Sound Practice No.1

Increasing Storm Water Drainage Capacity of Mithi River and Mumbai City drains

Overview

The Mithi River flows through the city of Mumbai and forms a principal channel to discharge storm water and sewage. This Sound Practice pertains to the widening and deepening of the Mithi river and other city drains in a scientific and well planned manner. This is intended not only to increase their discharge capacity but also to prevent flooding in low-lying areas adjoining the river by reducing gradients of the Mithi river in its' upper reaches.

The storm water drainage for the Mithi river catchment areas has been disrupted due to the encroachment of hutments in large numbers, storage facilities, processing industries, workshops and scrap yards situated along the banks of the Mithi River that make it difficult even to delineate its path. Direct discharges of untreated sewage, wastewater from the unauthorized settlements, and industrial effluents along the river's course are a cause of concern.

Following the damage caused by severe floods in Mumbai in 1985, the BRIMSTOWAD Project was initiated by the Municipal Corporation of Greater Mumbai (MCGM). Engineers and Researchers, under this project, studied the storm water drainage system of Mumbai in detail and submitted a report in 1993 to MCGM giving suitable recommendations, but they largely remain unimplemented.

Mumbai was again hit by a more disastrous flood in 2005, which necessitated a fresh study on increasing storm water drainage capacity of the Mithi river and other city drains. Central Water and Power Research Station (CWPRS), Pune – Central Government's Principal Hydrological Research Institute, conducted 1-D Mathematical Model and Desk Studies for mitigating floods of the MIthi river and submitted its report with suitable recommendations in January, 2006.

MCGM and Mumbai Metropolitan Region Development Authority (MMRDA), which is a government body responsible for development of areas surrounding lower reaches of the Mithi river, have accepted almost all the recommendations and have chalked out a plan to implement them in two phases.

The first phase has been completed in June 2006. The second phase is proposed for the period from October 2006 to June 2007.

Background Information

History

Mumbai city receives seasonal rainfall for four months, from June to September. Average rainfall is 2500 mm, of which 70 per cent is during July and August. Mumbai is lined on the west by Arabian Sea and is intercepted by number of creeks (Mahim, Mahul and Thane creeks), rivers (Mithi, Dahisa, Poisar and Oshiwara rivers, and their tributaries) and a complex nallah (drain) system.

The Storm Water Drainage (SWD) system of Mumbai comprises a hierarchical network of roadside surface drains (about 2000 km length, mainly in the suburbs), underground drains and laterals (about 440 km length in the island city area), major and minor channels (200 km and 87 km length, respectively) and 186 outfalls, which discharge all the surface runoff into rivers and the Arabian Sea. Of the 186 outfalls, there are 107 major outfalls in city, which drain to Arabian Sea directly, 4 at Mahim creek and 4 at Mahul creek. There are 29 out-falls in western suburbs draining directly into sea while 14 drain into Mithi river which ultimately joins Mahim creek.

Topography of the Mithi River

The Mithi River in Mumbai city is a confluence of tail water discharges of Powai and Vihar lakes. Originating at Powai, Mithi River flows through Saki Naka, Safed Pool, around Santacruz airstrip, passing through thickly populated and industrial areas like Jarimari, Bail Bazar, old airport road, Kalina (CST road), Vakola, Bandra Kurla complex, Dharavi and meets the Arabian Sea at Mahim creek with a total length of about 17.84 km and a catchment area of 7,295 ha. It serves a duel purpose of a sewer for the area carrying sewage as well as storm water to sea. The river bed is narrow in the initial stretch but it increases downstream. The present average depth of the river at the centerline is only 5.5 m.

The topography of the river is marked by four distinct segments:

S. No.	Segment	Slope	Type of Slope
1	Origin at Powai Lake Boundary to Jogeshwari – Vikhroli Link Road	1 : 200	Steep
2	Jogeshwari – Vikhroli Link Road to Sir MV Road	1 : 450	Steep
3	Sir MV Road to CST Bridge	1 : 850	Moderate
4	CST Bridge to Mahim Causeway	1 : 4000	Flat

Importance of Mithi River

The location of the Mithi river is an important administrative boundary that divides the City and the Suburbs. Flooding in the river has direct or indirect implications for disrupting traffic on five transport corridors; Central Railway Main Line, Central Railway Harbor Line, Western Railway Line, Western Express Highway, and Eastern Express Highway.

Significance of the Problem in terms of City's Hazardscape

The core of the present SWD system in city is about 70 year old, comprising of underground drains and laterals built on the basis of population and weather conditions that existed at that time. The old SWD system is capable of handling rain intensity of 25 mm per hour at low tide. If the rain intensity is more than 25 mm per hour and high tide occurs, there is always a possibility of water logging in some parts of the city.

