Critical Review on Smart Systems adopted in Stormwater Drainage Design

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Abstract

The Smart City mission in India was implemented with the view to improve and optimize the city functions utilizing smart technologies. Stormwater drainage is an important aspect for proper functioning of the city. In case of its inadequacy, the city has to contend with major economic loss, environmental impact and sometimes loss of life too. The major criteria of a smart city being usage of smart technologies, it is essential to integrate various software and systems available with the Stormwater drainage infrastructure too. Studies carried out by past researchers, mostly conducted for towns or cities of Gujarat, incorporating such smart resources have been studied and presented in this paper.

Keyword- Stormwater, Drainage, Smart City, Dahod

I. BACKGROUND

Stormwater is the water generated from rainfall, it can infiltrate the ground surface and join with the ground water table or contribute to subsurface flow and the remaining portion ends up as surface runoff which ultimately joins with the streams, rivers, etc. Under natural condition, most of the Stormwater gets infiltrated into the soil due to higher permeability of the surface. However, due to rapid urbanization resulting into formation of more impervious surface, the Stormwater that normally would have been infiltrated gets trapped onto the surface. For this, it becomes essential to establish a system to properly dispose off the extra runoff in such a way that there is minimal impact on the functioning of society. In the absence of such systems, the major issue that arise in the developed areas is the accumulation of high volume of Stormwater resulting into flooding. Proper Stormwater drainage is essential from environmental, economical, aesthetic and social aspect.

Stormwater drainage system in ancient times were not provided separately, but were combined with the sewage disposal network as found in Lothal, as early as 3000 B.C. and in 1500 B.C. in the Island of Crete. Prior to 1930, most of the drainage network designed were of combined nature, i.e. handled both Stormwater and sewage. However, due to issues such as heavy load on treatment plants during rainy seasons, inability of sewers to handle the flow along with restriction of disposal of Stormwater directly into streams or rivers resulted into the newer networks being separate in nature. As time has passed, more sophisticated techniques are increasingly being used. The current trend of development of Smart cities has resulted into an increased use of software such as StormCAD, CivilCAD, Dren-Urba, Stormwater Management Model (SWMM), MasterDRAIN, etc. to save time and improve accuracy. The increased focus on sustainability of a city to minimize the environmental impact has also resulted in development of concepts like Sustainable Urban Drainage System (SUDS), Low Impact Development (LID), Best Management Practice (BMP), etc.

II. CRITICAL LITERATURE REVIEW

S. K. Raval (2017) in the paper "Stormwater Drainage Solutions for Urban Area" studied the area of Bopal and the lack of stormwater drainage network there. The author used rational method for analysis of rainfall data to obtain discharge. The rainfall data of past 20 years was used to design the network. Out of the total area, 60% of it was taken as impervious area. The road maps, topographical data, town planning scheme maps, etc. of Bopal was collected from the concerned urban development authority. Manning's coefficient of roughness N was taken as 0.013. Final outlet was decided as Sabarmati River through Sarkhej Lake.

Sanjay Parmar & Prof. Vikash Bhavsar (2017) in the paper "Stormwater Management a Case Study of Gandhinagar City" focused on usage of Best Management Practice (BMP) to minimize the effects of stormwater. This stormwater can be used to bolster the Green Infrastructure and recharge the ground water table. Gandhinagar was identified to have 52% of green cover. Study was focused on sector 15, 16, 22, 23, 24, 27, 28 and 29. Sedimentation in stormwater sewers were identified as a major issue. A sedimentation control structure design was provided for affected regions. Use of permeable pavement has also been suggested for decreasing the impervious surface quantity.

Darshan Mali, Dipesh Agrawal, et al. (2017) in the paper "Estimation of Storm Runoff Quantity using Rational Method and SWMM" focused on the rainfall analysis portion of the stormwater drainage design. The Stormwater Management Model (SWMM) was suggested to calculate the total runoff quantity and its functionality was compared to that of traditional rational method. The basic principle of SWMM is the formation of sub catchment as a surface having uniform slope and it drains to a singular outlet channel. The various data required to be entered into the SWMM software are area of the catchment, time series of rainfall, and the infiltration properties of the surface. After running the simulation we get results like total runoff, peak runoff, etc. Total precipitation data can also be obtained through it. The result can be displayed in both tabular and graphical format. The author suggested using SWMM for calculation of runoff across a catchment for higher precision.

