SMART STORMWATER DRAINAGE

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Abstract—**In this paper, a comparison has been done between various systems of drainage. This paper aims to analyze various ways of quick draining of storm water. Selecting a proper drainage system always has been discussed in various fields. In anisotropic soils, this problem is more sensitive for experts. Geology of a region is primarily divided into sandy, clayey and hard rock regions. Therefore percolation rate of water is different for each type of soil. Therefore suitable drainage system should be used depending on the type of soil. Rather than letting the water fall under gravity, which happens with traditional downpipes, it sucks the water off the area at high velocities than normal traditional systems. Siphonic drainage works in a different way when compared to other systems.**

Keywords—**Siphonic, Quick Drain**

I. INTRODUCTION

Selecting a proper drainage system always has been discussed in various fields. This paper aims to propose various ways of quick draining of storm water. In anisotropic soils, this problem is more sensitive for experts. In this project, a comparison has been done between various systems of drainage.

Geology of a region is primarily divided into sandy, clayey and hard rock regions. Therefore percolation rate of water is different for each type of soil. Therefore suitable drainage system should be used depending on the type of soil. Various advanced drainage systems such as vertical drainage, underground discharge channel, smart tunnel system and techniques such as blasting, pop-up flow well which is followed in other countries has been suggested and model is to be done on siphonic drainage system.

Siphonic drainage works in a different way when compared to other systems. Rather than letting the water fall under gravity, which happens with traditional downpipes, it sucks the water off the area at high velocities than normal traditional systems.

II. GENERAL

The geology of a region is divided into sandy clayey and hard rock regions. Sandy areas are found along the banks and coasts. Clayey regions cover most of the city. In sandy areas which are nearest of coastal region, rainwater run-off percolates very quickly. In clayey and hard rock areas, rainwater percolates slowly, but it is held by the soil for a longer time. Comparison is done between various types of drainage followed in other countries and few drain systems are suggested for quick drain of storm water.

III. LITERATURE REVIEW

Various research works have been carried out for effective drain of water. In current time, in Ponneri, a town in a rural part of Chennai Metropolitan Area, developers are executing Chennai Metropolitan Development Authority-approved plans with no regard to drainage. During the heavy rains, Ponneri received 370 mm of rain – 135 mm more than Chennai did. While it suffered from flooding, damage to property and life was not high. Ponneri is slotted to be developed as a Smart City. The study was undertaken by Saravanan J M.E Environmental Engineering and working Professor in Department of Civil Engineering in Renganayagi Varatharaj College of Engineering, Sivakasi, TamilNadu, India and Naveen Chander K, M.E Environmental Engineering and working as BIM Modeler in SYConE CPMC Pvt. Ltd. Bangalore, India.

The research work of Mohammad Valipour Department of Irrigation and Drainage Engineering, College of Abureyhan, University of Tehran, Pakdasht, has done a comparison study between Horizontal and Vertical Drainage Systems and found that vertical drainage system to be effective drainage than horizontal lateral drainage system. In addition to this, the research works of Abdul Karim Yusufzai D and Mark E. Grismer on Vertical drainage shown in fig 1, may improve soil salinity and moisture is found to be an effective proposal for clayey fields. Existing drainage systems in many clay fields have failed to improve soil salinity and to provide moisture conditions favorable to crop growth.

SIPHONIC DRAINAGE

Various Construction of Automatic Bell Siphons (see fig 3) by Bradley K. Fox, Robert Howerton and Clyde S. Tamaru, Department of Molecular Biosciences and Bioengineering,

