International Journal of Engineering Science Invention Research & Development; Vol. 12, Special Issue 11, May 2026
www.ijesird.com, E-ISSN: 2349-6185

ANALYSIS AND DESIGN OF STORM WATER DRAINAGE SYSTEM IN CHIKKABANAVARA

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Abstract:- **Rapid urbanization, increased impervious surfaces in the Chikkabanavara Road area have brought about the improper management of surface runoff that results in frequent waterlogging and flooding during high-intensity rainfall events. A comprehensive analysis of the existing storm water drainage system is presented in this study. This system presents a redesigned hydraulically efficient system to alleviate flood conditions within the urban areas which improve the durability of the road pavement. The methodology entailed hydrological analysis to determine the peak runoff discharge for the study area with the Rational Method, incorporating data collected on the catchment area, land use/land cover, soil type and rainfall data for a selected design return period of 25 year. Then, the hydraulic analysis of the existing drainage network was performed in order to identify critical choke points, insufficient capacities, and sections with inadequate slope using software such now known as EPA-SWMM. The analysis confirmed that the current system was deficient in capacity, based on the calculated peak discharge, the study will propose a new drainage system design, identifying alignment, and cross-sectional dimensions for all the proposed drainage system. The redesign employs Manning's equation for open-channel flow and suggests measures like introduction of laying of new drain sections, improvement of the cross section of the existing and inlet / outlet end structures. The successful execution of the proposed design will, as expected, translate effectively into peak storm runoff of water, thereby considerably reducing the stagnation of water, and avoiding damage to the pavement of the road, and ensuring a safer, flood-resilient urban environment along Chikkabanavara Road.**

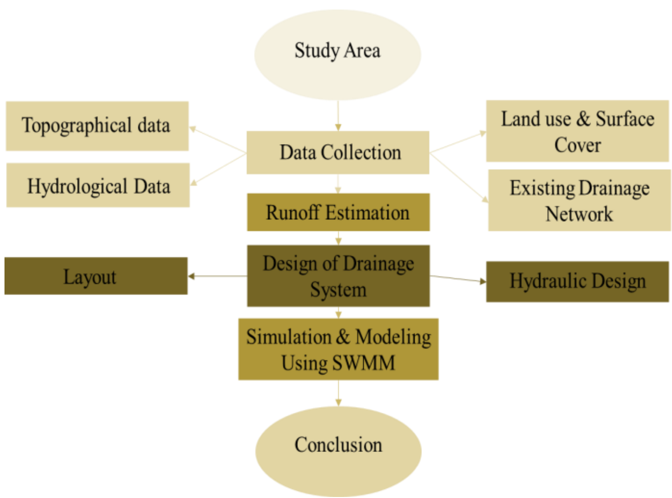
***Keywords*:-** **Stormwater Drainage, Urban Flooding, Peak Runoff, Hydraulic Analysis, Drainage System Design**

I. INTRODUCTION

Urban areas in India are facing increasing flooding issues due to rapid urbanization and climate change. The replacement of natural land with impervious surfaces like roads and buildings increases surface runoff, leading to waterlogging, traffic disruption, and property damage, especially during heavy rainfall. Existing stormwater drainage systems are often inadequate and unable to handle the increased runoff. An efficient and well-planned stormwater drainage system is essential to manage rainwater, reduce flooding, and protect public health and infrastructure. Proper design must consider local factors such as topography, soil type, rainfall patterns, and land use. Additionally, sustainable solutions like improved drainage networks, pollution control measures, and regular maintenance are necessary to ensure a safe, resilient, and environmentally friendly urban environment. Effective design requires understanding rainfall, soil, and catchment characteristics using methods like the Rational Method and Manning's equation. Proper maintenance and community involvement are also crucial for creating sustainable, efficient, and flood-resilient urban drainage systems.

II. OBJECTIVE

- To study rainfall data of study area.
- To find the elevation of the catchment area.
- To design the parameters manually and analysing it with aid of SWMM software.
- Comparing the existing & required drainage system of the catchment area.



III. METHODOLOGY

Based on topography and land usage information, a whole project area has been divided into individual catchments. Every individual catchment has been studied for a contributing area, runoff path, and point of discharge. A suitable return period for a design storm based on the significance of a project has been considered.

