

Annexure-7

Process Calculation & Basic Engg. Doc



Executive Engineer (Desai)
Chennai Metropolitan Water Supply &
Sewerage Board
Chennai - 600 002.

AECOM



சென்னைக் குழுநீர் வாரியம்
CHENNAI METRO WATER

PROJECT : 400 MLD SWRO DESALINATION PLANT	PRE. BY: AR
CLIENT : CMWSSB	CHECKED BY : UK
CONSULTANT : AECOM	APPROVED BY : PG
DOC. NAME : HYDRAULIC FLOW CALCULATION	
	REV. : R1
	Rev

(1) Gravity Dual Media Filter Outlet Pipe to Filtered Water Storage Tank Inlet

Flow rate , Q = .	:	990	MLD
Flow rate , Q =	:	41250.0	m3/hr
		11.46	m3/sec
FGL :	:	7.0	M
Water level in Storage Tank		9.5	M
Dia. Of pipe	:	2400	mm
Length of pipe	:	25	m


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Manning Equation :

$$V = ((1/n) * (R^2 / 3 * S^{1/2}))$$

Where,

V = vel. In m/s

K = Conversion constant, $K = 1$

n = Mannings coeff. Of roughness, 0.011 for
GRP

R = hydraulic radius = A/P

Flow rate , to each conduit $Q =$

: 20625.00 m³/hr

: 5.73 m³/sec

: 1.27 m/sec

Hydraulic Radius

: 0.60 m

Head Loss

0.00961 m

Across full length

: 0.00961 m

Losses due to fitting

Sr. No.	Description	Qty	K value	Total K value
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1	Exit	1	1	1	1
2	Bend	1	0.3	0.3	0.3
3	Valve	1	0.46	0.46	0.46
	Total K value	:	1.76		
	Total Head loss due to fittings	:	$Kv^2/2g$		
		:	0.144	m	
	Thus, Frictional head loss	:	0.154	m	
	Level required	:	9.65	m	
	Level Provided in Pipe	:	9.65	m	
	(2) Gravity Dual Media Filter to Outlet Pipe to RO feed Tank				
	Flow rate , Q =	:	41250.00	m ³ /hr	
			11.458	m ³ /sec	
	Dia. Of pipe	:	2600	mm	

(2) Gravity Dual Media Filter to Outlet Pipe to RO feed Tank

Flow rate, $Q =$

111.458 m³/sec

2600 mm

Dia. Of pipe

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Head Loss of Rectangular Weir in Outlet Chamber			
Flow through Each weir	1031.25	m ³ /hr	
$Q = H^1.5 * (L - 0.1H) / 5320$, where h is mm and Q is m ³ /hr			
Add for Free Fall	70.83368443	mm	
Head Loss Through Outlet valve	0.07339	m	
Thus, Frictional head loss	:	95.834	mm
Loss due to media	:	0.1	m
Loss due to strainer	:	50	mm
Level required	:	9.97	m
WL provided in Filters	1500	mm	

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Level Provided in Gravity Dual media Filter	:	11.47	m
Level Provided in Gravity Dual media Filter	:	11.50	m

(3) DAF Pipe to Dual Gravity Media Filter

Water level in Dual Gravity Media Filter

Flow (X 2 Nos of inlet Channel)	11.50	m
Flow	20625.00	m ³ /hr

Manning Equation :

$$V = ((1/n) * (R^{1/2} / 3 * S^{1/2}))$$

Where,

V= vel. In m/s

K= Conversion constant,K= 1

n=Mannings coeff. Of roughness, 0.015

R= hydraulic radius=A/P

A= Cross sectional area, m²

P=Wetted perimeter=b+2d

S=Slope in hydraulic gradient=H/L

H=Headloss due to friction over length in m

L=length of channel

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Q (provided)		20625.000		m ³ /hr
Q (provided)	Q _{designed} - 0.005		5.73	m ³ /s
V (selected)			0.90	m/s
A (area required)			6.37	m ²
b (selected)			3.00	m
d (required)			2.12	m
d (provided)			2.250	m
P			7.5	m
R			0.849	m
n			0.015	m
S=Slope in hydraulic gradient=H/L				
H=Headloss due to friction over length in m			175.0	m
L=length of channel				
$H = ((L^{0.5} * V * n) / (1 * R^{0.67}))^2$				
H=			0.03973	m
Free Fall			100.00	mm
Total Head Loss			= 0.140	m
Water level required in RCC channel			= 11.65	M
Flow rate , Q =		:	20625.000	m ³ /hr



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Dia. Of pipe	:	2400	m ³ /sec
Length of pipe	:	25	mm
Manning Equation:			
$V = ((1/n) * (R^{1/2} / 3 * S^{1/2})$			
Where,			
V= vel. In m/s			
K= Conversion constant,K= 1			
n=Mannings coeff. Of roughness, 0.011			
R= hydraulic radius=A/P			
A= Cross sectional area, m ²			
Flow rate , Q =	:	20625.000	m ³ /hr
V	:	5.73	m ³ /sec
Hydraulic Radius	:	1.27	m/sec
Head Loss	:	0.60	m
	0.00961	m	


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Across full length	:	0.0096	m
Losses due to fitting			
Sr. No.	Description	Qty	K value
1	Exit	1	1
2	Bend	4	0.3
3	Valve	2	0.46
	Total K value	:	3.12
Total Head loss due to fittings	:	$Kv^2/2g$	
	:	0.255	m
Thus, Frictional head loss	:	0.265	m
Level required	:	11.91	m
Level Provided in Pipe	:	11.95	m

(5) DAF unit to DAF Outlet Pipe

Flow rate , Q =	:	1031	MLD
Flow rate , Q =	:	42958.33	m3/hr
Head Loss in Orifices and Outlet Collection Pipes	:	11.933	m3/sec
Manning Equation :			
$V=((1/n)*(R^2/3*S^{1/2}))$			
Where,			
V= vel. In m/s			
K= Conversion constant,K= 1			
n=Mannings coeff. Of roughness, 0.011			
R= hydraulic radius=A/P			
A= Cross sectional area, m ²			
Head Loss Through Orifice			
$Q= Cd * (2gh)^{0.5}$, where Q is in M3/hr, H is mm			
Flow rate , to each DAF Q =			
V			

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Head Loss in Collection Pipes		0.0036	m
Head Loss Through Orifices	=	231.966	mm
Allow for Free Fall	=	100.00	mm
Total Loss		0.437466	m
Level in DAF	:	12.39	m
Level Provided in DAF	:	12.50	m

(6) Lamella Clarifier Outlet Pipe DAF Unit

Water level in DAF Unit		0.00	m
Flow (X 2 Nos of inlet Channel)	:	21479.16667	m ³ /hr
Flow	:	5.966	m ³ /s
Manning Equation :			
V = ((1/n)*(R^2/3 * S^1/2))			
Where,			

V= vel. In m/s								
K= Conversion constant,K= 1								
n=Mannings coeff. Of roughness, 0.011 for GRP pipe								
R= hydraulic radius=A/P								
A= Cross sectional area, m ²								
P= Wetted perimeter=b+2d								
S=Slope in hydraulic gradient=H/L								
H=Headloss due to friction over length in m								
L=length of channel								
Q (provided)	21479.16667	m ³ /hr						
Dia of pipe	2.40	m						
V (selected)	1.32	m/s						
R	0.600	m						
n	0.011	m						
S=Slope in hydraulic gradient=H/L								
H=Headloss due to friction over length in m								
	45.0	m						
Losses due to fitting								
Sr. No.	Description	Qty	K value	Total K value				

		Exit	1	1	1	1	1
	2	Bend	3	0.3	0.9		
1							
3		Valve	2	0.46	0.92		

Total K value : 2.82

Total Head loss due to fittings

$$H = (((L^0.5) * V^n) / (1 * R^{0.67})) ^ 2$$

End E-mail

Total Head Loss

Water level provided in outlet pipe

12.90
Say =

18

(7) Lamella Clarifier Outlet Lauder to pipe toof DAF

Flow rate , Q =	:	42958.33	m ³ /hr
		11.933	m ³ /sec
Water level in RCC Channel		12.90	M
Di. Of pipe	:	2600	mm

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Length of pipe/Channel	:	45	m
Manning Equation :			
$V = ((1/n) * (R^{1/2} / 3 * S^{1/2}))$			
Where,			
V = vel. In m/s			
K = Conversion constant, $K = 1$			
n = Mannings coeff. Of roughness, 0.015 for Concrete			
R = hydraulic radius = A/P			
A = Cross sectional area, m^2			
P = Wetted perimeter = $b + 2d$			
S = Slope in hydraulic gradient = H/L			
H = Headloss due to friction over length in m			
L = length of channel	:	1789.93	m^3/hr
Flow in each Lamella Unit	:		
Launder Length	:	65.00	m
Velocity in Launder	:	0.90	m/sec
Loss In launder	:	0.134	m
Loss through V notch ($Q = H^{2.5} / 5320$) where in q is m^3/hr and h is mm		220.59	mm
Total Head Loss			

