Storm Water Drainage in Mumbai

Subrata Bhattacharjee

The city of Mumbai, as we all know was, originally, a cluster of seven islands. Over the last five decades, the city got extended moving northwards by areas known as the suburbs and extended suburbs. The entire city of Mumbai geographically admeasuring about 440 sq km as per the latest Draft Development Plan 2014 is developed by landfills between the seven islands North to South. The central area comprises mainly low lying reclaimed area. Mumbai is also served by five rivers viz. Mithi, Poisar, Dahisar, Oshiwara and Mahul, which ultimately discharge into the Arabian Sea. The present exercise is a summary study of the watershed management of the city of Mumbai.

The growing population, which stands at 12.8 million coupled with the rapid urbanisation since the early 80's has resulted in creating a huge burden on the city infrastructure. The present study is an attempt to understand one of the most important infrastructures i.e. the storm water network of the city of Mumbai.

A cursory glance at the existing storm water network (As per the Fact Finding Committee Report 2006) is given in Table 1.

The city, as we understand is developed on reclaimed land. At many locations, the land levels are below the High Tide level. This results in the inundation of these low lying lands when high rainfall coincides with the high tide. One would easily recount the deluge which occurred on the 26 July, 2005, which brought the city to a standstill, throwing all mechanisms out of gear. The city experienced unprecedented rainfall which was approximately 1000 mm in 24 hours with an extreme intensity of precipitation of 136 mm per hour. The cause was due to the creation of low pressure area over

OWING TO THE ANALYTICAL NATURE OF THE PAPER, THE REFERENCES ARE BASED ON THE FACT FINDING COMMITTEE REPORT AND BRIMSTOWAD 1993 REPORT 2006

IMAGE CREDIT: AMIT DEVALE

Description	City	ES	WS	Total
Major nullah width > 1.5m	8.545	90.20	101.509	200.254
Minor nullah width < 1.5m	20.762	66.40	42.104	129.266
Arch/ Box drains	59.20	40.00	51.93	151.13
Road side open drains	20.00	669.48	1297.50	1986.98
No. of water entrance	27893	609.00	1706.0	30208
Closed pipe or dhapa drains	443.180	36.20	86.031	565.411

Table 1 : Comparison of the length of nullahs and drains(kms)

SOURCE: FACT FINDING COMMITTEE 2006

Madhya Pradesh. The downpour was the result of a combination of a synoptic scale weather systems which have a span of 1000km – 2000km and the meso scale weather system localised over 20-30km. There was no formal survey of loss but there was an indication that about 20,000 cars, 2500 BEST buses, large number of two/ three wheelers were damaged, 2400 animal carcasses had to be disposed off, including 2 lakh tonnes of garbage consisting of household belongings, furniture, foodstuff and electronic gadgets. A massive quantity of disinfectant had to be used to prevent any epidemic. About 500 lives were lost in the deluge.

Apart from the unprecedented rainfall, the causes which led to the disaster, were that there was a large accumulation of silt at the culverts, cofferdams at the bridge mouth under airport-taxi bay which triggered a continuous flow of Mithi river across Eastern Express Highway, submerging Central Railway tracks and encroachments along the Mithi banks constricting flow of the storm water. Bottlenecks were therefore created near the airport and the MMRDA area and the other on the downstream of MMRDA region near the outfalls in Mahim bay. The first one led to the flooding of Kurla, Chembur and the other, at the catchment near Mahim. The Mithi river was at the centre of the deluge as the nallah systems including the Mahul system failed to accommodate the flow. In the city proper, low land levels e.g. Saat Rasta, Lower Parel and Grant Road compounded the problem, unable to withstand this high intensity of rainfall coinciding with the High Tide. The low lying areas otherwise get relief only during low tide with the low tide level being 2m below the mean sea level. It may be mentioned here that 45 number of outfalls of the city drainage system discharging storm water are below the mean sea level. Therefore, surrounding areas get submerged if storm water is not held in the system.

