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Design of Drainage Network for the Bhagyanagar Area, Belagavi City Using SWMM

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Abstract:- **Storm Water Management Model (SWMM) is used in this study for simulating rainfall driven flow in a sewer system that can cause overflow in sewer networks. The simulation is carried out in a residential area located in the Bhagyanagar, Belagavi city. The study reveals that severe rainfall events cause sewer overflow and surface inundation in the area. A number of measures have been proposed including capacity improvement of sewer system, reduction of discharge peak to solve the flood problem. It is expected that the study will help in operational management of the sewerage system and mitigate the flooding problem. The main objectives of the project are to control the runoff from small rain events and provide safe path or storage runoff from the major storms. Management of storm water by suitable design of drainage system which controls unforeseen disaster. Storm management controls flood by diverting the excess water. It aims for sustainability development using storm water management techniques.**

Keywords:**--Storm water management, drainage design, surface runoff, sub-catchment, urban drainage, digital elevation model.**

I. INTRODUCTION

The currently happening of global earth space which leads to the intensity and volume of the runoff melt water which is producing from snow as well as storm water. These storm water and snow water are collected in the sewerage systems which are constructed by recent modern techniques, of pipes with clear smooth internal surfaces can be immediately supplied to the collectors. [4]

Urban flooding in particular is not an un-known occasion in India. The un-even conveyance of storm water rainfall combined with undemanding urbanization, interfering upon and substantial off common drainage channels and urban lakes to utilize the high-esteem urban area for structures are the reason for urban flooding. The unlawful filling of urban aquatic bodies in urban communities like Chennai, Bengaluru, Calcutta, Delhi, and Hyderabad and so on is an uncontrolled. A large number of prohibited states have developed in city and planning has been mixed to the winds bringing about building of normal drainage inviting severe flood. This project manages causes, impacts, preventive measures to handle urban flooding by and large with spotlight on given study area. [2]

II.STUDY AREA

Bhagyanagar is one of the well urbanized and sophisticated residential areas almost located in South part of the Belagavi. The study includes the overall area of the Bhagyanagar is 11,85,300m2. The residential area and roads covers upto 8,68,500m2 and 2,19,900m2 respectively and also the miscellaneous area is about 96,500m2 overall in the Bhagyanagar study area. The proposed study area of Bhagyanagar comes under the Markandeyacatchment area. Latitude and longitude of the study area N 15°49'38.98" and E 74°30'34.91" respectively.

A.Climate

Bhagyanagar is the south part of the Belagavi city. This is more rainfall prone area. Usually it rains heavily in the month of June to October. It rains moderately in the month of November to February.

B. Rainfall

The highest rainfall occurred in the Bhagyanagar is about 199mm/day. Generally Rainfall data is collected from the rain gauges which are fixed as per IMD(Indian Meteorological Department)which are placed at different locations and are called as rain gauge stations and the study area of Bhagyanagar rainfall data is preferably collected from Belagavi rain station's rain gauge. If in any case data were missing, then data should be collect from the nearby rain gauge station by IMD recourses.The maximum rainfall occurred in the month of July 1994 of about 821.7mm, which is further used for the calculation of discharge and time series graph by SWMM.

C. Temperature

As per Wikipedia source data the highest temperature recorded in the study area of project is about 380 C in the month of May and minimum temperature is about 90C in the month of the December.

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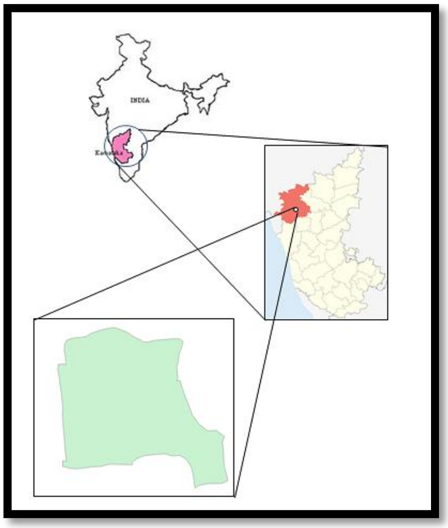

Fig. 1. Study Area, Bhagyanagar, Belagavi.

