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Storm Water Network Design of Jodhpur Tekra Area of City of Ahmedabad

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***Abstract* – This paper presents novel design of storm water drainage system for Jodhpur Tekra Area of city of Ahmedabad. The present design is based on rainfall data. Past 20 years rainfall data has been taken for stydy. The system has been designed considering in total of 65% of the impervious area. Different methods have been used for runoff estimation. Here, Rational method has been used for estimation of storm water runoff. The outfalls of system are directed to proposed lakes.**

***Keywords:* Drainage, Runoff, Storm water**

I. INTRODUCTION

Storm water drainage is the process of draining excess water from streets, sidewalks, roofs, buildings, and other areas. The system used to drain storm water are often referred to as storm drains, but they are also called storm sewers and drainage wells. Storm water collects because of precipitation, such as rain, snow, and sleet. Some of this water soaks into the ground, but without proper drainage, excess water may collect and present dangers to both people and physical property.

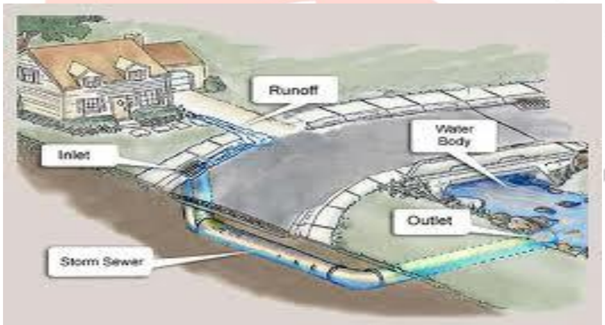

Fig 1 Typical Stormwater Drainage System

Storm water drainage design is basically based on runoff quantity estimation. Various methods are available for runoff quantity estimation.

1. Rational Method
2. Hydrograph Method
3. Empirical Formula Method
4. Rainfall-Runoff Correlation Studies

In this research, Rational Method is used for drainage design. It is also suggested in CPHEEO Manual published by Central Government.

II. STUDY AREA

Total area of Ahmedabad city is 464 sq.km. Jodhpur Tekra of Ahmedabad city is taken as study area. It is situated in West zone of Ahmedabad city. In this research work, study area is taken as 9 sq.km. Rainfall data of past twenty years of Jodhpur Tekra area is taken for calculation.

Latitude – $23^0$02' N
Longitude – $72^0$5' E

III. DESIGN CRIETERIA

The main factor for design of storm water drainage system is storm runoff. Storm runoff is that portion of precipitation which drains over the ground surface.

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

- Direction of prevailing storm
- Humidity , temperature
- Growing vegetation , crops , trees in the catchment

Rational method for estimation of Stormwater 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 formulae of rational method :

$Q = 10\,C\,i\,A$

Where ,

Q = Runoff in m^3 / hour

C = coefficient of runoff

i = intensity of rainfall in mm/ hour

A = area of drainage basin in hectares

Thus , for estimation of runoff , the basic data required are as follow :

- The runoff coefficient
- Rainfall intensity
- Time of concentration t_c
- Probable future condition of the area to be drain

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 stormwater flow . This factor that governs the amount of flow reaching the drain is known as "coefficient of runoff" .

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
	Low density	35 to 60
3	Parks and other undeveloped area	10 to 20

The weighted average imperviousness of the drainage basin may be estimated as :

$c = A_1I_1+A_2I_2+\ldots+A_NI_N / A_1+A_2+\ldots+A_N$

where ,

A_1 , A_2 , A_n = Drainage area contributory to section of drain

I_1 , I_2 ,I_N = Imperviousness factor f respective area

Storm Frequency

Storm water drains are not designed for the peak storm water frequency. However, there may be some flooding when the rainfall exceeds the design value, which has to be permitted. The frequency of such permissible flooding may vary from place to place, depending on the importance of the area.

Type of Area	Frequency
(a) Residential	
Peripheral	Twice in a year
Central (high value)	Once in a year
(b) Commercial	Once in 2 years

Rainfall intensity and Frequency

The design of storm water drain is principally based on the assumptions of rainfall in a particular area. The reasonable predictions for the runoff in the future can be made from the statistical analysis of the rainfall figures taken from the past records for number of years. Such predictions, though statically sound, are still not entirely reliable.

$I=a/t^n$

Table 2 Time Intensity Values of Storm in AMC Area

t (minutes)	i (mm / hour)
5	50.0
10	36.0
15	30.0

30	20.0
45	15.0
60	12.0
75	10.0
90	9.0

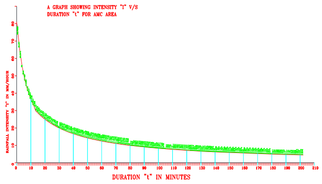

Fig 2 Graph 1. Intensity I vs Duration t

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:

Inlet time or overland flow time or time of equilibrium (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:

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

Where,

t_i = Inlet time in minutes

L = Length of overland flow in kilometers 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

Time of Flow 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 = Length of proposed drain / Flow velocity

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

$T_c = t_i + t_f$

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).

$V = 1 / NR^{2/3}\ S^{1/2}$

Where,

N = Manning's Coefficient of roughness

S = Slope of hydraulic gradient

R = Hydraulic radius in meter
=area/velocity

V = Velocity in meter/second

Coefficient of roughness 'N' for adopting Manning's formula with the use of RCC pipes with collar joints are –

(1) If internal surface of pipes are in good conditions = 0.013

(2) If internal surface of pipes are in fair conditions = 0.015

IV. RESULTS

- Jodhpur Tekra are is high priced residential area so percentage of imperviousness is taken as 65%. So, coefficient of runoff is taken as 0.65 in this study.
- Minimum size of pipe used is taken as 450mm diameter pipe and maximum size is taken as 2000mm diameter.
- Total discharge at proposed outlets is 10 cu.m/sec and it is directed towards proposed outlets.

Figure 2. Flow direction

V. CONCLUSION

Rational method is very useful and appropriate method for estimating storm water runoff discharge.
Final outfalls and flow directions of runoff are shown in figure 2.

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