Runoff Estimation by Rational Method and SWMM in Vasai

[1] Mr. Chougale J.B, [2]Siddesh Inamdar, [3]Prathamesh Nachanekar, [4]Mayuri Tukrul, [5] Shreya Vyas
Department of Civil Engg, Vidyavadhini's College of Engineering and Technology, Vasai

***Abstract*—**India is a developing country and due to haphazard growth, cities have witnessed huge problems due to flooding in the recent years. Thus, the focus on flood management and flood risk assessment has increased. In this phase the new cities are being developed in accordance to flood risk management but the older cities facing the problem of water logging and floods very often due to heavy rainfall. It was found that 'Vasai' faces such problems very severely during monsoon. City gets water logged most of the time as intensity of rain is heavy. This is a major issue for Municipal Corporation and also the residents of Vasai. The haphazard growth of the population has imparted huge load on the existing sewers which failed to work efficiently during rainy season. Hence water logging is more frequent. Therefore, to avoid such difficulties water need to be obstructed where it won't impart any damage to the public life and water can be utilized while detaining, for different purposes and the water which is let into sea can be reduced. Runoff estimation can be done by Rational Method and empirical formulae like Lacy's Method, Khosla's Method etc. and also with the help of modern softwares like HEC-HMS, Storm Water Management Model (SWMM). Widely used method for runoff estimation and drainage modelling is SWMM; using SWMM we get total runoff, peak runoff, runoff coefficient.

Keywords: *Runoff, SWMM, Rational method.*

I. INTRODUCTION

Storm water management is a neglected segment of the protective cover with all the other things taken into consideration for the development of the cities. Thus, need arises for the protection against any type of natural calamities which results in major losses to life as well as economically.

Since the last two decades urban water management has gained importance. This water need to be properly routed to a desired location where it can be treated to reuse for different purposes which is done by most of the cities around the world. Routing is done by culverts, drains, etc. which have impervious surfaces to carry storm water to their destination. Hence the design of drains must be done using correct tools, which might not cause a huge loss to life and economy. Therefore necessity for disaster management arises for Vasai with average annual rainfall above 2000 mm.

II. LITERATURE REVIEW

Bhadiyadra K., 2015, data collection and field survey was conducted. Past floods were studied and immediate solutions were put forth. The main cause of water logging was due to the river Tapi. To prevent water logging some temporary solutions like hydraulic pumps, ground water recharge well, etc. were suggested.

Khondekar T., 2004, data was collected and analyzed. Causes and effects of water logging were studied and solutions were proposed. Water logging is mainly due to unplanned developed towns and cities. Obstructed and Diverted storm water drainage systems also contributed in water logging.

Priyanka Sahoo, 2018, the committee of five members inclusive of the director of National Environmental Engineering Research Institute [NEERI]. The committee will not only recommend solutions but would prepare a master plan for Vasai-Virar belt. They would also carry out the marking of nullahs, creeks, boundaries of Vasai, Nallasopara and Virar.

Gargi Verma, 2018, the reasons of water logging are being studied and pinpointed. Comparing the past and present Rainfall Patterns and marking the catchment area also studying the development in the infrastructure in the region. At public hearing at least 300 residents stressed on the need of regular maintenance by de-silting of drains and expansion of the drainage systems in Vasai-Virar and claimed against the illegal constructions.

Swapnil Rawal and Ram Parmar, 2018, Sulakshana Mahajan, senior urban planner and team pointed out that "rampant development" is the major cause for water logging and ignorance of geological and environmental factors also led to water logging. Haphazard growth in construction development led to less permeability into the ground.

Khabat Khosravi, Haidar Mirzai and Iman Saleh, 2013, they tried out 9 empirical methods of runoff estimation in Banadaksadat. GIS was used for topographical data and area selection. They concluded that Lacey method was the best empirical method as confidence level was 95% with the observed value of runoff estimation.

Department of civil engineering IIT Bombay, 2008, suggested redesigning of various drains. Recommended provision of various sluice gates and pumping stations and proposed underground storm water drains. Proposed separate systems of pipes for sewage and drainage.

Department of Environment and Conservation, 2006, identify the project objectives, potential options, evaluate and recommend on option. The decision to implement a storm water harvesting and reuse system in existed urban areas should ideally be made.

III. METHODOLOGY

a. GENERAL

The Vasai-Virar region comprises of 311sq.km of area. Underground sewerage system does not exist anywhere in the sub-region. The house owners are dependent on their individual septic tanks. The effluent from these septic tanks is discharged into soak pits. However such soak pits cannot function in marine clay etc. and the untreated effluent of these soak pits flow into low-lying areas. The existing sewerage system is extremely insufficient and is in bad condition which may result in health hazards. Due to which number of objections were raised regarding the provisions of storm water drainage system requiring large areas of lands for holding ponds, channels, etc. Doubts were expressed about the affordability of the high cost of implementing this system. Suggestions were also received demanding optimal use of the existing natural drainage system.

b. STUDY AREA

The Vasai-Virar Sub-region (VVSR) is bounded on the north by the Vaitarna River, on the south by the Vasai creek and on the west by the Arabian Sea. The eastern boundary is the hill ranges of Tungar full of forest extending from village Sasunavghar upto village Chandip. A number of hillocks and isolated peaks dot the region in the east. The region on the whole, is low-lying mainly in the southern part along both sides of Western Railway line.