Since the discharge of all the storm water and treated sewage is into the Arabian Sea, tidal variation has a major bearing in the system of storm water drainage (SWD) resulting in flooding and water logging during heavy rains and recession of water during low tide.

There was heavy rainfall in June 1985 when entire city was flooded and rail & road traffic was disrupted resulting in heavy losses to the industries. The low-lying areas were marooned. Such events occur once every 2-3 times even today. Apart from the agony faced by the flood-affected people, the direct losses due to flooding per day in such events are estimated to be of the order of Rs. 100 crores.

Most of the key reasons for flooding apart from tidal variations, flat gradients downstream of Mithi river, and mud flats (in the eastern catchments, which cause

excessive siltation), are the inappropriate levels of manmade outfalls, poor placement of drainage channels, loss of holding ponds due to land development over the years, increase in runoff coefficient due to widespread development and paving of open areas, dilapidated drains (especially in the island city area), encroachments on drains, enhanced silting and choking of drains due to sewage inflows and garbage dumping in drains, obstruction due to crossing utility lines, poor structural conditions, etc.

Similar attempts at remediation of the Problem

The BRIMSTOWAD Project (initiated in response to 1985 floods and is the currently available Master Plan for Greater Bombay Storm Drainage) prepared for MCGM in 1993, had suggested an increase in the storm water drainage for the Mithi river catchments, but the recommendations largely remained unimplemented. Only about 15% of the recommendations were carried out by MCGM. Some of the reasons for non-implementation of the project recommendations were lack of financial resources, institutional hurdles as a assortment of agencies were involved with regards to procedural formalities for permission and execution of specific components, ownership of the water bodies, shifting of utilities, other issues with regards construction of pumping stations at outfall locations, and encroachment removal issues, rehabilitation and relocation costs, and implementation issues.

Report on Model Studies on the Effect of Proposed Reclamation in Mahim Creek by Central Water and Power Research Station (CWPRS), Pune, conducted in 1978, formed the basis for Bandra Kurla Complex (BKC), which is a special economic region developed along the banks of Mithi river downstream and was severely affected from flooding of the Mithi river in 2005, development by MMRDA. In recent years more concern has been expressed by individuals, professionals, and institutions of the Government of India, and the Government of Maharashtra for improving the condition of Mithi river.

Details of Operations

The intensity of flooding following the unprecedented rainfall of 944 mm recorded at Santa Cruz airport on 26th July 2005 led to the submergence of large areas adjoining the Mithi river to an alarming extent which caused disruption of the abovementioned corridors of railways and surface transport. The reduced flood discharge capacity of the river may have worsened the situation.

Following the flooding in 2005, the MMRDA commissioned two studies regarding the Mithi River. The CWPRS, Pune was asked to undertake the hydrological study, whose report was submitted in January 2006, and includes recommendations. In addition, IIT Bombay was asked to prepare the development plan for environmental improvement of the Mithi River, and the preliminary report has now been submitted.

Results and Recommendations of the Technical Report submitted by CWPRS, Pune

The first two segments, which have an origin to Jogeshwari and Vikhroli Link Road to Sir MV Road have Steep Slopes, they provide a swift discharge of water eliminating the chances of flooding. The downstream segments, however, have flat slopes and hence may cause flooding. Presently, a maximum of 50 m^3/s discharge can be accommodated in the downstream courses of the river without causing any spill over. But the discharge corresponding to 50 yr rainfall (382.5 mm per hour) or 100 yr rainfall (418.3 mm per hour) averaged throughout the stream length will cause a severe flood in the surrounding areas.
In order to mitigate floods, following remedial measures are recommended by CWPRS, Pune:

(a) Bandra Kurla Complex (BKC) area

1. Providing a dredged channel of 60 m width from -2 m (with respect to Mean Sea Level or MSL) contour in the sea to Mahim Causeway bed level (dredged to -1 m) and removing existing rock over-crops.
2. Widening of the waterway from Mahim Causeway to Dharavi Bridge to 100 m.
3. Widening of the bed width from the existing 175 m to 200 m between Dharavi Bridge and CST Bridge.
4. Widening of Vakola Nalla from the earlier designed width of 40 m to 60 m.
5. Deepening of bed level at Mahim Causeway to -1 m and at CST Bridge to +0.67 m.

