

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly Peer Reviewed Journal)

Vol. 5, Issue 1, Januray 2016

Study of Storm Water Drainage Condition for Naya Nagar Catchment Area

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ABSTRACT: The flooding occurrences are increasing in the metropolitan cities due to rapid urbanization and reduction of natural watersheds. Thane city has increased exponentially, imposing more burdens on urban drainage system which is already unable to drain rainfall above 25mm/hr. Rapid urbanization is continuously encroaching the drainage system of Mira Road. Rainfall of depth 944 mm that occurred on 26th July 2005 caused water logging in many part of the Mira Road. The severity of flood was so extreme that it took many lives. The financial cost of flood was unprecedented and affected the entire commercial, trading, and industrial activity for 3 days. This study develops the methodology which uses the different physical characteristics of watershed and critical rainfall events to describe the response of Mira Road drainage system. The present study uses the Storm Water Management Model (SWMM) and estimates the discharge and flooded areas of Mira Road.

KEYWORDS: Flooding, SWMM, simulation, Mira Road, Drainage Redesign.

I. INTRODUCTION

India has been undergoing rapid urbanization since independence and population is increasing day by day which has caused the water supply to out space in the drainage sector. With increase in water supply to urban metros, the drainage managers are faced with the task of managing the additional waste water from the highly populated areas for which the existing drains are inadequate. In addition, over 75 percent of the total rainfall occurs mainly in the monsoon season during the four months from June to September. A major challenge is to manage the huge volume of monsoon runoff during these four months. There have been increasing instances of severe flooding followed by epidemics not only disrupting the daily life during monsoons, but also affecting the overall quality of life in most of the metros.

Mumbai receives almost all its 2300 mm rainfall during June to September and several catchments in Mumbai experience severe flooding usually when high tide is preceded by heavy rainfall for four hours. This period of heavy rainfall causes severe disruption to the transportation system and paralyzes commercial activities at least twice a year and the losses are estimated at 5 million USD per flood even [1]. Intensive redevelopments and urban consolidations cause increase in surface storm water runoff due to the increased paved surface. This excess runoff in most of the cases cannot be accommodated by existing drainage system and thus there is flooding in downstream area. This may also result in flooding of private property.

One of the solutions to this, is provision of detention system and inline weir which provides temporary storage of storm water runoff from developments and releases runoff from the detention pond at a controlled rate for which existing drainage system is capable of accommodating, hence provision of proper drainage system or similar structure is very essential for controlling flood and preventing damages caused by flooding, avoiding which may lead to severe damage and loss.

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II. PROBLEM DEFINITION

After 26th July 2005 Rainfall event, study on flood has acquired great importance as the destruction caused by the same was very high. The Government has taken some initial steps to prevent further disaster due to flood in Mira road (E), Thane. It is very important to find out the responsible factors which causes such disaster and also to take possible remedial actions.

III. OBJECTIVE OF STUDY

- 1) Study of drainage channel for a part of Naya Nagar catchment of Mira Road (from Mira Road station to beside of Ibrahim Masjid).
- 2) Identification of the flood zone in respective catchment.
- 3) Proposal of new drainage system and best management practice to control flood in Naya Nagar catchment, Mira Road (E), Thane.

IV. LITERATURE REVIEW

The growth of urban and suburban areas has been a dominant phenomenon all over the world. During the 20th century, the proportion of the human population living in urban areas has risen from 14 percent to over 50 percent [2]. Urbanization is one of the most widespread anthropogenic causes of the loss of arable land [3], habitat destruction [4], and the decline in natural vegetation cover. Due to rapid urbanization world is losing pervious area, water storage area, lakes, swales etc. Urbanization has profound impact on generation of runoff due to precipitation which has increase the frequency of flood.

Flooding is defined as temporary inundation of all or part of the floodplain or temporary localized inundation occurring when surface water runoff moves via surface flow, gutters and sewers. Floods also occur when water levels of lakes, ponds, reservoirs, aquifers and estuaries exceed some critical values and inundate the adjacent land [5]. A survey conducted by the US Department of Agriculture, found that urbanization was implicated in wetland loss in nearly all surveyed watersheds (96 percent) and may account for as much as 58 percent of the total wetland loss [6]; [7].

Determining the extent of flooding is an important role of the hydrological research community and provides a vital service to planners and engineers [8]. There is a growing realization about the importance of non-structural measures, including flood forecasting and early warning in flood management. Establishing a flood forecasting system, which would enhance the effectiveness of all other mitigation measures by providing time for appropriate actions. Detention ponds are designed to reduce on-site peak flows, but some research has shown that a system of detention ponds may actually exacerbate flooding at downstream locations, if runoff from fast and slow responding portions of a watershed responds synchronously at the watershed outlet [9]. System of detention ponds did little to reduce peak flows of the 62 km² area and could potentially increase peak flow rates [10]. Goff and Gentry suggested that a system of detention ponds may not effectively reduce peak discharge at all points in a watershed [11]. Bio retention systems, also known as bio filters or rain gardens, are the most widely used for storm water as the best management practice in the US [12] and are widely promoted and used elsewhere in the world [13]. Reduction in flood damages due to forecast improvements can range from a few percentage points to as much as 35 percent of annual flood damages [14].