All levels being referred to are with respect to the Town Hall Datum existing on one of the entrance steps of the Town Hall (now Asiatic Library) arbitrarily taken to be at 100 ft (30.48m) above an imaginary T.H.D of 0.00. With reference to this Datum, the mean sea level is at 80.23 ft (i.e. at 24.46m) above the T.H.D.

A 1925 survey record shows that the entire area south of airport boundary wall was a portion of the waterlogged wetland system of the Mithi estuary (then named as Mahim estuary). The entire estuary of Mithi has undergone extensive land filling, reclamation, encroachment, modification in the river course and all these have impacted the estuary movement and hydraulics of the entire creek and bay.

There was no disaster management in place. Also the IMD failed to communicate the impending danger after sighting 15 km deep cloud formation gathering and approaching towards Mumbai. In a nutshell, besides high tides occurring at the same time, constriction of natural waterways, clogging of culverts, changes in the direction of natural stream flow, increased coefficients of rugosity due to crowding of structures, reduced hydraulic gradients due to silting gave rise to high flood levels and longer periods of inundation.

The local authorities viz: MCGM, MMRDA put in all efforts to redeem the situation upfront and in about a week's time, the city was back to normal. But this extreme event surely was a wake up call which compelled the authorities to think and devise ways and steps to rectify the inadequacies in the system on a war footing.

Apropos all what happened, Government of Maharashtra vide its decision under GR NO.BMC/2324/05 C No.97/UD -21 dated 19/08/05 appointed a Fact Finding Committee (known as the Chitale Committee) comprising 8 members. The scope of the work entrusted to this committee broadly was to:

1) Analyse short term and long term factors responsible for the deluge;

2) To analyse the present status, deficiencies, limitations of storm water and sewerage disposal systems, their development plans and implementation;

3) To study the development of various river basins and the factors responsible for ineffective routing of natural flow in their watersheds and;

4) To suggest guiding principles for short term and long term Development Plans.

The Fact Finding Committee submitted its report in the year 2006. In the past, various committees/agencies were appointed to mitigate the problems caused by several events in the past decades. They are as under:

1) Natu committee report (1975) to study reasons for 1974 floods and suggest remedies.

2) CWPRS-BKC Report (1978) –Central Water and Power Research Stations: To study the requirements of the storm water systems for development of BKC (Bandra Kurla complex);

3) Shah Technical Consultants for Dharavi Storm Water System (1988);

4) BRIMSTOWAD report (1993):

In the year 1989, Municipal Corporation of Greater Mumbai (MCGM) had appointed M/s. Watson Hawksley International Ltd.

of U.K with their Indian Associate, M/s Associated Industrial consultant(India) Pvt.Ltd as consultants to carry out detailed studies for the improvement of the storm water drainage system of Mumbai (except Dharavi and BKC);

5) CWPRS- Study of hydraulics of Mithi and Vakola rivers;

6) CESE (Centre for Environmental Science and Engineering)-to study environmental aspects of Mithi;

7) WAPCOS (Water and Power Consultancy Services India Limited): To study channelisation requirements of Dahisar, Poisar and Oshiwara rivers.

In all reports, proper desilting/ dredging/ maintaining waterways clean, clearing encroachments and removing impediments have been stressed. Mixing of sewage with storm water has been strongly objected to.

Findings of the Fact Finding Committee and suggestions- overall study :

Deficiency in the system and causes of floods:

1) Many gradients are flat, leading to silting and therefore to low velocities. Time period between high flows allow silt to consolidate.

2) Obstruction in drains – i.e utilities causing head loss.

3) Turbulence caused by obstruction leads to structural deterioration.

4) Number of siphons in the system, major are the water pipes and other utilities leading to high head loss and silting thereof.

5) Gullies poorly placed and at wrong levels to collect maximum amount of water- spacing inadequate and siltation of gullies.

6) Some catchment areas in the east of the city are affected by mudflats in the harbour area.

7) Manholes are concealed/developed over. Therefore, maintenance can't be done.