III.METHODOLOGY

There are various number of techniques for evaluation of storm water runoff on bases of water balance equation and empirical equation, CN strategies and viable models like SCS curve number, SHETRAN model, SWAT by such strategies calculations for penetration, overflow of surface, routing of flow, and slacking of surface overflow have been re arranged to permit simulation of flow with a hydraulic and Hydrologic Simulation Program-Fortran (HSPF) with a generally utilized GIS and so on.For each one of those number of techniques they have some limitations and advantages however for our project targets the SWMM is favored for urban runoff estimation. SWMM considered is a dynamic rainfall runoff network model shows that calculating quality of runoff from major urban areas. [7]

A. Arc GIS

Arc GIS Software was established by ESRI (environmental system research institute) in the year of 1969 as consulting firm, which was held by privately. And that is specialized in analysis of land use projects.Arc Info is the software of initial version, where ‘Arc’ denotes two segments of line in map elements. Arc view is developed in the year of 1990, which is the first release of a window based, graphical user interface (GUI) based GIS system for computers. [24] -Applications of Arc GIS

To fix the longitudinal and latitudinal co-ordinates to the basic map of study area by geo-referencing process.

The study area can be converted to digitization map in order to get accurate bifurcation of different sub-catchments. Arc-GIS helps in order to find out the slope by using land use and land cover map. The main application of this software is to measure the area of un-even boundaries and length of the conduits accurately.

B. Rational equation method

This method is used to calculate the peak surface runoff rate to design storm water management constructions storm sewers, storm drains and rain water detention facilities by considering parameters like runoff coefficient (C), rainfall intensity (i) and watershed area (A).

$Q=CiA$

C. Continuity equation

Continuity equation can be used to estimate discharge (Q) of storm drain by multiplying area of drainage pipe (A) to flow of velocity (V)
i.e.,
$Q = A \times V$
Where,
$V = \frac{1}{n} \times R^{2/3} \times S^{1/2}$ (Manning’s equation)
$1.432 = \frac{\pi \times d^2}{4} \times \frac{1}{n} \times R^{2/3} \times S^{1/2}$
Where $R = A/P$
A= Cross sectional area of pipe = $\frac{\pi \times d^2}{4}$
P= Perimeter of pipe = πd
S = Slope = 0.01643
By substituting these values, diameter of the pipe will be designed
d= 0.73m say 0.8m
and V= 2.84m/s

IV. RESULTS AND DISCUSSIONS

The surface runoff, sewer design, water elevation profile were obtained by simulating the SWMM. The study area has been bifurcated into 12 different regions called as sub-catchments (S) with uneven perimeters. Each sub-catchment is designed with sewer lines by providing proper slope at intermediate junctions by connecting with conduits. The overall runoff which was delivered from all the sub-catchments was discharged to outfalls through conduits with required slope. From the present simulated model S1 to S12 denotes twelve sub-catchments, J indicates junctions between the nodes and C stands for conduits which connects the flow between successive junctions.

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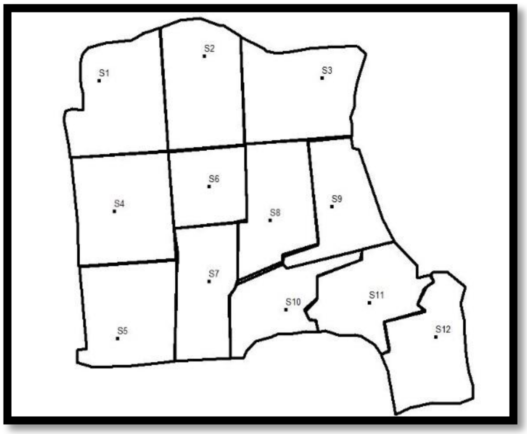