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Free Fall				150.000	mm
Water level required in Lamella Unit	=		13.40	M	
Water level provided in Lamella Unit	=		13.50	M	


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S.No.	Description	Capacity	Unit
1	Intake Flow		
	Product Water Production at Plant Outlet	400	MLD
	Loss in Transmission Main	1%	
	Total Production	404	MLD
	RO Recovery (42-46%)	42%	
	Inlet to RO Plant	961.90	MLD
	Water Required for B/W Screen (as per manf.)	3.00	MLD
	Sludge and Float Losses	24.05	MLD
	Filter Back Wash Loss	14.43	MLD
	Filter to waste losses **	10.58	MLD
	** Filter is brought back into service following backwashing, the water quality can be poor and it is good practice to discharge the first product water after every backwash from the filters to waste. If this water is not discharged to waste there is the potential for higher loads on the cartridge filters and ultimately membrane fouling.		
	Total inlet Flow	1013.96	
	Say Total inlet Flow	1014	MLD
	Say Inlet Flow as	1014.00	MLD
	Velocity through Offshore screen (0.1-0.15 m/sec)	0.11	m/sec
	Area of each Offshore Screen	53.35	m ²

Diameter required	8.23	m
Diameter of screen provided	8.50	m
Inlet Pipe to Plant	0.5	m
Loss through Screen offshore and Entry losses	2	Nos.
Nos. intake pipes	1.5	m/sec
Inlet Velocity (1.3-1.5 m/sec)	507.00	MLD
Flow in each Pipe	2.23	m
Diameter of Pipe	2500.0	mm
Diameter of pipe provided is HDPE 2500 mm OD	1150	m
Length of pipe to pump house		
Head Loss by Modified Hazen William Equation		
Head Loss by Modified Hazen William Equation with C=0.80	0.56	m
Exit losses as K=1	0.11	m
Total Head loss upto the Intake well	1.18	m
Say Total Head loss upto the Intake well	1.60	m

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No. of Screen On shore (W)	4.00	Nos.
Stand by 50% as per CMWSSB	2.00	Nos.
Flow through Each Screen	253.50	MLD
Velocity in approach channel	0.50	m/sec
Area of Approach Channel	5.87	m ²
Water Depth	1.80	m
Width of Approach Channel	3.26	m
Velocity through Screen	0.90	m/sec
Area of each Screen Channel	3.26	m ²
Water Depth in Screen Channel	1.10	m
Width of Screen Channel	2.96	m
Width of Screen Channel Provided	3.00	m
Actual Velocity through Screen	0.89	m/sec
Head Loss Through Coarse Screen		(Metcalf & Eddy, Pg 320-321)

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$h_L = 1/C((V^2 \cdot v^2)/2g)$	Where in h_L = Head loss in m
C is the empirical discharge coefficient to account for turbulence and eddy losses, typical 0.7 for a clean screen and 0.6 for clogged screen	'
$g = 9.81 \text{ m/sec}^2$	

V = Velocity of Flow through opening of bar screen in m/sec

v = Approach Velocity in upstream channel in m/sec

Head Loss through Clean Screen	0.0393	m
Head Loss through Clean Screen	39.34	mm
Head Loss through 50% clogged Screen		
Reduce the area of Screen by 50%, hence Velocity	1.78	m/sec
Head Loss through 50% Clogged Screen	0.202	m
Head Loss through 50% Clogged Screen	250	mm
Total Loss upto Pump Chamber	1.85	m

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Say	1.9	m	
	Chart Datum	RL	
Mean High Water Spring	1.15	RL 0.5	
Mean High Water Neaps	0.84	RL 0.19	
Mean Sea Level	0.65	RL 0.0	
Mean Low Water Neaps	0.43	RL - 0.22	
Mean Low Water Spring	0.14	RL - 0.51	

Onshore survey levels are recorded as metres above Mean Sea Level. Thus Mean High Water Springs is 1.15 – 0.65 = RL 0.5, and Mean Low Water Springs is 0.14 – 0.65 = RL – 0.51.

The low no flow level in the pump well has been taken as RL – 0.50. At a flow of 507 MLD per conduit , the hydraulic grade line entering the proposed pumping station will be approximately 1.6 m lower, at RL – 2.1. A head loss of 0.3 is provided/allowed for loss through screens resulting in low-low water levels in sump cum pump station as RL-2.4 say RL-2.5 m.

Three point Five (3.5) metres has been provided to the bottom of the pumps (as per manf.), which has been assumed to be 0.5 m above the bottom of the pumping station at RL – 6.0 to ensure sufficient submergence for the pumps, and to allow for surging in the intake line. Further taking a reverse slope from +10 m WL offshore with a slope of 1:70 near the shore as per offshore survey, the pipe enters the Pump Well as RL-7.0


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Now We consider No of pumps working		6	nos.
Standby		1	nos.
Flow through Each Pump		169.00	MLD
Flow through Each Pump		7041.67	m ³ /hr
Pump Type	Vertical Turbine, Casing, shaft Impeller as Super Duplex with PREN >41		
Now Static head (refer HYD calc.)		20.00	m

3 Flash Mixer				
Total Flow rate		1014	MLD	
		42250.00	m ³ /hr.	
No. of unit		4	Nos.	
Flow rate / Flash Mixer		254	MLD	
		10562.5	m ³ /hr.	
Retention time		25.00	Sec	
Volume required		73.35	m ³	
Water depth provided		6.50	m	
Freeboard provided		0.50	m	
Area required		11.28	m ²	

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	Width selected	3.50	m
Length required	'	3.22	m
Overall Flash Mixer Dimensions provided		$3.5 \times 3.5 \times 6.5$ (LD) + 0.5 FB + m	
Tank MOC		RCC (internal ceramic tiles/Epoxy Paint)	

Power Requirement ($P = \mu G^2 V$)

Viscosity	0.00103	N.s/m ²
Velocity Gradient	600	
Required Power in Watt	27198.4375	Watt
Required Power in KW	27.1984375	KW
Provided Power each Flash Mixer	36	KW

4 FLOCCULATOR		MLD	MLD
Total Flow rate		1014	
		42250.00	$m^3/hr.$
No. of units	96	Nos.	
Flow rate / Flocculator	11	MLD	
	440	$m^3/hr.$	
Retention time	10	min	
Capacity required	73.35	m^3	
Water depth provided	6.5	m	
Freeboard provided	0.5	m	


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Area required		11.28	m^2
Length	3.0		m
Width	3.75		m
Tank Dimensions provided	3.5 L x 3.75 W x 6.5 H+0.5FB	$m \times m \times m$	
Tank MOC	RCC (internal ceramic tiles/Epoxy Paint)		
Power Requirement ($P = \mu G^2 V$)			
For Stage-1			
Viscosity	0.00103	$N.s/m^2$	
Velocity Gradient	70		
Required Power in Watt	370.2009549	Watt	
Required Power in KW	0.37	KW	
Provided Power	2.2	KW	
For Stage-2			
Viscosity	0.00103	$N.s/m^2$	
Velocity Gradient	30		
Required Power in Watt	68.00	Watt	
Required Power in KW	0.07	KW	
Provided Power	1.8	KW	

5 LAMELLA CLARIFIER	Qty	24	
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Total Outlet Flow		1014	MLD
Total Outlet Flow		42250	m ³ /hr.
Flow Through Each Clarifier		42.25	MLD
Flow Through Each Clarifier Provided		1760.42	m ³ /hr.
Inlet Suspended Solids	200		mg/l
Sludge (1% Sludge Consistency)	10000		mg/l
Outlet suspended Solids	30		mg/l
Sludge flow rate	0.73		m ³ /hr.
Total Inlet flow rate	1760		m ³ /hr.
Plate length	2.1		m
Plate width	1.20		m
Plate thickness	0.01		m
Plate inclination from horz.(in radians)	0.96	(55 deg.)	
Rise rate	1.30		m/h
Efficency	95%	%	
Area required/unit	1425.44		m ²
Area of each plate	2.52		m ²
Projected area (at inclination of 55° from horz.)	1.45		m ²
Assuming plate efficiency (Actual Immersed area in water for functional requirement)	90%		
Available Projected area of each plate	1.30		m ²
Distance between Lamella Plates	75.00		mm

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	h horizontal projection of the Lamella spacing	91.58	mm
No of lamella per m		10.92	nos.
Say		11.00	nos.
As project plate area		1.30	m ²
Total Project Surface area per m		14.31	m ²
AS/Astp		11.00	
Plan surface area required for Lamella		129.59	m ²
Length of Lamella Provided	;	18.00	m
Width of Lamella		7.20	m
Width of Lamella Provided		7.50	m
Internal Size of the Each Lamella		18 m x 7.5 m	m x m
Lamella Surface loading rate (vertically projected surface area)		13.04	m/hr
Internal Size of the Each Lamella		18 m x 7.5 m	m x m
6 Flash Mixer For DAF			
Total Flow rate		1002	MLD
Total Flow rate		41749.01	m ³ /hr.
No. of unit		2	Nos.
Flow rate / Flash Mixer		501	MLD
Flow rate / Flash Mixer		20874.5	m ³ /hr.
Retention time		30.00	Sec

