CASE STUDY

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Strom Water Drainage Design – A Case Study

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Abstract

Strom water drainage drains excess water from streets, sidewalks, roofs, buildings and other areas. A system used to drain strom water at various places has different names like sewers and drainage wells. Strom water can be any rainfall, such as rain, snow and sleet that falls on the surface of the earth. In areas with natural groundwater, about 10% of the precipitation becomes runoff and about 50% infiltrates into the soil to form or replenish groundwater and flows into streams. In view of the existing status of drainage systems in urban areas that cause frequent flooding leading to loss of property and life, it necessitates looking into the problem more closely and coming out with planning, designing, implementation and operation & maintenance guidelines to overcome the problems in urban areas. In this paper study of the drainage system of Bharti Vidyapeeth complex is shown which has been done throughout the project. Various phrases has been studied during the study of this particular project. It has been found that drainage system is not a factor that depends on a single particular section but equally on various interrelated factors .In this research paper, one can have idea about the several methods which has been used throughout the project.

Keywords: Area, Coefficient, Runoff, Zone, Discharge, Velocity.

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Introduction

A proper strom water design means a proper knowledge of a collection of data like understanding the precipitation data clearly, know the infiltration indices, concentration time, intensity of rainfall, runoff details etc. While doing the project Strom Water Drainage System for Bharti Vidyapeeth Complex has been studied and designed. All required data has been collected to study and design the strom water drainage system. While designing all the areas has been taken into consideration as it was the very first stage of project, and it has been known that this would be the major factor that will help to find out the remaining important factors like the weighted coefficient of runoff, time of concentration, discharge etc. therefore, whole Bharti Vidyapeeth Complex plan has been divided into Fourteen different zones. And as per the strategy, further procedure has been taken into account to determine the remaining important factors which would help the project complete.

Study Area

Bharti Vidtapeeth Complex, Dhankawadi Pune as shown Figure 1.

Literature Review

In this Research paper, Mishra *et al.,* (2020) studied the whole Dewas district drainage system situated on the Malwa platean in the west-central part of Madhyapradesh. Dewas is located in the North-East of Indore, South-East of Ujjain, and South-West of Shajapur. In this paper author made a comparison between the existing drainage system and the drainage system which should be installed in the same location to get optimum outputs regarding Strom water drainage system. Harpalani *et al.*, (2013) in their research paper states that the design of the Strom water drainage system is based on the estimation of the quantity of runoff. Gajjar *et al.*, (2014) in their research paper states that Strom water drainage is the process of draining excess water from streets, sidewalks, roofs, buildings, and other areas. The system used to drain strom water is often called strom drain, but they are also called strom sewers and drainage wells. This research paper shows a detailed study of Jodhpur Tekra of Ahmedabad city. Palaka *et al.*, (2021) studied Design of Urban Strom Water Drainage System using GIS and SWMM Software. Researchers found in their study that The rapid growth of villages and towns

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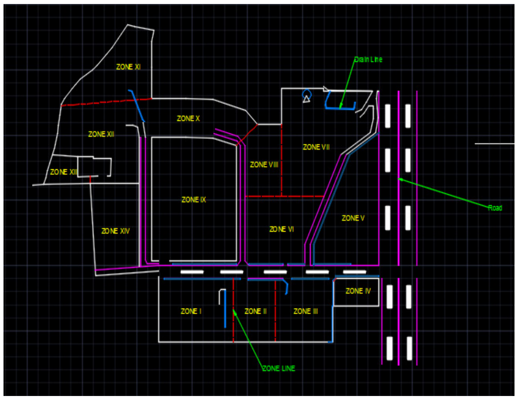


Figure 1: Bharti Vidtapeeth Complex, Dhankawadi Pune

affects natural drainage channels.. Parmar *et al.*, (2019), in their research paper states that strom water is the water generated from rainfall, it can infiltrate the ground surface and join with the groundwater table or contribute to subsurface flow and the remaining portion ends up as surface runoff which ultimately joins with the streams, rivers, etc. Ramachandran *et al.*, (2019) in their Research paper, states that Nearly 54% of the world's population lives in urban areas and it is expected to increase up to 66% by 2050 and most of these urban areas are coastal cities. Saraswat *et al.*, (2016**)** in their research paper states that As human history is changing on many fronts, it is appropriate for us to understand the different perspectives of major global challenges, of which, water is a major priority. Remote sensing and Geographic Information System (GIS) technology have been widely applied, and the integration of both is recognized as a powerful and effective tool to design and formulate strategies for strom water management. Author found that, To control and manage strom water runoff, BMPs are considered less expensive than conventional centralized systems and efficient in improving water quality. However, they require considerable investment. Sewnet (2020), in their research paper states that Urban flooding is a major catastrophic trait of many cities around the world, which is a result of manifold and uncertain factors such as, hydrological factors, urbanization, climate change and infrastructure inadequacy and failures that result in property damage, critical infrastructure distraction and loss of lives. Sewnet *et al.*, (2020) stated that Strom water drainage and urban flooding are the popular issues in policy agendas and academia. Although the research on these title increases steadily, an integrated review on strom water drainage and urban flood with a focus on pluvial flooding has yet to be produced. This paper presents a critical review on strom water drainage and urban flood based on 78 selected journal papers published over the period of 1990 to 2018.