1. STUDY AREA

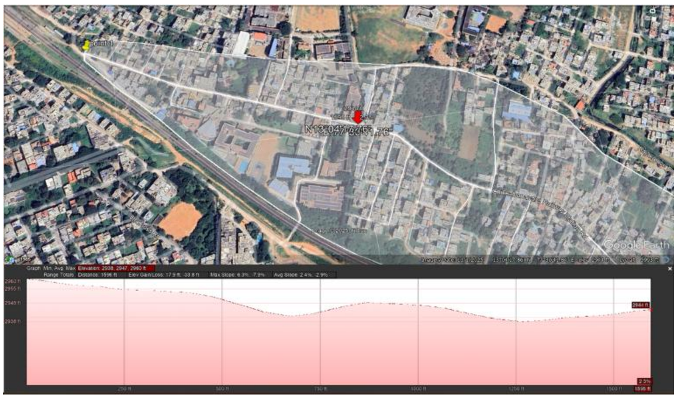
Chikkabanavara is one of the most developing places in the north-western part of Bengaluru city, Karnataka. During the last couple of years, the area has grown quite visibly by way of new residential, commercial, and small-scale industries. This has been triggering rapid changes in land use. The study area has all types of road pavements, residential layouts, open plots, and very few natural drainage paths; these, altogether, cause significant variations in the movement of surface runoff emanating from the catchment area.

2. CATCHMENT AREA

The catchment area in Chikkabanavara was determined based on observations of ground slopes and existing drainage paths. Additionally, roads and developed areas were considered because they affect runoff directions.

3. ELEVATION PROFILE

Elevation information for the area of interest was derived using Google Earth to establish the level and slope information of Chikkabanavara. Elevation points were measured at fixed intervals along road and water course paths to detect natural directions of water flow. Such information facilitated the identification of the catchment area and low-lying regions where water would settle when it rains.



4. DESIGN METHODOLOGY

Design Criteria as per IRC (Indian Road Congress)/ CPHEEO (Central Public Health & Environmental Engineering Organization)

- Design rainfall intensity is obtained from long-term rainfall data with an appropriate return period for the urban area.
- It adopts a return period of 2–5 years, as recommended by CPHEEO, for economic and efficient design.
- The Rational Method is used in estimating peak discharge, which is applicable for small to medium urban catchments.
- The runoff coefficients are assigned based on the land use, which considers residential areas, paved surfaces, and open spaces.
- Manning's equation is utilized to calculate the capacity and size of drains.
- Taking Manning's roughness coefficient, n usually concreted drain varies between 0.013 0.015 for concrete drains.
- Minimum self-cleansing velocity of 0.6 m/s is maintained to prevent sediment deposition.
- The maximum velocity is kept within 3 m/s to avoid erosion of the drain surfaces.

5. RATIONAL METHOD

The Rational Method is the most commonly adopted methods in estimating peak stormwater runoff from a small urban catchment. It is a simple, practical, and especially suitable method for areas with limited detailed hydrological data.

6. MANNING'S EQUATION

The Rational Method is a common technique used for calculating peak runoff of storm water runoff in a small urban watershed. The Rational Method is simple and can be used in regions with minimal information about runoff.

7. RUNOFF COEFFICIENT CALCULATION

Runoff coefficient is a function of rainfall runoff and represents the amount of rainfall that flows over land rather than infiltrating into it. A higher runoff coefficient takes place in paved surfaces with built-up area. However, a lower runoff coefficient takes place in open and vegetated regions.

Runoff Coefficient = 0.8

8. DESIGN OF PROPOSED SYSTEM

Design for Area 1

Catchment Area, Ac = 9.35 ha (0.0935 km^2)
Channel Slope, S = 0.003
Runoff Coefficient, C= 0.8
Manning's Roughness Coefficient, n = 0.013
Calculate peak runoff flow, Q
Q = (C*I*Ac*1000)/3600
Q= 2.5 m^3/s
Discharge for one side drainage = 1.25 m^3/s
Assume design velocity (safe velocity range)
V = 0.6 to 3 m/s
V = 1.5 m/s
Calculate cross sectional area, A
A = Q/v = 0.83 m^2
Assume channel width
b = 0.7 m
A = b*d
0.83 = 0.7* d
d = 1.2m
Calculate wetted perimeter, P
P = b+2d
P= 2.8m
Calculate hydraulic radius, R
R = A/P = 0.29 m
Calculate velocity using manning's equation

