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Underground Drainage System for Flood Mitigation for Mumbai Region

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Abstract- *It has been observed that, the amount of rainfall precipitation at the sea side city like Mumbai is being increasing every year. The urbanization, deforestation, replacing the soil pavements with bituminous and concrete pavements have resulted in the infiltration capacity of the Mumbai Region to reduce to an almost negligible extent. As the infiltration capacity is reduced, all the excess water present turns into runoff and escapes through the drainage system. As a direct result, the load on the drainage system increases tremendously. The present system of drainage of rain water is not effective. The drainage system designed for Mumbai city was constructed in pre-independence era with rainfall consideration of 25 mm/hour. Since water logging continues to be a big problem for the city every year. This has caused heavy loss of property and also the affected the social and economic prospects of the city. Along with the floods there is a huge risk of loss of human life. All over the world countries have already taken innovative steps for controlling high water discharge in their regions. This paper provides for best possible solution for the flood problem of Mumbai Region with the construction of underground tunnel for conveyance of water. The possible locations of surge and discharge tanks are identified and this will help us to tackle the flooding issue.*
Key words-*Underground tunnel, Floods, Drainage system, Surge tank, Discharge tank*

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I. Introduction

Flooding usually occurs as an overflow of water from aquatic bodies, such as a river, lake, or ocean, in which the water escapes by exceeding its usual boundaries, or it may occur due to an accumulation of rainwater on saturated ground and it does not get infiltrated and escapes as run-off. While the size of a lake or any other similar aquatic body will vary with seasonal change in precipitation and snow melt, these changes in size are unlikely to be considered significantly unless its flood property or drown domestic animals. The melting of ice sheets due to global warming in Green land and Antarctica is a major contributor to sea level rise. The study carried in the Journal Science Advances predicts that the glacial melt over next 100 years would push Mumbai's sea levels by almost 15.26cm. Urban cities like Mumbai, New York and other similar cities are believed to be the most vulnerable due to their huge populations, presence of huge aquatic bodies and rapid urbanization. The findings are based on a forecasting tool which was developed by the United States Space Agency Jet Propulsion Laboratory. The floods are the most dangerous natural disaster and cause a huge loss of lives, property and money. Almost every year it strikes one or the other coastal regions of India and put the place at high risk. The flood in Mumbai in the near future is very high as it can be confirmed from the flooding that occurred during the recent monsoon and post monsoon floods. Being financial capital of India, it is very important to safe guard the city from any suspected risks. This can be done by building underground reservoir connected by tunnels, for storage of excess water. This project throws light on this system that can be implemented for mitigating the floods.

II. Literature Review

[1]**W. H. Hager, M. ASCE and R. Sinniger** (1985) found Flood storage in reservoirs. It was found by controlling the free-overflowing, rectangular spillways. It was investigated by accounting for arbitrary reservoir bathymetry and single peaked inflow hydrographs. Storage factor was found as the general solution of the storage equation. It is found that adequate substitution of the effective hydrograph by a model hydrograph has only a secondary effect on the maximum reservoir outflow when using a proper shape factor. The proposed method by them allowed an immediate application to the practical cases in reality.

[2]**S.S. Shahapure, T.I. Eldho and E.P. Rao** (2011) derived a rainfall runoff model for a coastal urban watershed considering the effects of tidal variations using Finite Element Method (FEM). Slope values for the overland flow region were determined by them using the Geographical Information System (GIS) from the digital elevation model (DEM) of the area. The land usage is determined by the Remote Sensing. The model could satisfactorily predict the runoff due to monsoon rains coupled with tidal variations.

[3]**Marie Thomas , Makiko Obana, TetsuroTsujimoto** (2015) compared the Tokai Flood (2000) and Shonai Flood (2015) and found that these two events had the same type of hazards in intensity and location, allowing the study in the terms of adaptation to flood disaster in the river basin to focus on the structural and nonstructural efforts to increase resilience of the disaster dependent on time .

[4]**Di Dunlop** (2015) gave us idea about the various mitigation measures present in Tokyo and also the various natural conditions existing in Tokyo city, Japan.