(b) Upstream of BKC area

1. Widening of existing bed from CST Bridge to MV Road to 100 m.
2. Widening of existing bed from MV Road to Jogeshwari – Vikhroli Link Road to 60 m
3. Widening of existing bed from Jogeshwari – Vikhroli Link Road to Morarji Nagar to 40 m.
4. Deepening of existing bed levels:

    - CST Bridge (Ch. 5.88 km) from +2 m to 0.67 m
    - Air India Colony (Ch. 7.05 km) from +3.11 m to +1.0 m
    - Airport (Ch. 9.38 km) from +6.15 m to +4 m
    - MV Road (Ch. 10.47 km) from +8.12 m to +6.35 m
    - Aarey Dairy Foot Over Bridge (Ch. 12.18 km) from +12.75 m to +10 m
    - Jogeshwari-Vikhroli (Ch. 14 km) from +20.25 m to +18 m

All the suggested cross sections of Mithi River upto Ch. 10.5 km need to be provided with slopes of 1 : 1.5. Further upstream upto Morarji Nagar, the required slope is 1 : 2.
All the suggested measures taken together would roughly double the discharge capacity of the River.

Additional Recommendations

1. Moderating the river course by replacing existing sharp bends with longer gentler bends.
2. Providing Non-return valves for cross drains.
3. Providing Regular maintenance and dredging.
4. Providing smooth transition for waterways near bridges.

Action taken by the City Administration on these recommendations

The City Administration acting swiftly on recommendations accepted most of them and directed Mumbai Metropolitan Region Development Authority (MMRDA) and Municipal Corporation of Greater Mumbai (MCGM) to take the necessary action. The work was divided in two parts. The 11.84 km upstream stretch from Vihar Lake to CST Bridge was given to MCGM and the critical downstream part of the remaining 6 km was undertaken by MMRDA. The downstream stretch was more critical due to flat slopes and nearness to sea and was further divided into two phases by MMRDA:

Phase 1: It involves de-silting and widening of the stretch. The time frame decided for this was 1 March 2006 to 30 June 2006 and is now finished. The amount sanctioned for the work was Rs. 30 crores.

Phase 2: It is planned for the post-monsoon period from 1 Oct 2006 to 30 June 2007 with a budget of Rs. 100 crores (subject to variation after post monsoon study). It will involve dredging, widening, construction of retaining wall, beautification and building of service roads.

The Megacity Context

The severity of floods in Mumbai, in July 2005, was due to a combination of record rainfall as well as the simultaneous occurrence of high tides and lack of an adequate drainage system. Most of the drains and the Mithi river were blocked by plastic waste material and sewage, hence were unable to discharge the flood waters into the sea. All coastal megacities of the world are posed with similar problem.

CWPRS studied the drainage situation and gave recommendations for flood mitigation. It's expected, based on the 1-D Mathematical Model and Desk Studies conducted by the Institute, that if the recommendations are implemented *in to* the discharge capacity will be doubled and the resulting drainage capacity will be sufficient to discharge storm-water due to a 100 yr rainfall. The upstream reaches of Mithi River have steep gradients presently, due to which water flows down swiftly and floods low-lying flat areas. It's recommended that the depth of the upstream stretches of the River be altered in such a way that the gradients may be flat or moderate. As a consequence the water retaining capacity of the upper reaches will increase and hence flooding downstream will be prevented. Also blocked drains are being cleared to prevent water-logging. Similar Studies can be carried out for other cities and suitable recommendations be

implemented to counter the problem.

Over the last two decades, with rapid increase of population, floods have become a major risk in Mumbai, especially in low-lying slums; hence their mitigation by a swift discharge of storm water reduces the overall level of risk in the entire megacity.

The recommendations of CWPRS are based on the present demographic data and topography. Mumbai is a rapidly growing megacity with an ever increasing population, which is already far more than the city can support with the present infrastructure. The topography is being drastically altered as more and more area is reclaimed and hills and forests are replaced by concrete jungles. If it's done without keeping in mind the safe flood levels (as is the case generally), it may lead to an increase in flood prone areas and the overall risk of Mumbai. The first phase of the work was completed June, 2006 and positive results are immediately expected in the forthcoming monsoon in July.

References

1. "1-D Mathematical Model and Desk Studies for mitigating floods of MIthi River of Mumbai", *Technical Report No. 4297*, CWPRS, Pune, January 2006.

2. Gupta, Kapil, "Urban Flooding: Vulnerability, Preparedness and Mitigation – 944 mm Mumbai 26/07/2005 event", Presentation, *International Centre for Excellence in Water Resources Management*, Adelaide, 29 May 2006.
[Available at http://www.icewarm.com.au/userfiles/File/ICEWARM_Adelaide%20290506.pdf]

Source: Report on Mithi River Water Pollution by "Klean Environmental Consultants Pvt Ltd.", July 2004, prepared for Maharashtra Pollution Control Board Photographs # 7 and #11

Source: A Report titled "Urban Flooding: Vulnerability, Preparedness and Mitigation – 944 mm Mumbai 26/07/2005 event" by Prof. Kapil Gupta of IIT Bombay presented at International Centre for Excellence in Water Resources Management

Knowledge Base Coding Reference:

Name of the Practice: Increasing Storm Water Drainage Capacity of Mithi River and Mumbai City drains

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