“Mixing of sewage with storm water has been strongly objected to.”

8) The age old dhapa drains have limited access, have flat inverts and are more prone to siltation than pipe drains.

9) Absence of adequate holding ponds/tanks to hold storm water during high tide.

10) Interconnection of sewage and storm water network leading to siltation and loss of drainage capacity.

11) Encroachment on system; reducing areas for maintenance/desilting and using system for dumping garbage/refuse causing reduction of capacity of drains.

12) 45 number of outfalls out of the 186 outfalls discharge below mean sea level.

Overall study and suggestions

Water moves in the environment through the process of cloud formation, precipitation, evaporation, condensation, retention, infiltration, run off on the earth's surface and as groundwater-Runoff is that part of the rainfall which flows over the ground into the streams, channels and rivers.

For any urban drainage systems, the local intensity of precipitation is more relevant than the annual precipitation. The storm water arrangements are required to be handled on the basis of a return period of different values of rainfall intensities i.e. the probability of the occurrence of rainfall of different intensities in a 1 year, 10 years, 25 years period and so on. In the urban areas, the percentage runoff is higher because of impervious ground cover and less of evaporation loss in the short length run of the storm water flow. As per today's general hydrological characteristics, the run off shall be considered as 100%. The coefficient of run off of 0.5 is not appropriate. Hence existing SWD system would need retrofitting to cater to 100% runoff. The rainfall intensity is also to be considered as 50 mm per hour with runoff coefficient as 1 in place of earlier design intensity of 25 mm per hour with runoff coefficient as 1.

Rainfall is called heavy if precipitation is more than 65 mm and very heavy if the same is more than 130 mm in a day. The IMD records rainfall from 8:30 a.m to 8:30 a.m the next day.

On 26th July 2005, the rainfall received was 380 mm in 3 hrs from 14:30 hrs to 17:30 hours which was more than 125 mm per hour i.e. 5 times more than 25 mm per hour and 2.5 times than 50 mm per hour. Flooding was inevitable as rainfall intensity was substantially more than the designed capacity of the storm water drainage system.

Studies in global warming suggest that extreme rainfall events are likely to become more frequent in time. i.e. for example, 1 in 50 years probability could be 1 in 25 years for an extreme event. It is therefore evident that the storm water network needs to be designed for higher intensities of precipitation for important traffic routes and twice in one-year event for minor and internal traffic routes. The city part may at best, be planned for three different levels of hydrological risks. The cross drainage works on small streams and for minor/internal roads could be designed as per BRIMSTOWAD 1993. Channel width of main rivers and cross drainage works for major roads to be planned and handled for higher intensities of rainfall and more severe contingency plans will have to be kept ready. The rainfall intensity as per BRIMSTOWAD report 1993 is given in Table 2.

Design rainfall intensity of 50 mm per hour is good enough for a 4-hour storm of 1 in 5-year storm period. Hence to continue with BRIMSTOWAD recommendations except for those required for major roads, main traffic corridor where a greater dependability of traffic movement needs to be ensured and for river channels management where levels of risk are high.

"Design rainfall intensity of 50 mm per hour is good enough for a 4-hour storm of 1 in 5-year storm period."

Design criteria

Going by the regional trends in the western coastal area and experience, it could be adequate if Mumbai storm water systems are basically designed in simpler terms for the following hourly intensities of precipitation:

1) Small catchments – 50 mm per hour – twice in a year probability vide BRIMSTOWAD report;

2) 70 mm per hour – 1 in 10-year probability for river channels areas to be kept free from any intrusion;

3) 80 mm per hour – 1 in 25-year probability – River bank area with restriction on pattern of land use and type of contribution and for cross drain works on major roads;

4) 100 mm per hour – 1 in 100-year – River bank areas as a risk zone and cross drain works on major traffic routes.

For rivers, risk zones to be as per general guidelines in the flood zoning bill recommended by Government of India to the states. Local residents to be apprised and only permissible type of developments will have to be allowed in these zones.

