pressure in Psi = 14.2 Psi

Pv = Vapour Pressure Psi = 0.36 psi

d = Outside diameter of pipe = 80"

C = 5×10^7

$$Ct = 80 \times 3\sqrt{\frac{1.5}{S \times 10^7}(14.2-0.36)}$$

= 0.5968 "

= 15.159 mm < 20 mm

-- Hence O.K.

5.2.4. Design Calculations for Ring Girder Support

5.2.4.1 Design Data

1. Dia of Pipe Line

D = 2032 mm OD

2. Shell Thickness

t = 20 mm (Proposed)

3. Internal pressure of water

P = 26.5 ksc

4. C/ C distance between roller supports

L = 10.8 mt

5. R.G. Channel Section - MCP 400 x 100 mm (Proposed)

Wt / mt	=	50.1	Kg
t_f	=	15.3	mm
Iy	=	572	cm^2
Y_6	=	5.02	cm
A/c	=	63.8	cm^2
Cy	=	2.6	cm
Y_t	=	6.18	cm

6. Stool channel section
M.C. 250 x 80 mm (Proposed)

Wt / mt	=	30.6	Kg
t_w	=	7.2	mm
Cy	=	2.3	cm
Iyy	=	211	cm^2
A/c	=	39	cm^2
t_f	=	14.1	mm
Ixx	=	3880	cm^4

7. Permissible stresses :-

a) Combined bending & direct tensile stress

f_t = 2600 x 0.6 x 1 = 1560 ksc

b) Combined bending & direct Compression

f_C = 2600 x 0.5 x 1 = 1300 ksc

c) Maximum wrinkling stress

f_{Cr} = 2600 x 0.333 = 867 ksc

8. Density of water q = 0.001 kg / cm^3

9. Density of steel w = 0.00785 kg / cm^3

5.2.4.2 Design Calcultion

1) Hoop stress $f_t = \frac{Pd}{2t} = \frac{26.5 \times 2032}{2 \times 20} = 1346.2 < 1560$

2) Longitudinal stresses

a) Beam Stress

$$f_t = \frac{2}{3} \times \frac{L^2}{4t} \times (2w\frac{t}{D} + \frac{q}{2})$$

$$= \frac{2}{3} \times \frac{1080^2}{4 \times 2.0} \times (\frac{2 \times 0.00785 \times 20}{203.0} + \frac{0.001}{2})$$

$$= \pm 63.63 \text{ ksc} \quad \textbf{- a}$$

b) Direct stress due to gravity component of shell weight :-

Maximum gradient

Assume = 1 in 30

$$f_g = \frac{WL}{AG}$$

$$= \frac{\pi \times (203+2.0) \times 2.0 \times 0.00785 \times 150 \times 100}{\pi \times (203+2.0) \times 2.0 \times 30}$$

$$= 3.925 \text{ ksc} \quad \textbf{- b}$$

c) Axial stress due to hydrostatic force, acting on exposed end of expansion Joint inner stroke of 22 mm thickness (assumed)

$$f_a = 10 \times \frac{t_i}{t}$$

$$f_a = 10 \times \frac{22}{18} = 12.22 \quad \textbf{- c}$$

d) i) Friction force at expansion joint

fc = π m.p.D.B.

fc = $\pi \times 0.3 \times 26.5 \times 203 \times 15$

= 76087.22 Kg

Where B = Width of packing used in expansion joint = 15 cm

ii) Frictional forces at supports

fc = 4wlm

Wt. of water = $\frac{\pi}{4} \times 199.2^2 \times 0.001 \times 100 kg/m$

= 3116.51

Wt. of shell = $\frac{\pi}{4} \times (203.2^2 - 199.2^2) \times 0.00785 \times 100$

= 992.379

fc = 4 x (4108.889) x 10.8 x 0.1 = 17750 Kg

Total unbalanced force

= 76087.22 + 17750 = 93837.22 Kg

= 93837.22 kg

Longitudinal Stress = $\frac{93837.22}{\pi \times (203.2+2.0) \times 2.0}$

= 72.78 ksc -d

e) Rim bending stress

$f_{bo} = 1.82 \times p \times \frac{R}{t} \times \frac{(Ar - C.t)}{(Ar + 1.56 \times t \times (R \times t)^{\frac{1}{2}})}$

Where Ar = Half the C/s area of ring girder channel

$= (1.82 \times 26.5 \times \frac{101.6}{2.0}) \times \frac{(31.9 - 1.53 \times 2.0)}{31.9 + 1.56 \times 2.0 \times \sqrt{101.6 \times 2.0}}$

= ±925.17 -e

Total longitudinal stre: = 69.020 + 3.925 + 12.22 + 80.627 + 1135.547

= 1301.339 ksc < 1560 ksc

Hence assumed shell thickness is adequate
Corresponding value of total stress is circumferencial & longitudinal direction is less than permissible.
Corresponding value of total stress at mid span will be :

= a + b + c + d

$f_t = \frac{63.63}{2} + 3.925 + 12.22 + 72.78$

= 120.74 ksc

Critical section for wrinkling stress will be at mid span where maximum stress is 120.74 ksc

This is lower than 0.33 fy = 0.33 x 2600 = 858 ksc

Hence safe

Collapse pressure likely to be developed (due to vacuum) in pipeline is 0.33 kg/cm^2
As the shell is stiffened with ring girders the collapse pressure is given by expression
Collapse pressure

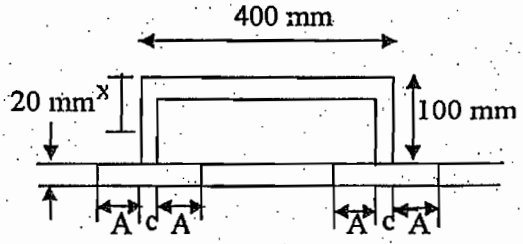
$$w = \frac{2.0 \times E \times t \times (\frac{t}{d})^{1.5}}{S}$$

$$= \frac{2.0 \times 2.1 \times 10^6 \times 2.0 \times (\frac{2.0}{203.2})^{1.5}}{1080}$$

$$= 7.595 \text{ ksc}$$

$$\text{F.O.S.} = \frac{7.595}{0.33} = 23.014 > 2$$

Hence safe



Check for stresses in Ring Girders :

i) Length of shell acting alongwith ring girder is

$$= 2 \times (2 \times A + Cr)$$

Where A $= 0.78(R \times t)^{0.5}$

Cy $= t_f = 1.53$ cm

L $= 2 \times (2 \times 0.78 \times (101.6 \times 2.0)^{0.5} + 1.53) = 47.535$ cm

ii) Cross sectional area of ring girder

$$= \text{Area of channel} + \text{area of plate}$$

$$= 63.80 + 47.535 \times 2.0$$

$$= 158.87 \text{ cm}^2$$

iii) Neutral axis of composite section of ring girder measured from centroidal axis. (Cy = 2.6 cm)

$$X = \frac{63.80 \times 2.6 + (47.535 \times 2.0) \times (10 + \frac{2}{2})}{158.87}$$

$= 7.627$ cm

$Y_t = 7.627$ cm

$\therefore Y_b = 10 + 2.0 - 7.627$

$= 4.373$ cm

MI of ring girder

$=$ Iyy of channel + A/c of channel $(Y_1 - Cy)^2$
+ Iyy of plate + A/c of plate$(Yb - t/_2)^2$

$= 572 + 63.8 \times (7.627 - 2.6)^2$
$+47.535 \times 2.0^3 + 47.535 \times 2.0 \times (4.373-0.9)^2$

$= 3362.67\ cm^4$

$$Z_{top} = \frac{M.I.}{Y_t} = \frac{3362.67}{7.627} = 440.89 cm^3$$

$$Z_{bottom} = \frac{M.I.}{Y_b} = \frac{3362.67}{4.373} = 768.96 cm^3$$

Calculation for angle of support : - (Refer fig. 6.6)

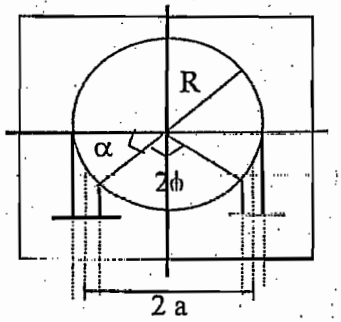
C/c distance of supports

$= 2a$

$=$ D + 2t + 15 - width of web of stool channel

$= 203.2 + 2 \times 2.0 + 15 - 25$

$= 197.2$ cm



Radius of center of ring girder

$$Rc.g = \frac{D}{2} + Y_b$$

$= 101.6 + 4.373 = 105.973$ cm

$\text{Cos } \alpha = \frac{a}{Rcg} = \frac{197.2}{2 \times 105.973} = 0.932$

$\alpha = 21.24$ degre $= 0.3708$ Radians

Evaluations of bending stress, direct stress & hoop stress in ring Girder

Moment in ring girder

a) For angle $o < \alpha < \theta$

$$M = [\frac{WR}{2\pi} \times [1.5\cos\alpha - cas^2\theta.\text{cas}\alpha + \alpha.\sin\alpha + \text{Cos}\theta - (\pi - \theta)\sin\theta]$$

$\theta = 68.76^0 = 1.20$ radians

$\alpha = \theta$

$M = \frac{WR}{2\pi} \times 0.1664$

$= \frac{(4108.889 \times 10.8 \times 1.1) \times (203 \div 2)}{2\pi} \times 0.1664$

$= 131214.05$ kg.cm

Direct tension in ring Girder

a) For angle $o < \alpha < \theta$

$$T_1 = [\frac{W}{2\pi}] \times [\alpha \sin\alpha - Cos^2\theta.Cos\alpha - 0.5Cos\alpha]$$

Taking $\alpha = \theta$

Substituting value of

$\theta = 68.76^0$

$= 1.20$ radians

$T_1 = \frac{4108.889 \times 10.8 \times 1.1}{2\pi} \times 0.88936$

$= 7768.9 \times 0.88936$

$= 6909.38$ kg

b) For angle $\theta < \alpha < \pi$

$T = [\frac{W}{2\pi}] \times [\alpha \sin\alpha - Cos^2\theta.Cos\alpha - 0.5Cos\alpha - \pi \sin\alpha]$

$= [\frac{W}{2\pi}] \times [1.118 - 0.0475 - 0.1811 - 2.928]$

$$T_2 = \frac{4108.889 \times 10.8 \times 1.1}{2\pi} \times (-2.0386)$$

$$= -15837.73$$

Hoop stress in ring girder

$$F_{hr} = [P \times Rcg / Ar] \times [C + \frac{1.56(R \times t)^{0.5}(Ar - C.t)}{Ar + 1.56 \times t(r \times t)^{0.5}}]$$

$$= 26.5 \times \frac{105.973}{158.87 \times 0.5}[1.53 + \frac{1.56(101.6 \times 2.0)^{0.5} \times (158.87 \times 0.5 - 1.53 \times 2.0)}{158.87 \times 0.5 + 1.56 \times 2.0 \times (101.6 \times 2.0)^{0.5}}]$$

F_{hr} = 538.66 ksc

Total stress @ the junction of R.G. of stool

$$= \pm \frac{M}{Z_b} - \frac{T_2}{A} + f_{hr}$$

below junction

$$F_1 = + \frac{131214.05}{768.96} - \frac{15837.73}{158.87} + 538.66$$

$$= 609.61 < 1560 \text{ (Outer Face)}$$

$$F_2 = [\frac{131214.05}{768.96} - \frac{15837.73}{158.87} + 538.66]$$

$$= 268.33 \text{ ksc} < 1300 \text{ ksc (Inner Face)}$$

OR

Total stress @ the junction of RG & stool

$$= \pm \frac{M}{Z_t} - \frac{T_1}{A} + f_{hr}$$

$$F_3 = + \frac{131214.05}{440.89} + \frac{6909.38}{158.87} + 538.66$$

$$= 297.61 + 43.49 + 538.66$$

$$= 879.76 < 1560 \text{ (Outer Face)}$$

$$F_4 = -297.61 + 43.49 + 538.66$$

$$= 284.54 \text{ ksc} < 1300 \text{ ksc (Inner Face)}$$

Hence section of ring girder is adequate

4) Check for stool(Roller Supports)

I) a) Load on each support

= 4108.889 x 10.8 x 1.1

= 48813.6 kg

i) C/s area of stool channel

= 2 x 39 = 78 cm^2

ii) MI @ YY

$$= 2 \times [I_{yy} + 39 \times [\frac{\text{Width of r.g. channel}}{(2\times 10)} + Cy + 0.1]^2$$

$$= 2\times[211+39\times[\frac{400}{(2\times 10)}+2.3+0.1]^2]$$

= 39559.28 cm^4

II) Zyy

$$= \frac{\text{MI@YY}}{[\frac{\text{Width of r.g. channel}}{10\times 2} + \frac{\text{depth of stool channel}}{10} + 0.1]}$$

= 1407.8 cm^3

$$fa = \frac{W}{A} = \frac{48813.6}{2\times 2\times 39} = 312.907$$

Height of stool = Rcg(1-Sin α)

= 105.973(1-Sin21.24)

= 67.58 cm

Moment on stool = $\frac{\text{load}}{\text{stool}} \times$ height of stool $\times m$

Where m = Coeff of friction between rollers & base plate. = 0.1

$$M = \frac{48813.6}{2}\times 67.58\times 0.1$$

= 164945 kg.cm

$$f_{bc} = \frac{m}{z} = \frac{164945.04}{1407.8} = 117.165 \text{ ksc}$$

$$r_{yy} = \sqrt{\frac{I_{yy}}{a}} = \sqrt{\frac{39559.28}{2\times 39}} = 22.52cm$$

Slenderness ratio of stool

$$= \frac{\text{left}}{r_{yy}}$$

$$= \frac{67.58 \times 2}{22.52} = 6.001$$

Fa allowable = 1239 KSA $\left(For \frac{l}{r} < 20\right)$

$$\therefore \frac{fbc}{Fbc} + \frac{fa}{Fa}$$

$$= \frac{117.165}{1560} + \frac{312.907}{1239}$$

$$= 0.3276 < 1$$

Hence channel proposed for stool is adequate

b) Check for stool (fixity supports)

Max unbalanced force

F = Fe + fe = 76087.22+17750

= 93837.22 kg

This force will be resisted by three ring girder supports

∴ Force resisted by each stool = $\frac{93837.22}{6} = 15639.54 kg$

moment / stool = F x eff. height of stool

= 15639.54 x 67.58

= 1056919.900 Kg.cm

$$\frac{M}{Z} = \frac{1056919.9}{1407.8} = 750.76 \text{ ksc}$$

fa = W/A = 312.907 ksc

∴ F_{total} = 750.76 + 312.907 = 1063.667 ksc

$$\frac{l}{r} = \frac{0.5 \times 67.58}{22.52} = 1.5 < 20$$

∴ F_{total} Allowable = 1239 ksc

$$\therefore \frac{fa}{Fa} + \frac{fe}{feb} = \frac{312.907}{1239} + \frac{750.76}{1560}$$

$$= 0.7338 < 1$$

∴ Hence the channel section proposed for stool is adequate.

5.3 Break Pressure Tank

To take the advantage of available topography it is proposed to construct a Break Pressure Tank at a hillock near Head Works. Not only, it will circumvent pumping of water for over 27 km length upto Mahadulla, also the water will be carried under gravity upto Gorewada converting one of the twin rising mains (running from Mahadula pumping station to BPT at Gorewada) into Gravity Main. The existing pumping at Mahadula will thus be avoided.

5.3.1 Design of Break Pressure Tank

Accumulation of water in B.P.T. is mainly governed by flow characteristics at downstream side Break Pressure Tank. The inflow to the BPT is assumed to be constant right from the start and is equal to steady state discharge of the system.

As stated earlier, 315 MLD of water will be conveyed from B.P.T. through 1930 mm dia (O.D.) M.S. pipe upto Mahadula, where it will get bifurcated to

i) Proposed WTP at Godhani (115 MLD) through 1422 mm (OD), 12 mm thick M.S. pipeline at about 2600 m length and

ii) B.P.T. at Gorewada (200 MLD) through existing 1626 mm (O.D.), 12 mm thick M.S. pipeline about 5350 m in length.

Both lines will run parallel upto proposed WTP at Godhani.

The salient features of various locations are :-

1.	F.S.L. of B.P.T. at Gorewada Tank	- 320.000 M
2.	Lip of Aeration Fountain of proposed WTP	- 330.000 M
3.	G.L. at bifurcation point at Mahadulla	- 300.000 M

CALCULATION OF HEAD LOSS FOR 200 MLD FLOW, FROM MAHADULLA B.P.T. AT GOREWADA.

Head loss is calculated using Hazen - Williams formula,

$$Q = 7.436 \times 10^{-9} \times c \times d^{2.63} \times (H_f)^{0.54}$$

Where

Q = Flow in MLD = 200 MLD

C = Roughness coefficient = 130

d = Internal diameter = (1626 - 2 x 12 - 2 x 12)

Assuming shell thickness =12mm

Inlining =12 mm

= 1578 mm

H_f = Head loss / 1000 m

$\therefore$ $200 = 7.436 \times 10^{-9} \times 130 \times (1578)^{2.63} \times (Hf)^{0.54}$

$H_f = 0.666$ m / 100 m

For length of 5350, head loss - $H_f = 0.666 \times 5.350$

$H_f = 3.563$ M

H.G.L required at Mahadulla, to convey the water upto Gorewada,

H_1 = F.S.L @ Gorewada+ (Frictional Head) x 1.1 + Residual Head

$= (320.000) + 3.563 \times 1.1 + 2$

$H_1 = 325.9193$ M 1

CALCULATIONS OF HEADLOSS FOR 115 MLD FLOW FROM MAHADULLA TO PROPOSED WTP AT GODHANI.

Discharge Q = 115 MLD

Internal dia = 1422 - 2 x (10) - 2 (12)

= 1378 mm

C = 130

By Hazen William formula

$\therefore$ 115 = $7.436 \times 10^{-9} \times 130 \times (1378)^{2.63} \times (H_f)^{0.54}$

$\therefore$ H_f = 0.463 m / 1000 m

For the length of 2600 M, Head loss H_f = 0.463 x 2.6

= 1.203 M

H.G.L. required at Mahadula to carry water to proposed WTP of Godhani

H_2 = Lip Of A.F + frictional head x 1.1 + Velocity head

= 330.000 + 1.203 x 1.1 + 2

H_2 = 333.203 M 2

CALCULATIONS OF HEAD LOSS FOR 315 MLD FLOW FROM PROPOSED BPT TO MAHADULLA

Q = 315 MLD

C = 130

d = 1930 - 2 x (10) - 2 x (12)

Assuming shell thickness =10mm

and In lining =12 mm

= 1886 mm

By Hazen Williams formula,

$$315 = 7.436 \times 10^{-9} \times 130 \times (1886)^{2.63} \times (H_f)^{0.54}$$

$$H_f = 0.648 \text{ m / } 1000 \text{ m}$$

For the length of 27360m, total head loss = 0.648 x 27.360

= 17.729 M

Since HGL required at Mahadula, for conveying water to proposed WTP at Godhani is higher, the LDL of BPT will be governed by the same.

HGL required at Mahadula	=	333.203
	+	
Head loss from proposed BPT to Mahadula	=	19.502
Hence Minimum LDL at BPT	=	352.705
Say	=	353.00 M.

Hence LDL adopted for BPT is 353.0 M.

5.4 Raw Water Transmission Main from B.P.T. to Mahadula

As mentioned earlier combined requirement for NMC and Cargo Hub are 230 Mm^3/year Or 630 MLD. With 24 hours pumping, the rate of pumping works out to 26.25 ML per hour.

Out of the two options available ie. either use a single main to carry a discharge of 630 MLD or provide duplicate mains to deal with 315 MLD. Each, we have proposed 1930 mm diameter (out side) M.S. main to be laid in the immediate stage and to be duplicated at a later stage. As given in the discussions on choice of raw water pumping machinery 1930 mm x 10 mm M.S. main will be able to deal with 78 Mm^3 + 40 Mm^3 = 118 Mm^3/year or 323 MLD.

Also 77% of raw water supply is from Pench source therefore we do not propose a single main.

Pipeline Features:

Total Discharge = 630 MLD

1 Discharge through single main = 630 / 2

= 315 MLD

= 3.645 m^3/s

2 1930 mm dia, Mild steel pipes with shell thickness =10 mm are adopted Confirming to IS 3589 : 2001

3 Grade of steel = Fe 410

4 In-lining = 12 mm Thick cc

5 Out-coating = 20 mm Thick cc

6 Ave. depth of fill material above top = 1 M

DESIGN CONSIDERATIONS:

Hazen Williams Fornlula is used to calculate frictional losses. The value adopted for Roughness coefficient, 'C' is 130.

Structural design has been made by checking against deflection and buckling.

Thickness has been checked by minimum wall/plate thickness required for handling.