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Volume required	173.95	m ³
Effective Capacity provided	173.95	m ³
Water depth provided	5.00	m
Freeboard provided	0.50	m
Area required	34.79	m ²
Width selected	5.90	m
Length required	5.90	m
Overall Flash Mixer Dimensions provided	6.0 X6.0 X 5 (ID) + 0.5 FB + m	m X m X m
Tank MOC	RCC (internal Epoxy Paint)	
Power Requirement (P = $\mu G^2 V$)		
Viscosity	0.00103	N.s/m ²
Velocity Gradient	300	
Required Power in Watt	16125.55432	Watt
Required Power in KW	16.13	KW
Provided Power	0.55	KW

7 <u>FLOCCULATOR For DAF</u>	Total Flow rate	MLD
	41749.01	m ³ /hr.
No. of unit for each lamella clarifier	32	Nos.
Flow rate / Flocculator	31	MLD

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Cylindrical Tank		1305	m ³ /hr.
Retention time	10 min		
Capacity required	217.44 m ³		
Capacity provided	217.44 m ³		
Water depth provided	5 m		
Freeboard provided	0.5 m		
Area required	43.49 m ²		
Width selected	7.2 m		
Length required	6.04 m		
Tank Dimensions provided	7.2 L x 6.1 W x 5.0 H+0.5FB m x m x m		
Tank MOC	RCC		
Power Requirement (P = $\mu G^2 V$)			
For Stage-1			
Viscosity	0.00103 N.s/m ²		
Velocity Gradient	70		
Required Power in Watt	1097.433558 Watt		
Required Power in KW	1.10 KW		
Provided Power	2.2 KW		
For Stage-2			
Viscosity	0.00103 N.s/m ²		
Velocity Gradient	30		

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	Required Power in Watt		201.5694289	Watt
	Required Power in KW		0.20	KW
	Provided Power		0.55	KW

8	DAF			
	Total Average flow	1002	MLD	
	Total Average flow	:	1001976	m ³ /day
	No of Total Units	32	Nos.	
	No of Working Units	32.00	Nos.	
	Flow to each clarifier (Average)	31312	m ³ /day	
	Total Flow	31312	m ³ /day	
	Recycle Rate (5-10%)	8%	m ³ /day	
	SOR (Average)	15.00	m ³ /m ² /hr.	
	Surface Area of DAF Tank Required	93.94	m ²	
	Width	6.30	m	
	Length	15.00	m	
	C/s area	94.50	m ²	
	Consider Detention time	0.33	hrs.	
	Liquid Depth	5.00	m	
	Dimensions (Effective)	15 m L X 6.3 m W X 5 m SWD		

9 Dual Media Gravity Filter

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Configuration	Quadrilateral - Configuration	Rectangular (Twin Compartment)
Total flow rate	990	MLD
Nos. of Total Units	41250.00	$m^3/hr.$
Nos. of Working Units	40.00	Nos.
Influent flow rate per filter	39.00	Nos.
Rate of filtration (N-1)	1057.69	$m^3/hr.$
Total Surface area provided Each	8	$m^3/hr-m^2$
Length provided	132.21	m^2
Width Required	15.6	m
Say	8.48	m
Height of media (Anthracite)	8.5	m
Height of media (Sand)	0.8	m
Supporting media	0.25	m
Backwash velocity	40	$m^3/hr-m^2$
Backwash flow rate	5288	$m^3/hr.$
Backwash duration	10	min
Backwash volume per backwash	881.41	m^3
Dimensions provided	16.2 m L x 8.5 m W	$m \times m$
MOC	RCC	



Type	Horizontal Centrifugal
Capacity required	5288 m ³ /hr.
Capacity provided	5500 m ³ /hr.
MOC	
Casing	Super Duplex with PERN >= 41
Impeller	Super Duplex with PERN >= 41
Shaft	Super Duplex with PERN >= 41
IL of Back Wash Sump RL	1 m
Top of Outlet Sump to be discharged RL	7.5 m
Total Static Head	6.5 m
Head Provided	8 mwc
Quantity	2(1W + 1S) Nos.

11 Air Blower For Dual Media Gravity Filter	
Air surface flow rate	60 m ³ /hr-m ²
Air flow rate required	7932.69 m ³ /hr.
Blower Capacity Provided.	8200 m ³ /hr.
Head Provided	0.4 kg/cm ²

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MOC	
Casing	CI-NI 2.5%
Impeller	CF8M
Shaft	EN 8
Quantity	2 (1W + 1S)
Nos.	

12 RO Permeate Water Storage Tank	
Type	Vertical Cylindrical
Flow rate	408 MLD
	17000.00 m ³ /hr.
No. of Storage Tanks	2 Nos.
Retention time	30.00 min
Volume required	4250.00 m ³
Water depth provided	9.50 m
Freeboard provided	0.50 m
Area required	447.37 m ²
Diameter required	23.84 m
Say Diameter provided	23.85 m
Overall Tank Dimensions provided	20 m Dia * 9.5 m Ht m X m
Tank MOC	Glass Fused Steel Bolted

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13 RO Flushing Pumps	
Type	Horizontal Centrifugal
Capacity Each Pump	25.50 MLD
MOC	1063 m ³ /hr.
Casing	Super Duplex with PERN >= 41
Impeller	Super Duplex with PERN >= 41
Shaft	Super Duplex with PERN >= 41
Head Provided	30 m w.c
Quantity	4 (2W + 2S) Nos.

14 Post Treatment (Re-mineralization/Stabilization)	
Stabilization Process	Limewater/Carbon Dioxide Dosing
Target pH range	7.5 to 8.5
Target Langlier Index	Positive
Maximum Total Dissolved Solids	350 mg/L
Carbon dioxide dosage (as 100% pure product)	For lime/CO ₂ systems-88 mg/L For calcite/CO ₂ systems-44 mg/L per 1.0 mg/L of target

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CO ₂ consumption	alkalinity and hardness concentrations (as CaCO ₃)	(kg/day as 100% pure product) per 1000 m ³ /day of desalinated water for addition of alkalinity and hardness in a range of 80 to 120 m/L (as CaCO ₃)
CO ₂ consumption	70.4-105.6	
CO ₂ purity	100	%
Liquid CO ₂ storage tank-Storage pressure	20	bar
Liquid CO ₂ storage tank-Storage temperature	20	Deg C
Liquid CO ₂ storage tank Diameter	0.8 - 0.3	m
Length/Height	5.0 - 15.0	m
Storage time	15 - 60	Days
Structure-material	Carbon steel	
Vaporizer		
Type	Electric	hp/kg CO ₂ .day
Capacity	Executive Engineer (Desal) Chennai Metropolitan Water Supply & Sewerage Board Chennai - 600 009	0.03-0.05

	Delivery pressure	3	bars
	Delivery temperature	12	°C
Vapor Heater			
Type	Electric		
Capacity	0.01-0.02 hp/kg CO ₂ .day		

15 Product Water Storage Tank		Rectangular	
Type	MLD	Flow rate	m ³ /hr.
Flow rate	404	16833.33	
Flow rate			
No. of Tanks	:	1	Nos.
Retention time		125.00	min
Volume required		35069.44	m ³
Volume provided		35000.00	m ³
Water depth provided		4.00	m
Freeboard provided		0.50	m
Area required		8750.00	m ²
Tank MOC		RCC (internal Epoxy Coating)	
<i>E. S. S.</i>		Executive Engineer (Desai) Chennai Metropolitan Water Supply & Sewerage Board Chennai - 600 002	
16 Product Water Transfer Pump			

Type		Horizontal Centrifugal
Capacity Each Pump	66.67	MLD
Capacity Each Pump Provided	2778	$m^3/hr.$
MOC	2800	$m^3/hr.$
Casing	Super Duplex with PERN $>= 41$	
Impeller	Super Duplex with PERN $>= 41$	
Shaft	Super Duplex with PERN $>= 41$	
Head Provided * (Calculation enclosed in Annexure-IV)	75	mwc
Quantity	9 (6W + 3S)	Nos.