[5]**P.E. Zope, T.I. Eldho, V. Jothiprakash**. (2016) found that the total flood hazard area is increased by 22.27 %. They developed plains of floods and mapped the hazardous region impacted by the floods which could be used by the local authorities to prepare for flood mitigation and early evacuation management plans during heavy floods and as criteria for insurance of any property by insurance organizations.

[6]**P.E. Zope, T.I. Eldho, V. Jothiprakash** (2016) found that for the appropriate design and the planning of the urban drainage system in an area, Intensity Duration Frequency (IDF) curves for a given rainfall conditions are required. IDF curves give good results in the changing hydrological conditions and are compatible even with extreme rainfall.

[7]**Kazuaki Ohtsuki, Yasuo Nihei** (2017) studied the Kinugawa River's flood disaster (2015) and this study focused on the flood behavior in the area, in particular, the effect of a small drainage channel around the flooding region which resulted in the faster diffusion of flood which occurred due to overflowing of river.

Findings from Literature survey:

1. It is clearly observed that as the urbanization has increased, the infiltration has decreased and thereby increasing the chance of flooding.
2. The cities like Tokyo having good mitigation measures for flood like advanced drainage system can sustain extreme rainfall and tidal conditions more efficiently and the chances of disaster situation are reduced considerably.
3. With the help of technologies like FEM, GIS and DEM, the runoff data can be obtained successfully.
4. As the extremities faced in rainfall for a coastal city like Mumbai are somewhat similar to a city like Tokyo, we can try to implement measures for mitigation and prevention of flood conditions in Mumbai like them.

Case Study and Data Collected:

The case studies include various information of the most efficient and innovative storm water management projects carried out in various countries all around the globe. The case study of the following projects has been done:

1. SMART Tunnel- Kuala Lumpur, Malaysia
2. Temple Tunnel- Tokyo

SMART TUNNEL- KUALA LUMPUR, MALAYSIA

Introduction:

The Storm water Management And Road Tunnel (SMART Tunnel), is a storm drainage and road structure inKuala Lumpur,Malaysia. It is a majornational projectin the country. The 9.7 km (6.0 mi) tunnel is the longeststorm waterdrainage tunnelinSouth East Asiaand second longest in Asia. Fig.1 shows the SMART

Fig 1. Entry and Exit points of SMART

The main objective of the SMART system is to solve the problem offlash floodsin Kuala Lumpur and also to reduce heavy traffic jams along Jalan Sungai Besi and Loke Yew flyover at Pudu during rush hour. There are two components of this tunnel, the stormwater tunnel and motorway tunnel as shown in fig.2. It is the longest multi-purpose tunnel in the world and is an engineering marvel.

Fig 2. Animated view of SMART tunnel

Functioning:

In the first mode, as there is no storm, the flood water will not be diverted into the system. As the second mode is activated, flood water entering the system is diverted into the bypass tunnel underneath the motorway tunnel. In the second stage, the motorway section is still open to traffic. The motorway will be closed to all traffic when the third mode is in operation. After confirming that all the vehicles have exited the motorway, automated water-tight gates will be then opened to allow flood waters to pass through. After the termination of flood, the tunnel is verified and cleaned via pressure-washing, and the motorway will be accessible to the traffic within 48 hours of closure.

Technical specifications:

- Storm water tunnel
- *Construction cost*: RM(Malaysian Ringgit) 1,887 million- (US$514.6 million)
- *Storm water tunnel length*:9.7 km (6.0 mi)
- *Diameter:* 13.2 m (43.3 ft.) (outer diameter)
- *Tunneling method*:Tunnel Boring Machine(TBM)
- *TBM type*: Slurry shield Motorway tunnel
- *Motorway tunnel length:* 4 km (2.5 mi)
- *Structure type:* Double Deck
- *Ingress and egress:* 1.5 km (0.93 mi) at Jalan Sultan Ismail and JalanImbi
- *Length:* 1.4 km (0.87 mi) at Jalan Tun Razak
- *Links*: 1.6 km (0.99 mi) atKuala Lumpur–Seremban ExpresswayLinks: City Centre near Kg. Pandan Roundabout KL–Seremban Expressway nearSungai Besi Airport