A number of hydrological models have been developed for flood forecasting and the study of rainfall-runoff processes [15]. Hydrological and hydraulic models have been developed to formulate mitigation strategies and to take effective protective action [16]. Smith presented a semi-distributed model where the spatial heterogeneity of the hydrological characteristics within a basin is considered modeling separately each sub-basin using GIS information proposed a hydrological model for urban areas, which incorporates distributed parameter modeling in which the catchment is represented as a cascade of cells [17].

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V. METHODOLOGY

The following steps are taken to carry out this study

- 1) **Selection of the study area:** The area selected for the study is Naya Nagar, a part of Mira Road (East) Thane, located at north of Mumbai and is governed by Mira-Bhayandar Municipal Corporation (MBMC) (Fig. 1).
- 2) **Survey of the area:** Survey was conducted to find out the size and shape of existing drainage channels, invert level and slope of the catchment and sub-catchment area. Survey is done by using Auto-level, measuring tape, levelling staff and ranging rod. Also land characteristics and percentage of impervious area due to development has been recorded. During the survey the flooded channels were identified for later comparison with the Storm Water Management Model (SWMM) software.
- 3) **Collection of the rainfall data:** The data was collected for 26th and 27th July 2005 from Thane Municipal Corporation (TMC). The rainfall data of this day was selected because it caused water logging in many parts of Mira Road and the severity of flood was such that it took 447 lives in Mumbai alone and many other lives in adjacent cities.

Table 1: Rainfall data

Date	Time	Rainfall (mm)
26.07.05	8.30 to 11.30	0.9
26.07.05	11.30 to 14.30	18.4
26.07.05	14.30 to 15.30	100.2
26.07.05	15.30 to 16.30	190.3
26.07.05	16.30 to 17.30	90.3
26.07.05	17.30 to 18.30	100.4
26.07.05	18.30 to 19.30	95.0
26.07.05	19.30 to 20.30	72.2
26.07.05	20.30 to 21.30	60.2
26.07.05	21.30 to 22.30	22.5
26.07.05	22.30 to 23.30	18.4
26.07.05	23.30 to 00.30	40.0
27.07.05	00.30 to 01.30	42.5
27.07.05	01.30 to 02.30	33.7
27.07.05	02.30 to 05.30	11.0
27.07.05	05.30 to 08.30	48.2
		Total: 944.2

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- 4) **Preparation of map and calculation of catchment area:** The map of the study area was prepared by using Google Earth software. The area calculated is 9.51 hectare.



Fig. 1 Map of the Study Area

- 5) **Model Development using SWMM software:** In this study, it has been assumed that channel having flow more than 75 percent with respect to depth are flooded because there will always some amount of sediment be present in drainage system and waste water coming from residential buildings are not taken into account, hence for safety factor this value has been assumed. Links represent the channel and nodes indicate junction or change in direction. Following parameters have been used for modelling

- Length of channel
- Width of channel
- Depth of channel
- Invert elevation
- Sub-catchment area
- Percentage slope of sub-catchment
- Manning's constant

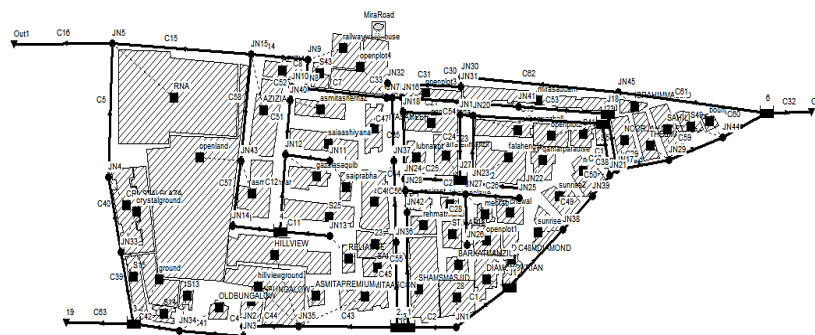


Fig. 2 Developed Model of Study Area in SWMM

- 6) **Simulation of storm water runoff for existing drainage system:** Simulation is done in SWMM software for 26th and 27th July 2005 (24 hours) rainfall data to find out most critical flooded channels. Dynamic Wave Routing analysis simulation method has be adopted which works on the Saint Venant's flow equation and produces most theoretical accurate result.

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7) **Modification of existing drainage systems:** The flooded channels were redesigned with respect to its width, depth and shape to avoid flooding. The redesigned system was again simulated for same rainfall intensity to check the response of redesigned drainage system for the critical rainfall event data.