Table 2 : The rainfall intensity as per BRIMSTOWAD report 1993

RETURN PERIOD	DURATION IN HOURS				
	1 hour	2hours	4 hours	8 hours	12 hours
1 in 10 years	109.00	89	61.5	35.5	28.0
1 in 5 years	91.40	70.3	51.0	27.6	24.0
1 in 2 years	74.00	53.3	38.00	22.50	19.4
1 in 1 year	58.00	40.6	30.40	18.10	16.5
2 in 1 year	48.00	33.0	23.20	14.60	12.0
10 in 1 year	25.00	17.00	12.00	7.60	5.90

· The role of hydrology in the planning and design of infrastructure of the urban areas has become important. Measurements of rainfall, river discharges, stream flow levels, tidal effect and delineating location of inundated area will need systematic recording and monitoring. Mumbai needs to have an adequate spread of Hydro-meteorological observation stations immediately. The existing provisions of IMD's (2 numbers) gauge station at Vihar lake are far too inadequate for Mumbai. The requirement norms are generally 1 station for every 25 sq km (i.e population of every 5 lakhs).

· Stream gauges: Which are vital for establishing a hydrological connection between the rainfall and the surface flows on the ground are to be provided one for every 10 sq km, i.e, approximately 50 stream gauges are required to be provided above the tide level or above the confluence of the stream with the main river channel so that quantitative information about the flood flows in the stream channels, accumulated water in and around it can be made available.

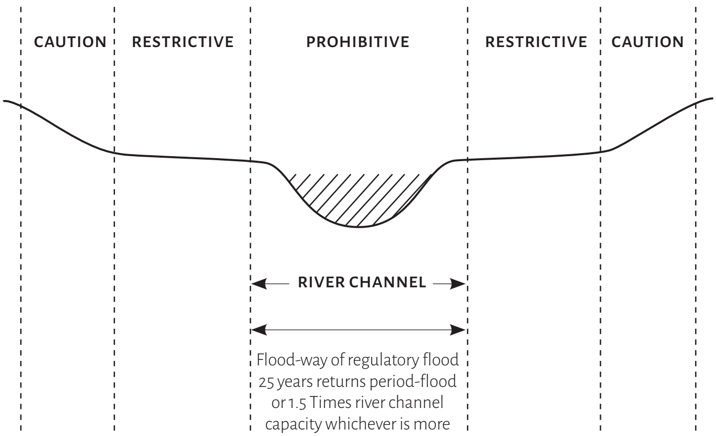

Fig 1 : Section through the river channel

CREDIT: FACT FINDING COMMITTEE 2006

"Mumbai needs to have an adequate spread of Hydro-meteorological observation stations immediately."

· Time unit for analysis – The 15-minute value of rainfall is relevant for Mumbai because the time of concentration in many small catchments in Mumbai is small. Water can get accumulated in this much time at critical points to cause inundation and flooding.

· Serving by radars is vital as extreme events can be predicted a few hours in advance (3 to 4 hours). This is possible with Doppler radars.

· Contour maps: The entire city of Mumbai is developed by landfills between the seven islands, North to South – Central area comprises mainly low lying reclaimed areas. There are mostly closed drains in the city and open in the suburbs.

Both discharge storm water flow by gravity either in the creek area or into the open sea along the east and west coast of Mumbai. At many locations, land levels are below the High Tide Level (H.T.L). Average H.T.L is 2.5 m. Annual highest peak tide level is 2.75 m and average L.T.L (Low Tide Level) is -2.0 m i.e 2 m below the M.S.L (Mean Sea Level). The low tide periods approximately 10 hours to 12 hours per day give relief.

The study of the storm water flow and design of the network will necessarily be based on contour maps. As per the Fact Finding Committee's (F.F.C) suggestions, the MCGM in its efforts to upgrade the BRIMSTOWAD report 1993 has carried out aerial survey of the Mumbai landscapes and prepared contour maps with contour intervals of 0.2 m. It has been observed that the ground topography has undergone a sea change due to incompatible development of lands and heavy encroachments blocking service lines thereby reducing the carrying capacity of the drains.