Features:

- Longest tunnel in Malaysia.
- 9.7 km (6.03 miles) stormwater by-pass tunnel.
- 4 km (2.49 miles) double-deck motorway within stormwater tunnel.
- The motorway tunnel is suitable for light vehicles only. Motorcycles and heavy vehicles are not allowed.
- Ingress and egress connections to the motorway tunnel linking the southern gateway to the city centre.
- Holding basin complete with diversion and tunnel intake structures.
- Storage reservoir and a twin-box culvert to release flood discharge.
- State-of-the-art operations control room equipped with the latest systems in operations management, surveillance and maintenance of the SMART system.
- Custom-madefire engineunits consisting of two modifiedToyota Hiluxpickup trucks, parked at two different locations for quick access to the tunnel in case of fire on both carriageways.

TEMPLE TUNNEL- TOKYO

Introduction:

Since early ages the rivers running into Tokyo Bay paved its course through nature and (in recent centuries) agricultural land. However, gradually since the mid-1950s, this land has undergone massive urbanization – a tenfold increase from 5% in 1955 to over 50% today. This has been primarily at the expense of rice fields and other agricultural land, which is used to absorb most of the rainfall in the area. Of course, as concrete replaced earth, the amount of run-off increased and the drainage systems built earlier were simply not

enough to sustain the humungous volumes of water falling during the typhoon and rainy season, which, with each passing year, had less soil available to soak into due to increased concretization and urbanisation. As a result, six major floods in the 1980s and 1990s hugely affected the area. Out of the six, two floods caused major damage to approximately 30,000 homes. Japanese ingenuity came to the rescue and they soaked up 17 years and 2 billion dollars, and constructed the "Tokyo Tunnel". The Water Discharge Tunnel on the Outskirts of the Metropolitan
Area project is commonly referred to as "G-Cans" for short, shown in fig.3, from the Japanese gesuikanaru, meaning "drainage canal". It is the biggest man-made drain in the world and is truly a engineering marvel.

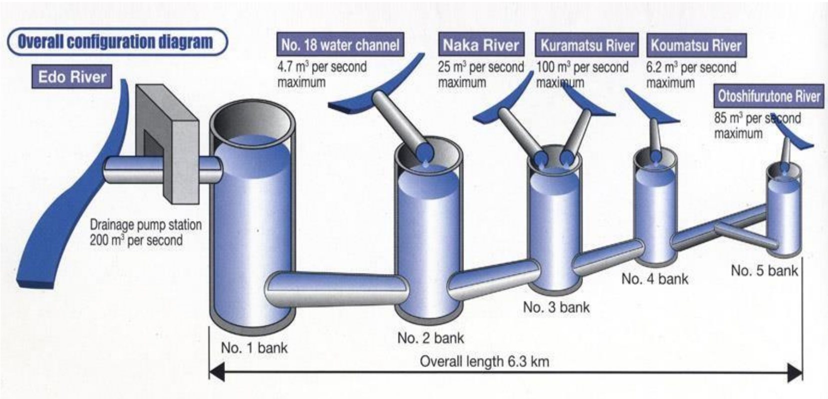

Fig.3 Overall configuration of Temple

Functioning:

The aim was simple: to take all the excess precipitation from disasters such as typhoons and floods away before it can cause any devastating impact. They implemented the project by construction of a big drain. However, the enormity and engineering complexity of the construction is staggering (fig.4)