VI. RESULTS AND DISCUSSION

The model generated in SWMM was simulated for the above mentioned rainfall event data of 26th July 2005 for existing (in Fig. 3) and redesigned storm water drainage system (in Fig. 4). The simulation results for existing drainage system is given below. Simulation shows that major channels are getting flooded after 4:15 (Hrs:Min) of precipitations.

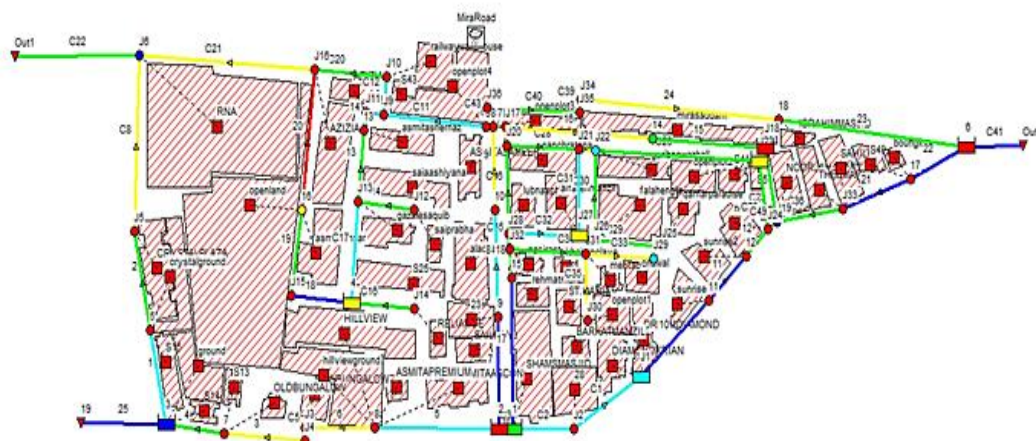


Fig. 3 Existing Drainage Condition

The channels indicated by red colour are completely flooded. Yellow colour channels are flowing at depth more than 75 percent. Blue and cyan colour channels are below flooding level.

The simulation result obtained as shown below for redesigned model shows that flooding can be avoided at most of the places just by increasing depth.



Fig. 4 Drainage Condition for Redesigned Channels

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Table 2 shows the comparison between existing and redesigned drainage channel dimension.

Table 2: Existing and Redesigned Drainage Channel Dimensional Comparison

Channels	Breadth(ft)		Depth(ft)		Water Depth/Total Depth		Shapes	
	Existing	Redesign	Existing	Redesign	Existing	Redesign	Existing	Redesign
C4	3.52	3.52	2.72	4	0.82	0.75	Rectangular Closed	Rectangular Closed
C5	5.44	5.44	3.52	5	0.82	0.71	Rectangular Open	Rectangular Open
C15	10.24	9	7.04	8	0.86	0.74	Unlined Parabolic	Rectangular Open
C20	2.4	2.4	2.72	2.72	0.78	0.83	Rectangular Closed	Rectangular Closed
C26	2.4	2.4	2.6	4	0.86	0.74	Rectangular Closed	Rectangular Closed
C28	2.4	2.4	2.24	2.5	0.79	0.73	Rectangular Closed	Rectangular Closed
C30	13.44	7	4.8	10	0.95	0.63	Unlined Parabolic	Rectangular Open
C36	1.92	1.92	2.68	3	0.75	0.69	Rectangular Closed	Rectangular Closed
C37	3.2	3.2	3.52	4.5	0.88	0.7	Rectangular Open	Rectangular Closed
C38	2.5	4.8	5.76	6	0.98	0.7	Rectangular Closed	Rectangular Closed
C41	3.52	3.52	2.72	4	0.82	0.69	Rectangular Closed	Rectangular Closed
C44	3.52	3.52	2.72	4.5	0.94	0.73	Rectangular Closed	Rectangular Closed
C47	3.04	3.2	3.2	4	0.86	0.7	Rectangular Closed	Rectangular Closed
C54	2.8	2.4	2.4	5.5	0.98	0.75	Rectangular Open	Rectangular Closed
C58	3	3.5	5.2	5	1	0.69	Unlined Parabolic	Rectangular Open
C62	6.4	7	13.44	12	0.91	0.71	Rectangular Closed	Rectangular Open

VII. CONCLUSION

This model develops a methodology to decide the response of Mira Road catchment area and storm water drainage system to rainfall event and peak discharge respectively. SWMM analyse the watershed and storm water drainage system and predicts the peak discharge and water surface elevation at critical junction of study area. The overflow of the channel impact in peak discharge. The application of this model can be extended to impact of urbanization, estimating flood frequency, flood forecasting, efficiency of detention ponds, efficiency of weirs, reservoir capacity, flood damage study, etc.

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