· Training of rivers and stream channels: This is an essential need where the streams are to be channelised with proper hydrological consideration. Besides, a proper water shed management is to be put in place in regards to the main rivers:-

Mithi – Mahul and others, whereby in case of heavy precipitation, the overflow from the drains, the basins gets interconnected and try to behave like a combined system. The Mithi floods which took place, is attributable to extreme precipitation near Vihar, inadequate width of Mithi channel with encroachments on both the banks, constricting the flow and causing flooding in the upstream.

· We need to have healthy watersheds where it is very essential to reduce run off by absorbing precipitation by way of infiltration and evapotranspiration by having land cover with vegetation and trees by absorbing run off through infiltration and pondages. Holding ponds play an important role in water shed management. Pressures of urbanisation and dense developments including road and pavement developments have prevented infiltration of storm water into the ground. The useful role of holding ponds have got ignored. Therefore, it is essential to retain existing holding spaces and to provide systematic new holding spaces at critical locations. This has to be treated as a part of the urban land space and as an integral part of the land use plan. The cumulative capacity of such holding ponds should be at least 10% of the catchment's estimated run off. These holding ponds act as temporary storages. E.g. playgrounds, parks, race courses, golf clubs, open lands of airports not used for air traffic.

Efforts to be made for creation of holding ponds, for the four rivers, Mahul and spaces near BKC, downstream of Oshiwara and Poisar wetlands and open spaces downstream of Eastern Express Highway. These spaces are to be reserved and developed at lower levels than the surrounding locality but slightly higher than the high tide level.

· Gates at outfalls: The discharging capacity of the storm water channels is governed by relative clearance available for the storm water outfall over the tide level in the sea at that time. If discharge levels are lower than High tide level, part of the storm water remains

“Pressures of urbanisation and dense developments including road and pavement developments have prevented infiltration of storm water into the ground.”

accumulated in the system till the high tide recedes. The greater this tidal lock in period, the greater has to be the ponding/ water accumulating facility that is required to be provided near the outfall. If the system cannot withhold this water, it spreads around, submerging the area. Therefore, tidal gates are necessary to prevent ingress of the tide and conserve the storage capacity of the channel required to be provided. For catchments greater than 10 sq km, it would be desirable to provide gates to a flood flow of 1 in 100 year probability, and for smaller catchments for 1 in 25 year probability.

· Pumping: For a coastal city on reclaimed lands like Mumbai, pumping has to be an integral part of the storm water system. Such pumping stations will have to cater to additional 25% capacity to hold the precipitation intensity corresponding to a 1 in 10 year probability.

BRIMSTOWAD Report 1993

The consultants submitted their final study to the MCGM in the form of a report known as the BRIMSTOWAD (BrihanMumbai Storm Water Disposal Systems) Report 1993. The entire Mumbai topography is divided into totally 116 catchments, 42 numbers with 16 nullah/ drain systems in the city, 24 numbers with 24 nallah systems in the Eastern suburbs and 50 numbers with 51 nallah systems in the Western suburbs.

In the report, number of proposals were suggested to protect the city against monsoon flooding which causes disruption, distress and economic losses. These proposals were not taken up for implementation until the year 2007, mainly due to paucity of funds. After the major flood event caused by extreme rainfall on 26 – 27 July 2005, the Fact Finding Committee set up by the Government suggested updating the BRIMSTOWAD report 1993, in which, the terms of reference for the studies on storm water management did not highlight looking at heavy rainfall events and the ameliorative measures necessary.