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Annexure-8

RO Projection



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Reverse Osmosis System Analysis for FILMTEC™ Membranes
 Project: Chennai Projection Runs Interim Report
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CASE 1

3/12/2013

Project Information: Chennai Interim Report

Case-specific: 32,000mg/L

System Details

Feed Flow to Stage 1	9538.13 m³/h	Pass 1 Permeate Flow	4250.04 m³/h	Osmotic Pressure:	
Raw Water Flow to System	9239.13 m³/h	Pass 1 Recovery	46.00 %	Feed	23.16 bar
Feed Pressure	51.92 bar	Feed Temperature	33.0 C	Concentrate	43.99 bar
Flow Factor	0.90	Feed TDS	32042.25 mg/l	Average	33.58 bar
Chem. Dose (100% H2SO4)	28.73 mg/l	Number of Elements	7680	Average NDP	17.12 bar
Total Active Area	313927.68 M²	Average Pass 1 Flux	13.54 lmh	Power	16187.15 kW
Water Classification: Seawater with Conventional pretreatment, SDI < 5				Specific Energy	3.81 kWh/m³

Stage	Element	#PV	#Ele	Feed Flow (m³/h)	Feed Press (bar)	Recirc Flow (m³/h)	Conc Flow (m³/h)	Conc Press (bar)	Perm Flow (lmh)	Avg Flux (lmh)	Perm Press (bar)	Boost Press (bar)	Perm TDS (mg/l)
1	SW30XHR-440i	960	8	9538.13	51.58	299.00	5288.09	50.13	4250.04	13.54	1.20	0.00	191.19

Pass Streams (mg/l as Ion)						
Name	Feed	Adjusted Feed		Concentrate	Permeate	
		Initial	After Recycles		Stage 1	Total
NH4+ + NH3	0.16	0.18	0.18	0.35	0.03	0.03
K	355.50	355.50	364.91	655.87	2.90	2.90
Na	9809.14	9811.69	10071.86	18112.32	67.57	67.57
Mg	1143.77	1143.77	1174.26	2116.63	1.73	1.73
Ca	424.60	424.60	435.92	785.76	0.63	0.63
Sr	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.45	0.45	0.46	0.83	0.00	0.00
CO3	29.70	2.20	2.28	7.17	0.00	0.00
HCO3	114.83	135.04	138.34	242.29	1.35	1.35
NO3	3.64	3.64	3.73	6.52	0.25	0.25
Cl	17499.33	17501.15	17965.47	32315.15	110.96	110.96
F	1.48	1.48	1.52	2.73	0.01	0.01
SO4	2616.67	2644.82	2715.39	4896.42	1.65	1.65
SiO2	1.25	1.25	1.28	2.30	0.01	0.01
Boron	2.89	2.88	2.94	4.72	0.72	0.72
CO2	0.32	5.89	6.06	7.91	6.49	6.48
TDS	32017.01	32042.25	32892.42	59171.30	191.19	191.19
pH	8.20	7.00	7.00	7.14	5.44	5.44

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 Project: Chennai Projection Runs Interim Report
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CASE 1
 3/12/2013

Design Warnings

-None-

Solubility Warnings

Langelier Saturation Index > 0

BaSO4 (% Saturation) > 100%

CaF2 (% Saturation) > 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Stage Details

Stage 1 Element	Recovery	Perm Flow (m³/h)	Perm TDS (mg/l)	Feed Flow (m³/h)	Feed TDS (mg/l)	Feed Press (bar)
1	0.10	1.01	82.81	9.94	32892.42	51.58
2	0.10	0.86	106.06	8.93	36595.25	51.31
3	0.09	0.71	138.11	8.07	40472.86	51.08
4	0.08	0.57	182.55	7.36	44371.56	50.88
5	0.07	0.45	244.23	6.78	48116.37	50.70
6	0.06	0.35	329.57	6.33	51548.63	50.54
7	0.04	0.27	447.02	5.98	54557.80	50.40
8	0.04	0.20	605.37	5.71	57094.17	50.26

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Scaling Calculations

CASE 1

	Raw Water	Adjusted Feed	Concentrate
pH	8.20	7.00	7.14
Langelier Saturation Index	1.36	0.23	0.88
Stiff & Davis Stability Index	0.38	-0.75	-0.36
Ionic Strength (Molal)	0.66	0.66	1.25
TDS (mg/l)	32017.01	32042.25	59171.30
HCO ₃	114.83	135.04	242.29
CO ₂	0.32	5.89	7.91
CO ₃	29.70	2.20	7.17
CaSO ₄ (% Saturation)	21.33	21.56	45.36
BaSO ₄ (% Saturation)	1572.11	1589.21	3309.95
SrSO ₄ (% Saturation)	0.00	0.00	0.00
CaF ₂ (% Saturation)	123.63	123.63	778.19
SiO ₂ (% Saturation)	0.72	0.89	1.63
Mg(OH) ₂ (% Saturation)	0.98	0.00	0.01

To balance: 2.56 mg/l Na added to feed.

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Reverse Osmosis System Analysis for FILMTEC™ Membranes
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CASE 2 - pH 7.0
3/11/2013

Project Information: Chennai Interim Report

Case-specific: 38,000mg/L

System Details

Feed Flow to Stage 1	9538.13 m³/h	Pass 1 Permeate Flow	4249.99 m³/h	Osmotic Pressure:	
Raw Water Flow to System	9239.13 m³/h	Pass 1 Recovery	46.00 %	Feed	27.65 bar
Feed Pressure	62.26 bar	Feed Temperature	33.0 C	Concentrate	53.02 bar
Flow Factor	0.81	Feed TDS	38065.47 mg/l	Average	40.33 bar
Chem. Dose (100% H2SO4)	37.46 mg/l	Number of Elements	7680	Average NDP	20.66 bar
Total Active Area	313927.68 M²	Average Pass 1 Flux	13.54 lmh	Power	19410.02 kW
Water Classification: Seawater with Conventional pretreatment, SDI < 5				Specific Energy	4.57 kWh/m³

Stage	Element	#PV	#Ele	Feed Flow (m³/h)	Press (bar)	Recirc Flow (m³/h)	Conc Flow (m³/h)	Conc Press (bar)	Perm (m³/h)	Avg Flux (lmh)	Perm Press (bar)	Boost Press (bar)	Perm TDS (mg/l)
1	SW30XHR-440i	960	8	9538.13	61.91	299.00	5288.14	60.46	4249.99	13.54	1.20	0.00	227.46

Pass Streams (mg/l as Ion)						
Name	Feed	Adjusted Feed		Concentrate	Permeate	
		Initial	After Recycles		Stage 1	Total
NH4+ + NH3	0.19	0.22	0.23	0.43	0.03	0.03
K	422.15	422.15	433.33	778.82	3.45	3.45
Na	11656.38	11656.38	11965.46	21517.28	80.40	80.40
Mg	1358.23	1358.23	1394.44	2513.47	2.06	2.06
Ca	504.21	504.21	517.65	933.07	0.75	0.75
Sr	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.54	0.54	0.55	1.00	0.00	0.00
CO3	39.87	3.04	3.14	9.55	0.00	0.00
HCO3	136.36	164.69	168.71	295.08	1.60	1.60
NO3	4.32	4.32	4.43	7.74	0.30	0.30
Cl	20780.46	20784.89	21336.32	38377.88	132.00	132.00
F	1.76	1.76	1.81	3.25	0.02	0.02
SO4	3107.30	3144.00	3227.89	5820.52	1.96	1.96
SiO2	1.49	1.49	1.53	2.75	0.02	0.02
Boron	3.43	3.42	3.49	5.60	0.86	0.86
CO2	0.36	6.93	7.13	9.51	7.73	7.73
TDS	38032.85	38065.47	39075.43	70292.86	227.46	227.46
pH	8.20	7.00	7.00	7.20	5.43	5.43

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CASE 2 - pH 7.0
3/11/2013

Design Warnings

-None-

Solubility Warnings

Langlier Saturation Index > 0

BaSO4 (% Saturation) > 100%

CaF2 (% Saturation) > 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Stage Details

Stage 1 Element	Recovery	Perm Flow (m³/h)	Perm TDS (mg/l)	Feed Flow (m³/h)	Feed TDS (mg/l)	Feed Press (bar)
1	0.10	1.02	97.55	9.94	39075.43	61.91
2	0.10	0.86	125.36	8.92	43525.17	61.65
3	0.09	0.71	163.96	8.05	48183.01	61.42
4	0.08	0.57	217.90	7.34	52853.58	61.22
5	0.07	0.45	293.20	6.77	57316.94	61.04
6	0.05	0.35	397.88	6.32	61379.64	60.88
7	0.04	0.26	541.27	5.97	64913.74	60.73
8	0.03	0.20	734.15	5.71	67876.29	60.59

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Scaling Calculations

CASE 2 - pH 7.0

	Raw Water	Adjusted Feed	Concentrate
pH	8.20	7.00	7.20
Langelier Saturation Index	1.51	0.39	1.10
Stiff & Davis Stability Index	0.47	-0.65	-0.15
Ionic Strength (Molar)	0.79	0.79	1.50
TDS (mg/l)	38032.85	38065.47	70292.86
HCO3	136.36	164.69	295.08
CO2	0.36	6.93	9.51
CO3	39.87	3.04	9.55
CaSO4 (% Saturation)	26.07	26.38	56.86
BaSO4 (% Saturation)	1929.75	1952.90	4209.87
SrSO4 (% Saturation)	0.00	0.00	0.00
CaF2 (% Saturation)	207.62	207.62	1306.78
SiO2 (% Saturation)	0.86	1.06	1.95
Mg(OH)2 (% Saturation)	1.17	0.00	0.02

To balance: 2.23 mg/l Cl added to feed.

