

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 4, April 2018

## Storm Water Drainage Solutions for Urban Area

S. K. Raval

Lecturer, Architecture Department, Government Polytechnic for Girls, Ahmedabad, India

**ABSTRACT:** Due to urbanisation and fast growth of the cities, the need for proper storm water disposal is required. The augmentation of the existing storm water drainage (SWD) network of the city is assessed, followed by in depth analysis, planning and design. Ahmedabad city stands firm in Mega cities list of India and its rate of infrastructure development is very high. As there is no existing storm water drainage system in Bopal, an urban town-planning scheme of Ahmedabad is taken as a case study for design of storm water drainage system. The present design is based on the rainfall data observed in past 20 years, using Rational Method considering in total of 60% of the impervious area, which is going to increase in future with increasing urbanization and the population increase. The outfalls of the system are directed to Sarkhej Lake, after overflow meet in to Sabarmati river.

**KEYWORDS:** storm water drainage, rainfall data, storm water drainage system, Rational Method, impervious area.

### I. INTRODUCTION

Life on the earth cannot be sustained without fresh water. Rainwater, if not drained proper in urban areas can cause disasters like traffic problems, inundation of areas, loss of life and properties etc. Hence it desired to prevent escape of rainwater back to ocean. At present most of the civic bodies are practicing to drain the storm water in the rivers. Our storm water system should be designed in such a way that rainwater is evacuated as early as possible, simultaneously it does not go to ocean, but it is stored either as surface water in form of ponds or it should be diverted to ground to augment the water table.

### II. RELATED WORK

Urban hydrology is an applied science that will have an increasing role to play in the development of human societies. Facing present growth of urban population, it is difficult to find and utilize new sources of water necessary to satisfy growing water demand. Growth of urban areas brings changes in local environments and alters local conditions in impressive manner. Future challenges in urban water management include development of new technical solutions in order to turn present problems into future opportunities. (Niemczynowicz, March 1999)

The water environment is most adversely affected by urbanisation. Any type of activity in a catchment that changes the existing land use will have a direct impact on its quantity and quality characteristics.(Goonetilleke, Thomas, & C., April 2004) Increases in storm water runoff volumes have resulted from increasing urbanization and the accompanying growth of impervious surfaces. Up to 70% of the impervious area in urban catchments is set aside for transport (40-50% for roads). Findings from urban hydrological studies based on collection of urban hydrological data, calculations and modelling constitute a necessary fundamental for meaningful water management.

Effective planning of flow paths across urban areas can reduce accumulation of flood water and speed of runoff, and increase filtering and infiltration of storm water runoff. Combined with effective detention and retention basins, large loads of sediment can be intercepted before they impact on the ecosystems of urban waterways. The optimum solution for managing an increased volume of storm runoff is to encourage infiltration, storage, safe disposal and reuse.(department environment and heritage Australia, 2002)

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 4, April 2018

## III. STUDY AREA

The Bopal city is located on the periphery of Ahmedabad city, Figure 1 shows the area. Previously the area was not included in the Ahmedabad Municipal Corporation (AMC). There was small civic body called as municipality, hence the storm drainage system was also of very low capacity. After inclusion of this area in the AMC, there is very rapid growth. The population density increased due to heavy urbanisation with ribbon development around city. Hence during monsoon even small rainfall creates inundation of most of areas due to poor capacity of drainage system, so providing disposal network for storm water is prime necessity for the area.

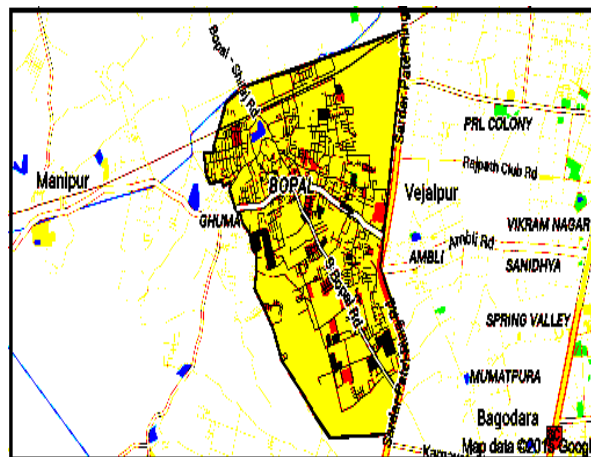


Figure 1. Bopal (Ahmedabad) map: study area for design of storm water drainage network (source : Google Earth)

### Data Collection:

The data collection is the main factor that plays a vital role in the design of storm water network system. Rainfall data of Ahmedabad city is collected. Topographical data, soil survey data, various town planning schemes maps, road maps etc. of Bopal are collected and shown in Figure 2.