Fig.4 Interior of Temple Tunnel

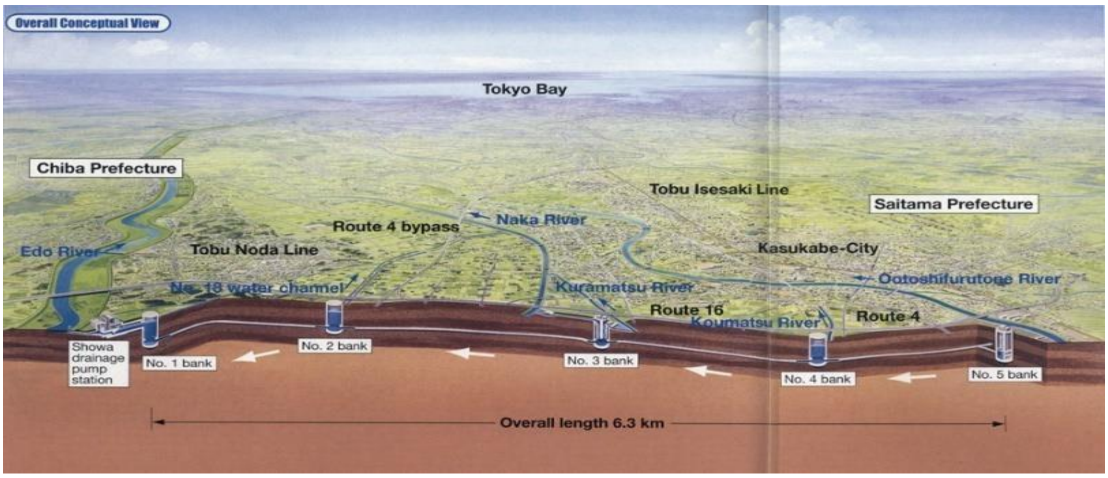

Fig.5 Overall conceptual view of Tokyo Tunnel

A series of 5 giant sinkholes, as shown in fig.5, has been dug into the ground, each designed to catch the runoff and overflow from nearby rivers. The sinks range up to 74 m in height and 32 m diameter. That is big enough to house a Space Shuttle or one and a half Statues of Liberty with plenty of room to spare. During heavy precipitation and typhoons, lots of flood water and rainwater pours down these sinkholes and falls into the next marvelous engineering structure – a giant concrete pipeline which acts as an "underground river" transporting the water more than 6.3 km through a tunnel 50 m below the river basin. Finally, the water reaches the

"Underground Parthenon", an incredible subterranean reservoir almost 180m long, 80m wide and 18m high. From there, modified jet engine turbines pump the water out into the nearby Edogawa (Edo River) at the massive rate of 200 tonnes per second through sluiceways which are large enough to comfortably fit almost the entire carriages of metro trains.

Importance:

Overall, the Water Discharge Tunnel on the Outskirts of the Metropolitan Area is estimated to reduce the potential flood impact on buildings, homes and urban areas by over 80%. Tested many times during high precipitations and disasters over the last few years since completion, it has clearly proven its value by reducing the loss of human life significantly. Rainfall levels which previously devastated thousands of homes now affect almost less than hundreds.

Specifications:

- Discharge received through intakes at surge tank – 221 m^3/sec
- Total storm water storage capacity – 6,70,000 m^3

COMPARISON BETWEEN TOKYO AND MUMBAI:

Table 1: Comparison between Mumbai & Tokyo

Point	Tokyo	Mumbai
Population	Metropolis- 13,617,445	Mega- 12,442,373
	Metro- 37,800,000	Metro- 18,414,288
Area	Metropolis- 2187.66 sq.Km	Mega- 603 sq.Km
	Metro- 13,572.00 sq.Km	Metro- 4365 sq.Km
Population Density	Metropolis- 6224 /sq.Km	Mega-210000/sq.Km
GDP	US $2.5 Trillion	US $0.368 Trillion
Avg. Annual Rainfall	(1528.8 mm + 110 mm) (Chiyodaward)	2514 mm
	1623 mm (Okatama)	
Avg. rainy days in year	(114 + 9.7) days (Chiyodaward)	78.9 days
Max precipitation in a single day	(114 + 9.7) days (Chiyodaward) N.A	944 mm (26th July, 2005)
		576.6 mm (5Jul1974)

MUMBAI AVAILABLE DATA RECORDS:

From the report of M.M.C known as Brihanmumbai Stormwater Disposal System (BRIMSTOWAD), report for Storm Water Drains (SWD):

- 220 to 239 drains.
- Catering area of 437.5 sq.Km.
- SWD network 100 yrs. old.
- Designated with 25 mm/hr rainfall intensity at low tide and with runoff coefficient 0.5-2000mm average rainfall receive.
- General information regarding outfalls (table 2)
- Length of Drains and Nallas (in Km) as given in table.3