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Reverse Osmosis System Analysis for FILMTEC™ Membranes
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 ABr, GHD

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CASE 2 - pH 8.2
3/11/2013

Project Information: Chennai Interim Report

Case-specific: 38,000mg/L

System Details

Feed Flow to Stage 1	9538.13 m³/h	Pass 1 Permeate Flow	4249.99 m³/h	Osmotic Pressure:	
Raw Water Flow to System	9239.13 m³/h	Pass 1 Recovery	46.00 %	Feed	27.64 bar
Feed Pressure	62.24 bar	Feed Temperature	33.0 C	Concentrate	53.00 bar
Flow Factor	0.81	Feed TDS	38035.11 mg/l	Average	40.32 bar
Chem. Dose (100% H2SO4)	0.00 mg/l	Number of Elements	7680	Average NDP	20.66 bar
Total Active Area	313927.68 M²	Average Pass 1 Flux	13.54 lmh	Power	19404.51 kW
Water Classification: Seawater with Conventional pretreatment, SDI < 5				Specific Energy	4.57 kWh/m³

Stage	Element	#PV	#Ele	Feed Flow (m³/h)	Feed Press (bar)	Recirc Flow (m³/h)	Conc Flow (m³/h)	Conc Press (bar)	Perm Flow (lmh)	Avg Flux (lmh)	Perm Press (bar)	Boost Press (bar)	Press (bar)	TDS (mg/l)
1	SW30XHR-440i	960	8	9538.13	61.90	299.00	5288.14	60.44	4249.99	13.54	1.20	0.00	226.67	

Pass Streams (mg/l as Ion)						
Name	Feed	Adjusted Feed		Concentrate	Permeate	
		Initial	After Recycles		Stage 1	Total
NH4+ + NH3	0.19	0.22	0.23	0.43	0.03	0.03
K	422.15	422.15	433.33	778.80	3.47	3.47
Na	11656.38	11656.38	11965.49	21517.34	80.40	80.40
Mg	1358.23	1358.23	1394.44	2513.48	2.06	2.06
Ca	504.21	504.21	517.65	933.07	0.76	0.76
Sr	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.54	0.54	0.55	1.00	0.00	0.00
CO3	39.87	39.87	41.06	75.78	0.00	0.00
HCO3	136.36	136.36	139.82	248.63	1.43	1.43
NO3	4.32	4.32	4.43	7.74	0.30	0.30
Cl	20780.46	20782.69	21334.13	38373.86	132.08	132.08
F	1.76	1.76	1.81	3.25	0.02	0.02
SO4	3107.30	3107.30	3190.22	5752.59	1.94	1.94
SiO2	1.49	1.49	1.53	2.75	0.02	0.02
Boron	3.43	3.43	3.50	5.73	0.73	0.73
CO2	0.36	0.36	0.37	0.85	0.36	0.36
TDS	38032.85	38035.11	39044.68	70241.40	226.67	226.67
pH	8.20	8.20	8.19	8.17	6.71	6.71

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CASE 2 - pH 8.2

3/11/2013

Design Warnings

-None-

Solubility Warnings

Langlier Saturation Index > 0

Stiff & Davis Stability Index > 0

BaSO4 (% Saturation) > 100%

CaF2 (% Saturation) > 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Stage Details

Stage 1	Element	Recovery	Perm Flow (m³/h)	Perm TDS (mg/l)	Feed Flow (m³/h)	Feed TDS (mg/l)	Feed Press (bar)
	1	0.10	1.02	96.94	9.94	39044.68	61.90
	2	0.10	0.86	124.70	8.92	43490.90	61.63
	3	0.09	0.71	163.24	8.05	48145.20	61.40
	4	0.08	0.57	217.08	7.34	52812.40	61.20
	5	0.07	0.45	292.26	6.77	57272.75	61.02
	6	0.05	0.35	396.76	6.32	61332.92	60.86
	7	0.04	0.26	539.94	5.97	64865.01	60.71
	8	0.03	0.20	732.57	5.71	67826.01	60.57

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Scaling Calculations

	Raw Water	Adjusted Feed	Concentrate	CASE 2 - pH 8.2
pH	8.20	8.20	8.17	
Langlier Saturation Index	1.51	1.51	2.00	
Stiff & Davis Stability Index	0.47	0.47	0.75	
Ionic Strength (Molar)	0.79	0.79	1.50	
TDS (mg/l)	38032.85	38035.11	70241.40	
HCO3	136.36	136.36	248.63	
CO2	0.36	0.36	0.85	
CO3	39.87	39.87	75.78	
CaSO4 (% Saturation)	26.07	26.38	56.19	
BaSO4 (% Saturation)	1929.74	1952.90	4160.17	
SrSO4 (% Saturation)	0.00	0.00	0.00	
CaF2 (% Saturation)	207.62	207.62	1306.79	
SiO2 (% Saturation)	0.86	1.06	1.60	
Mg(OH)2 (% Saturation)	1.17	0.00	1.92	

To balance: 2.23 mg/l Cl added to feed.

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Reverse Osmosis System Analysis for FILMTEC™ Membranes
 Project: Chennai Projection Runs Interim Report
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ROSA 8.0.3 ConfigDB U412142_201

CASE 3

3/11/2013

Project Information: Chennai Interim Report

Case-specific: 38,000mg/L

System Details

Feed Flow to Stage 1	9538.13 m³/h	Pass 1 Permeate Flow	4249.99 m³/h	Osmotic Pressure:	
Raw Water Flow to System	9239.13 m³/h	Pass 1 Recovery	46.00 %	Feed	26.83 bar
Feed Pressure	63.91 bar	Feed Temperature	25.0 C	Concentrate	51.35 bar
Flow Factor	0.81	Feed TDS	38037.27 mg/l	Average	39.09 bar
Chem. Dose (100% H2SO4)	0.00 mg/l	Number of Elements	7680	Average NDP	23.40 bar
Total Active Area	313927.68 M²	Average Pass 1 Flux	13.54 lmh	Power	19924.84 kW
Water Classification: Seawater with Conventional pretreatment, SDI < 5				Specific Energy	4.69 kWh/m³

Stage	Element	#PV	#Ele	Feed Flow (m³/h)	Feed Press (bar)	Recirc Flow (m³/h)	Conc Flow (m³/h)	Conc Press (bar)	Perm Flow (m³/h)	Avg Flux (lmh)	Perm Press (bar)	Boost Press (bar)	Press (bar)	TDS (mg/l)
1	SW30XHR-440i	960	8	9538.13	63.57	299.00	5288.14	61.91	4249.99	13.54	1.20	0.00	148.06	

Pass Streams (mg/l as Ion)						
Name	Feed	Adjusted Feed		Concentrate	Permeate	
		Initial	After Recycles		Stage 1	Total
NH4+ + NH3	0.20	0.22	0.23	0.42	0.02	0.02
K	422.15	422.15	433.36	779.83	2.26	2.26
Na	11656.38	11656.38	11966.18	21541.04	52.44	52.44
Mg	1358.23	1358.23	1394.45	2514.07	1.35	1.35
Ca	504.21	504.21	517.66	933.29	0.49	0.49
Sr	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.54	0.54	0.55	1.00	0.00	0.00
CO3	29.38	29.38	30.27	56.21	0.00	0.00
HCO3	136.36	136.36	139.84	249.00	0.96	0.96
NO3	4.32	4.32	4.43	7.83	0.20	0.20
Cl	20780.46	20795.35	21348.23	38436.20	86.17	86.17
F	1.76	1.76	1.81	3.25	0.01	0.01
SO4	3107.30	3107.30	3190.22	5753.13	1.26	1.26
SiO2	1.49	1.49	1.53	2.75	0.01	0.01
Boron	3.43	3.43	3.51	5.92	0.51	0.51
CO2	0.43	0.43	0.44	0.99	0.49	0.49
TDS	38022.37	38037.27	39048.80	70311.82	148.06	148.06
pH	8.20	8.20	8.20	8.18	6.45	6.45

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Reverse Osmosis System Analysis for FILMTEC™ Membranes
 Project: Chennai Projection Runs Interim Report
 ABr, GHD

ROSA 8.0.3 ConfigDB U412142_201

CASE 3

3/11/2013

Design Warnings

-None-

Solubility Warnings

Langelier Saturation Index > 0

Stiff & Davis Stability Index > 0

BaSO4 (% Saturation) > 100%

CaF2 (% Saturation) > 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Stage Details

Stage 1	Element	Recovery	Perm Flow (m³/h)	Perm TDS (mg/l)	Feed Flow (m³/h)	Feed TDS (mg/l)	Feed Press (bar)
	1	0.09	0.93	68.99	9.94	39048.80	63.57
	2	0.09	0.81	85.64	9.01	43061.13	63.27
	3	0.09	0.70	107.89	8.20	47321.48	63.00
	4	0.08	0.58	137.88	7.50	51709.64	62.77
	5	0.07	0.48	178.55	6.91	56069.41	62.57
	6	0.06	0.39	233.73	6.43	60232.25	62.38
	7	0.05	0.30	308.18	6.05	64050.35	62.21
	8	0.04	0.24	407.93	5.75	67424.61	62.06

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Scaling Calculations**CASE 3**

	Raw Water	Adjusted Feed	Concentrate
pH	8.20	8.20	8.18
Langelier Saturation Index	1.34	1.34	1.83
Stiff & Davis Stability Index	0.32	0.32	0.61
Ionic Strength (Molar)	0.79	0.79	1.50
TDS (mg/l)	38022.37	38037.27	70311.82
HCO ₃	136.36	136.36	249.00
CO ₂	0.43	0.43	0.99
CO ₃	29.38	29.38	56.21
CaSO ₄ (% Saturation)	26.07	26.38	56.19
BaSO ₄ (% Saturation)	1930.47	1952.90	4160.15
SrSO ₄ (% Saturation)	0.00	0.00	0.00
CaF ₂ (% Saturation)	207.62	207.62	1310.83
SiO ₂ (% Saturation)	0.97	1.06	1.81
Mg(OH) ₂ (% Saturation)	1.17	0.00	1.95

To balance: 14.89 mg/l Cl added to feed.