MCGM entrusted the previous consultants M/s MWH the task of updating the original BRIMSTOWAD report to include hydraulic modelling, flooding solutions and preliminary design, engineering design and preparation of tender documents for immediate works. At the time of preparation of Detailed Project Report (DPR) in the year 2007 for immediate work, the proposal recommended in the BRIMSTOWAD report was modified considering recommendations of the Fact Finding Committee. Sanctioned values of BRIMSTOWAD project works as per DPR 2007 are as follows:

1) City – INR 504.95 crores

2) Eastern Suburbs – INR 383.31 crores

3) Western suburbs – INR 312.37 crores

Total – INR 1200.53 crores, say INR 1200 crores

After the approval of DPR and sanction of funds by the Central Government, the works were started in the year 2008. The total number of works envisaged in two phases were 58 nos. These included construction of Storm Water Pumping stations (8 nos), widening, deepening, training of nullahs, reconstruction, construction, remodeling, of nullahs, culverts, carrying out conditional assessment of old arch/ box drains and rehabilitation of the same. A few works were to be reviewed in the Master plan to be updated and prepared by the consultants M/s MWH. Most of the works envisaged are completed notable among them being the pumping stations viz: Haji Ali, Irla, Worli, Cleveland Bunder and Britannia pumping station. The pumping station at Guzder Bandh, Santacruz (west) is nearing completion. A few of the works are hampered where encroachments and shifting of the (Project Affected Persons) PAPs are major bottlenecks.

“For a coastal city on reclaimed lands like Mumbai, pumping has to be an integral part of the storm water system.”

The work of pumping stations at Mahul (Eastern suburbs) and Mogra (western Suburbs) are held up due to land acquisition issues. Also, the main work of contour maps is completed which is of vital importance. Aerial surveys have been completed and contour maps have been prepared by the consultants M/s. The projected cost of implementation of the BRIMSTOWAD project will presumably reach INR 4000 crores or more, depending on the additional works to be carried out as per the updated master plan which is at the finalisation stage. Reasons for delay and increase in cost are many viz.- cost estimates presented in DPR were based on 2004/ 2005 schedule of rates, change in scope of work due to actual site condition, cost escalation due to inflation, new methodology for foundation of drains in marshy land/ tidal zones, impediments due to other ongoing developmental works and traffic congestion, time consumed in getting MoEF clearance, NOC from various departments i.e. Railway, Airport, Traffic Authorities, Mumbai Port trust etc., diversion of utilities, lack of access road to sites due to existing slums on both sides of the nallah/ drain, delay in land acquisition, removal of encroachments and shifting of Project Affected Persons (PAPs). The MCGM received INR 1000 crores from the Prime Minister's fund for these works and the excess cost is now being met from MCGM's own funds.

A part of the construction for BRIMSOWAD i.e. construction of storm water pumping stations

IMAGE CREDIT:
SUBRATA BHATTACHARJEE

Besides, as a part of maintenance, MCGM carries out the works such as desilting of water entrances, laterals, manholes, dhapa/ pipe, arch/ box drains, minor/major nullahs, culverts, outfalls and road side open drains, repairs of storm water drain systems, conversion of old dhapa drains into pipe drains, removal of obstruction, replacement of dilapidated storm water drains, their augmentation, pumping out water at several chronic water logging spots and other related works.

The desilting work is carried out in three stages i.e, pre-monsoon, during monsoon and post monsoon through contracted agencies or departmentally, through labour and machines such as suction machines, jetting machines, choke removal machines, road side drain desilting machines, excavators and amphibian dredger machines. The major nullah, as we observe, are desilted regularly. However, we find that with the advent of the first monsoon showers, there are several complaints of water logging. In this respect, it is observed that the feeder drains and the road side storm water drains are unable to drain away the water due to blockages in the system. A strict vigil on the desilting works therefore need to be enforced to ensure that these drains effectively convey the storm water into the major drains/ nullahs and the outfalls.

Mithi river development

The Government of Maharashtra has formed the Mithi river development and Protection Authority for improvement of the Mithi river. The total length of the Mithi river is 17.8 km, out of which, 11.8 km is in the jurisdiction of MCGM and the balance of 6 km under MMRDA. Work entails cleaning/ desilting of the river, construction of the river banks, shifting of the polluting industries along the banks, removing encroachments and construction of bridges across the river at 11 locations. This is expected to be completed in a couple of years.