Findings

Map

We have used "DETAIL SURVEY FOR BHARTI VIDYAPEETH AT-DHANKWADI, PUNE." Map for our Study. The map was made by "MONARCH" SURVEYORS AND CONTRACTORS Pvt. Ltd. They have surveyed whole Bharti Vidyapeeth Campus and made the Detail Survey map. The dimensions of the map are in Meters. During the study we have used the scale of 1cm=10 m. and did all the calculations with respect to that scale. We have divided the map in 14 different zones. The zones are divided approximately so as to calculate area of each zone.

Area Table

First of all the area of each zone in m^2 and area of each building of a particular zone were found as the building area was necessary for further calculations.

Weighted Coefficient of Runoff (c)

- The runoff coefficient (C) is a dimensionless coefficient relating the amount of runoff to the amount of precipitation received.
- It is a larger value for areas with low infiltration and high runoff (pavement, steep gradient), and lower for permeable, well-vegetated areas (forest, flat land).

The weighted coefficient of runoff is calculated as,

$$c = \frac{c1A1+c2A2+c3A3}{A1+A2+A3} \text{ (m)}$$

were,

- c_1 = Coefficient of Runoff for Building Area.
- c_2 = Coefficient of Runoff for Paved Area.
- c_3 = Coefficient of Runoff for lawns/garden.
- A_1 = Building Area.
- A_2 = Paved Area.
- A_3 = Lawns Area.

Time Of Concentration (t_c)

- It is defined as the time needed for water to flow from the most remote point in a watershed to the watershed outlet.
- Time of concentration is useful in predicting flow rates that would result from hypothetical stroms, which are based on statistically derived return periods through IDF curves.
- Time of concentration is calculated as,
-

$$t_c = t_o + t_f \text{ (min)}$$

- t_0 is nothing but the initial time of the flow where water starts flowing or gaining some velocity.

Were,

$$t_o = \frac{0.218\,(1.1-c)\ L^{0.5}}{S^{0.333}} \text{ (min.)}$$

Were,

C = Weighted Coefficient of Runoff

L = Inclined Length Of Zone

- 'S' denotes the slope of the zone, which is calculated as,

$$S = \frac{H2-H1}{L}$$

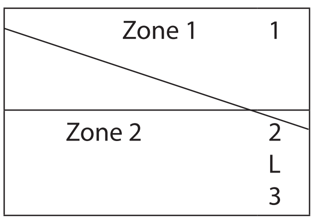
Were,
(H2 – H1) = Difference Between Height
Of Zone.
L = Inclined Length Of Zone

- t_f is the ratio of longitudinal drain and the velocity of flow.
- Final time (t_f) shows the final velocity the water or discharge acquired.
- t_f is calculated as,

$$t_f = \frac{Ldrain}{v} \text{ (m)}$$

Were,
L_{Dreain} = Longitudinal distance of zone
Situated below
For e.g.

H2



V = Velocity of flow (v = 1.2 assumed)

Intensity of Rainfall (I)

- The above IDF curve represents the Intensity of rainfall and the duration of the same in minutes.
- Above IDF curve is for 5 year return period (Figure 2).

Discharge (Q_p)

- The Rational equation is the simplest method to determine peak discharge from drainage basin runoff.
- It is the most common method used for sizing sewer systems.
- Rational Method Equation,

Discharge is calculated as,

$$Q_p = 10 \text{ CIA } (m^3/hr)$$

Were,
C = Runoff coefficient.
I = Average Rainfall Intensity
A = Catchment Area.
Therefore,

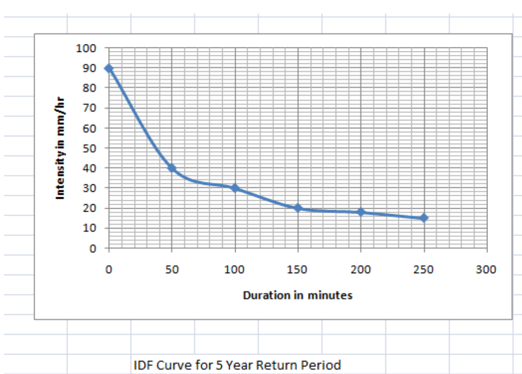


Figure 2:

Discharge (Q_p) = A x V (m^3/sec)
Where,
A = Drainage Area (m^2)
V = Velocity of Flow (m/s)

Depth (d)

- A = w x d (m^2)

Therefore,

$$d = \frac{A}{w} \text{ (m)}$$

Actual Velocity (V_{actual})

- We have assumed the strom water velocity as 1.2 m/s, but it is necessary to find out the actual velocity of strom water so as to compare between assumed and actual velocity.
- Actual velocity of strom water is calculated by using Manning's Formulae,

$$\frac{1}{n} \text{ x } R^{2/3} \text{ x } S^{1/2} \text{ (m/sec)}$$

(For calculation results refer to the Study Area Table.)