Valves

Butterfly valves

We have proposed 1400 mm diameter butterfly valves. Valves are positioned as:

- At the beginning and the end of the line
- At either side of major river crossings
- Intermediate at 5 to 10 km

Air Valves

We have proposed cluster of kinetic air valves with isolating sluice valves.

Air valves are proposed at

- All peaks with respect to horizontal datum and with respect to maximum hydraulic gradient.
- At points where down grade/ upgrade changes
- In long ascending / descending sections at 0.5 to 0.75 km
- Long horizontal structures of gradients less than 1 in 50 at interval of 0.5 to 0.75 km

Scour Valves.

Scour valves are proposed at suitable locations to drain the line.

20 mm thick Cement Mortar coating is proposed for protection against external corrosion As per IS 10221: 1982

Thrust blocks are provided for horizontal and vertical bends where length of pipe with restrained joint is not available.

Necessary checks against buoyancy is taken while designing the section of pipe for Nalla /Canal crossings.

5.4.1 Calculations of Frictional Losses

Head loss due to friction is calculated using Hazen Williams Formula

$$Q = 7.436 \times 10^{-9} \times C \times D^{2.63} \times H_f^{0.54}$$

Where

	Q	=	Discharge in MLD
	C	=	130
	D	=	Internal diameter in mm
		=	1930 - (2 x 10) - (2 x 12)
		=	1886 mm
	H_f	=	Head loss in m/1000 m
i.e.	315	=	$7.436 \times 10^{-9} \times 130 \times 1886^{2.63} \times H_f^{0.54}$
	H_f	=	0.6482 m / 1000 m

Therefore total loss in the pipe line = 0.6482 x 27.36

= 17.734 m

With internal diameter of 1886 mm

Actual velocity, (V) = Q / A

$$= \frac{3.645}{\frac{\pi}{4}(1886)^2}$$

$$V = 1.304 \text{ m/s}$$

5.4.2 Design Notes - Structural Design of M.S. Pipe Line

For the design of shell thickness following critical conditions are considered.

1. Stress in shell due to internal pressure (60% of the specified minimum yield stress)

2. Deflection of shell under prism load

3. Buckling from elastic instability resulting from loads and deformation.

The following references are considered for the design of Steel Shell

1. IS 3589 : 2001 Steel Pipes for Water and Sewage 168.3 to 2540 mm outside diameter - specification
   Bureau of Indian Standards
   Bureau of Indian Standards

2. Pipe Material Selection Manual
   1st Edition – 1988
   WRc plc.

3. AWWA Manual M 11

Steel Pipe of Guide for Design & Installation – Third Edition 1999

4. IS 783 : 1985
Code of practice for laying of concrete pipes 1st revision

5. Standard Specification & Code of Practice for Road Bridges
Section II Loads & Stresses – 4th revision 2000
Indian Roads Congress

1. For checking vertical deflection of the pipe line Iowa Spangler Equation has been considered.

$$\frac{\Delta}{D} = \frac{k\left(D_L\, Pb + Ps\right)}{8\frac{EI}{D^3} + 0.061\, E^1} x\, D_R$$

Where,

Δ = Linear deflection of pipe vertical diameter

D = Pipe diameter

D_L = Deflection lag factor

D_R = Re-rounding factor

Pb = Vertical pressure due to backfill

Ps = Vertical pressure to surcharge loads

EI/D^3 = Pipe stiffness

E^1 = Modulus of passive resistance of pipe zone fill material

k = Bedding constant

Allowable deflection for various lining and coating systems are :

Mortar lined and coated = 2 percent of pipe diameter

Mortar lined and flexible coated = 3 percent of pipe diameter

Flexible lined and coated = 5 percent of pipe diameter

2. AWWA M11 gives a formula for horizontal deflection of pipe in inches

$$\Delta x = Dl \left(\frac{kWr^3}{EI + 0.061 E r^3} \right)$$

Where,

Δx = Horizontal deflection of pipe (in.)

Dl = Deflection lag factor (1-1.5)

k = Bedding constant (0.1)

W = load / unit length of pipe length (lb/in. of pipe)

r = radius (in.)

EI = Pipe wall stiffness (in. – lb)

E = Modulus of elasticity

I = Transverse moment of inertia, per unit length of wall

E' = Modulus of soil reaction (lb/in.^{2})

3. IRC class AA loading has been considered for load. A single maximum wheel load of 6.25 T has been considered as a point load.

4. Minimum plate or sheet thickness for handling for pipe sizes greater than 54 inches internal diameter is given by

$$t = \frac{D+20}{400} \ in.$$

5. Buckling :

Pipe embedded in soil may collapse or buckle from elastic instability resulting from loads and deformations. The summation of external loads should be less than or equal to allowable buckling pressure.

The allowable buckling pressure is determined by

$$qa = \left(\frac{1}{FS}\right) x \left(32 \times Rw \times B' \times E' \times \frac{EI}{D^3}\right)^{1/2}$$

qa = allowable buckling pressure

FS = design factor 2.5 for h/D ≥ 2

3.0 for h/D < 2

where h = ht of ground surface above top of pipe (in.)

D = diameter of pipe (in.)

Rw = Water buoyancy factor

$$= 1 - 0.33\left(\frac{hw}{h}\right), \quad 0 \le hw < h$$

Where

hw = height of water surface above top of pipe (in.)

In the worst case hw = h

B' = empirical coefficient of elastic support (dimension less)

$$= \left(\frac{1}{1 + 4e^{-0.065\ H}}\right)$$

Where

H = height of fill above pipe in ft.

$$\gamma_w \times hw + Rw\frac{Wc}{D} + \frac{W_L}{D} < qa$$

Structural Design Calculation for Raw Water Transmission Main

Data

Raw water pumping main	:	27.360 km
Internal diameter	:	1886 mm
C.M. lining	:	12 mm
Plate thickness	:	10 mm
Outcoating	:	20 mm
For present flow	:	315 MLD

Calculation

$$Q = \frac{315 \times 1000}{24 \times 3600}$$

$$= 3.6458 \text{ m}^3/\text{s}.$$

$$\text{Velocity} = \frac{Q}{A}$$

$$= \frac{3.6458}{\frac{\pi}{4} \times 1.886^2}$$

$$= 1.30 \text{ m/s}$$

Check for Deflection

Iowa Spangler Equation

$$\frac{\Delta}{D} = \frac{k\left(D_L\, Pb + Ps\right)}{8\frac{EI}{D^3} + 0.061\, E^1} \times D_R$$

Where

Δ = Linear deflection of pipe vertical diameter

D = Pipe diameter

D_L = Deflection lag factor

D_R = Re-rounding factor

Pb = Vertical pressure due to backfill

Ps = Vertical pressure to surcharge loads

EI/D^3 = Pipe stiffness

E^1 = Modulus of passive resistance of pipe zone fill material

k = Bedding constant 0.1 for sand

Load on pipe due to backfill

= w x H x Bc

= 18 x 1 x 1.970

= 35.46 kN/m.

Pb = $\frac{15.988}{1.970}$ 35.46

= 18 kN / m^2 or 18 kPa

Ps

Wheel load IRC class AA = 6.25 T

IS 783-85 Cl. 11.2

Cover > 600 mm, Impact factor 1.1

Wc = $\frac{P\alpha}{l}$ CP

Where l = 1.15H + 2D + S

= 1.15 x 1 + 2 x 1.970 + 0

= 1.15 + 3.94

= 5.09 m

$\frac{l}{2H}$ = 2.545,

$\frac{D}{2H}$ = $\frac{1.4804}{2H}$ = 0.985

$\frac{l}{2H}$ $\frac{D}{2H}$

From fig. 3, IS 783 – 1985 for = 2.595, = 0.985

Cp = 0.80

$$Wc = \frac{0.80 \times 6.25 \times 1}{5.09}$$

= 0.9823 T

= 10.218 kN/m.

$$Ps = \frac{10.218}{1.97}$$

= 5.1868 kN/m^2

or 5.187 kPa

Pipe stiffness = EI / D^3

$$= \frac{2 \times 10^5 \times \frac{1}{12} \times 10^3}{1970^3} \times (1000)^2$$

= 2179.97 N/m^2

or

2.179 kPa

$$\frac{\Delta}{D} = \frac{k\left(D_L\, Pb + Ps\right)}{8\frac{EI}{D^3} + 0.061\, E^1} \times D_R$$

k = 0.1

D_L = 1

E^1 = 3000 kPa

D_R = 1

$$= \frac{0.1(1\times 18+5.187)}{8\times 2.179+0.061\times 3000}$$

$$= \frac{0.1\times 24.187}{17.432+183}$$

= 0.01206 or 1.2 %

This is within permissible limit of 2% for cement mortar lined and coated pipes

Horizontal Deflection (AS per M-11)

$$\Delta x = Dl\left(\frac{kWr^3}{EI+0.061E'r^3}\right)$$

Where,

Δx = Horizontal deflection of pipe (in.)

Dl = Deflection lag factor (1)

k = Bedding constant (0.1)

W = load / unit length (lb/in. of pipe)

r = radius (in.)

EI = Pipe wall stiffness (in. – lb)

E = Modulus of elasticity (30000000 p.s.i. for steel)

I = Transverse moment of inertia, per unit length of pipe wall

E' = Modulus of soil reaction (lb/in.^{2})

W = load due to back fill + load due to live load

= 35.46 + 10.218 kN/m.

= 45.678 kN/m

= 46678 x 0.06852 lb/ft.

= 3129.85 lb/ft.

= 260.82 lb/in.

$$I = \frac{t^3}{12} \qquad r = \frac{77.589}{2}$$

$$= \frac{\left(\frac{10}{25.4}\right)^3}{12} \qquad = 38.77 \text{ inches}$$

$$= 5.0853 \times 10^{-3}$$

$$EI = 30000000 \times 5.0853 \times 10^{-3}$$

$$= 152559$$

$$\Delta x = Dl\left(\frac{kWr^3}{EI + 0.061E'r^3}\right)$$

$$\Delta x = 1\left(\frac{0.1 \times 260.82 \times 38.77^3}{152559 + 0.61 \times 400 \times 38.77^3}\right)$$

$$= 1 \times \frac{0.1 \times 260.82 \times 58275.68}{152559 + 14219267.66}$$

$$= \frac{1519946.286}{14371826.66}$$

$$= 0.105 \text{ in.}$$

$$\frac{\Delta x}{D} = \frac{0.105}{77.559} \times 100$$

$$= 0.136 \text{ percent}$$

This is within 2% allowed for cement mortar inlined and out coated pipes.

Minimum Wall Thickness

Minimum plate or sheet thickness for handling for pipe sizes greater than 54 in. ID is given by

$$t = \frac{D+20}{400} \text{ in.}$$

$$1930 = \frac{1930}{25.4}$$

$$= 75.98 \text{ in.}$$

$$t = \frac{75.98+20}{400}$$

$$= 0.239 \text{ in.} \quad \text{or} \quad 6.09 \text{ mm.}$$

Check Against Buckling

Allowable buckling pressure p.s.i

$$qa = \left(\frac{1}{Fs}\right)\left(32\,Rw\,B'\,E'\,\frac{EI}{D^3}\right)^{1/2}$$

FS = Design factor $\frac{h}{D} \geq 2$ 2.5

$\frac{h}{D} < 2$ 3.0

h = ht. of ground surface above top of pipe in.

D = diameter of pipe in.

Rw = water buoyancy factor

$1 - 0.33\frac{hw}{h}, \quad 0, < hw \leq h$

Where, hw = ht.of water surface above top of pipe in.

B' empirical coefficient of elastic support

$$= \frac{1}{1+4e^{-(0.065H)}}$$

Where, H = ht.of fill above pipe ft.

D = 1930 + 40

= 1970 mm

= 77.55 in.

h = 1000 mm = 39.37 inch

$\frac{h}{D}$ = 0.507 < 2

Fs = 3.0

$Rw = 1 - 0.33 \frac{hw}{h}$

Assuming that ground water table reaches the ground level

$Rw = 1 - 0.33 \frac{0.6}{0.6}$

= 0.67

$$B^{I} = \frac{1}{1+4e^{(-0.065H)}}$$

$$= \frac{1}{1+4e^{-.065\times1.969}}$$

$$= \frac{1}{1+4e^{-(0.1280)}}$$

$$= \frac{1}{1+4\times0.87989}$$

$$= 0.2213$$

$$I = \frac{t^3}{12}$$

$$= \frac{\left(\frac{10}{25.4}\right)^3}{12}$$

$$= 5.0853 \times 10^{-3}$$

$$\frac{EI}{D^3} = \frac{30\times10^6\times5.0853\times10^{-3}}{77.55^3}$$

$$= 0.3271089 \text{ lb/in.}^2$$

Say = 3.827 lb/in.^{2}

Allowable buckling pressure

$$qa = \left(\frac{1}{Fs}\right)\left(32\,Rw\,B'\,E'\frac{EI}{D^3}\right)^{1/2}$$

$$= \frac{1}{3}\left(32\times 0.67\times 0.2213\times 400\times 0.327\right)^{1/2}$$

$$= \frac{1}{3}\times 25.776$$

= 8.592 p.s.i.

Actual buckling pressure :

Load on pipe due to backfill = 35.46 kN/m

= 2429.72 lb/ft.

Load due to line load = 10.218 kN/m

= 700.137 lb/ft.

$$\gamma_w \times hw + Rw\frac{Wc}{D} + \frac{W_L}{D} < qa$$

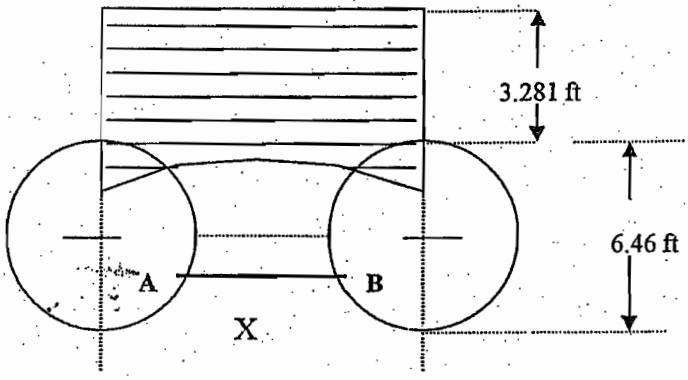
$$\gamma_w \times hw + Rw\frac{Wc}{D} + \frac{W_L}{D} = 0.0361 \times 3.28\times 12 + \frac{0.67\times 2429.72}{12\times 77.55} + \frac{700.137}{12\times 77.55}$$

$$= 1.42 + 1.74 + 0.752$$

= 3.912 p.s.i. < 8.592 p.s.i.

5.4.3 Spacing Between Pipes Required

Ref.: Buried pipe Design (Second Edition) By A.P. Moser



Outer dia, D = 1930 mm + 40 mm = 1970 mm = 77.56" = 6.46 ft

Spacing between pipes = 1.8 m = 70.86 " = 5.90 ft

Soil cover = 1 m = 3.281 ft

Unit wt. Of soil = 120 1b / ft^3

Surface wheel load = W = 120 Kips

Thickness t = 16 mm = 0.623"

The pressure on pipe due to dead load,

Pd = γH = 120 x 3.281 = 393.72. 1b / ft^2

$\therefore$ Pd x D = 393.72 x 6.46 = 2543.43 1b /ft

By Bousinesq Equation -

$$W_1 = \frac{0.477WD}{H^2} = \frac{0.477 \times 20{,}000 \times 6.46}{(3.281)^2}$$

$$W_1 = 5724 \text{ lb / ft}$$

$$Pi = \frac{W_2}{H^2} = \frac{5724}{6.46}$$

$$= 886 \text{ LB/ ft}^2$$

$\therefore$ $P = Pd + Pi = 393.72 + 886 = 1280\ 1b/ft^2$

$\therefore$ Total vehicle load (per length) on pipe

$= Wd + W_9$

$= 2543.43+5724$

$= 8267\ 43\ 1b/\ ft$

$= 689\ 1b/in$

The ring compression stress is = 6t

$$6t = \frac{PD}{2t} = \frac{V}{2t} = \frac{689}{2(0.623)} = 553^{2b/in^2}$$

Pipe will not crush as 6t < V

For the dead load on section – AA

Using eq^n

$$Wd=[(x+2r)(H+r)-\frac{\pi r^2}{2}]120$$

$= ((12.36)(6.511)-(16.28))x120$

$= 7703.51\ 1b/ft$

$= \frac{7763.51}{5.90} = 1305.68^{2b/ft^2}$

For the live load on - AA

$$P_z = \frac{0.477 \times W}{H^2}$$

H = 3.281 + 3.231 = 6.512
(Cover 1M) (Pipe Radius)

And $P_2 = \frac{0.477 \times 20,000}{(6.512)^2}$

= 224.97 1b/ft^2

The soil pressure on section AA

As $P^1 = Pd + PL - VH$

= 1305.68 + 224.97 - 120 (3.281)

= 1136.93 1b/ft^2

The maximum pressure in at the side of the pipe should not be greater than vertical load at the top of pipe.

δx = 378.97 2b / ft^2.....$\delta x = \delta y/3$

And VH = 393.72 2b / ft^2

$\therefore$ 6x < VH Hence O.K.

Provide clear spacing of 1.8m

Adopted Spacing = 2 M.

5.4.4 DESIGN CALCULATIONS FOR RING GIRDER SUPPORT

5.4.4.1 DESIGN DATA :

1. Dia of Pipe line

D	=	1930	mm	OD

2. Shell thickness

t	=	12	mm (Proposed)

3. Internal pressure of water

P	=	12.4	ksc

4. c/c distance between roller supports

L	=	10.8	mt

5. R.G. Channel Section - MCP 400 x 100 mm (Proposed)

Wt / mt	=	50.1	Kg
t_f	=	15.3	mm
Iy	=	572	cm^2
Y_6	=	5.02	cm
A/c	=	63.8	cm^2
Cy	=	2.6	cm
Y_t	=	6.18	cm

6. Stool channel section

M.C. 250 x 80 mm (Proposed)

Wt / mt	=	30.6	Kg
t_w	=	7.2	mm
Cy	=	2.3	cm
Iyy	=	211	cm^2
A/c	=	39	cm^2
t_f	=	14.1	mm
Ixx	=	3880	cm^4

7. Permissible stresses :-

a) Combined bending & direct tensile stress

f_t = 2600 x 0.6 x 1 = 1560 ksc

b) Combined bending & direct Compression

f_c = 2600 x 0.5 x 1 = 1300 ksc

c) Maximum wrinkling stress

f_{Cr} = 2600 x 0.333 = 867 ksc

8. Density of water q = 0.001 kg / cm^3

9. Density of steel w = 0.00785 kg / cm^3

DESIGN CALCULATIONS :-

1 Hoop stress = $Fr = \frac{Pd}{2t} = \frac{12.4 \times 193.0}{2 \times 1.2} = 997.1667 < 1560$

2 Longitudinal stresses

a) Beam Stress

$$f_t = \frac{2}{3} \times \frac{L^2}{4t} \times (2w\frac{t}{D} + \frac{q}{2})$$

$$= \frac{2}{3} \times \frac{1080^2}{4 \times 1.2} \times (\frac{2 \times 0.00785 \times 1.2}{193.0} + \frac{0.001}{2})$$

$$= \pm 96.81 \text{ ksc} \quad \textbf{- a}$$

b) Direct stress due to gravity component of shell weight :-

Max. gradient

Assume = gradient 1 in 30

$$f_g = \frac{WL}{AG}$$

$$= \frac{\pi \times (193+1.2) \times 1.2 \times 0.00785 \times 150 \times 100}{\pi \times (193+1.2) \times 1.2 \times 30}$$

$$= 3.925 \text{ ksc} \quad \textbf{- b}$$

c) Arial stress due to hydrostatic force, acting on exposed end of expansion Joint inner stroke of 22 mm thickness (assumed)

$$f_a = 10 \times \frac{t_\ell}{t}$$

$$f_a = 10 \times \frac{22}{18} = 12.22 \quad \textbf{- c}$$

d) i) Friction force at expansion joint

fc = π m.p.D.B.

fc = $\pi \times 0.3 \times 12.4 \times 193 \times 15$

= 33815.92 Kg

Where B = Width of packing used in expansion joint = 15 cm

ii) Frictional forces at supports

fc = 4wlm

Wt. of water = $\frac{\pi}{4} \times 190.6^2 \times 0.001 \times 100 kg/m$

= 2853.22

Wt. of shell = $\frac{\pi}{4} \times (193^2 - 190.6^2) \times 0.00785 \times 100$

= 567.609

fc = 4 x (2853.22+567.609) x 10.8 x 0.1 = 14770.5 Kg

Total unbalanced force

= 33815.92 + 14770.5

= 48586.42 kg

Longitudinal Stress = $\frac{48586.42}{\pi \times (193+1.2) \times 1.2}$

= 66.39 ksc **-d**

e) Rim bending stress

$f_{bo} = 1.82 \times p \times \frac{R}{t} \times \frac{(Ar - C.t)}{(Ar + 1.56 \times t \times (R \times t)^{\frac{1}{2}})}$

Where Ar = Half the C/s area of ring girder channel

= $(1.82 \times 12.4 \times \frac{96.5}{1.2}) \times \frac{(31.9 - 1.53 \times 1.2)}{31.9 + 1.56 \times 1.2 \times \sqrt{96.5 \times 1.2}}$

= ±1048.358 **-e**

Total longitudinal stre = 96.81 + 3.925 + 12.22 + 66.39 + 1048.358

= 1233.828 ksc < 1560 ksc

Hence assumed shell thickness is adequate

Corresponding value of total stress is circumferencial & longitudinal direction is less than permissible.