A part of the construction of box drain for BRIMSTOWAD

IMAGE CREDIT:
SUBRATA BHATTACHARJEE

The revised cost of this joint venture by MCGM and MMRDA would be somewhere in the region of INR 1700 crores.

Modified Master Plan

Consultants M/S MWH have submitted the updated draft Master plan for storm water management to the MCGM and the same, it is learnt, is in the finalisation stage. In the modified plan, few of the works mainly envisaged are

1) Augmentation of capacity of the drains by deepening, widening, replacement with bigger pipes and conduits and creating additional capacity.

2) Combined area of SWD catchments as per BRIMSTOWAD 1993 was 281 sq km and now proposed to be increased to 398 sq km considering fast development and change in topography/ formation levels over the years as per contours now available.

3) Pumping stations with Tidal Gates: New pumping stations at Dadar with discharge capacity of 24 cubic metre per sec, Charni road with a capacity of 30 cubic metre per sec, Dharavi with a capacity of 30 cubic metre per sec, Mankhurd with a discharge capacity of 78 cubic metre per sec in addition to the two pumping stations at Mahul and the other at Mogra as envisaged in the previous BRIMSTOWAD report.

4) The role of holding spaces is stressed upon along with modified design criteria for developing the storm water network for rainfall intensity higher than 50 mm per hour. Vast open spaces wherever available and not meant for development are to be kept open to act as storm water receptors.

5) Complete segregation of the storm water system and sewerage system to ensure smooth flow of storm water.

The metropolis with its huge population and transformation by way of rapid urbanisation has experienced quite some relief post July 2005 consequential to several works being undertaken as per BRIMSTOWAD report requirements. The vertical growth which is happening now, is inevitable considering huge demand on the housing stock. This, beyond doubt has led to huge pressure build up on the city infrastructure including the transport system. One needs to accept the fact that the city is choking but we cannot look the other way. The authorities are battling it out to redress the issue. Notwithstanding the recent events which occurred in the city on 29 August, 2017 no doubt causing some inconvenience to the citizens, the efforts put in by the various authorities to abate the situation were now visible with the recession time of the floodwater having reduced to a great extent.

It is necessary to anticipate what the situation will be after the implementation of BRIMSTOWAD. Currently the storm water in the city recedes at 30 mm per hour to 50 mm per hour. The BRIMSTOWAD aims to increase it to 50 mm per hour and above.

“The total length of the Mithi River is 17.8 km, out of which length of 11.8 km is in the jurisdiction of MCGM and the balance of 6 km under MMRDA.”

A part of the rehabilitation of arch drain for BRIMSTOWAD

IMAGE CREDIT: SUBRATA BHATTACHARJEE

However, in the recent years, the city has been receiving around 50 to 100 mm per hour rainfall sometimes. It is to be seen how the city will mitigate the situation when it gets a rainfall of this intensity or even more. The BRIMSTOWAD measures, though beneficial, should not be inadequate for the amount of rainfall that Mumbai is receiving. A comprehensive study needs to be created for BRIMSTOWAD. The premise needs to be relooked into and necessary suggestions and recommendations need to be made.

The larger issues of climate change, such as global warming and rise in sea levels also need to be addressed. Also, design changes need to be recommended in lieu of increasing concretisation.

The only way to go forward is to preserve and guard whatever open spaces we have so that they can serve as great absorbers and breathe life into the gasping city. It is hoped that the new DP

(2014-2034) which is at the final stage of acceptance has taken cognisance of these vital aspects we have mentioned in the study.

Let us be optimistic and hope that with the completion of the remaining projects including those of our transport network, the citizens will have no reason to be inconvenienced and the city will be a better place to live in.

References :

Fact finding committee (Chitale committee) report 2006.

BRIMSTOWAD Report 1993

Inputs from the office of Chief Engineer (Storm water drains), MCGM.