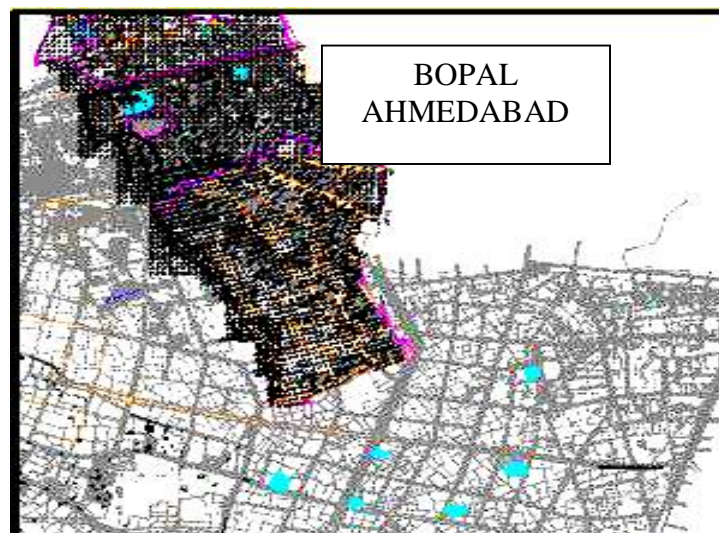


Figure 2. Data map of Bopal, Ahmedabad (Town Planning, Road, Topography map). (source : AUDA )

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 4, April 2018

**Methods:**

Once all the data is collected properly and analysis is done, storm water network design is carried out using these data. The design process is carried out either manually or by using some modelling techniques. Out of the different methods for estimation of runoff, the rational method is more commonly used.

**Rational Method for Estimation of Storm Water Runoff :**

The characteristics of drainage area such as imperviousness, topography including depressions and water pockets, shape of drainage basins and duration of rainfall determines the total runoff to be considered in the drainage system. The runoff reaching the drain is given by following formula of rational method:

$$Q = 10 C i A \tag{1}$$

Where,

- Q = Runoff in cu.m. / hour
- C = coefficient of runoff
- i = intensity of rainfall in mm/ hour
- A = area of drainage basin in hectares

## IV. DESIGN

The peak rate of runoff produced from particular catchment depends upon various factors such as, Pattern of precipitation, Intensity and duration of rainfall, Rainfall distribution, Deficiency of soil moisture at a particular time, Humidity , temperature, Direction of prevailing storm and Growing vegetation, crops, trees in the catchment. Estimation of storm water runoff, reaching the storm water drain is dependent on the intensity and duration of rainfall. The storm water flows for this purpose may be determined by using ‘Rational method’.

Coefficient of runoff: The part of the runoff that flows in the network depends on the imperviousness of drainage basin, shape of drainage basin, duration of storm water flow. This factor that governs the amount of flow reaching the drain is known as “coefficient of runoff”. Since it is difficult to obtain correct value of the runoff coefficient due to uncertainty of the development, the better way to determine the coefficient is to consider the site condition. As per CPHEEO “Manual on sewerage and sewage treatment”, (Table 1) we consider C=60% .

Table 1: Imperviousness Factor of Drainage Area

No.	Type of area	Percentage of Imperviousness
1	Commercial and industrial Area	70 to 90
2	Residential area High density	60 to 75
3	Residential area Low density	35 to 60
4	Parks and other undeveloped area	10 to 20

**Intensity of rainfall :**

The analysis of the observed data on rainfall intensity and duration of the rainfall of past records over a period of year in a drainage area under the design will be necessary to arrive at a fair estimate of intensity-duration for given frequencies. From the past records of daily rainfall data of last few years, the details of maximum rainfall intensity and duration for 5, 10, 15, 30, 45, 60, 75 and 90 minutes duration have been tabulated below from the rainfall table