Kamini Patel & Bhasker Bhatt (2017) in "Analysis of Two Existing Stormwater Drainage Lines of Surat in West Zone using Bentley StormCAD" worked on Surat city, specifically focusing on the west zone, whose area is 51.279 km2. Total number of outfall for the area was identified as 10. Data of the existing network with levels, pipe diameter, manhole locations, was obtained from the drainage department, Surat Municipal Corporation. The analysis for effectiveness of the network was run on StormCAD by importing the CAD files and the IDF curve into it. All the required data such as pipe diameter, levels, manhole elevation, etc. Are then inputted in the software and analysis is run. The author showed the usefulness of StormCAD in analysing the system by identifying three manholes that would overflow based on past rainfall data.

Ajay Gamit (2017) in his paper "Stormwater Management using Remote Sensing and GIS – A Case Study of Surat City" worked on the central zone of Surat city, specifically the north-west region of Variyali Bhagol. GIS technology was used to generate various thematic maps showing the natural drainage path superimposed upon the road network and the elevation map of area. Reduction formula of IMD was used to reduce the maximum yearly depth of rainfall to intervals of 5 min, 10 min, 20 min and so on. IDF curves were then generated and total discharge was calculated. Utilizing Manning's equation, the network was designed.
Dave Maitry (2016) in the paper "Design of Storm Water Network for Nagala Village, Tharad Taluka, Banaskantha" used GIS in the data collection phase for identification of area with greater depression and in generating contour maps and slope directions. The design portion was carried out using MS Excel by estimating the runoff using rational method. AutoCAD was also used in the network planning phase. A total of 2389m of pipe network was designed.

Snehal Baleva &Prof. Kinnari Mishra (2016) in their study "Overview of Stormwater Network of East Zone of Ahmedabad City" mentioned that in east zone of Ahmedabad only 23% of stormwater drainage system coverage exists. Three different methods for estimation of runoff were specified, Empirical method, Hydrograph method and rational method. Software relating to analysis or design portion of the stormwater network were not utilized in this study.

Pavan Kumar & Dilip Barik (2015) in "A Comparative Study of Stormwater Drainage Methods for Urban Stormwater Management" focused on the study area of Vellore town, three alternatives for drainage of stormwater: (i) Construction of a new network. (ii) Retrofitting of the existing network and (iii) Utilizing swales were compared with each other based upon their functionality and also economic conditions were considered. Option (i) and (iii) were found to be most suitable. In option (iii) swales are channels of shallow depth with vegetation cover around and on its slopes and bed. This concept is a part of Sustainable Urban Drainage System (SUDS) for further promoting the idea of Green Infrastructure.

Harshil Gaggar & Dr. M. B. Dholakia (2014) in the paper "Stormwater Network Design of Jodhpur Tekra Area of City of Ahmedabad" used rainfall data of past 20 years and assumed 65% of the total area to be impervious and rational method was used for calculation of total runoff. MS Excel was used for the designing phase and also for IDF curve generation.

Abid Khan & Mahmood Ahmed (2014) in "Integration of Stormwater Drains with Lakes: Expectations and Reality – A Case of Raipur, India" identified the issue of waste dumping in the stormwater drains and along its inlet on the lake. GIS base map of Raipur city and Google Earth was used to specify the various drain connecting to lakes. SWMM was also used to identify the total runoff and the total amount of water being stagnant in the area. It was found that by integrating the network with lakes, there can be seen a 34% reduction in flooding.

Dwiti Shah (2006) in the paper titled "Sustainable Urban Drainage System Planning Case Study-Vadodara City" proposed to formulate a sustainable urban drainage system. For this study the case of Vadodara city was taken. The study further tried to identify the various issues that lead floods which are primarily the result of poor urban drainage infrastructure. It was found that due to urbanization the path of natural drains were changed and also few of the ponds were replaced by construction or backfilling. It was identified that during the process of planning the drainage system is given the last priority and afterwards the planners have to sometimes ignore the natural topography and network while planning the system. This leads to problem like water logging and also increase in economical cost resulting from flooding. This paper gave long term and short term measures which can help to achieve the goal of sustainable urban drainage system which take into account the environmental aspects. The author identified two mains, one was the problem of illegal and legal encroachment resulting into obstruction of the natural drains and removal of ponds. The second issue was the process of planning in which drainage system should be given higher priority compared to current scenario.