Corresponding value of total stress at mid span will be :

$$= a + b + c + d$$

$$f_t = \frac{96.81}{2} + 3.925 + 12.22 + 66.39$$

$$= 137.0632 \text{ ksc}$$

Critical section for wrinkling stress will be at mid span where maximum stress is 131.066 ksc

This is lower than 0.33 fy = 0.33 x 2600 = 858 ksc

Hence safe

Collapse pressure likely to be developed (due to vacuum) in pipeline is 0.33 kg/cm^2
As the shell is stiffened with ring girders the collapse pressure is given by expression
Collapse pressure

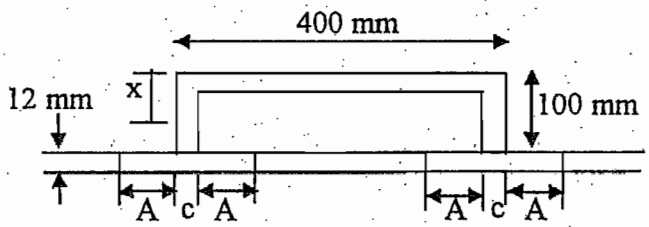
$$w = \frac{2.0 \times E \times t \times (\frac{t}{d})^{1.5}}{S}$$

$$= \frac{2.0 \times 2.1 \times 10^6 \times 1.2 \times (\frac{1.2}{193})^{1.5}}{1080}$$

$$= 2.287 \text{ ksc}$$

$$\text{F.O.S.} = \frac{2.287}{0.33} = 6.933 > 2$$

Hence safe



Check for stresses in Ring Girders :

i) Length of shell acting alongwith ring girder is

$$= 2 \times (2 \times A + Cy)$$

Where A $= 0.78(R \times t)^{0.5}$

Cy $= t_f = 1.53$ cm

L $= 2 \times (2 \times 0.78 \times (96.5 \times 1.2)^{0.5} + 1.53) = 36.63$ cm

ii) Cross sectional area of ring girder

= Area of channel + area of plate

= 63.80 + 36.63 x 1.2

= 107.76 cm^2

iii) Neutral axis of composite section of ring girder measured from centroidal axis. (Cy = 2.6 cm)

$$X = \frac{63.80 \times 2.6 + (36.63 \times 1.2) \times (10 + \frac{1.2}{2})}{107.76}$$

= 5.986 cm

Y_t = 5.986 cm

Y_b = 10 + 1.2 - 5.986

= 5.214 cm

MI of ring girder

= Iyy of channel + A/c of channel $(Y_1 - Cy)^2$
+ Iyy of plate + A/c of plate$(Yb - t/_2)^2$

= $572 + 63.8 \times (5.986 - 2.6)^2$
$+ {}^1/_{12} \times 36.63 \times 1.2^3 + 36.63 \times 1.2 \times (5.214 - 0.9)^2$

= 2244.635 cm^4

$Z_{top} = \frac{M.I.}{Y_t} = \frac{2044.635}{5.986} = 374.98 cm^3$

$Z_{bottom} = \frac{M.I.}{Y_b} = \frac{2244.635}{5.214} = 430.5009 cm^3$

Calculation for angle of support : -

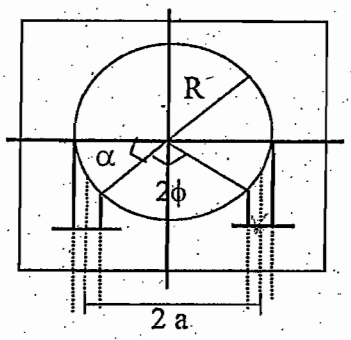
C/c distance of supports

= 2a

= D + 2t + 15 - width of web of stool channel

= 193 + 2 x 1.2 + 15 - 25

= 185.4 cm



Radius of center of ring girder

$$R_{c.g} = \frac{D}{2} + Y_b$$

$$= 96.5 + 5.214 = 101.714 \text{ cm}$$

$$\therefore \quad \text{Cos } \alpha = \frac{a}{R_{cg}} = \frac{185.4}{2 \times 101.714} = 0.9113$$

$$\alpha = 24.315 \text{ degree} = 0.4241 \text{ Radians}$$

Evaluations of bending stress, direct stress & hoop stress in ring Girder
Moment in ring girder

a) For angle $0 < \alpha < \theta$

$$M = [\frac{WR}{2\pi} \times [1.5\cos\alpha - cas^2\theta.\text{cas}\alpha + \alpha.\sin\alpha + \text{Cos}\theta - (\pi - \theta)\sin\theta]$$

$$\theta = 65.680^0 = 1.1458 \text{ radians}$$

by substituting

$$\alpha = \theta$$

$$M = \frac{WR}{2\pi} \times 0.187762$$

$$= \frac{(3420.829 \times 10.8 \times 1.1) \times (\frac{193}{2})}{2\pi} \times 0.187762$$

$$= 117193.40 \text{ kg.cm}$$

Direct tension in ring Girder

a) For angle $0 < \alpha < \theta$

$$T_1 = [\frac{W}{2\pi}] \times [\alpha \sin\alpha - Cos^2\theta.Cos\alpha - 0.5Cos\alpha]$$

Taking α = θ

Substituting value of

θ = 65.68^0

= 1.1458 radians

T_1 = $\frac{3420.829 \times 10.8 \times 1.1}{2\pi} \times 0.76767$

= 1.1656 x Sin 66.785 - $\cos^2$ 785 - 0.5 Cos 66.785

= 4965.297 kg

b) For angle θ < α < π

T = $[\frac{W}{2\pi}] \times [\alpha \sin\alpha - Cos^2\theta . Cos\alpha - 0.5Cos\alpha - \pi \sin\alpha]$

T_2 = $\frac{3420.829 \times 10.8 \times 1.1}{2\pi} \times (-2.09303)$

= -13537.6

Hoop stress in ring girder

F_{hr} = $[P \times Rcg / Ar] \times [C + \frac{1.56(R \times t)^{0.5}(Ar - C.t)}{Ar + 1.56 \times t(r \times t)^{0.5}}]$

= $12.4 \times \frac{101.714}{107.76 \times 0.5} [1.53 + \frac{1.56(96.5 \times 1.2)^{0.5} \times (107.76 \times 0.5 - 1.53 \times 1.2)}{107.76 \times 0.5 + 1.56 \times 1.2 \times (96.5 \times 1.2)^{0.5}}$

F_{hr} = 312.0913 ksc

∴ Total stress @ the junction of R.G. of stool

= $\pm \frac{M}{Z_b} - \frac{T_2}{A} + f_{hr}$

below junction

F_1 = $+\frac{117193.4}{430.5009} - \frac{13537.6}{107.76} + 312.093$

= 458.691 < 1560 (Outer Face)

F_2 = 272.22 - 125.62 + 312.093

= - 85.76 ksc < 1300 ksc (Inner Face)

OR

Total stress @ the junction of RG & stool

$$= \pm\frac{M}{Z_1} - \frac{T_1}{A} + f_{hr}$$

Above Junction :

$$F_3 = +\frac{117193.4}{374.98} + \frac{4965.297}{107.76} + 312.913$$

$$= 312.53 + 46.077 + 312.913$$

$$= 671.52 < 1560 \text{ (Outer Face)}$$

$$F_4 = -312.53 + 46.077 + 312.913$$

$$= 46.46 \text{ ksc} < 1300 \text{ ksc (Inner Face)}$$

Hence section of ring girder is adequate

4) Check for stool(Roller Supports)

I) a) Load on each support

$$= 3420.829 \times 10.8 \times 1.1$$

$$= 40639.4 \text{ kg}$$

i) C/s area of stool channel

$$= 2 \times 39 = 78 \text{ cm}^2$$

ii) MI @ YY

$$= 2\times[I_{yy} + 39\times[\frac{\text{Width of r.g. channel}}{(2\times10)} + Cy + 0.1]^2$$

$$= 2\times[211 + 39\times[\frac{400}{(2\times10)} + 2.3 + 0.1]^2]$$

$$= 39559.28 \text{ cm}^4$$

II) Zyy

$$= \frac{\text{MI@YY}}{[\frac{\text{Width of r.g. channel}}{10\times2} + \frac{\text{depth of stool channel}}{10} + 0.1]}$$

$$= 1407.8 \text{ cm}^3$$

$$fa = \frac{W}{A} = \frac{40639.4}{2\times2\times39} = 260.5 \text{ ksc}$$

Height of stool = Rcg(1-Sin α)

$$= 101.714(1-\text{Sin } 24.315)$$

$$= 59.833 \text{ cm}$$

Moment on stool = $\frac{\text{load}}{stool} \times \text{height of stool} \times m$

Where m = Coeff. of friction between rollers & base plate

= $\frac{40639.4}{2} \times 59.833 \times 0.1$

= 121578.861 kg.cm

f_{bc} = $\frac{m}{z}$ = $\frac{117193.4}{1407.8}$ = 83.24 ksc

r_{yy} = $\sqrt{\frac{I_{yy}}{a}} = \sqrt{\frac{39559.28}{2 \times 39}} = 22.52cm$

Slenderness ratio of stool

= $\frac{\text{left}}{r_{yy}}$

= $\frac{59.833 \times 2}{22.52}$ = 5.3137

Fa allowable = 1239 KSA $\left(For \frac{l}{r} < 20\right)$

$\therefore \frac{fbc}{Fbc} + \frac{fa}{Fa}$

= $\frac{83.24}{1560} + \frac{260.5}{1239}$

= 0.2636 < 1

Hence channel proposed for stool is adequate

b) Check for stool (fixity supports)

Max unbalanced force

F = Fe + fc = 33815.92 + 14770.5

= 48586.42 kg

This force will be resisted by three ring girder supports

∴ Force resisted by each stool = 8097.736 Kg

moment / stool = F x eff. height of stool

= 8097.736 x 59.833

= 484511.878 Kg.cm

$$\frac{M}{Z} = \frac{484511.878}{1407.8} = 344.16 KSC$$

$$fa = {}^{W}/_{A} = - \quad 260.5 \text{ ksc}$$

$$\therefore \quad F_{total} = 344.16 + 260.50 = 604.7 \text{ ksc}$$

$$\frac{l}{r} = \frac{0.5 \times 59.833}{22.52} = 1.328 < 20$$

$$\therefore \quad F_{total} \text{ Allowable} = 1239 \text{ ksc}$$

$$\therefore \quad \frac{fa}{Fa} + \frac{fe}{feb} = \frac{260.50}{1239} + \frac{344.16}{1560}$$

$$= 0.430 < 1$$

$\therefore$ Hence the channel section proposed for stool is adequate.

5.4.5 Calculations of Restrained Length for Horizontal bends

Inner diameter (D)	=	1886 mm
Thickness of Outlining	=	20 mm
Thickness of steel shell	=	10 mm
Inner lining	=	12 mm

If the soil prism above the pipe is restrained from movement:

$$L = \frac{PA \sin^2 \frac{\Delta}{2}}{f(2w_e + w_p + w_w)}$$

Where

L	=	Restrained length in cm
P	=	Internal pressure in kg/sq. cm
A	=	Cross section area of pipe in sq. cm
Δ	=	Bend deflection in degrees
We	=	Weight of prism of soil over the pipe in kg/cm
Wp	=	Weight of pipe in kg/cm
Ww	=	Weight of contained water in kg/cm
f	=	Friction between pipe and soil = 0.4

Weight of steel shell (W1)	=	4.78 kg/cm
Weight of Outer lining (W2)	=	3.297 kg/cm
Weight of inner coating (W3)	=	2.032 kg/cm
Total weight of pipe (Wp)	=	W1 + W2 + W3
	=	10.109 kg/cm
Outer diameter (Bc)	=	1970 mm

Weight of prims of soil over the pipe(We) $\gamma_s \times H \times B_c$

where, = Density of soil = 18 kN/m^3

H = Minimum depth of cover = 1 m

We = 36.147 kg/cm

Weight of contained water (Ww) = 27.948 kg/cm

$2w_e+w_p+w_w$ = 110.351 kg/cm

Area of pipe (A) = 27936.6 sq.cm

Maximum pressure (P) = 12.400 kg/sq.cm

Δ in degrees	90	60	45	30	22.5	15
sin(Δ/2)	0.707	0.500	0.383	0.259	0.195	0.131
$\sin^2(\Delta/2)$	0.500	0.250	0.147	0.067	0.038	0.017
L in m	39.24	19.62	11.54	5.26	2.98	1.33
L say	40	20	12	6	3	2

5.4.6 Calculation of Restrained length for vertical downward bends.

Inner diameter (D)	=	1886 mm
Thickness of Outlining	=	20 mm
Thickness of steel shell	=	10 mm
Thickness of inner lining	=	12 mm

If the soil prism above the pipe is restrained from movement:

$$L = \frac{S_f P A Tan \frac{\theta}{2}}{F_f}$$

Where,

Ff	=	Frictional force = $(\pi Bc/2)*C+(2We+Wp+Ww)Tan\delta$		
L	=	Restrained length in cm		
P	=	Internal pressure in kg/sq. cm		
A	=	Cross section area of pipe in sq. cm		
q	=	Bend deflection in degrees		
We	=	Weight of prism of soil over the pipe in kg/cm		
Wp	=	Weight of pipe in kg/cm		
Ww	=	Weight of contained water in kg/cm		
ϕ	=	Angle of friction	=	30 Degrees
$F\phi$	=	Ratio of pipe friction angle to soil friction angle	=	0.75
$Tan\delta$	=	Friction between pipe and soil $=Tan(F\phi*\phi)$	=	0.4
C	=	Cohision	=	0.00 kg/cm^2
S_f	=	Factor of safity	=	1.5

Weight of steel shell (W1)	=	4.78 kg/cm
Weight ofOuter Lining (W2)	=	3.297 kg/cm
Weight of Inner lining (W3)	=	2.032 kg/cm
Total weight of pipe (Wp)	=	W1 + W2 + W3
	=	10.105 kg/cm
Outer diameter (Bc)	=	1970 mm

Weight of prims of soil over the pipe(We) = $\gamma_s \times H \times B_c$

where, = Density of soil = 0.001835 kg/cm^3

H = Minimum depth of cover = 1.0 m

We = 36.1 kg/cm

Weight of contained water (Ww = 27.9 kg/cm

$2w_e+w_p+w_w$ = 110.4 kg/cm

Area of pipe (A) = 27936.6 sq.cm

Maximum pressure (P) = 12.4 kg/sq.cm

Frictional force (Ff) = 45.7 kg/cm

θ in degrees	90	60	45	30	22.5	15	10
Tan(θ/2)	1.000	0.577	0.414	0.268	0.199	0.132	0.087
L in m	113.74	65.67	47.11	30.48	22.62	14.97	9.95
L say	114	66	48	31	23	15	10

5.4.7 Calculations of Restrained Length for Vertical Upward Bends.

Inner diameter (D)	=	1886 mm
Thickness of Outlining	=	20 mm
Thickness of steel shell	=	10 mm
Inner lining	=	12 mm

If the soil prism above the pipe is restrained from movement:

$$L = \frac{S_f PA Tan\frac{\theta}{2}}{F_f + (1/2)R_s}$$

Where,

Ff	=	Frictional force = (πBc/2)*C+(2We+Wp+Ww)Tanδ		
L	=	Restrained length in cm		
P	=	Internal pressure in kg/sq. cm		
A	=	Cross section area of pipe in sq. cm		
θ	=	Bend deflection in degrees		
We	=	Weight of prism of soil over the pipe in kg/cm		
Wp	=	Weight of pipe in kg/cm		
Ww	=	Weight of contained water in kg/cm		
ϕ	=	Angle of friction	=	30 Degrees
Fϕ	=	Ratio of pipe friction angle to soil friction angle	=	0.75
Tanδ	=	Friction between pipe and soil = Tan(Fϕ*ϕ)	=	0.4
C	=	Cohision	=	0.00 kg/cm^2
γs	=	Unit weight of soil	=	0.001835 kg/cm^3
S_f	=	Factor of safity	=	1.5
Rs	=	Unit Bearing Resistance	=	Kn*Pp*Bc
Pp	=	Passive soil presure = γ*Hc*Nϕ +2*Cs*sqrt(Nϕ)		
Kn	=	Reduction Constant	=	0.6
Nϕ	=	Tan^2(45+ϕ/2)	=	3.00
Hc	=	Height between center line of the pipe to GL	=	198.5 cm

Weight of steel shell (W_1) = 4.78 kg/cm

Weight of Outer lining (W_2) = 3.297 kg/cm

Weight of Innert coating, W_3 = 2.032 kg/cm

Total weight of pipe (Wp) = W1 + W2 + W3
= 10.105 kg/cm

Outer diameter (Bc) = 1970 mm

Weight of prims of soil over the pipe(We) = $\gamma s \times H \times Bc$ = 1.0 m

Where,

H = Minimum depth of cover

We = 36.150 kg/cm

Weight of contained water, W_w = 27.948 kg/cm

$2w_e+w_p+w_w$ = 110.352 kg/cm

Area of pipe (A) = 27936.58 sq.cm

Maximum pressure (P) = 12.40 kg/sq.cm

Frictinal force (Ff) = 45.7 kg/cm

Passive presure (Pp) = 1.09 kg/cm^2

Unit bearing resistence (Rs) = 129.2 kg/cm

θ in degrees	90	60	45	30	22.5	15
Tan(θ/2)	1.00	0.577	0.414	0.268	0.199	0.132
L in m	47.12	27.21	19.52	12.63	9.37	6.20
L say	48	28	20	13	10	7

5.4.8 TYPICAL DESIGN OF HORIZONTAL THRUST BLOCK.

Inside Diameter of the Pipe (D)		=	188.6 cm
Outline Coating		=	2.0 cm
Steel Plate Thickness		=	1.0 cm
Internal Coating		=	1.2 cm
Outer diameter of the pipe (Bc)		=	197 cm
Field Test Pressure		=	Internal Pressure x 1.5
Internal Pressure		=	Maximum FSL in BPT - Lowest Invert Level of the Pipe Line
		=	365.0 - 282.35
		=	82.65 m
		=	8.27 kg/cm^2
Field Test Pressure (P)		=	12.41 kg/cm^2
Angle of Bend (θ)		=	60 Degree
Horizantal Bearing Capacity of Soil		=	15.29 T/m^2
Cross Section Area of Pipe	A	=	27936.65 cm^2
Trench Depth	H	=	312 cm
Resultant Thrust	T	=	$\frac{2 \times P \times A \times \sin\frac{\theta}{2}}{1000}$
		=	346.8 Tone

Thrust Block Dimentions

Contact area of thrust block		=	$\frac{Applied Thrust}{Horz.\ Bearing Capacity of soil}$
		=	22.68 m^2
Height of block	B	=	Trench depth - 20

= 292 cm

Say = 2.92 m

Length of block $L = \frac{ContactAreaofThrustBlock}{HeightofBlock}$

= 776.71 cm

Say = 7.77 m

Width of block d = 0.5 m

Volume of concrete V = 7348213 cm^2

= 7.348 m^2

	7.77	2.9	0.5
Angle of Bend	**Length**	**Width**	**Depth**
10	1.71	2.3	0.5
15	2.55	2.3	0.5
22.5	3.81	2.3	0.5
30	4.5	2.6	0.5
45	6.63	2.6	0.5
60	7.8	2.9	0.5
90	11	2.9	0.5

Details of Thrust Block for Horizontal bends			
Angle of Bend	Thrust Block Dimentions		
	Length(m)	Width (m)	Height(m)
15	2.55	0.5	2.3
22.5	3.81	0.5	2.3
30	4.5	0.5	2.6
45	6.63	0.5	2.6
60	7.8	0.5	2.9
90	11	0.5	2.9

5.4.9 TYPICAL DESIGN OF THRUST BLOCKS FOR VERTICAL DOWNWARD BENDS

Inside Diameter of the Pipe (D)	=	188.6 cm
Outline Coating	=	2.0 cm
Steel Plate Thickness	=	1.0 cm
Internal Coating	=	1.2 cm
Outer diameter of the pipe (Bc)	=	197 cm
Field Test Pressure	=	Internal Pressure x 1.:
Internal Pressure	=	Maximum FSL in BPT - Lowest Invert Level of the Pipe Line
	=	365.0 - 282.35
	=	82.65 m
	=	8.27 kg/cm^2
Field test pesure (P)	=	12.41 kg/cm^2
Unit weight of the concrete (W_m)	=	24 kN/m^3
	=	0.002446 kg/cm^3
Factor of safety (Sf)	=	1
Angle of Bend (θ)	=	60 degree
Horizontal bearing capacity of the soil (qh)	=	3000 lb/ft^2
	=	143.692 kN/m^2
Cross section area of pipe (A)	=	27936.58 cm^2
Upward thrust (T_v)	=	P x A x Sin0
Volume of the block required (Vg)	=	$\frac{S_f \times P \times A \times Sin\theta}{W_m}$
	=	122.7251 m^3