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Reverse Osmosis System Analysis for FILMTEC™ Membranes
 Project: Chennai Projection Runs Interim Report
 ABr, GHD

ROSA 8.0.3 ConfigDB U412142_201

CASE 4

3/12/2013

Project Information: Chennai Interim Report

Case-specific: 35,200mg/L

System Details

Feed Flow to Stage 1	9538.13 m³/h	Pass 1 Permeate Flow	4249.98 m³/h	Osmotic Pressure:	
Raw Water Flow to System	9239.13 m³/h	Pass 1 Recovery	46.00 %	Feed	25.15 bar
Feed Pressure	58.66 bar	Feed Temperature	28.9 C	Concentrate	47.97 bar
Flow Factor	0.81	Feed TDS	35204.48 mg/l	Average	36.56 bar
Chem. Dose (100% H ₂ SO ₄)	29.91 mg/l	Number of Elements	7680	Average NDP	20.76 bar
Total Active Area	313927.68 M ²	Average Pass 1 Flux	13.54 lmh	Power	18287.18 kW
Water Classification: Seawater with Conventional pretreatment, SDI < 5				Specific Energy	4.30 kWh/m ³

Stage	Element	#PV	#Ele	Feed Flow (m³/h)	Feed Press (bar)	Recirc Flow (m³/h)	Conc Flow (m³/h)	Conc Press (bar)	Perm Flow (m³/h)	Avg Flux (lmh)	Perm Press (bar)	Boost Press (bar)	Perm TDS (mg/l)
1	SW30XHR-440i	960	8	9538.13	58.31	299.00	5288.15	56.76	4249.98	13.54	1.20	0.00	168.93

Pass Streams (mg/l as Ion)						
Name	Feed	Adjusted Feed		Concentrate	Permeate	
		Initial	After Recycles	Stage 1	Stage 1	Total
NH4+ + NH3	0.18	0.20	0.21	0.39	0.02	0.02
K	305.82	305.82	313.93	564.60	2.02	2.02
Na	10840.13	10840.94	11128.85	20024.66	60.03	60.03
Mg	1258.15	1258.15	1291.71	2328.60	1.53	1.53
Ca	467.00	467.00	479.46	864.34	0.56	0.56
Sr	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.50	0.50	0.51	0.93	0.00	0.00
CO3	30.02	2.19	2.26	7.24	0.00	0.00
HCO3	126.31	145.75	149.32	261.94	1.24	1.24
NO3	4.00	4.00	4.10	7.21	0.23	0.23
Cl	19249.26	19251.16	19762.66	35566.72	98.07	98.07
F	1.63	1.63	1.67	3.01	0.01	0.01
SO4	2878.34	2907.64	2985.25	5383.27	1.45	1.45
SiO2	1.38	1.38	1.42	2.55	0.01	0.01
Boron	3.18	3.17	3.24	5.31	0.66	0.66
CO2	0.37	6.75	6.93	8.87	7.36	7.36
TDS	35180.87	35204.48	36139.86	65045.80	168.93	168.93
pH	8.20	7.00	7.00	7.18	5.36	5.36

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Reverse Osmosis System Analysis for FILMTEC™ Membranes

Project: Chennai Projection Runs Interim Report

ABr, GHD

ROSA 8.0.3 ConfigDB U412142_201

CASE 4

3/12/2013

Design Warnings

-None-

Solubility Warnings

Langlier Saturation Index > 0

BaSO4 (% Saturation) > 100%

CaF2 (% Saturation) > 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Stage Details

Stage 1	Element	Recovery	Perm Flow (m³/h)	Perm TDS (mg/l)	Feed Flow (m³/h)	Feed TDS (mg/l)	Feed Press (bar)
1		0.10	0.95	77.55	9.94	36139.86	58.31
2		0.09	0.82	96.91	8.99	39933.05	58.03
3		0.09	0.70	122.93	8.17	43946.38	57.78
4		0.08	0.58	158.24	7.47	48057.19	57.57
5		0.07	0.47	206.25	6.88	52109.18	57.37
6		0.06	0.38	271.70	6.41	55943.94	57.20
7		0.05	0.30	360.48	6.03	59425.68	57.04
8		0.04	0.23	479.46	5.74	62468.68	56.89

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Chennai - 600 002

Scaling Calculations

CASE 4

	Raw Water	Adjusted Feed	Concentrate
pH	8.20	7.00	7.18
Langelier Saturation Index	1.36	0.22	0.91
Stiff & Davis Stability Index	0.36	-0.78	-0.32
Ionic Strength (Molar)	0.73	0.73	1.38
TDS (mg/l)	35180.87	35204.48	65045.80
HCO ₃	126.31	145.75	261.94
CO ₂	0.37	6.75	8.87
CO ₃	30.02	2.19	7.24
CaSO ₄ (% Saturation)	23.83	24.08	51.28
BaSO ₄ (% Saturation)	1768.28	1786.55	3786.83
SrSO ₄ (% Saturation)	0.00	0.00	0.00
CaF ₂ (% Saturation)	164.94	164.94	1039.99
SiO ₂ (% Saturation)	0.84	1.04	1.92
Mg(OH) ₂ (% Saturation)	1.08	0.00	0.02

To balance: 0.81 mg/l Na added to feed.



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Annexure-9

Hydraulic Cal for Product Water Main



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Pump Head Calculation

I. Headloss in pipeline

Frictional Headloss $hf = [L * (Q/CR)^{1.81}]/(994.62D)^{4.81}$ (by using Modified Hazen William's Formula)

where CR =

S. No.	Stretch (Chainage) (in Km)		Description	Unit	Quantity
	From	To			
1	0.00	7.00	Length	Km	7.00
			Flow (Q)	MLD	400
			Flow (Q)	cumecs	4.63
			Velocity (as considered for pipeline design)	m/s	1.47
			Diameter of pipe (D)	m	2.00
			Diameter of pipe (D) provided	m	2.00
			Frictional Headloss (hf)	m	4.41
			G.L. (start)	m	3.00
			G.L. (stop)	m	18.00
			Static Head	m	-15.00
			Losses at Bends, TEEs and other fittings etc. (5%)	m	0.75
			Total Head	m	-9.84
2	7.00	11.00	Length	Km	4.00
			Flow (Q)	MLD	400
			Flow (Q)	cumecs	4.63
			Velocity (as considered for pipeline design)	m/s	1.47
			Diameter of pipe (D)	m	2.00
			Diameter of pipe (D) provided	m	2.00
			Frictional Headloss (hf)	m	2.52
			G.L. (start)	m	18.00
			G.L. (stop)	m	3.00
			Static Head	m	15.00
			Losses at Bends, TEEs and other fittings etc. (5%)	m	0.75
			Total Head	m	18.27
3	11.00	25.00	Length	Km	14.00
			Flow (Q)	MLD	380
			Flow (Q)	cumecs	4.40
			Velocity (as considered for pipeline design)	m/s	1.4
			Diameter of pipe (D)	m	2.00
			Diameter of pipe (D) provided	m	2.00
			Frictional Headloss (hf)	m	8.04
			G.L. (start)	m	3.00
			G.L. (stop)	m	19.00
			Static Head	m	-16.00
			Losses at Bends, TEEs and other fittings etc. (5%)	m	0.80
			Total Head	m	-7.16
4	25.00	34.00	Length	Km	9.00
			Flow (Q)	MLD	380
			Flow (Q)	cumecs	4.40
			Velocity (as considered for pipeline design)	m/s	1.4
			Diameter of pipe (D)	m	2.00
			Diameter of pipe (D) provided	m	2.00
			Frictional Headloss (hf)	m	5.17
			G.L. (start)	m	19.00
			G.L. (stop)	m	11.00
			Static Head	m	8.00
			Losses at Bends, TEEs and other fittings etc. (5%)	m	0.40
			Total Head	m	13.57