III. FINDINGS

1) Rapid urbanization has led to reduction in infiltration capacity of the surface and hence resulting in more runoff generation.
2) Proper Stormwater management can support the concept of Green Infrastructure.
3) Rational method is very effective and is widely used for calculation of Stormwater runoff.

4) Integrating the drainage network with lakes can reduce the waterlogging issue.
5) Software such as StormCAD & GeoSWMM are nowadays increasingly being used for analysing and designing Stormwater drainage networks.
6) Geographical Information System is also being integrated with the drainage network in some cases utilizing software such as ArcGIS & QGIS.

REFERENCES

[1] Abid Ali Khan, Mahmood Ahmad, 2014, "Integration of Stormwater Drains with Lakes: Expectations and Reality – A Case of Raipur, India", HYCR, an open access journal, ISSN: 2157-7587, Hydrol Current Res Volume 5, Issue 2, 1000166.
[2] Ajay Gamit, P. P. Lodha , Indra Prakash, Khalid Mehmood, 2017, "Storm Water Management Using Remote Sensing and Gis- A Case Study of Surat City", Journal of Emerging Technologies and Innovative Research, ISSN-2349-5162, Volume 4, Issue 05.
[3] Darshan Mali, Dipesh Agrawal, Paresh Parmar, 2017, "Estimation of Storm Runoff Quantity Using Rational Method and SWMM", International Journal of Recent Advances in Engineering & Technology, ISSN: 2347 - 2812, Volume-5, Issue -2.
[4] Dave Maitry, Dr. Gargi Rajpara, N. R. Chaudhary, M. D. Patel, 2016, "Design of Storm Water Network for Nagala Village, Tharad Taluka, Banaskantha", International Journal of Advance Research in Engineering, Science & Technology, ISSN: 2393-9877, Volume 3, Issue 2.
[5] Harshil H. Gajjar, Dr. M.B.Dholakia, 2014, "Storm Water Network Design of Jodhpur Tekra Area of City of Ahmedabad", International Journal of Engineering Development and Research, ISSN: 2321-9939, Volume 2, Issue 1.
[6] Kamini Hasmukhbhai Patel, Bhasker Vijaykumar Bhatt, 2017, "Analysis of Two existing Stormwater Drainage Lines of Surat in West Zone using Bentley StormCAD", Journal of Emerging Technologies and Innovative Research (JETIR), ISSN-2349-5162, Volume 4, Issue 05.
[7] K. Pavan Kumar, Dilip Kumar Barik and Ch. Manideep, 2015, "A Comparative Study of Storm Water Drainage Methods for Urban Storm Water Management", Indian Journal of Science and Technology, ISSN (Online): 0974-5645, Vol 8(33).
[8] Neil Armitage, "The removal of urban solid waste from stormwater drains", Department of Civil Engineering, University of Cape Town, Private Bag Rondebosch, 7701, South Africa.
[9] R. Kellagher1 and H. Udale-Clarke, 2008, "Sustainability Criteria for the Design of Stormwater Drainage Systems for the 21st Century", 11th International Conference on Urban Drainage, Edinburgh, Scotland, UK, 2008.
[10] Sanjay B. Parmar, Prof. Vikash D. Bhavsar, 2017, "Stormwater Management a Case Study of Gandhinagar City", International Research Journal of Engineering and Technology (IRJET), ISSN: 2395-0056, Volume: 04 Issue: 12.
[11] S. K. Raval, 2018, "Storm Water Drainage Solutions for Urban Area", International Journal of Innovative Research in Science, Engineering and Technology, ISSN (Online): 2319-8753, Vol. 7, Issue 4.
[12] Snehal N Baleva, Prof. Kinnari R. Mishra, 2016, "Overview of Storm Water Network of East Zone of Ahmedabad City", International Journal of Advance Engineering and Research Development, ISSN (O): 2348-4470, Volume 3, Issue 2.