Horizontal thrust (T_h) = $P \times A \times (1 - \cos\theta)$

= 173346.5 kg

Required vertical surface area = $\frac{T_h \times S_f}{q_h}$

= 11.83 m^2

Size of Thrust Block

Width of the Block, B = 4.50 m

Height of the Block, H = Trench Depth-20

2.92 m

Vertical Surface Area of the Block = 13.14 > 11.8 m^2

Hence safe

Length of the Block,] = $\frac{Volume of Concrete Block}{vertical Surface Area}$

= 9.340 m

Say = 9.400 m

	9.400	4.50	2.92
Angle of Bend	Length	Width	Depth
10	3	3	2.92
15	4.5	3	2.92
22.5	6.5	3	2.92
30	8.1	3	2.92
45	8.6	4	2.92
60	9.4	4.5	2.92
90	6	8	3.00

Details of Vertical Downward Bends			
Angle of Bend	**Length (m)**	**Width (m)**	**Depth (m)**
15	4.5	3	2.92
22.5	6.5	3	2.92
30	8.1	3	2.92
45	8.6	4	2.92
60	9.4	4.5	2.92
90	6	8	3.00

5.4.10 TYPICAL DESIGN OF THRUST BLOCK FOR VERTICAL UP WARD BENDS

Inside Diameter of the Pipe (D)	=	188.6 cm	
Outline Coating	=	2.0 cm	
Steel Plate Thickness	=	1.0 cm	
Internal Coating	=	1.2 cm	
Outer diameter of the pipe (Bc)	=	197 cm	
Field Test Pressure	=	Internal Pressure x 1.5	
Internal Pressure	=	Maximum FSL in BPT - Lowest Invert Level of the Pipe Line	
	=	365.0 - 282.35	
	=	82.65 m	
	=	8.27 kg/cm^2	
Field Test Pressure (P)	=	12.40 kg/cm^2	
Unit weight of the concrete (W_m)	=	24 kN/m^3	
	=	2.45 t/m^3	
Angle of Bend (θ)	=	60 degree	
Angle of Repose (ϕ)	=	30 degree	
Outer diameter of the pipe (Bc)	=	197 cm	
Cross section area of pipe (A)	=	27936.6 cm^2	
Horizontal Thrust (Th)	=	P x A x (1-cos θ)	
	=	173.17 MT	
Vertical Thrust (Tv)	=	P x A x Sin θ	
	=	299.94 MT	
Height of Ground level above the centre of the Pipe (hc)	=	Cover + Bc/2	
	=	1.985 m	

Minimum Height of Thrust Block (H) = Trench depth-20

= 2.9 m

Size of Thrust Block:

L = 8.00 m

b = 2.57 m

H = 2.6 m

Passive resistance Coefficient (kp) = $\frac{1+\sin\phi}{1-\sin\phi}$

= 3

Unit weight of soil (γ) = 1.8 t/m3

Friction Coefficient (μ) = 0.3

Passive Resistance by soil (Fp) = kp x hc x γ x H x L

= 222.96 MT

Frictional Resistance between soil and concrete (Ff) = Weight of concrete x Friction coefficient

= 39.234 MT

Total Horozontal Resistance (Fh) = Fp + Ff

= 262.19 MT > 173.17 MT

Hence Safe

Bearing Capacity of the soil (qv) = 15 t/m^3

Total Vertical Resistance offered by the soil (Qv) = qv x Bottom area of thrust block

= 308.4 MT > 299.94 MT

Hence Safe

Therefore provide Thrust Block of size 8.0m X 2.57 m X 2.6 m

Details of Vertical Upward Bends			
Angle of Bend	Dimentions of Thrust Block (m)		
	Length	Width	depth
15	3.3	2.57	2.6
22.5	4	2.57	2.6
30	5	2.57	2.6
45	7	2.57	2.6
60	8	2.57	2.6
90	10	2.57	2.92

5.4.11 Dimentions for Pipe Elbows

For Two Piece Elbow : $0^0 < \Delta <= 22.5^0$

Deflection Angle = 10 Degree

D	=	OutSide Diameter of the Pipe	=	74.5 Inches
R	=	Radius of Elbow	=	2.5D
			=	186.25 Inches
Δ	=	Deflection Angle of Bend	=	10 Degree
θ	=	Segment Deflection Angle	=	Δ
			=	10 Degree

S.No	Deflection Angle(Δ)	Dimentions (Inches)	
1	10^0	S=4D Tanθ/2	26.11
2		L=0.5D Tanθ/2	3.26
3		T=2.5D TanΔ/2	16.32
4		E=2.5D Tanθ/2	16.32
5		Z_2=f	16.00
6		L1=L+Z_2	19.26

Deflection Angle = 15 Degree

D	=	OutSide Diameter of the Pipe	=	74.5 Inches
R	=	Radius of Elbow	=	2.5D
			=	186.25 Inches
Δ	=	Deflection Angle of Bend	=	15 Degree
θ	=	Segment Deflection Angle	=	Δ
			=	15 Degree

S.No	Deflection Angle(Δ)	Dimentions (Inches)	
1	15^0	S=4D Tanθ/2	39.28
2		L=0.5D Tanθ/2	4.91
3		T=2.5D TanΔ/2	24.55
4		E=2.5D Tanθ/2	24.55
5		Z_2=f	16.00
6		L1=L+Z_2	20.91

Deflection Angle = 22.5 Degree

D	=	OutSide Diameter of the Pipe	=	74.5 Inches
R	=	Radius of Elbow	=	2.5D
			=	186.25 Inches
Δ	=	Deflection Angle of Bend	=	22.5 Degree
θ	=	Segment Deflection Angle	=	Δ
			=	22.5 Degree

S.No	Deflection Angle(Δ)	Dimentions (Inches)	
1	22.5^0	S=4D Tanθ/2	59.35
2		L=0.5D Tanθ/2	7.42
3		T=2.5D TanΔ/2	37.10
4		E=2.5D Tanθ/2	37.10
5		Z_2=f	16.00
6		L1=L+Z_2	23.42

For Three Piece Elbow : $22.5^0 < \Delta <= 45^0$

Deflection Angle = 30 Degree

D	=	OutSide Diameter of the Pipe	=	74.5 Inches
R	=	Radius of Elbow	=	2.5D
			=	186.25 Inches
Δ	=	Deflection Angle of Bend	=	30 Degree
θ	=	Segment Deflection Angle	=	Δ/2
			=	15 Degree

S.No	Deflection Angle(Δ)	Dimentions (Inches)	
1	30^0	S=4D Tanθ/2	39.28
2		L=0.5D Tanθ/2	4.91
3		T=2.5D TanΔ/2	49.97
4		E=2.5D Tanθ/2	24.55
5		Z_2=f	16.00
6		L1=L+Z_2+T-E	46.33

Deflection Angle = 45 Degree

D	=	OutSide Diameter of the Pipe	=	74.5 Inches
R	=	Radius of Elbow	=	2.5D
			=	186.25 Inches
Δ	=	Deflection Angle of Bend	=	45 Degree
θ	=	Segment Deflection Angle	=	Δ/2
			=	22.5 Degree

S.No	Deflection Angle(Δ)	Dimentions (Inches)	
1	45^0	S=4D Tanθ/2	59.35
2		L=0.5D Tanθ/2	7.42
3		T=2.5D TanΔ/2	77.26
4		E=2.5D Tanθ/2	37.10
5		Z_2=f	16.00
6		L1=L+Z_2+T-E	63.58

For Four Piece Elbow : $45^0 < \Delta <= 67.5^0$

Deflection Angle = 60 Degree

D	=	OutSide Diameter of the Pipe	=	74.5 Inches
R	=	Radius of Elbow	=	2.5D
			=	186.25 Inches
Δ	=	Deflection Angle of Bend	=	60 Degree
θ	=	Segment Deflection Angle	=	Δ/3
			=	20 Degree

S.No	Deflection Angle(Δ)	Dimentions (Inches)	
1	60^0	S=4D Tanθ/2	52.61
2		L=0.5D Tanθ/2	6.58
3		T=2.5D TanΔ/2	107.70
4		E=2.5D Tanθ/2	32.88
5		Z_2=f	16.00
6		L1=L+Z_2+T-E	97.39

For Five Piece Elbow : $67.5^0 < \Delta <= 90^0$

Deflection Angle = 90 Degree

D	=	OutSide Diameter of the Pipe	=	74.5 Inches
R	=	Radius of Elbow	=	2.5D
			=	186.25 Inches
Δ	=	Deflection Angle of Bend	=	90 Degree
θ	=	Segment Deflection Angle	=	Δ/4
			=	22.5 Degree

S.No	Deflection Angle(Δ)	Dimentions (Inches)	
1	90^0	S=4D Tanθ/2	59.35
2		L=0.5D Tanθ/2	7.42
3		T=2.5D TanΔ/2	186.62
4		E=2.5D Tanθ/2	37.10
5		Z_2=f	16.00
6		L1=L+Z_2+T-E	172.95

5.4.12 Design of Pipe for Nalla Crossing

When the pipe passes through the canal or Nalla, the pipe is under floatation, because buoyant force is more than pipe weight, is as shown in figure - i. To prevent floatation, concrete encasement is required for getting negative buoyant force. The forces acting on pipe after concrete encasement in shown in figure - ii. The thickeness of concrete required depends on negative buoyance required on pipe.

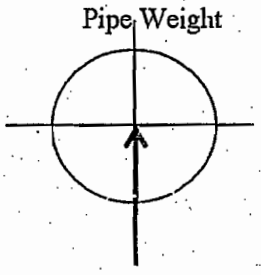


Fig.(i) Pipe is in floatation

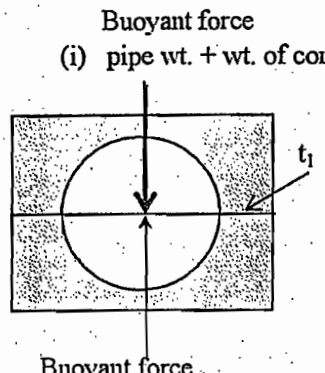


Fig.(ii) Pipe is in steady condition

Outer Diameter of the pipe	=	1970 mm
	=	77.6 inches
Wall Thickeness	=	10 mm
	=	0.4 inches
Buoyancy of the pipe (without encasement)	=	$D/3\,(D - 32t) + 11\,t^2$
B	=	1681.133 lb/ft^2

Buoyancy of pipe is possitive. Therefore the pipe is in floating condition.

Therefore concrete coating will be required to give negative buoyancy.

Assume the negative buoyancy on pipe = 1681 lb/ft^2

Therefore, concrete thickness required (t_1) can be calculated by,-

$$B = \frac{D}{3}(D-32\,t_1)+t_1 D\left(\frac{63-wc}{48}\right)$$

t_1 = Thickness of Concrete coating in inches

Wc = Unit Weight of concrete = 146 lb/ft^3

$\therefore t_1$ = 25.1 inches

= 0.6 m

5.4.13

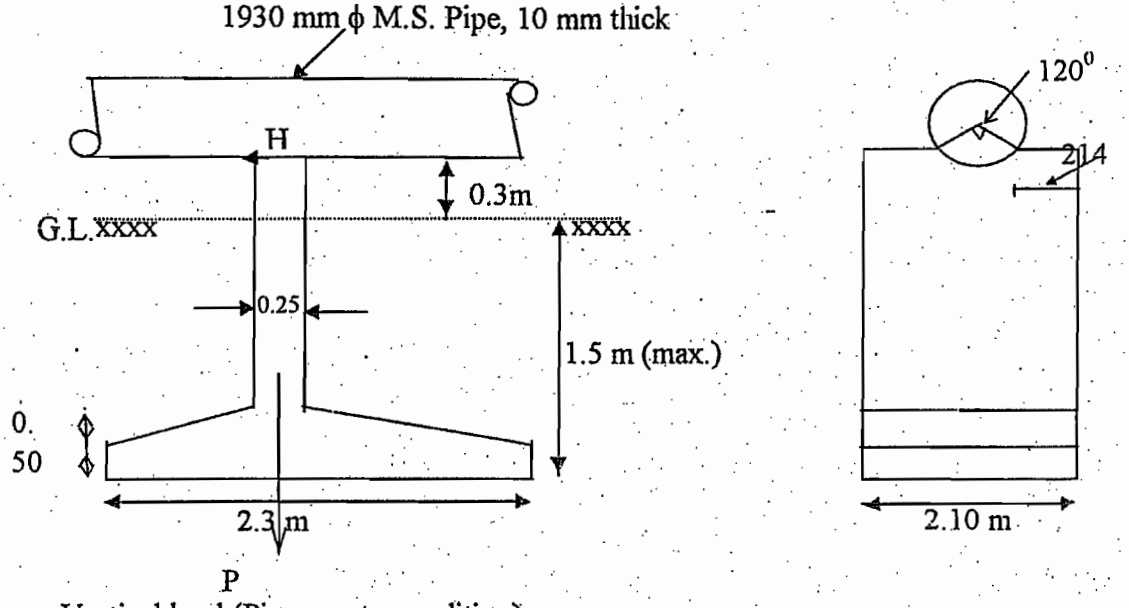
Location OF Valves			
Locations of Air Valves			
S.No.	Chainage (m)	S.No.	Chainage (m)
1	750	29	13980
2	1250	30	14480
3	1680	31	15000
4	2180	32	15480
5	2460	33	15840
6	2960	34	16320
7	3420	35	16740
8	3950	36	16920
9	4450	37	17190
10	4950	38	17790
11	5610	39	18060
12	5970	40	18740
13	6330	41	19200
14	6830	42	19980
15	7290	43	20700
16	7790	44	21120
17	8190	45	21750
18	8400	46	22050
19	8760	47	22530
20	9400	48	22980
21	9480	49	23100
22	10170	50	23725
23	10860	51	23850
24	11460	52	24330
25	11670	53	24660
26	12170	54	24990
27	12670	55	25710
28	13500	56	26400

Locations Of Scour Valves	
S.No.	Chainage(m)
1	3610
2	6417
3	7245
4	8772
5	11490
6	12978
7	13542
8	14244
9	16170
10	17250
11	18500
12	20580
13	22856
14	24090
15	27237

Locations Of Butterfly Valves	
S.No.	Chainage (m)
1	8400
2	11957
3	16946
4	22540
5	25785

4.14 Design of R.C.C. Pedestal for 1930 mm (O.D.) 10 mm thick Raw Water Transmission Main

Following sizes are assumed for pedestal and footing. Length of footing required will be more due to large B.M.



Vertical load (Pipe empty condition)

weight of pipe = $\frac{\pi}{4}\times(1.930^2-1.91^2)\times7.85\times6=2.84$

weight of pedestal = $0.25\times2.10\times1.8\times2.5+2\times(\frac{0.25+0.75}{2})\times1.025\times2.10\times2.5=7.744 Ton$

Total vertical load = 10.585 Ton

Horizontal forces due to temp. changes acting at top of pedestal:-

H = 0.6 x 2.841 = 1.7046 T

Taking moments @ Pt. A,

ε M @ A = $10.585\times\frac{2.3}{2}-1.7046\times1.8$

= 9.1044 T.M.

e = $\frac{2.3}{2}-\frac{9.1044}{10.585}=0.29<\frac{b}{6}(\frac{2.3}{6}=0.3833)$

No tension at the base

Hence O.K.

Factor of Safty against overturning = $\frac{10.585\times\frac{2.3}{2}}{1.7046\times1.8}$

= 3.967 > 2.5

Hence O.K.

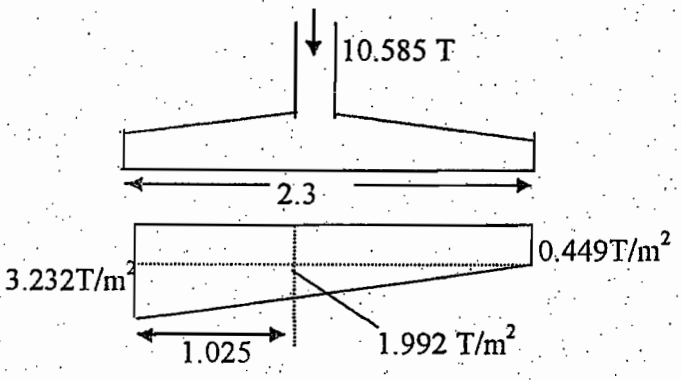
Factor of safty against sliding $= \frac{\mu \sum V}{H}$

$= \frac{0.6 \times 10.585}{1.7046}$

$= 3.726 > 2$

Hence O.K.

For checking depth of footing



$$\text{Stress} = \frac{P}{bd} \pm \frac{6M}{bd^2}$$

$= \frac{10.585}{2.3 \times 2.5} \pm \frac{6 \times 3.068}{2.5 \times 2.3^2}$

$= 1.841 \pm 1.392$

$= 3.232$ or
0.449

BM @ critical section

$= (\frac{1.992+3.232}{2}) \times 1.025 \times 2.1 \times (\frac{2 \times 3.232 + 1.992}{3.232+1.992}) \times \frac{1.025}{3}$

$= 3.109$ T.M.

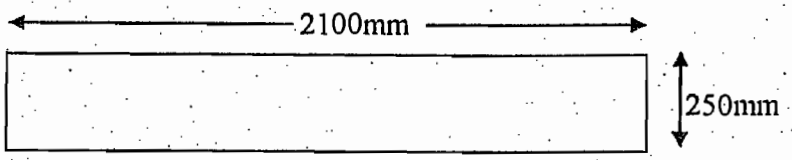
$d_{reqd} = \sqrt{\frac{3.109 \times 10^5}{0.92 \times 210}}$

$= 40.11$ cm

$d_{prov} = 75 - 5 = 70\text{cm} > 40.11\text{cm}$

Hence OK

Section of pedestal is subjected to combined axial force & B.M.
Assumed section for pedestal (i.e. 2100 x 250 mm) is checked for combined AF & BM
Check for section of pedestal



Nominal Steel = 0.8 % of column area

$$= 0.8 \times \frac{2100}{100} \times 250 = 4200 mm^2$$

Provide 11 nos. on each side 16mm ϕ

Using M20, Fe 415

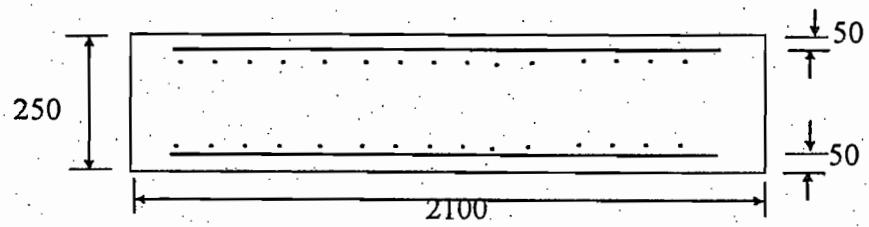
Vertical steel $= \frac{\pi}{4}(1.930^2 - 1.910^2) \times 7.85 \times 6 + 0.25 \times 2.1 \times 1.025 \times 2.5$

$= 4.186$ T

Horizontal force at top = M x 2.841 = 0.6 x 2.841 = 1.7046 T

BM = 1.7046 x 1.025 = 1.747 Tm

Asc = 11 nos. 16 ϕ = 2200 mm^2



Compressive stress in extreme fibre of conc.be σ_{cbc}& ncutral axis depth from top be 'n'

Compression in concrete:

$$Cc = \frac{\sigma_{cbc}}{2} \times n \times 165$$

Compression in steel:

$$Cs = \frac{n-5}{n} \times \sigma_{Cbc} \times (m-1)Asc$$

$$= \frac{n-5}{n} \times \sigma_{Cbc} \times 13 \times 18$$

Tension in steel $Tst = \frac{20-n}{n} \times \sigma_{Cbc} \times 14 \times 18$

Vartical load $P = Cc+Cst-Tst$

$$\therefore P = \sigma_{Cbc}[\frac{165n}{2}+18\{(\frac{n-5}{n})\times 13-\frac{(20-n)}{n}\times 14\}]$$

$$= \sigma_{Cbc}[82.5n+\frac{18}{n}(13n-65-280+14n)]$$

$$= \sigma_{Cbc}[82.5n+\frac{18}{n}(27n-345)] \quad -1$$

External moment

$M = \varepsilon$ moments @ C.g.

$$M = \sigma_{Cbc}[\frac{165n}{2}\times(12.5-\frac{n}{3})+18(\frac{(n-5)}{n}\times 13\times 7.5+\frac{20-n}{n}\times 14\times 7.5)]$$

$$= \sigma_{Cbc}[82.5n(12.5-\frac{n}{3})+\frac{18\times 7.5}{n}(13n-65+280-14n)]$$

$$= \sigma_{Cbc}[82.5n(12.5-\frac{n}{3})+\frac{135}{n}(215-n)] \quad -2$$

$$\frac{M}{P} = \frac{1.747\times 10^5}{4.186\times 10^3}$$

$$41.734 \text{ cm} = \frac{82.5n(12.5-\frac{n}{3})+\frac{135}{n}(215-n)}{82.5n+\frac{18}{n}(27n-345)}$$

$$3443n + 20282.72-\frac{259168}{n} = 1031.25n-27.5n^2+\frac{29025}{n}-135$$

$$3443n^2+20282.72n-259168 = 1031.25n^2-27.5n^3+25025-135n$$

$$27.5n^3+2412n^2+20418n-288193 = 0$$

By trial & error method

$$n = 7.2985$$

$$\sigma_{CbC} = \frac{4.186 \times 10^3}{82.5 \times 7.3 + \frac{18}{7.3}(27 \times 7.3 - 345)}$$

$$= 17.62 \text{ kg / cm}^2 \quad < 71.4 \text{ kg / cm}^2$$

(as per IS 456:2000 Table 21)

Hence O.K.