Table 2: Mumbai- Outfall Information

Outfall	City	Western	Eastern	Total
Arabian Sea	107	29	-	136
Mahim Creek	4	14	8	26
Mahul Creek	4	-	6	10
Thane Creek	-	-	14	14

Table 3: Mumbai- drain and nalla lengths

Type	City	Eastern	Western	Total
Major Nalla width > 1.5m	8.545	90.2	101.509	200.254
Minor Nalla width < 1.5m	20.762	66.4	42.104	129.266
Arch/Box drains	59.2	40	51.93	151.13

Roadside open drains	20	669.48	1297.5	1986.98
No. of water entrances	27893	609	1706	30208
Closed Pipes	443.18	36.2	86.03	565.41

∴ Area covered is 437.71 sq.Km.

Areas for which system is designed are (frequently flooding area- low lying regions):

- Region near Mithi river at Dharavi.
- Hindmata and Dadar at eastern expressway.
- Matunga East side.

Tentative catchment area:

Fig 6: Location of surge tanks and discharge tanks

- Effective catchment area – 4 sq.Km (as calculated from fig.6).

Locations for surge tanks/wells:

1. Maharashtra Nature Park, Dharavi, opp. Kala Killa
2. RPF ground, near western railway colony, hanuman nagar, Matunga, Mumbai.
3. Pramod Mahajan Kala Park, SenapatiBapatmarg, Babasaheb Ambedkar nagar, Mumbai.

Location for discharge tank:

- Mahalaxmi racecourse, Worli, Mumbai.

Storm intensities with return period (mm/hr):

As per BRIMSTOWARD, 2 in 1 year return period (refer table.4) is most appropriate and the intensity thus adopted is 23.2 mm/hr (= .0232m/hr).

Table 4: Mumbai- Storm intensities with return period

Return Period	**Duration in hrs.**				
	1	2	3	4	5
1 in 10 yrs.	109	89	61.5	35.5	28
1 in 5 yrs.	91.4	70.3	51	27.6	24
1 in 2 yrs.	74	53.3	38	22.5	19.4
1 in 1 yrs.	58	40.6	30.4	18.1	16.5
2 in 1 yrs.	48	33	23.2	14.69	12
10 in 1yrs	25	17	12	7.69	5.9

Calculation for runoff:

C = Runoff coefficient = 1.0

A = Area = 64 sq.Km. = 64 x 10^6 m^2

- Max R for P = 48.00 $\frac{mm}{hr}$ (Duration = 1 hr.)

$R^1 = \frac{CAP}{3600} = \frac{0.048\times64\times10^6\times1.0}{3600}$ = 853.33 m^3/sec

- R for duration – 2 hrs , P= 33 mm/hr = 0.33 m/hr

$R^2 = \frac{CAP}{3600} = \frac{0.033\times64\times10^6\times1.0}{3600}$ = 586.667 m^3/sec

- R for duration – 3 hrs , P= 23.2 mm/hr = 0.0232 m/hr

$R^3 = \frac{CAP}{3600} = \frac{0.0232\times64\times10^6\times1.0}{3600}$ = 412.44 m^3/sec

- R for duration – 4 hrs , P= 14.69 mm/hr = 0.01469 m/hr

$R^4 = \frac{CAP}{3600} = \frac{0.01469 \times 64 \times 10^6 \times 1.0}{3600} = 261.15\ m^3/sec$

- R for duration – 5 hrs, P= 12mm/hr = 0.012 m/hr.

$R^5 = \frac{CAP}{3600} = \frac{0.012 \times 64 \times 10^6 \times 1.0}{3600} = 213\ m^3/sec$

III. Design For Underground Drainage System

Three surge tank positions:
Surge tank 'A'
Surge tank 'B'
Surge tank 'C'
Discharge tank 'D'

Table 5: Distance (horizontal) of connecting tunnel between two surge tanks.

Sr. No.	Surge Tanks	Distance of connecting tunnel (Km)
1	A to B	2.727
2	B to C	3.090
3	C to Discharge tank	3.181

Table 6: Catchment areas for individual surge tank

Sr. No.	Surge Tanks	Actual catchment areas (km^2)
1	A	12.75
2	B	12.75
3	C	8.5

Now, Considering runoff intensity **0.0232** m/hr.