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 4, April 2018

Table 2 : Time Intensity Values of Storm

t (minutes)	5	10	15	30	45	60	75	90
i(mm/hour)	50	36	30	20	15	12	10	9

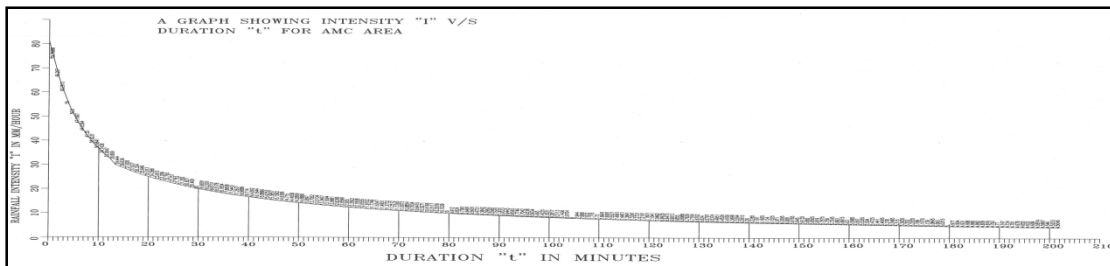


Figure 3. Intensity – Duration curve for Ahmedabad city. (source : AMC-AUDA )

A graph (Figure 3) is then plotted for once a year storm, using the above computed values of  $t$  and  $i$  from Table 2. The relationship between  $t$  and  $i$  may be expressed by a generalized mathematical formula. The commonly used equation is shown as under:

$$i = a / t^n \tag{2}$$

Where,

- $i$  = intensity of rainfall in mm/hour
- $t$  = duration of storm in minutes
- $a$  = constant
- $n$  = constant

**Time of Concentration :** The time of concentration is the summation of inlet time along the contributing catchment area and flow time within the network. Thus, the time of concentration ( $t_c$ ) for a given storm water drain generally consists of two parts:

(1) Inlet time or overland flow time ( $t_i$ ) : This is the time taken by the storm water, to flow overland from the critical (farthest) point up to the point; where it enters the storm water drain mouth. It may be estimated by the following equation:

$$t_i = (0.885 L^3 / H)^{0.385} \tag{3}$$

Where,

- $t_i$  = Inlet time in minutes
- $L$  = Length of overland flow in kilometres from the critical point to the mouth of the drain.
- $H$  = Total fall in level from the critical point to the mouth of the drain in meters

The values of  $L$  and  $H$  can be found from the survey contour plan of the area and then  $t_i$  can be easily calculated. For Bopal catchment area, the average inlet time calculated as low as 11.44 minutes.

(2) Flow time in the Drain or the Conduit Flow Time ( $t_f$ ): This can be obtained by dividing the length of the drain with the flow velocity in the drain.

$$t_f = (\text{Length of Proposed Drain} / \text{Flow Velocity}) \tag{4}$$

Thus, the time concentration ( $t_c$ ) at a given point in the drain, can be easily obtained as,

$$t_c = t_i + t_f \tag{5}$$

The runoff resulting from rain, having a duration lesser than  $t_c$  will not be maximum, as the entire catchment area will not contribute to runoff in this case.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 4, April 2018

Design of Storm Water Drain pipes:

The estimated design flows depend, to a large extent, on the assumption, the accuracy of which is variable. In spite of this, care is required to select an accurate friction-flow formula as to avoid compounding errors. However, the design practice is to use the Manning's formula for storm water drains (pipes).

$$V = (1/N) \cdot R^{2/3} \cdot S^{1/2} \tag{6}$$

Where,

- N = Manning's Coefficient of roughness
- S = Slope of hydraulic gradient
- R = Hydraulic radius in meter = Area / Perimeter
- V = Velocity in meter/second

Coefficient of roughness N for adopting Manning's formula with the use of new RCC pipes with collar joints is taken as 0.013

## V. RESULTS

Results obtained from data collected and above mentioned methodology, for the area of 275.53 hectores of Bopal of Ahmedabad city, total storm water peak flow calculated as 10.48 cumecs. To dispose this water quantity away from this area, creating no flood effect after storm, provided 12294 m. of pipes of varying diameters as shown in Table – 3.