Since stresses are well within limits, section of pedestal provided is sufficient.

6.0 Cost Estimate

The project comprises various components of water supply. While determining the unit rates the available schedule of rates of Maharashtra Jeevan Pradhikaran (MJP) and Public Works Department have been consulted.

In case of general civil engineering works, most items have been costed with respect to MJP's DSR, however certain items of works have been estimated as per present market rates (for e.g. pipe cost) and suitable rate analysis.

Prices of item relating to mechanical and electrical works have been obtained through enquiries made with suppliers. Factors relating to taxes, duties, packing, forwarding, transportation and insurance have been added as considered appropriate.

Some permission from MSEB are taken as granted to work out the cost of electrical installations, if those are not sought, the electrical installation cost may vary.

ABSTRACT OF COST ESTIMATES

S.No.	DESCRIPTION	AMOUNT (Rs.)
1	**HEADWORKS**	
	CIVIL WORKS	353728312
	MECHANICAL WORKS	66304641
	ELECTRICAL WORKS	29776938
2	**RAW WATER RISING MAIN** FROM PUMP HOUSE TO BPT	4964435
3	**BREAK PRESSURE TANK**	12331996
4	**RAW WATER GRAVITY MAIN**	1045014627
5	**MISCELLANEOUS WORKS**	114000000
	TOTAL	**1626120949**

Rupees, One Hundred Sixty Two Crore, Sixty One Lakh, Twenty Thousand, Nine Hundred Forty Nine Only.

6.1 HEAD WORKS

6.1.1 CIVIL WORKS

6.1.1.1 INTAKE TOWER

Sr. No	Description	Quantity	Unit	Rate	Amount
1	Excavation for foundation in earth, soils of all types, sand, gravel and soft murum, hard murum, rock excavation with chiseling or by control blasting including removing the excavated materials upto a distance of 50 meters and all lifts ,stacking and spreading as directed, normal dewatering, preparing the bed for foundation and excluding backfilling.	800	CuM	250	200000
2	Dewatering the excavated area by using pumps and other devices including disposing off water to safe distance & Providing, constructing coffer dam in river basin/dam storages as per type design including excavation, filling, the middle portion with B.C soil (in gunny bags if required). Providing pervious/ semipervious materials on both side of B.C soil (in gunny bags if required) including ramming, compacting to the satisfaction of Engineer-in-charge, till the completion of work including dismantling coffer dam after completion of works and disposing off the materials as directed by the Engineer-in-charge.			L.S	4500000
3	Providing and laying in situ cement concrete in proportion 1:2:4 of trap metal for foundation and bedding , including bailing out water manually, formwork, compacting and curing.	120	Cu.M	2500	300000

Sr. No	Description	Quantity	Unit	Rate	Amount
4	Providing and laying in situ cement concrete of trap/ granite/ quartzite/ gneiss metal for RCC piles, caps, footings, slabs, beams, columns, canopies, staircases, newels, chajjas, lintels, pardies, coping fins, arches, etc. including normal dewatering, form work, compaction, finishing and curing, etc, complete				
	In RCC M-300	1800	Cu.M	7500	13500000
5	Providing and fixing in position steel bar reinforcement for various diameters for RCC piles, caps, footings, slabs, beams, columns, canopies, staircases, newels, chajjas, lintels, pardies, coping fins, arches, etc. as per detailed designs, drawing and schedules; including cutting, bending, hooking the bars, binding with wires or tack welding and supporting as required, etc. complete.	360	T	50000	18000000
6	Providing structural steel work in single stanctions composed of RSJ, channel, etc, with caps, bases, mild steel plates, angles, brackets, cleats, gussets plates, anchor bolts, etc. as per detailed design and drawing or as directed by Engineer-in-charge including cutting, fabrication, hoisting, erecting, fixing in position, making riveted/bolted/welded connections and one coats of anticorrosive paint etc. complete.	70	T	50000	3500000

Sr. No	Description	Quantity	Unit	Rate	Amount
7	Chain Pulley Block - Providing erecting triple spur gear type Chain Pulley Block suitable for capacity of 8 T with lift complete with load chain and hand chain suitable for above lift, tested to 50% over load as per IS 3832 carrying ISI mark.			LS	300000
8	Providing & installing coarse screen as per specification, including fixing guide channels for maintenance, etc., complete.	10	Nos	30000	300000
9	Providing and fixing Thimble mounted Sluice Gate as per IS:13349 1992 being suitable for seating as well as unseating water head pressure as stated below, to be supplied with Cast Iron IS-210 grade FG:200 frame & shutter, Phosphor Bronze seat facing fitted in rectangular machined groove of frame and shutter C.I stem guide bracket, etc., complete.				
	CL-PL 5.00 M	4	Nos	700000	2800000
	CL-PL 15.00 M	4	Nos	933000	3732000
	CL-PL 22.00 M	4	Nos	1066100	4264400
10	Providing, fabricating, installing hand pushed trolley on rails as per specification, design and drawing,etc., complete.			LS	500000
					51896400
Cost Contingencies (@ 10%)					**5189640**
Physical Contingencies (@ 5%)					**2594820**
TOTAL					**5,96,80,860**

6.1.1.2	INTAKE CONDUIT AND ACCESS BRIDGE				
Sr. No	**Description**	**Quantity**	**Unit**	**Rate**	**Amount**
1	Providing and supplying IS:784:2003 R.C.C pipes in standard lengths of following class and diameter suitable for either collar joints or rubber ring joints, including all taxes (central and local), inspection charges, transport to department stores / site, unloading and stacking etc. complete RCC 2600 mm (ID) Class NP-IV	1000	RMT	26000	26000000
2	Lowering, laying and jointing in proper grade and alignment R.C.C pipes with collar joints in C.M.1:1 proportion or socketed R.C.C pipes with rubber joints (excluding cost of rubber ring or R.C.C collar,) including cost of conveyance from stores to site of work, cost of jointing materials, labour, giving hydraulic testing stc. complete as directed by Engineer-in-charge. RCC 2600 mm (ID) Class NP-IV	1000	RMT	1200	1200000
3	Excavation for foundation / pipe trenches in earth, soils of all types, sand, gravel and soft murum, including removing the excavated materials upto a distance of 50 meters and lifts as below, stacking and spreading as directed, normal dewatering, preparing the bed for foundation and excluding backfilling.				
	For Access Bridge Footing				
	Lift 0 to 1.5m	432	Cu.M	34	14688
	Lift 1.5 to 2.5m	288	Cu.M	37	10656
	For pipe conduit				
	Lift 0 to 1.5m	6010	Cu.M	34	204340
	Lift 1.5 to 2.5m	3880	Cu.M	37	143560
	MJP CSR 2004-2005				
	(Page No.39 , Sr. No. 1 & 4)				
4	Excavation for foundation / pipe trenches in hard rock by controlled blasting, including trimming and leveling the bed by chiseling where necessary and removing the excavated material and stacking it in measurable heaps within a distance of 50 meters from the area and lifts as below, normal dewatering, excluding backfilling, etc. complete.				
	For pipe conduit				
	Lift 2.5 to 3.0m	1815	Cu.M	225	408375
	Lift 3.0 to 4.5m	5445	Cu.M	230	1252350

Sr. No	Description	Quantity	Unit	Rate	Amount
	Lift 4.5 to 6.0m	5445	Cu.M	235	1279575
	Lift 6.0 to 7.5m	5445	Cu.M	240	1306800
	Lift 7.5 to 9.0m	5445	Cu.M	245	1334025
	Lift 9.0 to 10.5 m	5445	Cu.M	250	1361250
	Lift 10.5 to 12.0m	5445	Cu.M	255	1388475
	Lift 12.0 to 13.13m	4105	Cu.M	260	1067300
	MJP CSR 2004-2005				
	(Page No.40 & 41 , Sr. No. 7 & 11)				
5	Refilling the trench with available excavated stuff with soft material first over pipeline and then hard material in 15 cm layers with all leads and lifts including consolidation, surcharging, etc. complete.	40000	Cu.M	16	640000
	MJP CSR 2004-2005				
	(Page No.43 , Sr. No. 17)				
6	Providing and laying in situ cement concrete in proportion 1:3:6 of trap metal for foundation and bedding , including bailing out water manually, formwork, compacting and curing.	30	Cu.M	1450	43500
	PWD DSR 2003 - 2004				
	(Page No.15 , Sr. No. 19 C)				
7	Providing and laying in situ cement concrete of trap/granite/quartzite/gneiss metal for R.C.C work in foundation like raft, grillage, strip foundation and footing of RCC columns and steel stanctions including normal dewatering , form work, compaction, finishing and curing, etc, complete				
	In RCC M-250 (Footing)	290	Cu.M	2352	682080
	MJP CSR 2004-2005				
	(Page No.47 , Sr. No. 1)				
8	Providing and laying in situ cement concrete of trap/granite/quartzite/gneiss metal for R.C.C work in foundation like craddle foundation and footing of RCC columns and steel stanctions including normal dewatering, form work, compaction, finishing and curing, etc, complete				
	In RCC M-250 (cradle foundation)	1277	Cu.M	2352	3003504
	MJP CSR 2004-2005				
	(Page No.47 , Sr. No. 1)				

Sr. No	Description	Quantity	Unit	Rate	Amount
9	Providing and casting in situ cement concrete of trap/granite/quartzite/gneiss metal of approved quality for R.C.C work as per detailed drawings and designs or as directed by Engineer-in-charge including normal dewatering , form work, compaction, finishing of form surface with CM 1:3 of sufficient minimum thickness if special finish is to be provided and curing, etc, complete.				
	In RCC M-200 (Columns)	62.5	CuM	2250	140625
	MJP CSR 2004-2005				
	(Page No.47 , Sr. No. 2)				
10	Providing and casting in situ cement concrete of trap/granite/quartzite/gneiss metal of approved quality for R.C.C work as per detailed drawings and designs or as directed by Engineer-in-charge including normal dewatering , form work, Compaction, finishing of form surface with CM 1:3 of sufficient minimum thickness to give a smooth and even surface wherever necessary or roughness if special finish is to be provided and curing, etc, complete.				
	In RCC M-250 (Tie beams/beam)	300	CuM	2497	749100
	MJP CSR 2004-2005				
	(Page No.48 , Sr. No. 3)				
11	Providing and casting in situ cement concrete of trap/granite/quartzite/gneiss metal of approved quality for R.C.C work as per detailed drawings and designs or as directed by Engineer-in-charge including normal dewatering , form work, compaction, finishing of form surface with CM 1:3 of sufficient minimum thickness to give a smooth and even surface wherever necessary or roughness if special finish is to be provided and curing, etc, complete.				
	In RCC M-250 (Slab)	300	CuM	2600	780000
	MJP CSR 2004-2005				
	(Page No.48 , Sr. No. 4)				

Sr. No	Description	Quantity	Unit	Rate	Amount
12	Providing and fixing in position steel bar reinforcement for various diameters for RCC piles, caps, footings, slabs ,beams, columns, canopies, staircases, newels, chajjas, lintels, pardies, coping fins, arches, etc. as per detailed designs, drawing and schedules; including cutting, bending, hooking the bars, binding with wires or tack welding and supporting as required, etc. complete.				
	Mild steel	5	M.T	26292	131460
	TOR steel	207	M.T	26292	5442444
	MJP CSR 2004-2005				
	(Page No.50 , Sr. No. 7)				
13	Providing, constructing coffer dam in river basin/dam storages as per type design including excavation, filling, the middle portion with B.C soil (in gunny bags if required). Providing pervious/semi pervious materials on both side of B.C soil (in gunny bags if required) including ramming, compacting to the satisfaction of Engineer-in-charge, till the completion of work including dismantling coffer dam after completion of works and disposing off the materials as directed by the Engineer-in-charge.	35280	CuM	200	7056000
	MJP CSR 2004-2005				
	(Page No.219 , Sr. No. 1)				
14	Providing and fixing G.I pipe railing having 1.0M height consisting 50 x 50 x 6 mm thick M.S. angles as verticals at 1.5 M c/c, and additional posts at every corner with 3 rows of 25 mm dia G.I pipes of medium class variety as horizontal and painting 3 coats of oil paints over 1 coats of anticorrosive paints of approved colour and shade including cost of all labour, transporting bends to curved shape, etc, complete.	1000	RM	430	430000
	MJP CSR 2004-2005				
	(Page No.57 , Sr. No. 1)				
					56070107
	Cost Contingencies (@ 10%)				**5607011**
	Physical Contingencies (@ 5%)				**2803505**
	TOTAL				**6,44,80,623**

6.1.1.3 PUMPING STATION

Sr. No	Description	Quantity	Unit	Rate	Amount
1	Excavation for foundation / pipe trenches in earth, soils of all types, sand, gravel and soft murum, including removing the excavated materials upto a distance of 50 meters and lifts as below,stacking and spreading as directed, normal dewatering, preparing the bed for fooundation and excluding backfilling.	43534	CuM	250	10883500
2	Dewatering the excavated area by using pumps and other devices including disposing off water to safe distance & Providing, constructing coffer dam in river basin/dam storages as per type design including excavation, filling, the middle portion with B.C soil (in gunny bags if required).Providing pervious/ semipervious materials on both side of B.C soil (in gunny bags if required) including ramming, compacting to the satisfaction of Engineer-in-charge, till the completion of work including dismantling coffer dam after completion of works and disposing off the materials as directed by the Engineer-in-charge.			L.S	6000000
3	Providing and laying in situ cement concrete in M 10 of trap metal for foundation and bedding , including bailing out water manually, formwork, compacting and curing.	280	Cu.M	2500	700000
4	Providing and laying in situ cement concrete of trap/ granite/ quartzitc/ gneiss metal for R.C.C work in foundation like raft, grillage, strip foundation and footing of RCC columns and steel stanctions including normal dewatering , form work,compaction, finishing and curing, etc, complete				
	In RCC M-300	8200	Cu.M	7500	61500000

Sr. No	Description	Quantity	Unit	Rate	Amount
5	Providing and fixing in position steel bar reinforcement for various diameters for RCC piles, caps,footings,slabs,beams,columns, canopies, staircases, newels, chajjas, lintels,pardies, coping fins, arches,etc. as per detailed designs, drawing and schedules; including cutting, bending, hooking the bars, binding with wires or tack welding and supporting as required, etc. complete.	2284	T	50000	114200000
6	Providing Second class Burnt Brick masonary with conventional/ I.S. type bricks in cement mortar 1:4 including scaffolding, raking out joints and curing.	400	CuM	2500	1000000
7	Providing cement plaster 25 mm thick in two coats, in cement mortar 1:4 without neeru finishing to concrete/normal bricks in all positions including racking out joints, scaffolding and curing.	3280	CuM	150	492000
8	Providing and fixing door/windows of wood/pre-cast RCC/aluminium with all necessary sections, fixtures and fasteners ,etc. complete.	200	CuM	2000	400000
9	Providing structural steel work in single stanctions composed of RSJ, channel,etc, with caps, bases, mild steel plates, angles,brackets, cleats, gussets plates, anchor bolts, etc. as per detailed design and drawing or as directed by Engincer-in-charge including cutting, fabrication, hoisting, erecting,fixing in position, making riveted/bolted/welded connections and one coats of anticorrosive paint etc. complete.	16	T	50000	800000
					195975500
	Cost Contingencies (@ 10 %)				19597550
	Physical Contingencies (@ 5 %)				9798775
	TOTAL				22,53,71,825

6.1.1.4 ELECTRICAL SUB STATION

Sr. No	Description	Quantity	Unit	Rate	Amount
1	Providing and casting in situ cement concrete of trap/granite/quartzite/gneiss metal of approved quality for R.C.C work as per detailed drawings and designs or as directed by Engineer-in-charge including normal dewatering , form work, compaction, finishing of form surface with CM 1:3 of sufficient minimum thickness to give a smooth and even surface wherever necessary or roughness if special finish is to be provided and curing, etc, complete.				
	In RCC M-250 (Retaining wall)	340	CuM	2600	884000
	MJP CSR 2004-2005				
	(Page No.48 , Sr. No. 4)				
2	Providing and fixing in position steel bar reinforcement for various diameters for RCC piles, caps, footings, slabs beams, columns, canopies, staircases, newels, chajjas, lintels, pardies, coping fins, arches, etc. as per detailed designs, drawing and schedules; including cutting, bending, hooking the bars, binding with wires or tack welding and supporting as required, etc. complete.				
	Mild steel	5	M.T	26292	131460
	TOR steel	60	M.T	26292	1577520
	MJP CSR 2004-2005				
	(Page No.50 , Sr. No. 7)				
3	Providing earth work in embankment with approved materials obtained from Departmental land or sources, upto lead of 50 m including all lifts, laying in layers of 20 to 30cm. Thickness, breaking clods, dressing to the required lines, curves, grade & section, normal watering and compactioon with power roller etc. complete.	3080	Cu M	76.5	235620
	PWD DSR 2004-2005				
	(Page No.147 , Sr. No. 488 A (ii)				

Sr. No	Description	Quantity	Unit	Rate	Amount
4	Providing and laying in situ cement concrete of trap/granite/quartzite/gneiss metal for R.C.C work in foundation like raft, grillage, strip foundation and footing of RCC columns and steel stanctions including normal dewatering , form work, compaction, finishing and curing, etc, complete				
	In RCC M-250 (Footing)	7	Cu.M	2352	16464
	MJP CSR 2004-2005				
	(Page No.47 , Sr. No. 1)				
5	Construction of Electrical switch room with a provision of sufficient space to be kept reserved for installation of control panels etc. including provision for 2 nd stage pumping, complete as per specifications, drawings, design and instruction of Engineer in-charge.	21.6	Sq M	6500	140400
6	Providing, constructing RCC Cable ducts. Of Internal Size 1 mx1 m to carry all the cables i.e. from Switch Room.& Transformers etc.	50	Rmt	3000	150000
7	Providing and constructing W.B.M. road in layers of 75/100 mm compacted thickness, preparation of subgrade with murum screenings necessary testing including supplying and conveying all materials with all leads and lifts, spreading, sectioning, artificial watering and compacting in layer with vibratory roller as directed by Engineer incharge including maintenance of diversion road during construction etc. complete. (2 to 7 metre width) 4x0.38x50	76	Cu M	450	34200
	P.W.D D.S.R 2003-2004				
	Page No.156, Item No.518 C (ii)				

Sr. No	Description	Quantity	Unit	Rate	Amount
8	Providing 50 mm thick full grout bituminous road surface including supplying all materials, preparing the existing roads surface, laying the required thickness of metal layer, heating and spraying bitumen, spreading chips, laying with seal coat @ 125 Kg/100 square meter and compacting etc. complete with Bulk asphalt 60/70 grade.	225	Sq M	130.3	29318
	PWD DSR 2003-2004				
	(Page No.158 , Sr. No. 524)				
9	Providing and casting in situ cement concrete of trap/granite/quartzite/gneiss metal of approved quality for R.C.C work as per detailed drawings and designs or as directed by Engineer-in-charge including normal dewatering , form work, compaction, finishing of form surface with CM 1:3 of sufficient minimum thickness to give a smooth and even surface wherever necessary or roughness if special finish is to be provided and curing, etc, complete.				
	In RCC M-200 (. curtain walls / partition walls)	14	CuM	2400	33600
	MJP CSR 2004-2005				
	(Page No.48 , Sr. No. 4)				
10	Providing and erecting 1.0 m high wire fencing with seven rows of barbed wire supported on mild steel angles (50 x 50 x 6 mm) at 2.5 m c/c, fixing posts in retaining wall, fastening the wire and painting the mild steel angles with one coat of red lead primer and two coats of paints etc. complete.	100	RM	238	23800
	PWD DSR 2003-2004				
	(Page No.109 , Sr. No. 350)				