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

V = 1.88 m/s

Design for Area 2

Catchment Area, Ac = 14.2 ha (0.142 km^2)
Channel Slope, S = 0.002
Runoff Coefficient, C= 0.8
Manning's Roughness Coefficient, n = 0.013
Calculate peak runoff flow, Q
Q = (C*I*Ac*1000)/3600
Q= 3.8 m^3/s
Discharge for one side drainage = 1.9 m^3/s
Assume design velocity (safe velocity range)
V = 0.6 to 3 m/s
V = 2 m/s
Calculate cross sectional area, A
A = Q/v = 0.95 m^2
Assume channel width
b = 0.7 m
A = b*d
0.95 = 0.7* d
d = 1.3m
Calculate wetted perimeter, P
P = b+2d
P= 3.4m
Calculate hydraulic radius, R
R = A/P = 0.27 m
Calculate velocity using manning's equation

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

V = 1.47 m/s

IV. SWMM

The Storm Water Management Model (SWMM) is a one-dimensional dynamic computer-based tool developed to analyse rainfall-runoff processes that occur in an urban catchment area. It had been used to understand the manner in which storm water flows through drains, pipes, and channels under various rainfall conditions. This software is utilized to simulate runoff quantity, flow behaviour, and system performance for planning and improving urban drainage networks.

V. RESULT & DISCUSSION

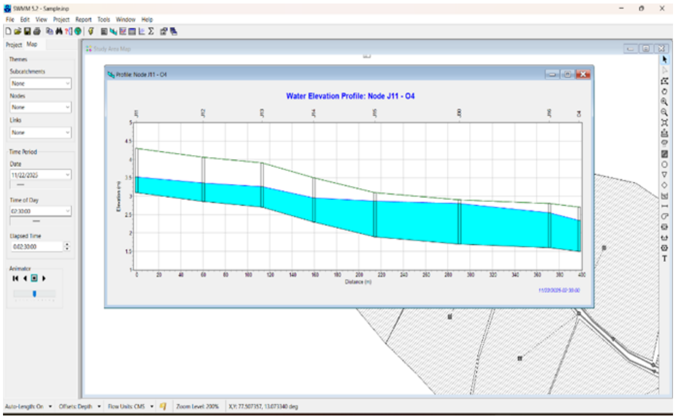
The proposed storm water drainage system was analyzed for its hydrologic and hydraulic performance under selected design rainfall conditions using the Storm Water Management Model (SWMM). Catchment characteristics, rainfall intensity, runoff parameters, and conduit properties were included in the model to determine how the system would behave at peak storm events. The model is simulated in SWMM at the peak intensity and all other parameters which are required so that our proposed system will enough to convey all the runoff of the study area.

This project work involved a comprehensive analysis and design for a storm water drainage system for the Chikkabanavara Railway Station Road, which serves a total catchment area of 23.55 hectares. The region of concern was divided into two sub-catchments that comprise 9.35 hectares (Area 1) and 14.2 hectares (Area 2), depending on terrain and direction of flow. A rainfall intensity of 120 mm/hr was considered for runoff calculations, which is representative for that region and its urban nature.

A hydrological analysis based on the Rational Method indicated that the existing drainage network is hydraulically inadequate. The existing discharge capacity of the drainage system was found to be 1.56 m^3/s, but the peak runoff contributed by Area 1 alone has been calculated as 2.49 m^3/s. Likewise, the remaining Area 2 has been found contributing a peak runoff of 3.79 m^3/s, which is substantially higher than the existing discharge capacity of the drainage system. There are also physical obstructions like culvert wall blocking, which hampers efficiency and causes waterlogging in heavy rainfall conditions. The new storm water drainage system was designed using the hydraulic model and Manning's equation. The new drain size was finalized as follows:

Area 1: Width = 0.7 m, Depth = 1.2 m

Area 2: Width = 0.7 m; Depth = 1.3 m



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