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S. No.	Stretch (Chainage) (in Km)		Description	Unit	Quantity		
	From	To					
5	34.00	39.00	Length	Km	5.00		
			Flow (Q)	MLD	308		
			Flow (Q)	cumecs	3.56		
			Velocity (as considered for pipeline design)	m/s	1.4		
			Diameter of pipe (D)	m	1.80		
			Diameter of pipe (D) provided	m	1.80		
			Frictional Headloss (hf)	m	3.26		
			G.L. (start)	m	11.00		
			G.L. (stop)	m	22.00		
			Static Head	m	-11.00		
			Losses at Bends, TEEs and other fittings etc. (5%)	m	0.55		
			Total Head	m	-7.19		
6	39.00	42.00	Length	Km	3.00		
			Flow (Q)	MLD	235		
			Flow (Q)	cumecs	2.72		
			Velocity (as considered for pipeline design)	m/s	1.35		
			Diameter of pipe (D)	m	1.60		
			Diameter of pipe (D) provided	m	1.60		
			Frictional Headloss (hf)	m	2.11		
			G.L. (start)	m	22.00		
			G.L. (stop)	m	27.00		
			Static Head	m	-5.00		
			Losses at Bends, TEEs and other fittings etc. (5%)	m	0.25		
			Total Head	m	-2.64		
7	42.00	43.50	Length	Km	1.50		
			Flow (Q)	MLD	139.4		
			Flow (Q)	cumecs	1.61		
			Velocity (as considered for pipeline design)	m/s	0.8		
			Diameter of pipe (D)	m	1.60		
			Diameter of pipe (D) provided	m	1.60		
			Frictional Headloss (hf)	m	0.41		
			G.L. (start)	m	27.00		
			G.L. (stop)	m	39.00		
			Static Head	m	-12.00		
			Losses at Bends, TEEs and other fittings etc. (5%)	m	0.60		
			Total Head	m	-10.99		
8	43.50	60.00	Length	Km	16.50		
			Flow (Q)	MLD	139.4		
			Flow (Q)	cumecs	1.61		
			Velocity (as considered for pipeline design)	m/s	0.8		
			Diameter of pipe (D)	m	1.60		
			Diameter of pipe (D) provided	m	1.60		
			Frictional Headloss (hf)	m	4.51		
			G.L. (start)	m	39.00		
			G.L. (stop)	m	13.00		
			Static Head	m	26.00		
			Losses at Bends, TEEs and other fittings etc. (5%)	m	1.30		
			Total Head	m	31.81		
			Total Head losses	m	26.00		
II. Headloss at critical point (at Chainage 42 Km) to enable water delivery to bulk supply user's storage				m	47.00		
II. Headloss at pumping station for entry, exit, bends, valves etc.				m	5.00		
				Total Head required	78.00		

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Annexure-10

Price Breakup



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Chouqui - 600 007
Exhibition
of modern
art
in
the
city
of
Beirut
Beirut
Lebanon

S. No.	Item	Cost based on SoR 2016-17 in Crore
A.		
A1.	Intake and Outfall System comprising of offshore intakes, pipelines, screens, intake pumping and associated piping.	57.46
A2.	Pre-Treatment System complete including all piping and dosing system.	246.62
A3.	Reverse Osmosis and associated RO feed tank and Cleaning in Place (CIP).	101.00
A4.	Re-Carbonation and Re-Mineralization system	22.23
A5.	Treated Water Sump and Pump House	30.21
A6.	Site Development (Site Grading Filling and Compaction to FGL of +6.5 m)	5.83
A7.	Roads, drains, Landscaping and Compound Wall with fencing	15.46
A8.	Building including administrative building, Maintenance Workshop, guard room.	7.64
A9.	Main receiving substation building for 110/11 KV Electrical substation within the plant	5.01
I	Subtotal – I (A1 to A9)	491.42
B.		
B1.	EME for Intake and Outfall System comprising of offshore intakes, pipelines, screens, intake pumping and associated piping.	207.64
B2.	EME for Pre-Treatment System complete including all piping and dosing system.	329.00
B3.	EME for Reverse Osmosis and associated RO feed tank and CIP.	586.00
B4.	EME for Re-Carbonation and Re-Mineralization system	51.00
B5.	EME for Treated Water Sump and Pump House	12.55
B6.	EME for Facilities for External Conveyance of Product Water Pipe/main	514.00
B7.	EME for Building including administrative building, Maintenance Workshop, Guard room.	0.062
B8.	110/11 KV Electrical Substation within the plant	25.65
B9.	TNEB 230/110 KV electrical Substation	112.50
II	Subtotal - II (B1 to B9)	1838.72

C	Construction of Pumping Stations and Reservoirs	28.75																						
	Improvement of the existing water distribution networks																							
	<table border="1"> <thead> <tr> <th>Item</th><th>Cost</th></tr> </thead> <tbody> <tr> <td>Reinforcement of the existing water distribution networks (101km, D100-600)</td><td>535,863,753</td></tr> <tr> <td>Reinforcement of storage capacity by UGT (1 location, 4.33 ML)</td><td>27,426,333</td></tr> <tr> <td>Reinforcement of storage capacity by ESRs (14 locations, 49.32 ML)</td><td>1,256,762,954</td></tr> <tr> <td>Replacement of existing pipes (375 km, D100-450)</td><td>1,606,602,678</td></tr> <tr> <td>Installation of supplementary pipes (113 km, D100-300)</td><td>455,692,474</td></tr> <tr> <td>Setup of DMAs</td><td>94,765,863</td></tr> <tr> <td>Replacement and new installation of service connections including water meters (in the section for above works) Nos. 185,496</td><td>1,156,641,758</td></tr> <tr> <td>Installation of water meters (for 100% metering in the Corporation) Nos 614,029</td><td>1,271,042,100</td></tr> <tr> <td>Total</td><td>6,404,797,914</td></tr> <tr> <td colspan="2">Total cost - 640.47 crore</td></tr> </tbody> </table>	Item	Cost	Reinforcement of the existing water distribution networks (101km, D100-600)	535,863,753	Reinforcement of storage capacity by UGT (1 location, 4.33 ML)	27,426,333	Reinforcement of storage capacity by ESRs (14 locations, 49.32 ML)	1,256,762,954	Replacement of existing pipes (375 km, D100-450)	1,606,602,678	Installation of supplementary pipes (113 km, D100-300)	455,692,474	Setup of DMAs	94,765,863	Replacement and new installation of service connections including water meters (in the section for above works) Nos. 185,496	1,156,641,758	Installation of water meters (for 100% metering in the Corporation) Nos 614,029	1,271,042,100	Total	6,404,797,914	Total cost - 640.47 crore		
Item	Cost																							
Reinforcement of the existing water distribution networks (101km, D100-600)	535,863,753																							
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Total	6,404,797,914																							
Total cost - 640.47 crore																								
III	Subtotal - III (C&D)	669.23																						
E																								
E1.	Erection cost @5%	60.62																						
E2.	Testing and Commissioning @5% on B1 to B5 ,B7 and B8	60.62																						
E3.	Contractors overhead and profit @15% on A& B (Excluding B6 ,B8 and B9)	251.72																						
E4	Provision for physical contingencies @ 5%	86.60																						
E5.	Project Management Consultancy @ 5%	86.60																						
IV	Subtotal - IV (E1 to E5)	546.17																						
F	Price escalation @ 13.61% (Construction cost excluding contingencies)	-																						

G	Administration Cost @ 1.0% (Construction cost of Eligible (excluding EB substation), Non-eligible(Distribution Improvements) and PMC works)	14.43
H	Interest during construction	-
I	Front End Fee @ 0.2% on eligible portion	-
J		
J1.	External Conveyance of shifting utility along Product Water Pipe/main .	2.57
J2.	shifting utility along Improvement of the existing water distribution networks.	3.20
K	Dispute Resolution Board cost	-
V	Subtotal-V (F to K)	20.20
M	Goods and Services Tax (GST @ 12 %)	346.42
Grand Total of I,II,III, IV,V Total Cost of the project		3912.16

Executive Engineer (Desai)
Chennai Metropolitan Water Supply &
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Chennai - 600 002.

SUMMARY CIVIL WORK COST ESTIMATE FOR 400 MLD SWRO

Item	INR
Site Development (Site Grading Filling and Compaction to FGL of +6.5 m) only for plant build up area	5,83,95,000
RO Building	89,43,62,843
Potabilization and Disinfection	22,23,22,647
All Water Tanks	53,69,53,529
All Other Buildings	12,65,83,166
Pre-treatment and offshore intake, intake pump house	2,92,09,77,799
Roads, drains, and Compound Wall with fencing	15,46,21,008
Total of Civil	4,91,42,15,993



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CIVIL WORK COST ESTIMATE FOR 400 MLD

400 MLD SEA WATER REVERSE OSMOSIS PLANT AT PERUR, ECR CHENNAI			Compound wall	Roads + Pathways	Rain water Harvesting	Landscaping	Site Filling	Remarks	
Sr. No.	DESCRIPTION	UNIT	Rate/unit	Qty	Amount	Qty	Amount	Qty	Amount
1.00	Roads + Pathways	M2	2,000.00	38,170.80	76,341,600.00				
2.00	Road Drains (350 mm X 350 mm)	RM	1,908.00	9,876.00	1,88,43,408.00				
3.00	Compound Wall	RM	22,860.00	2,600.00	5,94,36,000.00				
4.00	Backfilling to raise the site lve to +6.5m lvl	M3	229.00					2,55,000.00	5,83,95,000.00
	Total Amount			5,94,36,000.00	9,51,85,008.00	-	-		5,83,95,000.00

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Chennai Metropolitan Water Supply and Sewerage Board
Chennai - 600 002.