Sr. No	Description	Quantity	Unit	Rate	Amount
11	Providing and fixing mild steel grill gate with angle iron frame 65 x 65 x 10 mm with iron bars at 150 mm c/c and diagonal flats as per the detailed drawing, including hinges, pivot blocks, locking arrangement, welding, reveting with three coats of approved colour shade. (Weight of gate 35 Kg/ Sq M).	64	Sq M	1400	89600
	PWD DSR 2003-2004				
	(Page No.109 , Sr. No. 351)				
12	Providing and laying in situ cement concrete in proportion 1:3:6 of trap metal for foundation and bedding , including bailing out water manually, formwork, compacting and curing.	200	Cu.M	1450	290000
	PWD DSR 2003-2004				
	(Page No.15 , Sr. No. 19 C)				
13	Providing uncoursed rubble masonry of trap stones in cement mortar 1:6 in foundation and plinth of inner wall, including bailing out water manually, striking joints on unexposed faces and watering complete.	2.1	Cu.M	880	1848
	PWD DSR 2003-2004				
	(Page No.24 , Sr. No. 44)				
14	Supplying trap/quartzite/gnesis stone metal at the road side for metal including conveying & spreading.	40	Cu.M	250	10000
					3647830
	Cost Contingencies (@10%)				**364783**
	Physical Contingencies (@ 5%)				**182391**
	TOTAL				**41,95,004**

6.1.2 Cost Estiamtes for Mechanical Works

Sl. No.	Item	Quantity	unit	Rate	Amount
1	**Penstock** Providing, installing, inspection and commissioning and giving test and trail of 2250 mm x 2500 mm Cast Iron Single faced Thimble mounted sluice gate as per detailed (Electrically operated)	3	Nos.	1589000	4767000
2	**S.S. Screen** Providing, installing and commissioning and giving test and trail of SS 304 Screen with 40 mm. spacing (2800 mm x 3200 mm x screen of 388304, electrically operated with ladders	8	Nos.	944620	7556960
3	**V. T. Pumps** Providing, erecting, commissioning and giving test and trial of V.T. Pumps, water lubricated type and capable of discharging raw water 941 LPS at total head of 42 mtrs. Operating at 1000 RPM synchronous speed including providing fixing ISMB, grating etc. as per detailed specifications	6	Nos.	3604140	21624840
4	**Reflux Valve** Providing, erecting, coomissioning and giving test and trail of reflux valves of sizes and rating as mentioned below and as per specifications.				
a)	700 mm dia PN 1.0 rating CIDF Non-Return valve with buepass arrangement (on delivery side of each pump)	6	Nos.	539718	3238308
b)	1200 mm dia PN 1.0 rating Non- Return valve as per detailed specifications	2	Nos.	1664000	3328000
5	**Sluice Valve** Providing, erecting, commissioning and giving test and trail of CIDF Sluice Valve PN-1 rating as per detailed specifications				
a)	Slucice Valve 600 mm dia with Actuator (for pump delviery) PN - 1.0 rating	6	Nos.	586336	3518016
b)	Sluice valve 200 mm dia for scouring arrangement (PN-1.0 rating)	2	Nos.	25000	50000
6	**Butterfly Valve** Providing, erecting, commissioning and giving test and trail of Butterfly Valve as per detailed specifications of size 700 mm dia PN1.0 rating (Additional control valve on pump dclivery).	6	Nos.	153695	922170

Sl. No.	Item	Quantity	unit	Rate	Amount
7	**Kinetic Air Valve** Providing, erecting, commissioning and giving test and trail of Kinetic Air Valve of 100 and 200 mm dia PN1.0 rating isolating sluice valve as per detailed specifications.				
a)	100 mm dia (for expelling air in column pipes of pumps)	6	Nos.	16855	101130
b)	200 mm dia (on delivery header)	3	Nos.	61262	183786
8	**M.S. Pipe Work and Fabricated platforms** Providing fabricating, erecting, jointing and testing MS flanged pipes and specials and fabricated platforms as per detailed specifications including painting with epoxy paint	52492	kg	50	2624600
9	**RCC/CC Work for Pipes,Valves, Thrust Blocks and Pads** Designing, providing RCC/CC supports, thrust blocks for manifold pipes, valves in M-200 concrete with necessary reinforcement including excavation in all types of strata, frame work, curing plastering etc. complete as per detailed specifications.				
	RCC and PCC work in M-200 with excavation etc.	Job	LS	2200000	2200000
10	**Dismantallig Joints** Designing, Providing, erecting, commissioning and testing MS fabricated dismatalling joints 700 mm dia with required hardware as per detailed specifications.	6		58400	350400
11	**Lifting Equipments**				
a)	**EOT CRANE** Providing, erecting, commissioning and testing single girder EOT crane of 15 tonnes capacity complete with all accosiated electrical equipment, rail/sq. bar, DSL system, wire rope etc. as per detailed specifications.	Job	LS	1928000	1928000
b)	**Lifting Equipments for Penstocks and screens** Providing, erecting, commissioning and testing electricaly operated lifting equipments with allied works monorail etc.				
i)	for 2250 mm x 2500 mm CI gates - 10 MT Capacity	2	Nos.	856700	1713400

Sl. No.	Item	Quantity	unit	Rate	Amount
ii)	for 2800 mm x 3200 mm SS screens 3 MT capacity	8	Nos.	312200	2497600
12	**Sump Pump** Providing, erecting, commissioning and testing of non clog sump pumps having discharge capacity of 1,10,000 LPH raw water with silt and mud at a total head of 30 mtrs. With piping and control panels.	2	Nos.	526000	1052000
	Total				**57656210**
	Physical Contingencies (@5%)				2882810.5
	Cost Contingencies (@10%)				5765621
	Grand Total				**66304641.5**

6.1.3 ELECTRICAL WORKS

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
1	SUPPLY AND INSTALLATION OF OUTDOOR STEEL STRUCTURE FOR 33 KV INCOMING TWO LINES	No	1	300000.00	300000.00
2	**INDOOR HT SWITCHGEAR** SUPPLY AND INSTALLATION, TESTING AND COMMISSIONING OF FOLLOWING SWITCHBOARDS SCOPE INCLUDES UNLOADING SHIFTING ERECTION, LEVELLING AND FIXING THE PANELS TO THE CHANNEL BASE FRAME INSERT PLATE PROVIDED ON THE FLOOR. SCOPE ALSO INCLUDES TESTING OF ALL THE RELAYS, CTS. PTS. AND METERS (THIS SCOPE SHALL BE APPLICABLE FOR INSTALLATION OF ALL PANELS).				
2.1	33 KV VCB / SF6 SWITCHBOARD AS PER SINGLE LINE DIAGRAM.	No.	1	4892500.00	4892500.00
2.2	**3.3 Kv VCB SWITCHBOARD** SUPPLY AND INSTALLATION, TESTING AND COMMISSIONING OF 3.3 KV,250MVA VCB SWITCHBOARD COMPRISING 2 nos:1250 A, INCOMERS WITH LINE PT, 1 nos:1250 A, BUS-SECTION, 2 nos:630 A, OUTGOING TX FEEDERS, VACUUM CONTACTOR WITH FUSE COMPLETE NITH RELAYS, 6 nos:630 A, OUTGOING FEEDERS (FOR MOTOR D.O.L STARTERS WITH VACUUM CIRCUIT BREAKER COMPLETE WITH RELAYS) '2 nos:BUS PT PANELS APPROXIMATE DIMENSIONS 12000(L)+2000(D) TESTING &COMMISSIONING OF THE ABOVE PANEL UNDER SUPERVISION OF THE MANUFACTRURER	No	1	4256900.00	4256900.00
2.3	**3.3 Kv CAPACITOR PANEL** SUPPLY AND UNLOADING SHIFTING INSTALLATION TESTING AND COMMISSIONING OF 3.3 kv, 135 KVAR, POWER FACTOR IMPROVING CAPACITOR BANK COMPLETE WITH AIR COOLED SERIES REACTOR ,RVT& INSTRUMENT COMPo WITH METERS & RELAYS (TO BE CONNECTED TO EACH 3.3 Kv,580 Kw MOTOR) 6.PPROXIMATE DIMENSIONS:	Sets	6	56025.00	336150.00
3	**TRANSFORMERS**				
3.1	SUPPLY, UNLOADING SHIFTING INSTALLATION, TESTING AND COMMISSIONING OF OUTDOOR TYPE RATING				
3.1.1	33/3.6 KV,4000 KVA, ONAN, O.L.T.C. 'DYN11., SUITABLE FOR HT CABLE TERMINATION	Nos.	2	1933290.00	3866580.00
3.1.2	3.3 KV / 0.433 KV, 200 KVA, ONAL, DYN -11 suitable for H. T. and L. T. cable termination	Nos.	2	167600.00	335200.00
4	**415V SWITCHBOARD**				
4.1	SUPPLY AND UNLOADING SHIFTING INSTALLATION, TESTING AND COMMISSIONING OF 415 V SW BOARD [SINGLE FRONT), 415 VOLT.,50 kA TPN, AL BUSBAR, FLOOR MOUNTED.AS PER SLD AND LAYOUT APPROXIMATE DIMENSIONS : (L) x (D)	No.	1	138000.00	138000.00

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
5	**LIGHTING DISTRIBUTION BOARD** SUPPLY, INLOADING,SHIFTING INSTALLATION, TESTING AND COMMISSIONING OF DISTRIBUTION BOARDS / WALL MOUNTED PANELS.				
5.1	4 WAY AC LIGHTING PANELS INCOMER- 63 A TPN MCB+ELCB OUTGOING -12 NOS: 16A DP MCB	No.	2	3400.00	6800.00
5.2	4 WAY AC LIGHTING PANELS WITH PHOTO SENSOR NCOMER- 63 A TPN MCB+ELCB OUTGOING -12 NOS: 16A DP MCB	No.	1	4000.00	4000.00
5.3	4 WAY AC POWER PANELS INCOMER- 63 A TPN MCB+ELCB OUTGOING -9 NOS: 20A DP MCB	No.	2	3400.00	6800.00
5.4	4 WAY AC POWER PANELS INCOMER- 32 A TPN MCB+ELCB OUTGOING -10A DP MCB	No.	7	3600.00	25200.00
6	**DC SYSTEM**				
6.1	SUPPLY, UNLOADING, SHIFTING, INSTALLATION, TESTING AND 'COMMISSIONING OF 110 V DC SYSTEM COMPRISING THE FOLLOWING: FLOAT CHARGER-1 NO BOOST CHARGER-1 NO DCDB-1 NO 110 V LEAD ACID MAINTENANCE FREE BATTERY WITH MOUNTING RACK (110V, 130 AH),2 HOURS BACK UP	Set	2		210000.00
6.2	INSTALLATION RATE SHALL INCLUDE MOUNTING OF BATTERY ADJACENT TO THE CHARGER PANEL(TO BE MOUNTED ON THE RACK)	Set	2		
7	**L T MOTORS**				
	TESTING AND COMMISSIONING OF INDUSTRIAL TYPE LT SQUIRREL CAGE INDUCTION MOTORS				
	UPTO 7.5Kw	Nos.	18	500.00	9000.00
	7.5 KW TO 20 KW	Nos.	4	1000.00	4000.00
8	**HT MOTORS** SUPPLY & INSTALLATION, TESTING AND COMMISSIONING OF INDUSTRIAL TYPE SQUIRREL CAGE INDUCTION MOTORS 3.3Kv, 580 Kw	Nos.	6	1200000.00	7200000.00
9	**INSTALLATION OF CABLES** SUPPLY AND LAYING OF AL/CU, PVC,ARMOURED CABLE RATE TO INCLUDE SUPPLY AND FIXING OF CLAMPING MATERIAL, IDENTIFICATIONTAG. CLEATS, ETC.				
9.1	CABLES DIRECTLY IN GROUND, INCLUSIVE OF SUPPLY AND LAYING OF SAND, PROTECTIVE BRICK LAYERS AND CABLE MARKERS AND IDENTIFICATION				
A	**1100V LT POWER CABLES**				
	3.5C x 240 SQ MM (AYFY)	MTR	400	880.00	352000.00
	4C x 16 SQ MM (AYFY)	MTR	220	165.00	36300.00
	3C x 16 SQ. MM (AYFY)	MTR	UR	141.00	-

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
	3C x 10 SQ MM (AYFY)	MTR	50	131.00	6550.00
	4C x 6 SQ. MM (AYFY)	MTR	95	81.00	7695.00
	3C x 6 SQ. MM (A YFY)	MTR	50	67.00	3350.00
	4C x 4 SQ. MM (AYFY)	MTR	100	121.00	12100.00
	3C x 2.5 SQ. MM (YWY)	MTR	370	90.00	33300.00
B	CONTROL CABLES				
	PVC, ARMOURED CABLES WITH COPPER CONDUCTOR OF FOLLOWING SIZES				
	4C x 1.5 SQ. MM	MTR	470	133.00	62510.00
	6Cx1.5 SQ. MM	MTR	160	155.00	24800.00
	14C x 1.5 SQ. MM	MTR	210	202.00	42420.00
	3Cx2.5 SQ. MM	MTR	100	90.00	9000.00
9.2	SUPPLY AND CABLES LAID ON TRAYS, STRUCTURAL SUPPORTS PVC, ARMOURED CABLES WITH AL I COPPER CONDUCTOR, LAID IN CABLE TRAY,CLEATED ON STRUCT., PULL THROUGH PIPE SLEEVE INCLUDING SUPPLY & FIXING OF CLAMPING MATERIAL IIDENTIFICATION TAG,CLEATS ETC.,				
A	L T POWER CABLES				
	3.5C x 240 SQ MM (AYFY)	MTR	200	831.00	166200.00
	3C x 70 SQ. MM (A YFY)	MTR	UR	-	-
	4C x 16 SQ MM (AYFY)	MTR	620	115.00	71300.00
	3C x 16 SQ MM (AYFY)	MTR	UR	91.00	-
	3C x 10 SQ. MM (AYFY)	MTR	60	81.00	4860.00
	4C x 6 SQ. MM (AYFY)	MTR	160	81.00	12960.00
	4C x 4 SQ MM (A YFY)	MTR	155	71.00	11005.00
	3C x 2.5 SQ. MM (YWY)	MTR	400	122.00	48800.00
B	CONTROL CABLES				
	PVC, ARMOURED CABLES WITH COPPER CONDUCTOR OF FOLLOWING SIZES				
	3C x 1.5 SQ. MM	MTR	1800	71.00	127800.00
	4Cx1.5SQ.MM	MTR	480	83.00	39840.00
	6Cx1.5SQ.MM	MTR	1000	105.00	105000.00
	14C x 1.5 SQ. MM	MTR	540	201.00	108540.00
10	HT CABLES				
10.1	SUPPLY AND CABLES DIRECTLY IN GROUND, INCLUSIVE OF SUPPLY AND LAYING OF SAND, PROTECTIVE BRICK LAYERS AND CABLE MARKERS AND IDENTIFICATION TAGS.				
A	33 KV (UE),3C x 185 SQ. MM	MTR	90	1959.00	176310.00
B	3.3 KV (UE),3C x 240 SQ. MM	MTR	280	1150.00	322000.00
C	3.3 KV (UE),3C x 35 SQ. MM	MTR	130	437.00	56810.00
10.2	CABLES LAID IN BUIT UP TRENCH COMPLETE WITH COVER				
A	33 KV (UE),3C x 240 SQ. MM	MTR	UR		
B	3.3 KV (UE),3C x 300 SQ. MM	MTR	UR		
10.3	SUPPLY AND CABLES LAID ON TRAYS, STRUCTURAL SUPPORTS PVC, ARMOURED CABLES WITH AL I COPPER CONDUCTOR, LAID IN CABLE TRAY,CLEATED ON STRUCT., PULL THROUGH PIPE SLEEVE INCLUDING SUPPLY & FIXING OF CLAMPING MATERIAL IIDENTIFICATION TAG,CLEATS ETC.				

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
A	3.3 KV (UE),3C x 240 SQ. MM	MTR	380	1099.00	417620.00
B	3.3 KV (UE),3C x 300 SQ. MM	MTR	UR	-	-
C	3.3 KV (UE),3C x 35 SQ. MM	MTR	180	397.00	71460.00
11	**EARTHING AND LIGHTNING PROTECTION :**				
11.1	SUPPLY AND INSTALLATION OF FOLLOWING GI EARTHING & LIGHTNING PROTECTION CONDUCTORS OF FOLLOWING SIZES, THE GROUNDING CONDUCTOR SHALL TERMINATE IN APPROVED GROUNDING FITTING, EARTH STRIP SHALL BE LAID IN CABLE TRAY CLEATED ALONG BRICK WALURCC STRUCTURES STEEL STRUCTURES. INSTALLATION RATE SHALL INCLUDE ALL HARDWARES.				
	50 x 6 MM GI STRIP[MEL]	KG	2600	53.00	137800.00
	25 x 6MM GI STRIP[LIGHTNING]	KG	413	53.00	21889.00
	8 SWG WIRE	KG	UR	-	-
	12 SWG WIRE	KG	176	53.00	9328.00
11.2	SUPPLY & INSTALLATION OF TEST LINKS FOR LIGHTINING PROTECTION CONDUCTORS	Nos.	6	UR	
11.3	SUPPLY AND INSTALLTION OF 40MM DIA 3000MM LONG HEAVY DUTY GI PIPE ELECTRODE AS PER IS 3043 WITH INSPECTION CHAMBER ALL ACCESSORIES INCLUDING CIVIL WORK PIPE ELECTRODES WITH TEST PIT	Nos.	6	1890.00	11340.00
11.4	SUPPLY AND INSTALL TION OF 600x600x6MM THK. COPPER PLATE ELECTRODE AS PER IS 3043 WITH INSPECTION CHAMBER FOR TRF. NEUTRAL ALL ACCESSORIES INCLUDING CIVIL WORK PLATE ELECTRODES WITH TEST pit	Nos.	10	1320.00	13200.00
12	**TERMINATION KITS**				
12.1	SUPPLY & INSTALLATION OF HT HEATSHRINKABLE/ PUSH ON TYPE TERMINATION KITS FOR FOLLOWING SIZES. LUGS SHALL BE HEXAGONAL CRIMPINGTYPE. SCOPE ALSO INCLUDES PREPARATION FOR TERMINATION HIGH POT TESTING OF HT CABLE AFTER TERMINATION. '33/3.3KV(UE) TERMINATION KIT FOR XLPE INSULATED ALUMINIUM CONDUCTOR ARMOURED CABLE OF FOLLOWING SIZE				
	3C x 185 SQ. MM (OUTDOOR) 33 KV	Nos.	4	27245.00	108980.00
	3C x 185 SQ MM (INDOOR) 33 KV	Nos.	4	20065.00	80260.00
	3C x 35 SQ. MM (INDOOR) 3.3 KV	Nos.	12	4680.00	56160.00
	3C x 240 SQ. MM (OUTDOOR) 3.3 KV	Nos.	2	7750.00	15500.00
	3C x 240 SQ. MM(INDOOR) 3.3 KV	Nos.	14	5620.00	78680.00
13	**LOCAL PUSH BUTTON STATIONS**				
	SUPPLY, INSTALLATION. TESTING, COMMISSIONING OF WEATHERPROOF, DUSTPROOFCAST ALUMINUM HOUSED, INDUSTRIAL PUSH BUTTON STATION				
13.1	ONLY STOP PUSH BUTTON. (TRANSFORMER)	Nos.	4	600.00	2400.00
13.2	START/STOP PUSH BUTTON WITH KEY FOR STOP	Nos.	6	800.00	4800.00
13.3	START/STOP PUSH BUTTON WITH AMMETER.	Nos.	UR		
13.4	START/STOP PUSH BUTTON, STOP WITH KEY & AMMETER.	Nos.	UR		