Fig 2. Map with all sub-catchments of study area

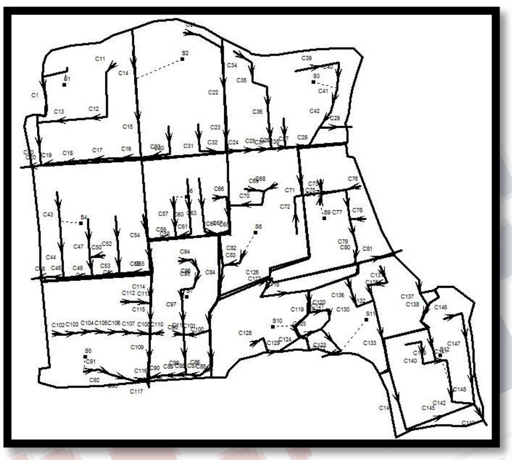

Fig 3. Map with all junctions of drainage system

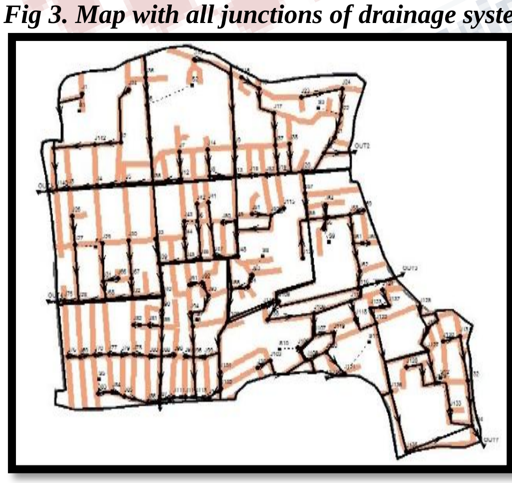

Fig 4. Map with all conduits of drainage system

Table 1
Peak surface runoff

Sl. No.	Sub-catchments	Total infiltration in mm	Total runoff 106 litres	Peak runoff in cms	Runoff co-efficient
1.	S1	83.94	5506.01	11.54	0.995
2.	S2	67.15	5329.74	11.16	0.996
3.	S3	33.58	5847.01	12.23	0.998
4.	S4	67.15	5772.35	12.09	0.996
5.	S5	25.18	5431.44	11.35	0.999
6.	S6	33.58	3273.22	6.84	0.998
7.	S7	41.97	4337.33	9.07	0.998
8.	S8	117.52	4366.19	9.17	0.994
9.	S9	117.52	4111.54	8.64	0.994
10.	S10	100.73	3498.72	7.34	0.995
11.	S11	100.73	4333.34	9.09	0.995
12.	S12	117.52	4795.94	10.07	0.994

Table 2
Simulated outfall loading results

Outfall node	Average flow cms	Maximum flow Cms	Total volume 106 litres
OUT1	1.093	1.432	2954.268
OUT2	0.264	1.432	726.609
OUT3	1.086	1.432	2968.131
OUT4	1.088	1.432	2996.006
OUT5	0.894	1.432	2493.254
OUT6	0.981	1.432	2726.872
OUT7	1.284	1.432	3434.730

V. VALIDATION

A. Validation of surface runoff

The surface runoff of all sub-catchment areas were calculated manually by using rational equation method. i.e., Q=CiA and those surface runoff values have been compared with simulated peak runoff values obtained by SWMM. And the validated results indicated that route mean square value came below one**.**

Table 3 Surface runoff values

Sl. No.	Sub-catchment	Manually calculated surface runoff in cms	Peak runoff in cms
1.	S1	4.88	11.54
2.	S2	4.724	11.16
3.	S3	5.17	12.23
4.	S4	5.11	12.09
5.	S5	4.8	11.35
6.	S6	3.2	6.84
7.	S7	3.83	9.07
8.	S8	3.88	9.17
9.	S9	3.65	8.64
10.	S10	3.1	7.34
11.	S11	3.84	9.09
12.	S12	4.26	10.07

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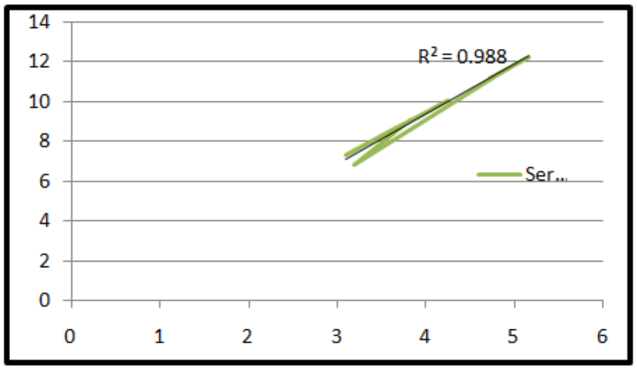

Fig 5: Root mean squared graph of both manually and model simulated surface runoff values

VI. CONCLUSIONS

1. The SWMM is the robust and powerful tool for analyzing the effective urban flood water control & management for the study area, Bhagyanagar, Belagavi.
2. The validation of SWMM was carried out using R2 mean value and the results are in limitations (i.e., R2< 1), which is quite satisfactory.
3. After providing of LID control data, the discharge values are lesser than as before to providing LID's data. Hence simulated model details are satisfactory.
4. The water elevation profile of different sub-catchment area was with proper gradual slope, hence model results and elevation profile are helpful for easy adopting technique drainage design.
5. DEM was used as an input for the SWMM and the results as discussed above were in line with ground control points.
6. The model evaluates the results obtained in the surface runoff within the watershed. The model eventually is utilized to evaluate the storm water infiltration and quality of water within the water shed.
7. The validated results by the model confirm that the SWMM has been validated and can expect accurately obtained independent set of data. This was essential due to the fluctuation in precipitation.

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