Using Rational formula: Q = CiA.... (1)

1) Discharge at surge tank 'A'= $\frac{0.0232 \times 12.75 \times 10^6 \times 1.0}{3600} = 82.16\ m^3/sec$
2) Discharge at surge tank 'B'= $\frac{0.0232 \times 12.75 \times 10^6 \times 1.0}{3600} = 82.16\ m^3/sec$
3) Discharge at surge tank 'C'= $\frac{0.0232 \times 8.5 \times 10^6 \times 1.0}{3600} = 54.77\ m^3/sec$

Total Discharge= 82.16+82.16+54.77
Q_{total}= **219.097** m^3/sec

SYSTEM DESIGN:

1- To determine minimum self-cleansing velocity required

$V_s = \sqrt{\frac{8g \times k \times d' \times (G-1)}{f'}}$ .....(2)

d'= diameter grain particle; for inorganic sand d'=1 mm
k= dimensional constant
0.04= start of scouring grit/ silt
0.80= for scouring sticky grit
Generally, k= 0.04 to 0.06
G= Specific gravity = 2.65 when d'= 1mm (Inorganic sand)
= 1.2 when d'= 5 mm
f'= constant; generally taken as 0.03
g= 9.81 m/sec^2

$\therefore V_s = \sqrt{\frac{8 \times 9.81 \times 0.04 \times 0.001 \times (2.65-1)}{0.03}} =$ **0.415m/sec**

Hence, self-cleansing minimum velocity required is 0.415 m/sec.

2- For concrete lining tunnel or for concrete pipes, non-scouring limiting velocity of flow= **2.5 to 3.0** m/sec.

DESIGN OF CONNECTING TUNNEL:

1) Tunnel between surge tanks 'A' and 'B'

Q_1= 82.16 m^3/sec,

let velocity of flow= V_1= 2.5 m/sec

Cross-sectional area required= $\frac{82.16}{2.5} = 32.864\ m^2$

a) Diameter of tunnel required,

$\frac{\pi}{4} \times D^2 = 32.864\ m^2$

∴ D= 6.468 m

⇒ D≈ **6.5** m (Approximately)

b) For calculating limiting slope that must be provided between 'A' to 'B'

Using William- Hazen's formula for the flow under pressure C_H

V = 0.85 CH×r0.63 × s0.54

C_H = 110 - for concrete lining and design consideration

= 140 – new pipes or tunnels with concrete

V= 2.5 m/sec

r= $\frac{D}{4} = \frac{6.5}{4} = 1.625\ m$

∴$2.5= 0.85\times110\times1.625^{0.63}\times s^{0.54}$

⇒ $s^{0.54}=\frac{2.5}{110\times1.625^{0.63}\times0.85}$

∴⇒ s= **1 in 1441.18**

For distance 2727 m, the vertical distance becomes 1.892 m i.e.

1.892: 2727 ∷ 1: 1441.18

Hence providing vertical distance less than 1.892, i.e. provide 1.8 m.

∴ 's' becomes 1 in 1515 which is mild than 1 in 1441.18 Hence, velocity will not increase beyond 2.5m/sec.

2) For tunnel between surge tanks 'B' and 'C'.

Q_2=82.16m^3/sec

Q= Q_1 + Q_2 = 82.16 + 82.16= 164.32 m^3/sec

Let velocity of flow= V_2= 2.7 m/sec

∴ Area required, A= $\frac{Q}{V} = \frac{164.32}{2.7} = 60.859\ m^2$

a) Diameter required= 8.802 m ≈ **9** m

b) For calculating limiting slope between B to C

Using William Hazen formula

V = 0.85 CH×r0.63 × s0.54 C_H = 110 V = 2.7 m/sec

r = $\frac{9}{4} = 2.25$

⇒$2.7 = 0.85 \text{ x } 110 \text{ x } (2.25)^{0.63}(s)^{0.54}$

⇒$s^{0.54} =\frac{2.7}{110\times(1.625)^{0.63}\times0.85}$

∴⇒s = **1 in 1826.87**

For a distance of 3090 m, vertical distance required is 1.6914 m; provide vertical distance of 1.6 m