Since Vasai is a huge area, a smaller fragment of this area, Suncity, has been considered for calculation. The total area is about 311000 sqm. The average rainfall is above 2000 mm which is due the south-west monsoon. The climate all around the year is humid due to its proximity with the sea.

c. ESTIMATION METHODS

Rational Method:
For any hydraulic design it is required to calculate maximum discharge and peak value of discharge. Rational method is one of the best methods to determine small watershed area runoff.
Formula

$$Q = C*i*A$$

Where,

Q = Design discharge (m^3/sec)
C = Coefficient of Runoff
i = Intensity of rainfall (mm/hr)
A = Watershed area (km^2)

Storm Water Management Model (SWMM):

a. Governing equation

SWMM conceptualizes a subcatchment as a rectangular surface that has a uniform slope (S) and a width (W) that drains to a single outlet channel. Overland flow is generated by modelling the subcatchment as a nonlinear reservoir shown in figure 1 below:

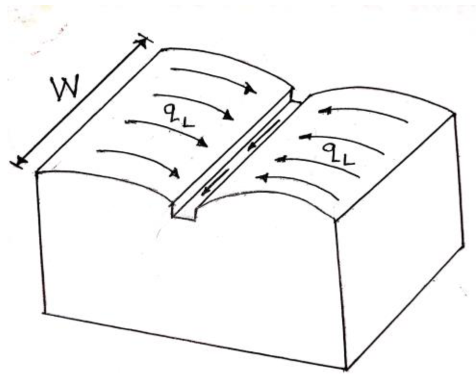

Figure 1 Idealized representation of a subcatchment (SWMM)

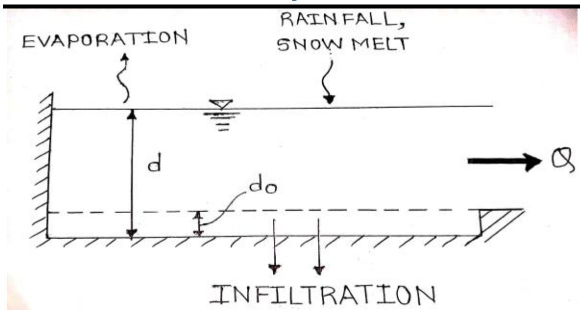

Figure 2 Nonlinear reservoir model of a subcatchment (SWMM)

In this representation, the subcatchment experiences inflow from precipitation (rainfall and snowmelt) and losses from evaporation and infiltration. The net excess ponds atop the subcatchment surface to a depth (d). Ponded water above the depression storage depth (ds) can become runoff outflow (q). Depression storage accounts for initial rainfall abstractions such as surface ponding, interception by flat roofs and vegetation, and surface wetting.
From conservation of mass, the net change in depth (d) per unit of time (t) is simply the difference between inflow and outflow rates over the subcatchment:

$$\partial d / \partial t = (i - e - f - q)$$

Where,

i = rate of rainfall + snowmelt (m/sec)
e = surface evaporation rate (m/sec)
f = infiltration rate (m/sec)
q = runoff rate (m/sec).

Manning's Formula:

For any hydraulic design of drains it is required to calculate maximum discharge and flow velocity.

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

Where,

Q =Discharge (m^3/sec)
v = Flow Velocity (m/sec)
A = Flow Area (m^2)
n = Manning's Rugosity Coefficient
R = Hydraulic Depth (m)
S = Bed Slope.

RESULT

On basis of the collected data of Vasai region. Some output results of software is given below:

Table No.1 Event Summary

Sub catchment	Total Precipitation (mm)	Total Runon (mm)	Total Infiltration (mm)	Total Runoff (mm)
SUB 1	2413	0.00	457.75	1937.22

Results obtained from the Storm Water Management Model (SWMM) software and Rational Method has been compiled in the Table 2. The results show that the average Runoff for the considered years is 2446 mm.

The peak runoff from both the methods when compared showed that the quantity of runoff from the Rational Method was lower than that calculated using SWMM.

Table No. 2 Compiled Results

Year	Precipitation (mm)	Infiltration (mm)	Runoff mm (SWMM)	Peak Runoff (SWMM) CMS	Peak Runoff (Rational Method) CMS
2014	2413	457.75	1937.22	0.14	0.10
2015	1640	335.48	1301.87	0.13	0.10
2016	2689	612.74	2078.43	0.15	0.11
2017	2769	569.58	2180.15	0.20	0.14
2018	2718	595.39	2115.09	0.28	0.20
AVG	2446	514.19	1922.56	0.18	0.13

Table No. 3 Sewer Parameters

Parameters	Values
Discharge(Q)	0.54 cumec
Velocity(V)	1.23 m/sec
Diameter(D)	0.75 m

CONCLUSION

The runoff quantity obtained using the Rational Method is less than that obtained by Storm Water Management Model. Hence, runoff from SWMM should be used for design the drain as it is much more reliable as compared to the runoff estimate during Rational Method. The peak runoff calculated using SWMM and Rational Method was 0.18CMS and 0.13CMS respectively. The SWMM software also provides the runoff graph, precipitation graph, hyetograph and histogram which cannot be obtained by Rational Method. Thus SWMM software easily overcomes the shortcomings of the Rational Method.