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
13.4	**LIGHT FITTINGS**				
	SUPPLY AND INSTALLATION, TESTING AND COMMISSIONING OF FOLLOWING LIGHT FITTING WITH BULBSfTUBES INSTALLATION RATE SHALL INCLUDE PROVISION OF ALL HARDWARE SUCH AS NUTS. ANCHOR FASTENERS. BOLTS, SCREWS, CLEATS, CLAMPS,INSULATED WIRES FROM JB/ CGB FABRICATION AND INSTALLATION OF SUPPORTING STRUCTURE,BRACKETS, STEEL SHALL BE INCLUDED.				
14.1	2 x 40W. INDUSTRIAL FLUORESCENT LIGHT FITTING WITHSTOVE ENAMELLED REFLECTOR, MOUNTING TYPE: CEILING/SUSPENDED.	Nos.	47	610.00	28670.00
14.2	1 x 400W, HPMV HIGH BAY INDUSTRIAL FITTING WITH INTEGRAL C.G. MOUNTING TYPE: CEILING/SUSPENDED.	Nos.	16	6000.00	96000.00
14.3	150 W, HPMV STREET LIGHTING FIXTURES SUITABLE FOR BRACKET MOUNTING	Nos.	16	3436.00	54976.00
14.4	70 W, HPSV STREET LIGin'ING FIXTURES SUITABLE FOR BRACKET MOUNTING	Nos.	25	1610.00	40250.00
14.5	SELF CONTAINED EMERGENCY LUMINAIRE SUPPLY & INSTALLATION OF SELF CONTAINED EMERGENCY LUMINAIRE WITH TWO 40W FLUORESCENT TUBES& Ni-Cd BATTERIES [gaMiN BACKUP] INVERTER, RECTIFIER.EACH FITTTING TO BE PROVIDED WITH 2 NOS. ENTRIES SUITABLE FOR 3C x 2.5 Sq.mm YWY CABLE. ALL HARDWARE REQUIRED FOR MOUNTING OF ASSEMBLY TO BE INCLUDED.	Nos.	8	2500.00	20000.00
15	**CONDUIT WIRING**				
	POINT WIRING USING 3C X 2,5 SQ.MM STRANDED CU CONDUCTOR PVC INSULATED WIRES IN GI CONDUIT ON SURFACE FOR THE ABOVE FITTINGS RATE SHALL INCLUDE SUPPLY & INSTALLATION OF CONDUITS,WIRES,JUNCTION BOXES,PULL BOXES ETC., FOR THE ABOVE FITTINGS				
	FULL POINT [FIRST FITTING FROM PANEL]	Nos.	15	665.00	9975.00
	HALF P01NT[SUBSEQUENT FITTINGS]	Nos.	80	450.00	36000.00
16	**STRUCTURAL STEEL**				
	SUPPLY, FABRICATION & INSTALLATION OF GALVANISED STEEL STRUCTURE FOR SUPPORTING VARIOUS ITEMS/EQUIPMENT SUCH AS VARIOUS PANELS, CABLE TRAYS, PUSH BUTTON STATIONS, JUNCTING BOXES LIGHT FITTING, DB, ETC, INCLUDING DRILLING WELDING, GROUTING, CHIPPING, BOLTING WITH SUPPLY OF REQUIRED HARDWARE.	K.G.	4200	5.00	21000.00
17	**CABLE TRAYS**				
	SUPPLY & INSTALLATION OF LADDER TYPE PREFABRICATED AL CABLE TRAY AS PER DRG. OF FOLLOWING SIZES				
	80 mm wide cable trays	MTR	100	64.00	6400.00
	200 WIDE CABLE TRAY.	MTR	100	126.00	12600.00
	400 WIDE CABLE TRAY.	MTR	310	246.00	76260.00
	600 WIDE CABLE TRAY.	MTR	UR		
	750 WIDE CABLE TRAY.	MTR	UR		

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
18	**EXCAVATION**				
	EXCAVATION ,PREPARATION OF SAND BEDDING BACKFILLING INCLUDING SUPPLY &INSTALLATION OF CABLE/JOINT MARKERS,PROTECTIVE COVER FOR 450MM WIDEX1000 MM DEEP ROUTE FOR INCOMING 33 kVCABLES	MTR	50	60.00	3000.00
19	**CABLE GLANDS & LUGS.**				
	END TERMINATION WITH Ni-Cr PLATED INDL DOUBLE COMPRESSION BRASS GLANDS AND CRIMPING TYPE COPPER LUGS FOR FOLLOWING CABLES SIZES. PVC SLEEVES SHALL BE PROVIDED OVER THE CABLE LUGS & GLANDS. SUPPLY OF GLANDS LUGS, ETC. TO BE INCLUDED. CABLES SHALL BE CU /AL.CONDUCTOR, PVC ARMOUR ED.				
19.1	L. T. POWER CABLES				
	3.5C x 240 SQ. MM (AYFY)	Nos.	4	302.00	1208.00
	3C x 35 SQ. MM (A YFY)	Nos.	UR	86.00	-
	4C x 16 SQ. MM (AYFY)	Nos.	20	65.00	1300.00
	3C x 16 SQ. MM (AYFY)	Nos.	4	62.00	248.00
	3C x 10 SQ. MM (YWY)	Nos.	4	32.00	128.00
	3C x 4 SQ. MM (YWY)	Nos.	26	29.00	754.00
	3C x 2.5 SQ. MM (VWY)	Nos.	60	29.00	1740.00
19.2	**CONTROL CABLES**				
	PVC, ARMOURED CABLES WITH COPPER CONDUCTOR OF FOLLOWING SIZES				
	4Cx 1.5 SQ. MM	Nos.	85	29.00	2465.00
	14C x 1.5 SQ. MM	Nos.	16	32.00	512.00
20	**LIGHTING POLES with M.V. Lamp fittings, Bracket, Terminal box. etc**	Nos.	6	8000.00	48000.00
21	**SWITCH/SOCKET UNIT**				
	SUPPLY & INSTALLATION OF SINGLE PHASE SWITCH SOCKET UNIT, INDUSTRIAL TYPE, (RATING- 5/15A, 240V) WITH MATCHING PLUG, CAP FOR SOCKET & MECHANICAL INTERLOCK THE ENCLOSURE SHALL BE OF CAST METAL WITH 2 NOS. ENTRIES SUITABLE FOR CONDUIT WIRING.	Nos.	24	210.00	5040.00
21.2	**CONDUIT WIRING**				
	POINT WIRING FOR THE ABOVE SWITCH SOCKET USING 3C X 2.5 SQ.MM STRANDED COPPER CONDUCTOR PVC INSULATED WIRES IN GI CONDUIT ON SURFACE. RATE : SHALL INCLUDE SUPPLY & INSTALLATION OF ICONDUITS,WIRES,JUNCTION BOXES,PULL BOXES ETC., FOR THE ABOVE FITTING				
	FULL POINT {FIRST SOCKET FROM PANEL}	Nos.	6	665.00	3990.00
	HALF POINT{SUBSEQUENT SOCKETS}	Nos.	18	450.00	8100.00
22	**L. T. CAPACITORS**				
	SUPPLY, UNLOADING SHIFTING INSTALLATION TESTING AND COMMISSIONING OF 430 VOLTS, 50 KVAR, APP POWER FACTOR IMPROVING	Sets	4	5900.00	23600.00

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
23	TPN WELDING SOCKET				
	SUPPLY & INSTALLATION OF TPN, WELDING SWITCH SOCKET UNIT, INDUSTRIAL TYPE, '(RATING- 30A, 415V) WITH MATCHING PLUG, CAP FOR SOCKET & MECHANICAL INTERLOCK THE ENCLOSURE WILL BE OF CAST METAL WITH 2 NOS. ENTRIES SUITABLE FOR	Nos.	4	2300.00	9200.00
	3.5C x 25 Sq.mm AYFY CABLE.				
24	JUNCTION BOXES				
	SUPPLY, INSTALLATION OF INDUSTRIAL TYPE SHEET STEEL ENCLOSED JUNCTION BOXES SUITABLE FOR 4 NOS. 3C x 1.5/2.5 Sqmm COPPER CONDUCTOR CABLE. JUNCTION BOX SHOULD HOUSE 12 NOS. STUD TYPE TERMINALS	Nos.	UR		
25	SAFETY EQUIPMENT FOR SWGR. ROOMS				
	ALL ITEMS OF SAFETY EQUIPMENT SHALL BE INCLUDED IN THE RATE QUOTED.				
25.1	SUPPLY & INSTALIATION OF RUBBER MAT.				
	RUBBER MAT SHALL BE CHEQURED TYPE AS PER IS 5425. RUBBER MAT OF 415V GRADE OF WIDTH 900 MM.	MTR	6	200.00	1200.00
	RUBBER MAT OF 33 KV GRADE OF WIDTH 900 MM.	MTR	20	600.00	12000.00
	RUBBER MAT OF 33 KV GRADE OF WIDTH 900 MM	MTR	20	400.00	8000.00
25.2	SHOCK TREATMENT CHART				
	SUPPLY, FIXING OF SHOCK TREATMENT CHART IN ENGLISH AND LOCAL LANGUAGE AT SUITABLE LOCATIONS. SHOCK TREATMENT CHART BE PRINTED TYPED AND FRAMED.	Nos.	2	100.00	200.00
25.3	SUPPLY, INSTALIATION OF METALIC CAUTION				
	BOARDS AS PER IS-2551 OF VOLTAGE GRADE AS GIVEN BELOW WITH RED COLOUR BASE AND WHITE PAINTED IN ENGLISH AND LOCAL LANGUAGE CAUTION BOARDS SHALL BE FIXED FIRMLY AT SUITABLE LOCATION BY NUTS, BOLTS, ETC.				
	440V GRADE CAUTION BOARDS	Nos.	2	500.00	1000.00
	33 KV GRADE CAUTION BOARDS	Nos.	1	500.00	500.00
	3.3 KV GRADE CAUTION BOARDS	Nos.	2	500.00	1000.00
25.4	FIRE EXTINGUISHER				
	SUPPLY, INSTALLATION AND FIXING OF DRY TYPE FIRE EXTINGUISHER OF 5 KG CAPACITY AT SUITABLE LOCATIONS.	Nos.	4	1899.00	7596.00
25.5	FIRST AID KIT				
	SUPPLY AND INSTALLATION OF FIRST AID KIT TO BE KEPT IN WOODEN STAND MOUNTED ON WALL AT SUITABLE LOCATION. FIRST AID KIT SHALL BE SUITABLE FOR 10 PERSONS.	Nos.	2	290.00	580.00
25.6	SAND BUCKETS WITH SAND.				
	SUPPLY AND INSTALLATION OF SAND BUCKETS WITH SAND AT SUITABLE LOCATIONS. CONTAINING '3 NO. BUCKETS IN ONE SET WITH M.S. STAND	Sets	2	635.00	1270.00

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
26	**Works Station (Control Panel) supply, installation, testing and commissioning works station for operation and control pump motor, transformers, complete with**				
i	Programmable logic controller with RS 232 & DH-485 Comm Inter face port (100% redundancy)	Set	1	660000.00	660000.00
ii	Valve Mounted Unit switches with DPDT contact for 6 Nos. Valves.				
iii	Power Transducer for 6 Nos. motor				
iv	Automatic load transfer system for two transformers				
v	Energy meter (power manager)	No.	1		
vi	Push Buttons, lamps, selector, switches	Lot			
vii	Relays	Lot			
viii	Erection materials	Lot			
ix	Software	Lot			
	SUB TOTAL				**25666759.00**
	Ventilation System				
1	**Supply, installation and commissioning of following switch gears at distribution position on angle iron frame / Teak wood board.**				
i	63 A TPN MCB and 12 way 10 AMP, TPMCB per way.	No.	1	4000.00	4000.00
ii	15 A TPN MCB and 4 way 10 Amp TPMCB per way	No.	2	2500.00	5000.00
iii	10 A MCB Tripple pole isolator with 20 Amp, 415 V, 3 P, LT control switch enclosed in metal box.	No.	13	1800.00	23400.00
2	**Supply & installation of following cables**				
i	4/25 sq.mm, A1 conductor PVC armoured 1100 Volt grade cable with G.I earth conductor of size 8 SWG fixed on wall/laid in cable tray in approved manner complete with cable lugs / terminations etc. for mains.	MTR	30	136.00	4080.00
ii	4/4 sq.mm Cu conductor 1100 Volt grade single PVC wires in 25mm G.t pipe fixed on wall/ in cable tray in approved manner and provided with 8 SWG G.I earth conductor, complete with terminations etc. for submain.	MTR	60	90.00	5400.00
iii	i. Wiring with 3/2.5 sq.mm Cu conductor, 1100 Volt grade, single PVC wires in 25 mm G.I pipe fixed on wall in approved manner and provided with 8 SWG G.I earth conductor, complete with 3P + earth socket & plug.	No	13	500.00	6500.00
3	**Supplying installation & commissioning of following Exhaust Fan complete with Loures & bird Quards**				
i	600 mm size 3 phase, 415 Volts having air delivering capacity of 10400 m3/hr (Min). Complete with suitable Cu conductor flexible cord.	No.	11	5900.00	64900.00
ii	300 mm size, 3 phase, 415 Volts having air delivering capacity of 1250 m3/hr (Min). Complete with suitable Cu conductor flexible cord.	No.	2	4225.00	8450.00
Intercom System					
1	Supply, installation & Commissioning following:	Job		59500.00	59500.00
i	2 x 16 EPABX System				
ii	Multi Core cu wire				

Sr. No.	Description	Unit	Qty.	Unit Rate Rs.	Total Rs.
iii	instruments				
iv	UPS -500 Watts				
Fire Alarm System					
1	Supply, installation & commissioning of fire alarm system for Pump House and substation complete with smoke detector, wiring, annunciation system.	Job		45000.00	45000.00
	Sub Total				**226230.00**
	Grand Total				**25892989.00**
	Physical Contingencies (@5%)				1294649.45
	Cost Contingencies (@10%)				2589298.90
	Grand Total				**29776937.35**

6.2 RAW WATER RISING MAIN FROM PUMP STATION TO BREAK PRESSURE TANK

Item No.	Description	Quantity	Unit	Rate	Amount
1	Manufacturing, Providing and Supplying Spirally welded /ERW/SAW/fabricated M.S. Pipes of following diameter as per IS - 3589 including procurements of plates, gas cutting to required size rolling, tack welding assembling in suitable lengths to form pipes welding on automatic welding machine and forming V edge on both ends of pipes including all taxes.				
	M.S 2032 mm (OD), 20mm shell thickness	60	RMT	49650	2979000
2	Supplying mild steel specials for M.S. pipes for internal dia. and thickness as item wised below, suitable for butt welding, specials with C.M. mortar lining and 2.4 mm thick external coal tar enamel coating.				
	10 % of Item No. 1				297900
3	Providing ,Fabricating, Fixing (a) Ring Girder as per drawing and specifications from M.S. channels, flats, plates and assembling the same on the ring girder stake and tack welding as per direction ;(b) stool as per drawing and specifications complete with top plates, base plates ,side flats for fixing rollers, grease box cover, etc.; and fabricating and assembling M.S rollers as per drawing etc.,	10	Nos	65000	650000
4	Providing and casting in situ cement concrete of trap/granite/quartzite/gneiss metal of approved quality for R.C.C work as per detailed drawings and designs or as directed by Engineer-in-charge including normal dewatering , form work, compaction, finishing of form surface with CM 1:3 of sufficient minimum thickness if special finish is to be provided and curing, etc, complete.			LS	300000
	(THRUST BLOCK)				

Item No.	Description	Quantity	Unit	Rate	Amount
5	Providing and casting in situ cement concrete of trap/ granite/ quartzite/ gneiss metal of approved quality for R.C.C work as per detailed drawings and designs or as directed by Engineer-in-charge including normal dewatering , form work, compaction, finishing of form surface with CM 1:3 of sufficient minimum thickness if special finish is to be provided and curing, etc, complete (with reinforcement).	10	Nos	9000	90000
	(R.C.C pedestal)				
					4316900
	Cost Contingencies (@ 10%)				**431690**
	Physical Contingencies (@ 5 %)				**215845**
	TOTAL				**49,64,435**

6.3 (A) WBM APPROACH ROAD TO BREAK PRESSURE TANK

Sl. No.	Description	Quantity	Unit	Rate (Rs.)	Amount (Rs.)
1	Excavation for service road in hard strata such as hard rock by wedge chiseling or line drilling , including dressing section to the required grade, camber and side slopes and conveying the excavated materials with all lifts upto a lead of 50m and spreading for embankment or stacking ,disposing as directed. 0.5x2.73x6x375	2812.5	Cu M	314	883125
	P.W.D D.S.R 2003-2004				
	Page No.144, Item No. 481 (c)				
2	Providing uncoursed rubble masonry of trap stones in cement mortar 1:6 in foundation and plinth of inner wall, including bailing out water manually, striking joints on unexposed faces and watering	300	Cu M	880	264000
	PWD DSR 2003-2004				
	(Page No.24 , Sr. No. 44)				
3	Providing and constructing W.B.M. road in layers of 75/100 mm compacted thickness, preparation of subgrade with murum screenings necessary testing including supplying and conveying all materials with all leads and lifts, spreading, sectioning, artificial watering and compacting in layer with vibratory roller as directed by Engineer-incharge including maintenance of diversion road during construction etc. complete. (2 to 7 metre width) 0.38x375	855	Cu M	450	384750
	P.W.D D.S.R 2003-2004				
	Page No.156, Item No. 518 C (ii)				
					1531875
	Cost Contingencies (@ 10 %)				**153188**
	Physical Contingencies (@ 5 %)				**76594**
	TOTAL				**17,61,656**

6.3 (B)	BREAK PRESSURE TANK				
Item No.	Description	Quantity	Unit	Rate (Rs.)	Amount (Rs.)
1	Excavation for foundation / pipe trenches in hard rock by controlled blasting, including trimming and levelling the bed by chiseling where necessary and removing the excavated material and stacking it in measurable heaps within a distance of 50 meters from the area and lifts as below, normal dewatering, excluding backfilling, etc. complete.	80	Cu M	315	25200
	MJP CSR 2004-2005				
	(Sr. No. 7 & 11 , Page No.40 & 41)				
2	Providing and laying in situ cement concrete of trap/granite/quartzite/gneiss metal for R.C.C work in foundation like raft, grillage, strip foundation and footing of RCC columns and steel stanctions including normal dewatering , form work, compaction, finishing and curing, etc, complete				
	In RCC M-250	400	Cu.M	7000	2800000
3	Providing and fixing in position steel bar reinforcement for various diameters for RCC piles, caps, footings, slabs, beams, columns, canopies, staircases, newels, chajjas, lintels, pardies, coping fins, arches, etc. as per detailed designs, drawing and schedules; including cutting, bending, hooking the bars, binding with wires or tack welding and supporting as required, etc. complete.	100	T	50000	5000000
4	Providing IS784:2003 R.C.C pipes in standard lengths of following class and diameter suitable for either collar joints or rubber ring joints, including all taxes (central and local), inspection charges, transport to department stores / site, unloading and stacking etc. complete				
	RCC 2000 mm : Class NP - III	80	RMT	11500	920000
	MJP CSR 2004-2005				
	(Page No.103 , Sr. No. 1 (e))				

Item No.	Description	Quantity	Unit	Rate (Rs.)	Amount (Rs.)
5	Lowering, laying and jointing in proper grade and alignment R.C.C pipes with collar joints in C.M.1:1 proportion or socketed R.C.C pipes with rubber joints (excluding cost of rubber ring or R.C.C collar,) including cost of conveyance from stores to site of work, cost of jointing materials, labour, giving hydraulic testing etc. complete as directed by Engineer-in-charge. (For all class of pipes.)	80	RMT	580	46400
	MJP CSR 2004-2005				
	(Page No.105 , Sr. No. 2)				
6	Manufacturing, Providing and Supplying Spirally welded /ERW/SAW/fabricated M.S. Pipes of following diameter as per IS - 3589 including procurements of plates, gas cutting to required size rolling, tack welding assembling in suitable lengths to form pipes welding on automatic welding machine and forming V edge on both ends of pipes including all taxes.				
	Outer Dia of 1930 with 12mm steel shell	20	RMT	20000	400000
	MJP CSR 2004-2005				
	(Page No.169 , Sr. No. 2(ai))				
					9191600
	Physical Contingencies (@ 5 %)				**919160**
	Cost Contingencies (@ 10 %)				**459580**
	TOTAL				**1,05,70,340**

6.4 RAW WATER GRAVITY MAIN FROM BPT TO MAHADULA

WORK - M.S PIPES WITH INTERNAL CEMENT CONCRETE LINING AND EXTERNAL COATING OF CEMENT CONCRETE INCLUDING EXCAVATION, BEDDING, LAYING, JOINTING, BACKFILLING, SPECIALS, LINE VALVES, WASHOUTS, APPURTENANCES, CHAMBERS, THRUST AND ANCHOR BLOCKS, ENCASEMENT HYDRAULIC TESTING etc. COMPLETE.