∴ 's' becomes 1 in 1931.25 which is mild slope than 1 in 1826.87

Hence, velocity will not increase beyond 2.7 m/sec

3) For connecting tunnel between surge tank C and discharge tank D

Q_3 = 54.77 m^3/sec

Q = Q_1 + Q_2 + Q_3

Q = 82.16 + 32.16 + 54.77 = 219.09 m^3/sec

Let velocity of flow V_3 = 2.8 m/sec

Area required = Q/V = 219.09/ 2.8 = 78.248 m^2

a) Diameter required = 9.981 m ≅**10** m

b) For calculating limiting slope between C and D Using William- Hazen's formula

V = 0.85 × CH × r0.63 ×s0.54

C_H = 110 V = 2.8 m/sec

r = 10/4 = 2.5

⇒$2.8 = 0.85 \times 110 \times 2.5^{0.63} \times s^{0.54}$

⇒$s^{0.54} =\frac{2.8}{110\times2.5^{0.63}\times0.85}$

∴ s = **1 in 1931.274**

For a distance of 3181 m, vertical distance required is 1.647 m.
Provide vertical distance of 1.6m
i.e. 1:1931.274::1.647:3181
Hence, providing vertical difference less than 1.647m let provide 1.5m.
∴ 's' becomes 1 in 2120.667 which is mild than 1 in 1931.274 Hence, velocity will not increase beyond 2.8 m/sec.

DIMENSIONS AND VOLUME CALCULATION:
For retaining water with Q = 219.09m^3/sec for 1 hour, required volume capacity
$V_{required}$ = 219.09 x 3600
= 7,88,749.2 m^3 (75%)
This is net volume required,
V_{net}= 7,88,749 m^3.
Considering free board in surge tank and discharge tank, volume occupied by large columns of discharge tank.
Gross volume required = (4/3) x 7,88,749.2
V_{gross} = 10,51,665.6 m^3 (100%)
We have dimensions of surge tanks and connecting tunnels

A) For surge tank – Diameter = 30 m
– Height = 65 m (min) at tank A
– Height = 65.33 m at tank B (By using slope)
– Height = 65.77 m at tank C (By using slope)

B) For connecting tunnel
1. A-B – length= 2727 m, diameter=6.5 m
2. B-C – length= 3090 m, diameter=9 m
3. C-D – length= 3181 m, diameter=10 m

Volume available = $\left[65 \times 30^2 \times \frac{\Pi}{4}\right] \times 3 + \left[2727 \times 6.5^2 \times \frac{\Pi}{4}\right] + \left[3090 \times 9^2 \times \frac{\Pi}{4}\right] + \left[3181 \times 10^2 \times \frac{\Pi}{4}\right]$
Volume available = 674740.078 m^3
∴$Volume_{required}$by discharge tank = 1051665.6 – 674740
Vrequired= 376925.6 m3
Hence, volume of discharge tank must be greater than 3,76,925.6 m^3
Provide dimensions of discharge tank as follows
Length = 250 m
Depth = 20 m
Width = 80 m
∴Volume will be = 250 × 80 × 20 = 4,00,000 m^3
4,00,000 > 3,76,925.6
Hence Okay

IV. Conclusion

Thus the underground drainage system for the Mumbai city has been designed with appropriate considerations of non scouring and non silting velocity. Also the designed system will sustain the worst combination of rainfall, since it has been designed for maximum rainfall recorded in Mumbai till date which was recorded on 26th July 2005. Total detention capacity of system is approximately around 7,90,000 m^3. The provision of the pumps and bar racks and radial gates can also be provided for future enhancement of design in the system. Also there are presence of other flood systems like MOSE, Italy but they cannot be used for a city like Mumbai as they are more suitable for lagoons. Thus, it can be finally concluded that although it can be an expensive project considering itssimilarity to Tokyo Tunnel, it can be most beneficially being installed for the safest future of our country's financial capital viz. Mumbai.

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