Using SWMM software we get results such as total runoff, total precipitation, total infiltration, runoff coefficient, peak runoff for the data inputted such as area of catchment, rainfall data, infiltration properties, etc. The results obtained from Rational Method and SWMM software can be used to design parameters for drains. Results are obtained in graphical and tabular scheme by SWMM software; some of the outputs have been shown in the figure 3 and figure 4.

The results obtained from SWMM software are used in designing the parameters of combined (sewage + storm runoff) drains. The results are listed in Table no 3.

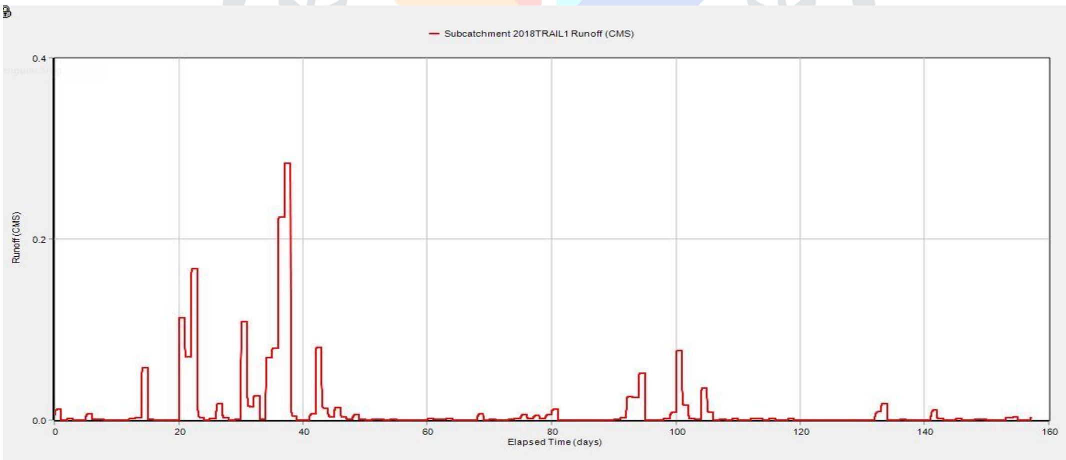

Figure 3 Runoff (CMS) vs. Elapsed Time (days)

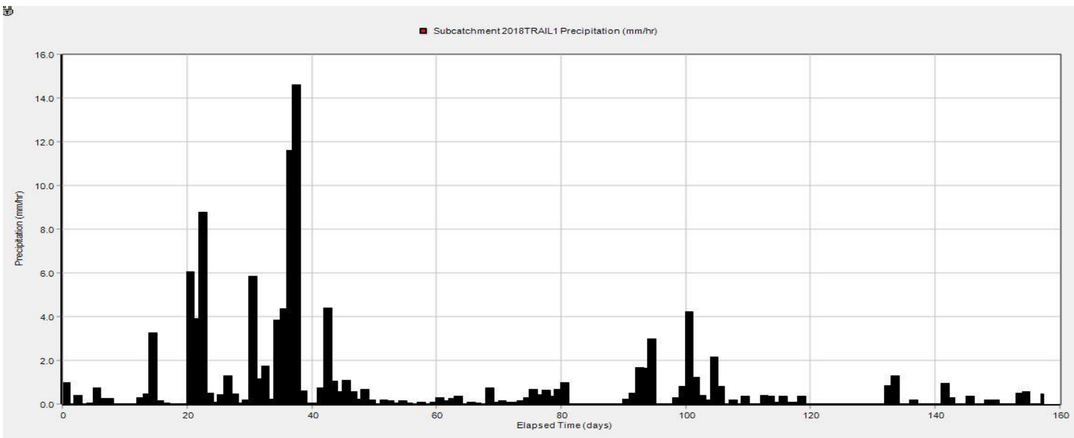

Figure 4 Precipitation (mm/hr) vs. Elapsed Time (days)

REFERENCES

1) Bhadiyadra K., "*Study of storm water drainage problem of surat city and its solution*", 2015.
2) Khondekar T., "*Causes of effects of water logging in Dhaka city, Bangladesh"*, 2004.
3) Priyanka Sahoo, "*Vasai-Virar Panel set up to probe water logging cause*", 2018, The Indian Express.
4) Gargi Verma, *"Designed to flood: Why Virar and Vasai remain water logged"*, 2018, The Indian Express.
5) Swapnil Rawal and Ram Parmar, *"Designed to flood: Why Virar and Vasai remain water logged"*, 2018, Hindustan Times.
6) Khabat Khosravi, Haidar Mirzai and Iman Saleh, *"Assessment of Empirical methods Runoff Estimation by Statistical test"* , 2013.
7) Department of Civil Engineering IIT Bombay, *"Yellow"*, 2008, The Fact Finding Committee Report.