Item No.		Description	Quantity	Unit	Rate	Ammount
		MATERIAL				
1		Manufacturing, Providing and Supplying Spirally welded /ERW/SAW/fabricated M.S.Pipes of following diamer as per IS - 3589 including procurements of plates, gas cutting to required size rolling,tack welding assembling in suitable lenghts to form pipes welding on automatic welding machine and forming V edge on both ends of pipes including all taxes.				
	i	M.S 1930 mm (OD), 12mm Shell thickness Inlining - 10mm thick C.C Outlining - 20mm thick C.C	60	m	29000	1740000
	ii	M.S 1930 mm (OD), 10mm Shell thickness Inlining - 10mm thick C.C Outlining - 20mm thick C.C	27300	m	24000	655200000
2		Supplying mild steel specials for M.S. pipes for internal dia. and thickness as item wised below, suitable for butt welding, specials with C.M. mortar lining and 2.4 mm thick external coal tar enamel coating.				
	a	Outer Dia of 1930mm with outer lining of 20 mm CC Coating and 12 mm inling.				
	i	Bends as specified below.				
		10° deg. Bends	12	Nos.	22574	270888
		15° deg. Bends	19	Nos.	24508	465652
		22.5° deg. Bends	18	Nos.	27438	493884
		30° deg. Bends	6	Nos.	54266	325596
		45° deg. Bends	13	Nos.	76805	998465
		60° deg. Bends	1	Nos.	114041	114041

Item No.		Description	Quantity	Unit	Rate	Ammount
3		Supplying double flanged Scour valves,Butterfly valves & Air Valve including packing, nuts, bolts, washers and storing in the stock yard				
	i	1400 mm dia. Butterfly valves (In line) P.N 1.0	6	Nos.	500000	3000000
	ii.	400 mm dia. Sluice valves (Scour valves) P.N 1.0	15	Nos.	32682	490230
	iii	Double Flanged Kinetic Air Valve with Isolating Sluice	56	Nos.	29158	1632848
		EARTH WORK				
4		**Excavation**				
		Clear cover = 1000 mm Dia. of Pipe =1970 mm bedding = 150 mm. Depth of excavation = 2.5788m. Say = 2.6 m. Width of trench = 1970 + (2 X 0.3) = 2.57				
	i	Excavation for pipe trenches in earth, soils of all types, **sand, gravel and soft murum,** including removing the excavated material upto a disstance of 50m , stacking na d spreading as directed, normal dewatering, preparing the bed for foundation and excluding backfilling etc., complete.	181597	m^3	34	6174298
	ii	Excavation for pipe trenches in **hard murum,** including removing the excavated material upto a disstance of 50m , stacking na d spreading as directed, normal dewatering, preparing the bed for foundation and excluding backfilling etc., complete.	20302	m^3	43	872986

Item No.		Description	Quantity	Unit	Rate	Ammount
	iii.	Excavation for pipe trenches in **Hard rock** including removing the excavated material upto a disstance of 50m , stacking na d spreading as directed, normal dewatering, preparing the bed for foundation and excluding backfilling etc., complete.	6310	m^3	220	1388200
	iv	Excavation for pipe trenches in **WBM road** including removing the excavated material upto a disstance of 50m , stacking and spreading as directed, normal dewatering, preparing the bed for foundation and excluding backfilling etc,, complete.	53.97	m^3	43	2320.71
5		Providing and filling in sand boxing in pipe line or for foundation with sand of approved quality including watering compaction etc. complete.	29165.76	m^3	300	8749728
6		Lowering, laying and jointing M.S pipes in trenches on prepared formation including marginal cutting wherever required, assembling and Butt Welding, preliminary air testing of each field joint and final hydraulic testing to required pressures etc. as per specification and drawings.				
	i.	*In Trench*				
		OD 1970 mm, 10 mm shell thickness with CC 20mm lining.	26512.44	m	343	9093766.92
	ii	*Above Ground*				
		OD 1970 mm, 10 mm shell thickness with CC 20mm lining.	847.56	m	286	242402.16
7		Welding in all positions with required nunber of runs for M.S. pipes internally and / or externally including gauging wherever nessasaty, fixing appurtenences and other accessories in connection with pipe laying work as per specification	16611.862	m	374	6212836.4

Item No.		Description	Quantity	Unit	Rate	Ammount
8		Lowering, laying and jointing M.S pipe Specials including marginal cutting wherever required, assembling and Butt Welding, The rate to including unloading, hoisting etc. complete as specified.				
	a.	Outside dia. 1930 mm, 20 mm outer lining with shell thickness 10mm				
	i.	Bends as specified below.				
		10° deg. Bends	12	Nos	390	4685
		15° deg. Bends	19	Nos	424	8053
		22.5° deg. Bends	18	Nos	475	8541
		30° deg. Bends	6	Nos	938	5631
		45° deg. Bends	13	Nos	1328	17267
		60° deg. Bends	1	Nos	1972	1972
9		Lowering ,laying joining and fixing in position valves including cost of convwyance, cost of all materials and giving factory hydraulic test.				
	i.	1400mm dia butterfly valves	6	Nos	50000	300000
	ii.	200mm dia kinetic air valves with isolating sluice.	56	Nos	220	12320
	iii.	Scour Valve of 400 mm dia.	15	Nos	2570	38550

Item No.		Description	Quantity	Unit	Rate	Ammount
10		Providing, fabricating and fixing expansion joints for pipe line of diameter as per the drawing. The rate to include machining the strakes and steel ring as shown in the drawing and welding on either automatic welding machine or manually. Rate includes plates and flats required for expansion joint and all other materials such as synthetic rubber, rubber ring etc., complete. Including packing as per specifications, grease, blots and nutsetc., including local handling, all types of taxes and duties etc. commplete.	4	Nos	300000 -	1200000
11		Providing and constructing valve chambers with RCC 1:2:4 walls with footings, foundation concrete 300mm thick in C.C 1: 3: 6 using trap metal 25 to 40 mm size 20mm cement plaster in C.M 1: 3 inside and outside with precast RCC slab 150mm thick, including cost of reinforcement as directed by engineer in charge including all taxes, complete including cost of excavation and refilling with ramming , watering and curing of civil works.				
	i.	Construction of RCC valve chambers for butterfly valves as per detail specifications of size 2.5 x 4.2 x 4 m.	6	Nos	130000	780000
	ii.	Construction of RCC valve chambers for scour valves as for detail specifications of size 2.5 x 2.3 x 3.3 m.	15	Nos	76100	1141500
	iii.	Construction of RCC valve chambers for Kinetic air valves as for detail specification of size 3.1 x 2.5 x 1.3 m.	56	Nos	56600	3169600
12		Mass concrete M-20 with 20 mm max aggregate size, for embeddment, anchor blocks and thrust blocks etc. including form work, embedding puddle flange, etc. complete as per drawing.				
	i.	Plain cement concrete (M-10)	31.5	m^3	1500	47250

Item No.		Description	Quantity	Unit	Rate	Ammount
	ii	Concrete for pre cast works (M-20) of Highway crossings, Nalla & Canal Crossings and thrustblocks	3458	m^3	2400	8299375.577
13		Reinforcement steel for RCC works with deformed high yield steel bars conforming to IS 1786. (Nominal bar size from 6 mm to 12 mm), including anticorrosive treatment as specified.(for road crossings)	11.4638579	Tonnes	30000	343915.7377
14		Backfilling trench with available excavated stuff in layers not exceeding 200 mm, including watering and compaction as directed.(including road crossings)	106713.334	m^3	16	1707413.337
15		Providing and fixing indicator posts along pipe line routes, post to be of precast concrete M20 of as for drawing.	50	Nos	1000	50000
16		Drain arrangement at scour valve locations including approx.20m .of RCC drain pipe size of 400mm dia and NP2 class from chamber to near by water course and outfall Arrangement.	750	m	500	375000
17		Fabricating ring gurder asper drawing and specifications from M.S. channels, flats, plates etc., supplied free of cost and assembling the same on the ring gurder strake and tack welding as per directions.	10	Nos	65000	650000
18		R.C.C. Pedestal	60	Nos	15000	900000
		Hydraulic testing	27.36	km	20437	559156.32
19		Major crossing (River, Rail, Canal)	LS			165000000
20		Service Road	8600	m	1500	12900000
21		Land Acquicission	25.8	Ha	400000	10320000
22		Providing and applying coal tar epoxy paint, externally,including cleaning the surface of pipe, etc.complete.	20	SqM	170000	3400000
						908708372
		Cost Contingencies (@ 10 %)				**90870837**
		Physical Contingencies (@ 5 %)				**45435419**
		TOTAL				**104,50,14,627**

AUGMENTATION TO NAGPUR CITY WATER SUPPLY SCHEME (PENCH-IV)

Salient Features

1		**Project:**		**Augmentation to Nagpur City water Supply Scheme (Pench-IV)**				
2		**Client:**		**Nagpur Municipal Corporation, Nagpur**				
3		**Consultant**		**Shah technical Consultant, Mumbai** in association with **Dinesh Rathi & Associates, Nagpur**				
4		**Work Order**		NMC/PPC.EE(PPC)/38/2004, dt.02-07-2004				
5		**Total Area of City** (within NMC limits)		**217.56 Sq.Km**				
6		**Projected Population**		2001	2004	2011	2021	2031
		Total		**2150000**	**2350000**	**2830000**	**3690000**	**47,50,000**
		Slum		752500	823900	990500	1291500	1662500
		Slum Pop.(Stand Post)		301000	329560	297150	258300	166250
7		**Water Reservation**		**Pench Project - 190 Mm3**			**i.e. = 521 MLD**	
				Kanhan Project - 55 Mm3			**i.e. = 151 MLD**	

8		**Water Availability (MLD)**	2004	2011	2021	2031
	A)	**Kanhan**				
		Raw water	126.75	150.70	150.70	150.70
		Pure Water @ WTP	108.00	136.21	136.21	136.21
	B)	**Pench + Gorewada Project**				
		Raw water	388.83	537.80	537.80	537.80
		Pure Water @ WTP	362.00	521.77	521.77	521.77
	C)	**Rahari Project (I & II)**				
		Raw water			175.00	350.00
		Pure Water @ WTP			169.78	339.57
		Total(A+B+C) Raw water	**515.58**	**688.50**	**863.50**	**1038.50**
		Total(A+B+C) Pure water	**470.00**	**657.98**	**827.76**	**997.55**

9		**Pure Water Demand (MLD)** (at consumer End)	2004	2011	2021	2031
	A)	**Within NMC limits**				
	a)	Domestic (House Connection)	303.07	379.93	514.76	687.56
	b)	Domestic (Stand Post)	13.18	11.89	10.33	6.65
	c)	Non Domestic (Bulk supply)	37.95	45.7	59.59	76.71
	d)	Fire Demand	4.85	5.32	6.07	6.89
		Total	**359.05**	**442.84**	**590.75**	**777.81**
	B)	**Outside NMC limits**				
	a)	Fringe Area		30.28	37.23	43.69
	b)	CIDCO		42.00	46.20	58.80
		Total		**72.28**	**83.43**	**102.49**
	B)	**Special Project**				
	a)	MIHAN	40.50	43.60	64.20	107.50
		Total (A+B+C)	**399.55**	**558.72**	**738.38**	**987.80**

10		Pure Water Demand (MLD) (at WTP)	2004	2011	2021	2031
	A)	**Within NMC limits**				
	a)	Domestic (House Connection)	412.34	456.1	617.96	825.4
	b)	Domestic (Stand Post)	17.93	14.27	12.4	7.98
	c)	Non Domestic (Bulk supply)	51.63	54.86	71.54	92.09
	d)	Fire Demand	6.6	6.39	7.29	8.27
		Total	**488.50**	**531.62**	**709.19**	**933.74**
	B)	**Outside NMC limits**				
	a)	Fringe Area		36.35	44.69	52.45
	b)	CIDCO		50.42	55.46	70.59
		Total		**86.77**	**100.15**	**123.04**
	B)	**Special Project**				
	a)	MIHAN	55.10	52.34	77.07	129.05
		Total (A+B+C)	**543.60**	**670.73**	**886.41**	**1185.83**

11		Rate of Water Supply LPCD (At consumer end)				
	a)	House connection	150	150	150	150
	b)	Stand Post	40	40	40	40

12	% Losses in the System				
	Component	2004	2011	2021	2031
	R.W.T.M.	2	2	2	2
	W.T.P.	5	1	1	1
	P.W.T.M.	2	2	2	2
	D. / SYS.	25	15	15	15

13	Proposed Scheme Component (Pench-IV)			
13.1	**Controlling Levels of Dam**			
a)	River Bed Level @ Intake	RBL =	304.000	m
b)	Canal Bed Level	CBL =	310.000	m
c)	Lowest Water Level	LWL =	314.000	m
d)	Full Reservoir Level	FRL =	325.000	m
e)	Highest Flood Level	HFL =	327.000	m

13.2	Head works	
a)	Location	In the submergence of Navegaon-Khairy Dam (Pench Project)
b)	Designed Capacity	(190 + 40) =230 Mm3 i.e. 630 MLD

13.2.1	Intake Well			
a)	Capacity	1.5 x 630	= 945 MLD	
b)	Diameter	19.60	m	
c)	Construction	R.C.C		
d)	Bottom RL	304.000	m	
e)	Top RL	328.000	m	
f)	Intake port RL			
	Emergency	305.000	m	2.50 x 1.60 m - 2 Nos
	First	311.400	m	2.50 x 1.60 m - 4 Nos
	Second	322.400	m	2.50 x 1.60 m - 4 Nos
g)	Type of gate	Thimble Mounted Sluice gate		

13.2.2	**Intake Conduit**					
a)	Capacity	Phase -I =	472.5 MLD	Phase -II =	472.5 MLD	
b)	Diameter (ID)	2 x 2600 mm (OD = 3030 mm)				
c)	Pipe Material	RCC NP-IV				
d)	Length	500 m each				
e)	Slope of Pipe	1:5000				
f)	Velocity	1.03 m/sec				
13.2.3	**Approach Bridge**					
a)	Width	4.0 m				
b)	Construction	Steel Trusses supported on RCC Piers @ 20.0 m Spacing				
c)	Top of Bridge	328.000	m			
13.2.4	**Sump well Pump House**					
a)	Capacity	Phase-I =	315 mld	Phase-I =	= 315 mld	
b)	Size of Sump	10.00 x 40.00 x 22.0 m (Two Compartment)				
c)	Size of Pump House	13.50 x 48.50 x 10.50m				
d)	Loading Unloading Bay	5.50 m wide				
e)	Sump Bottom Level	306.000	m			
f)	Mean Suction Level	319.500	m			
g)	Pump Floor Level	328.000	m			
h)	Panel Room Floor Level	331.000	m			
i)	EOT Crane Operating Level	336.000	m			
j)	Soffit of Roof beam	338.500	m			
13.2.5	**Raw Water Pumping Machinery**					
a)	Type of pump	VT pump (Self water lubricated)				
b)	Nominal Speed	980	rpm			
c)	Mean water Level	319.500	m			
d)	Discharge level @ BPT	358.000	m			
e)	Static Head	38.50	m			
f)	Gross Head	43.00	m			
g)	No. of Pump	(Phase-1) 4 working + 2 Stand By (Phase-2) 4 working + 2 Stand By				
h)	Discharge	Total 3764 lps i.e. 325 MLD 941 lps each i.e. 81.25 MLD each				
i)	Pump	750	Hp (Each) i.e. 560 KW			
j)	Head Range	31 to 50	m			
k)	Shut off Head	55.00	m			
l)	Efficiency (overall)	80%				
m)	Hours of Pumping	24.00	Hrs			
13.2.6	**EOT Crane**					
a)	Capacity	15.0	MT			
b)	Lift	10.0	m			

13.3	**Sub Station** (@ Head Works)			
a)	Location	At Head Works near Pump house		
b)	Size			
c)	Power supply	33 KV through 2 Separate Express feeder		
d)	Total Load	3175	KVA	
e)	Transformer Capacity	4000	KVA	
13.4	**Raw Water Rising Main (Head Work to BPT)**			
a)	Capacity	630	MLD	(Phase -I & II)
b)	Diameter (OD)	2032	mm	
c)	Thickness	20	mm	
d)	Pipe Material	MS confirming to IS 3589-2001		
e)	Length	100	m	
f)	Rate of Hf	1.96	m/Km	
g)	Velocity	2.38	m/sec	
h)	Inner lining thk.	12.0	mm CC	
i)	out Coating thk.	20.0	mm CC	
13.5	**Break Pressure Tank**			
a)	Location	On Hillock near Head Works.		
b)	Capacity	630	MLD	(Phase -I & II)
c)	Construction	R.C.C		
d)	Bottom RL	353.000	m	
e)	Top RL	363.000	m	
f)	Diameter	10.00	m	
13.6	**Raw Water Gravity Transmission Main** (BPT to Mahadula)			
a)	Capacity	630 / 2 = 315 MLD		(Phase -I)
b)	Diameter	1930	mm	
c)	Thickness	10	mm	
d)	Pipe Material	MS confirming to IS 3589-2001		
e)	Length	27360	m	
f)	Rate of Hf	0.648	m/Km	
g)	Velocity	1.304	m/sec	
h)	Inner lining thk.	12.0	mm CC	
i)	out Coating thk.	20.0	mm CC	
13.7	**Raw Water Transmission Main** (Mahadula to WTP)			
a)	Capacity	115 MLD		
b)	Diameter (OD)	1422	mm	
c)	Thickness	10	mm	
d)	Pipe Material	MS confirming to IS 3589-2001		
e)	Length	2825	m	
f)	Rate of Hf	0.463	m/Km	
g)	Velocity	0.89	m/sec	
h)	Inner lining thk.	12.0	mm	
i)	Out Coating thk.	20.0	mm	

13.8	**Water Treatment Plant** (@Godhani)				
a)	Location	About 2.6 Km South of Existing Mahadula Pump House.			
b)	Type	Conventional			
c)	Designed Capacity	115 MLD (Up-gradable to 146 MLD)			
d)	Ave. GL	324 to 328 m			
e)	Controlling RL				
	Lip of Aeration Fountain	330.000	m		
	Bottom of PW Sump	320.000	m		
	Pump Floor Level	324.800	m		
13.9	**Pure Water Pumping Machinery @ WTP**				
a)	Type of pump	VT pump (Self water lubricated)			
b)	Nominal Speed	1000	rpm		
c)	Floor level Pump	324.800	m		
d)	Full Supply Level of Sump	324.000	m		
e)	Lowest water Level of Sump	320.000	m		
f)	Discharge level (Govt House)	345.950	m		
g)	Static Head	25.95	m		
h)	Gross Head	33.00	m		
i)	No. of Pump	(Immediate) 2 working + 2 Stand By (Ultimate) 4 working + 2 Stand By			
j)	Discharge	Total 1331 lps i.e. 115MLD (Immediate) 666 lps each i.e. 57.50 MLD each			
k)	Pump	425 HP	each i.e	320 kw	
l)	Head Range	24 to 36 mts			
m)	Shut off Head	Above 42 mts.			
n)	Efficiency (overall)	80%			
o)	Hours of Pumping	24.00			
13.10	**Pure Water Rising Main** (WTP to Govt. House)				
a)	Capacity	115	MLD (Up-gradable to 150 MLD)		
b)	Diameter (OD)	1422	mm		
c)	Thickness	10	mm		
d)	Pipe Material	MS confirming to IS 3589-2001			
e)	Length	9285	m		
f)	Rate of Hf	0.47	m/km		
g)	Velocity	0.9	m/sec		
h)	Inner lining thk.	12.0	mm CC		
i)	out Coating thk.	20.0	mm CC		

Augumentation to Nagpur City W.S.S. (Pench–4)

Pench–IV (Part–1) — Pench–IV (Part–2)

Pench Dam
(Navegaon Kh)

Intake Well
D = 19.60 m
TRL+328.000
BRL+304.000

Head Works
Cap=630mld

SUMP & PH

Intake Pipe
ID=2x2600mm
L=500m

Sump
Size:10x40x22 m
BRL+306.000

Pump House
Size:+13.5x48.5x10.5m
FL+328.000

BPT
D= 10.0m
FSL+363.000
LSL+353.000

Raw Water Gr. Main
Phase–1
OD=1930ø M.S.
L = 27360m

(Phase–1) (Q=315MLD)

(Phase–2)

Alternative Provision of connectivity to sump

(Q=115MLD)

Bifercation Arrangement

RD48.5Km

PRBC

(Q=460MLD)
As Per Billing By ID

P1

P2

Mahadula
Pump House
Pump FL+300.000
Sump LSL+297.000

(Q=200MLD)

(Q=200MLD)

Raw Water Tr. Main
P–1 D=1606ø M.S.
L = 5730m
P–2 D=1626ø MS
L = 5730m

BPT
RL+320.000

Gorewada
Lake
FTL+315.000

Prop. WTP
@ Godhani
Cap. 115Mld
A/FLip +345.950
FSL Sump +324.000

Q=115Mld
Raw water Gr.Main
D=1422mmø
L= 2825m

Prop. WTP

Q=115Mld
Pure water R–Main
D=1422mmø
L= 9285m

Govt. House
Cap. 22.74Mld
FSL+345.950

MBR
3No.

TO E.S.R.

TO DISTRIBUTION

Pure Water Tr. Main (3Nos)
Pench–I D=1200ø M.S.
L = 3090m
Pench–II D=1321ø MS
L = 3720m
Pench–III D=1200øMS
L=3900m

TO DISTRIBUTION

MBR
3No.

TO E.S.R.

III

I

II

Seminary Hills
Cap. 24.97Mld
FSL+356.180

Pench WTPs
@ Gorewada
Lip of A/F +308.500
Pump FL+303.650
Capacity
Pench–I : 113 Mld
Pench–II : 133 Mld
Pench–III : 100–120 Mld

KEY PLAN