Study Area Table

1. **Area (m^2):-** This column represents the area of each zone in m^2.
2. **Area (Hectors):-** This column represents the area of each zone in Hectors.
3. **Building Area:-** This column represents the area of buildings of each zone in m^2.
4. **Weighted Coefficient of Runoff (c):-** The Weighted coefficient of runoff reflects the runoff potential of the drainage area. The weighted coefficient of runoff is the weighted average of all of the land uses within the drainage area.
5. **Time of Concentration (t_c):-** Time of concentration column represents the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet of each zone.
6. **Intensity of rainfall:-** Represents the 5 year rainfall Intensity of each zone.
7. **Discharge (Q_p):-** Represents the overall discharge of each zone in m^3/hr.
8. **Discharge (Q_p):-** Represents the overall discharge of each zone in m^3/sec.
9. **Depth of zone:-** Represents the depth of each zone in meters.
10. **Assumed Strom Water Velocity:-** Represents assumed strom water velocity i.e. 1.2 m/s.

Actual Strom Water Velocity:- Represents actual strom water velocity respect to assumed Strom water velocity.

Results and Discussion

- As mentioned earlier, we have divided our map i.e. "Detail Survey of Bharti Vidyapeeth, Dhankawadi Pune" in XIV different zones.

Table 1:

Zone No.	Area (m^2)	Area (Hector)	Building Area (m^2)	Weighted coefficient Of runoff (c)	Time Of Concentration t_c (minutes)	Intensity Of Rainfall (mm/hr)	Q_p (m^3/hr)	Q_p (m^3/sec)	Depth Of Zone (d) (m)	Assumed Strom Water Velocity (m/s)	Actual Strom Water Velocity (m/s)
I)	23715	2.37	4186	0.538	6.871	84	1055.79	0.29	0.6		0.68
II)	14570	3.82	5663	0.64	7.35	83.5	2045.95	0.56	1.4		0.65
III)	24490	6.27	7981	0.61	12.65	74	2883.66	0.80	2		0.68
IV)	8640	7.14	0	0.45	91.50	30	964.10	0.26	0.65	1.2	0.59
V)	7905	7.93	0	0.45	3.84	86	3089.684	0.85	1.75		0.74
VI)	24250	2.42	7547	0.60	6.52	82	1190.88	0.33	0.68		0.68
VII)	25488	4.96	8645	0.61	2.81	88	2667.53	0.74	1.525		0.74
VIII)	5929	5.56	3990	0.78	2.81	87	3774.50	1.04	2.15		0.77
IX)	71531	7.15	0	0.45	10.36	78	2510.73	0.69	1.43		0.74
X)	8679	8	1550	0.53	6.96	84.5	3592.20	0.99	2		0.77
XI)	19544	1.95	6216	0.60	0.91	89	1043.64	0.28	0.6	1.2	0.68
XII)	13642	2.47	607	0.47	7.001	83	964.99	0.26	0.525		0.65
XIII)	4893	2.96	0	0.45	5.09	84.7	1129.34	0.31	0.625		0.68
XIV)	20083	2	6547	0.61	5.49	85	1041.30	0.28	0.575		0.65

- After that using the scale 1:100 (1 cm=100 m), we found the area for different buildings of zone in m^2.
- Then we found the area for buildings of each zone.

Now we have found the weighted coefficient of runoff (c) for each zone but while calculating as we proceed further we have added the areas of previous zones as the drainage line of these zones would be the same.

For e.g.:- (For zone 3:- A_2 = 30 % of total zone area.

$$= \frac{30}{100} \text{X (Area of Zone 1+ Zone 2+ Zone 3)}$$

In this manner we have found the Weighted Coefficient Of Runoff for each zone using the formula,

$$\text{Weighted coefficient of runoff (c)} = \frac{c1A1+c2A2+c3A3}{A1+A2+A3}$$

Calculations for the weighted coefficient of runoff were shown in Table 1.

- Then after we have found the time of concentration for that, initial and final time were calculated so as to get time of concentration $\mathbf{t_c = t_0 + t_f}$
- While calculating t_0 zone length (L) has been taken as Inclined length of zone.
- Then, After finding the values of t_0 and t_f we found the t_c.
- Now using the rational formula we have found the discharge $\mathbf{Q_p = 10\ CIA}$.
- With the help of Discharge Q_p (m^3/s), Area has been found for each zone.
- With help of areas of each zone and assumed width (w = 0.4) we have found the depth for each zone.
- And at last we have found the Actual velocity using Manning's formula,

$$\frac{1}{n} \text{ x } R^\wedge\frac{2}{3} \text{ x } S^\wedge\frac{1}{2}$$

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