CPWD SOR 2016-17 Item No.
2.25+2.26 Pg. No.79

CIVIL WORK COST ESTIMATE FOR 400 MLD

400 MLD SEA WATER REVERSE OSMOSIS PLANT AT PERUR, ECR CHENNAI			RO BUILDING (66 W x 251.5 L)m			Reference as per CPWD SOR 2016-17		Reference as per CMWSSB 2016-17
SLNo	DESCRIPTION	UNIT	Rate/unit	Qty	Amount			
1.00	Excavation in soft/sandy soils including dewatering, disposal of excavated earth up to 1 Km	M ³	122.40	5,796.67	7,09,512.97			Schedule No. 31 Pg. No. 35
0.20	m	M ³	134.40	3,478.00	4,67,443.84			
2.00	3.0-4.0 m	M ³	146.60	2,318.67	3,39,917.00			
2.00	P.C.C. M10	M ³	4,090.00	2,078.41	85,00,687.29			Item No. 4.10 Pg. No. 94
3.00	450 Dia Pile	RM	4,970.00	14,220.80	7,06,77,376.00			
4.00	Concrete	M ³	7,523.55	0.00	0.00			
	(a) M35 WITH W.P.C. (Water and non water Retaining Structures)	M ³	7,386.83	22,106.22	16,32,94,773.93			Item No. 5.33.2+5.34.2+5.35 Pg. No. 102
	(b) M30 For Building	M ³	888.00	1,22,026.33	10,83,59,381.88			Item No. 5.33.2+5.34.1+5.35 Pg. No. 102
5.00	Fusion bonded epoxy painted Steel Reinforcement/j/c cutting,bending and placing)	MT	74,700.00	2,546.64	19,02,33,744.46			Item No. 4.19.2 Pg. No. 95 + Item No. 22 a Pg. No. 91
6.00	Formwork(Steel/WP Ply)	M ²						Item No. 4.20 Pg. No. 95
	(a)Plane	M ²						Item No. 4.17 Pg. No. 90
7.00	Plinth Protection 750 mm wide all around the building	RM	450.35	730.25	3,28,868.09			
9.00	250 x 150 mm deep Drain along plinth protection	RM	810.00	733.70	5,94,297.00	RA		
10.00	DPC - 50 MM THK 1:2:4	RM	460.10	730.25	3,35,988.03	item No. 4.11, 4.12, 4.13 Pg. No. 90		
11.00	Outside plastering - 20 thk. (1:4) WITH W.P.C	M ²	304.00	5,111.75	15,53,972.00			Item No. 11.7 Pg. No. 104
12.00	Inside plastering - 20 thk. (1:3) WITH W.P.C	M ²	322.00	7,301.35	23,51,634.70			Item No. 11.6 Pg. No. 104
13.00	Aluminum Doors /windows	M ²	6,600.00	2,290.66	1,51,18,369.20			Item No. 6 Pg. No. 124
14.00	Rolling shutter(MS epoxy painted)	M ²	5,080.00	46.00	2,33,680.00			Item No. 5 Pg. No. 124
15.00	Steel ventilators	M ²	3,297.00	572.67	18,88,078.15			Item No. 1 Pg. No. 121
16.00	OBD - Internal walls	M ²	76.00	12,413.10	9,43,395.60			Item No. 13.6 Pg. No. 105
17.00	cPVC Rainwater pipes (100 dia)	RM	985.00	759.00	7,47,615.00	item No. 8544 Pg. No. 317		
18.00	Structural steel	MT	67,600.00	4,387.25	29,65,78,100.00	item No. 10.6 Pg. No. 182		
19.00	Roof Sheetings - Recycled sheets	M ²	550.40	26,369.79	1,45,13,931.04	item No. 12.5 Pg. No. 216		
20.00	Marble mosaic tiles flooring/Granolithic Flooring	M ²	1,522.60	1,400.00	21,31,640.00	item No. 11.23.2 Pg. No. 194		
21.00	Rubble soiling	M ³	499.65	4,390.44	21,93,681.10	item No. 16.11 Pg. No. 266		
22.00	230 thk Brickwork (1:3)	M ³	6,273.00	1,428.43	89,60,555.50			Item No. 5.19 Pg. No. 99
23.00	Hand Rail SS	kg	472.40	7,000.00	33,06,800.00	item No. 10.28 Pg. No. 185		
	Total Amount				89,43,62,842.79			


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Chennai Sewerage Board
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CIVIL WORK COST ESTIMATE FOR 400 MLD

400 MLD SEA WATER REVERSE OSMOSIS PLANT AT PERUR, ECR CHENNAI				POTABILISATION		POST & PRE CHLORINATION BUILDING (21 W x 24 L)m		Reference as per CPWD SOR 2016-17	Reference as per CMWSSB 2016-17
SLNO	DESCRIPTION	UNIT	Rates/unit	Qty	Amount	Qty	Amount		
1.00	Excavation in soft/sandy soils including dewatering, disposal of excavated earth up to 1 Km								
	0-2.0 m	M3	122.40	838.62	1,02,647.48	961.54	1,17,692.98		
	2.0-3.0 m	M3	134.40	503.17	67,626.58	576.93	77,538.90		
	3.0-4.0 m	M3	146.60	335.45	49,176.87	384.62	56,384.94		
2.00	P.C.C. M10	M3	4,090.00	432.13	17,67,419.26	171.28	7,00,517.00		
3.00	450 Dia Pile	RM	4,970.00	13,560.75	67,39,927.50				
4.00	Concrete								
	(a) M35 WITH W.P.C (Water and non water Retaining Structures)	M3	7,523.55						
	(b) M30 For Building	M3	7,386.83	4,860.96	35,90,061.47	1,181.07	87,24,343.61		
5.00	Fusion bonded epoxy painted Steel Reinforcement(i/c cutting,bending and placing)	MT	#####	588.39	4,39,52,547.46	142.97	1,06,79,963.99		
6.00	Formwork(Steel/WP Ply)	M2							
	(a)Plane	M2	888.00	29,165.76	2,58,99,195.33	7,148.57	63,47,930.40		
7.00	Plinth Protection 750 mm wide all around the building	RM	450.35	1,027.00	4,62,509.45	188.80	85,027.16		
8.00	Sand Bitumen Pad	M2	590.00	1,570.21	9,26,423.90				
9.00	250 x 150 mm deep Drain along plinth protection	RM	810.00	315.10	2,55,231.00	197.43	1,59,916.19		
10.00	DPC - 50 MM THK 1:2:4	RM	460.10	391.00	1,79,899.10	188.80	86,867.98		
11.00	Outside plastering - 20 thk. (1:4) WITH W.P.C	M2	304.00	2,018.02	6,13,478.08	1,198.30	3,64,283.20		
12.00	Inside plastering - 20 thk. (1:3) WITH W.P.C	M2	322.00	1,366.20	4,39,916.40	1,750.30	5,63,596.60		
13.00	Ceiling plastering - 6 thk (1:3)	M2	205.20	1,843.16	3,78,216.85	1,154.33	2,36,868.37		
14.00	Aluminum Doors /windows	M2	6,600.00	74.52	4,91,832.00	120.06	7,92,396.00		
15.00	Rolling shutter(MS epoxy painted)	M2	5,080.00			42.32	2,14,985.60		
16.00	Steel ventilators	M2	3,297.00	14.90	49,138.49	30.02	98,959.46		
17.00	Ceiling - OBD	M2	74.00	1,843.16	1,36,394.03	1,154.33	85,420.37		
18.00	OBD - Internal walls	M2	76.00	3,384.22	2,57,200.72	1,750.30	1,33,022.80		
19.00	cPVC Rainwater pipes (100 dia)	RM	985.00	527.85	5,19,932.25	241.50	2,37,877.50		
20.00	Roof treatment	M2	459.65	1,567.16	7,20,346.24	1,154.33	5,30,587.46		
21.00	Acid Alkal Floor	M2	1,073.35			1,191.40	12,78,789.19		
22.00	Non Skid Ceramic tile Flooring	M2	660.20	731.40	4,82,870.28				
23.00	Rubble soling	M3	499.65	484.15	2,41,905.55	200.10	99,979.97		
24.00	230 thk Brickwork (1:3)	M3	6,273.00	450.21	28,24,189.29	287.50	18,03,487.50		
25.00	115 thk Brickwork (1:3)	M3	7,877.00	12.65	99,644.05				
26.00	Cement wash (2 coats)	M2	92.00			1,198.30	1,10,243.60		
27.00	Sand filling	M3	594.00	242.08	1,43,792.55	100.05	59,429.70		
28.00	Fencing	RM	819.00	124.20	1,01,719.80				
29.00	Hand Rail SS	kg	472.40	5,500.00	25,98,200.00				
30.00	IPS Flooring	M2	1,883.00	855.60	16,11,094.80				
	Total Amount				18,86,76,536.86		3,36,46,110.46		

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