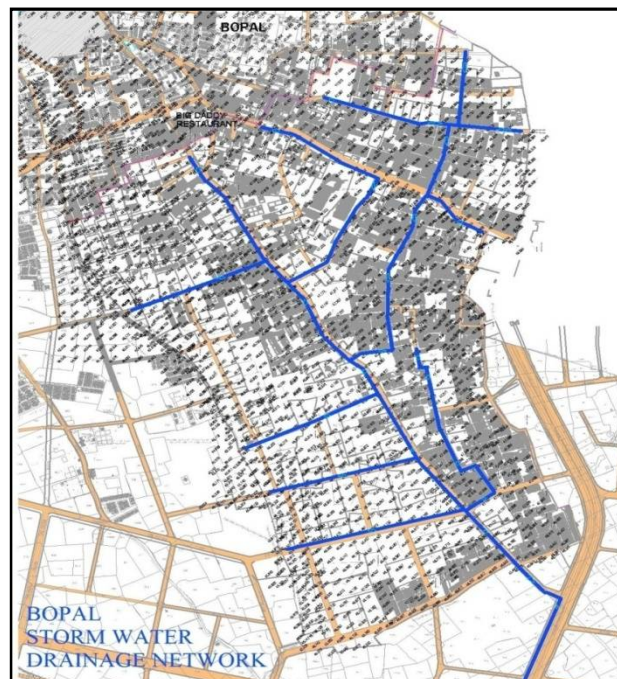


Figure 4. Bopal – Proposed storm water drainage network.

Figure-4 shows storm water drainage pipe network that collect storm water from different small areas and dispose it to the main drainage pipe, finally into the river Sabarmati via Sarkhej lake.

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 4, April 2018

Table : 3 Storm water drainage network having varying diameter (D) of pipes with its corresponding length (L) of pipes

D in mm	600	700	800	900	1000	1100	1200	1400	1500	1800	2100	2300	2400	2600
L in m	200	1539	2208	763	734	906	638	683	329	401	189	335	305	3064

Table 3 shows varying diameter (D) of pipes with its corresponding length (L) of pipes for storm water drainage network. Pipes laid at slopes range of 1 in 900 to 1 in 1200, according to the topography of Bopal area, highest ground level is 48.20 m. and lowest ground level is 46.55 m. Finally storm water flow collected in the pipes are dispose off into main line of storm water drainage network provided by AMC near Mahemadpura cross road, which dispose storm water into Sarkhej lake.

### VI. CONCLUSION

This paper presents related development of performance indicators for urban storm drainage. Although the methods for performance indicator described here. From all results here show that there should be properly storm drainage are provided in cities. While proper care should be taken when designing storm water network, as to select diameter of pipes and related slopes such that design discharge should be greater than calculated discharge for each area, i.e.  $Q_{design} > Q_{calculated}$

### REFERENCES

- [1] Congying Li, "Ecohydrology and good urban design for urban storm water-logging in Beijing, China", E&H, 12-4, 287-300, 2012.
- [2] Gajjar HH and Dr. Dholakia, "Storm Water Network Design of Jodhpur Tekra Area of City of Ahmedabad", IJEDR, 2-1, 744-747, 2014.
- [3] Patel K. and Chourushi, "To Study the Storm Water Drainage of Ahmedabad, Gandhinagar and Vadodara City", ParipeX - Indian Journal Of Research, 132-133, 2013.
- [4] Qianqian Z, "A Review of Sustainable Urban Drainage Systems Considering the Climate Change and Urbanization Impacts", Water, 6, 976-992, 2014.
- [5] LIZ D, "Are street trees and their soils an effective stormwater treatment measure?", National Street Tree Symposium, 7, 1-10, 2006.
- [6] Georgie W, "Green streets: creative storm water design", National Street Tree Symposium, 7, 1-5, 2006.
- [7] Chocat B, "Urban Drainage - Out-of-sight-out-of-mind?", IAHR/IWA Joint Committee On Urban Drainage Novatech, 2004, 1659-1690.
- [8] Bhagu R, Didier G and Shishir G "Storm-Water Management through Infiltration Trenches", JIDE ASCE, 138, 274-281, 2012.
- [9] Mohammad Karamouz, Ana Hosseinpour and Sara Nazif, "Improvement of Urban Drainage System Performance under Climate Change Impact: Case Study", J. Hydrol. Eng. © ASCE, 16, 395-412, 2011.
- [10] Kris Wernstedt and Fanny Carlet, "Climate Change, Urban Development, and Storm Water: Perspectives from the Field", J. Water Resour. Plan. Manage. © ASCE, 140, 543-552, 2014.
- [11] Dwi Tjahjanto, Sabariah Musa, and Mohd Baharudin Ridzuan, "A Study on Artificial Recharge Well as a Part of Drainage System and Water Supply in UTHM", PSISenviro, 106-111, 2008.