University of Hawai Sea Grant College Program has carried out a study on fast drain of water through siphon action. Siphonic drainage works in a different way when compared to other systems. Rather than letting the water fall under gravity, which happens with traditional downpipes, it sucks the water off the area at high velocities than normal traditional systems. This system is also used for roof drainage and design is done with the help of Siphonix software.
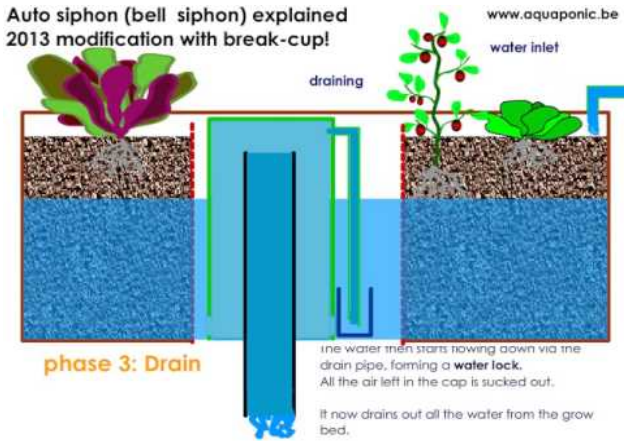

Fig 3 Siphonic drainage

Research works on Advance Drainage System by Niraj S Manekar and Shritej A Nirmal Dept. of Civil Engineering, P.R.M.I.T&R, Amravati, India has compared drainage systems in India (especially coastal cities) with world's best urban drainage in Tokyo. It intends to show is it possible to rectify the problems generally faced by our region in monsoon and also the financial losses during those three-four monsoon months. Govt. of Japan and university of Tokyo together proposed plan of advance drainage system which consist of 5 major water banks and one pumping plant which is connected by 6.3km long massive tunneling system. On contrary, in Chennai (Storm Water Drains) SWD department which are fairly based on just roadside, below footpath, open/closed drains, box drains, major gutters, minor gutters and outfalls. But these are not enough to control heavy rainfall. So that, if we focus to modify our older drainages and providing water treatment plant which will give an option for reuse of this waste water in industries, so it will be great for the concept Make In India. Underground discharge system shown in fig 4 and fig 5.

Fig 4 Underground discharge channel plan view

Fig 5 Underground discharge channel – (Source: Neeraj.S, Manekar and Shritej A Nirmal 2015 on Advanced Drainage System Tokyo, Japan.)

Ram Kumar M. KANNAPIRAN has done a research project on smart tunnel system in Malaysia. SMART is the acronym for "Storm water Management and Road Tunnel Project. This project is located in Kuala Lumpur the capital metropolitan city of Malaysia. Malaysia is located in the South East Asia in the equatorial climate region. The project was initiated by the Former Prime Minister Tun Dr. Mahatir Mohammad under the Malaysian Development Plan. The project is undertaken as a joint venture projects the government and the private sector corporation. The government departments involved in this project is the Department of Irrigation and Drainage Malaysia and Malaysian Highway Authority (Fig 6). The private sectors are MMC Berhad and GAMUDA Berhad. This project is done under close supervision of the above government department includes local consultants Sepakat Perunding Sdn Bhd in association with Mott MacDonald from United Kingdom.
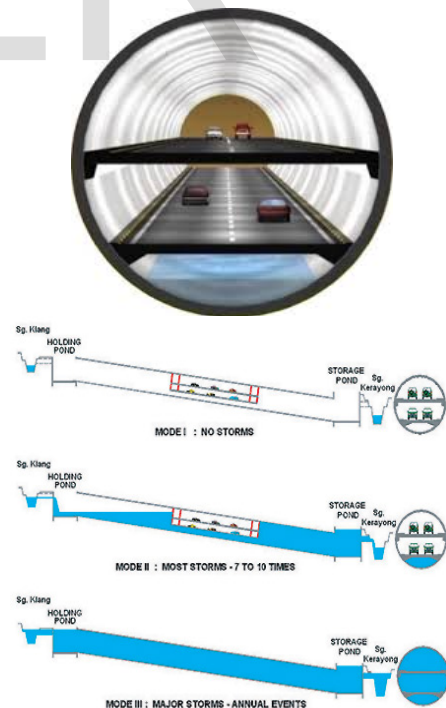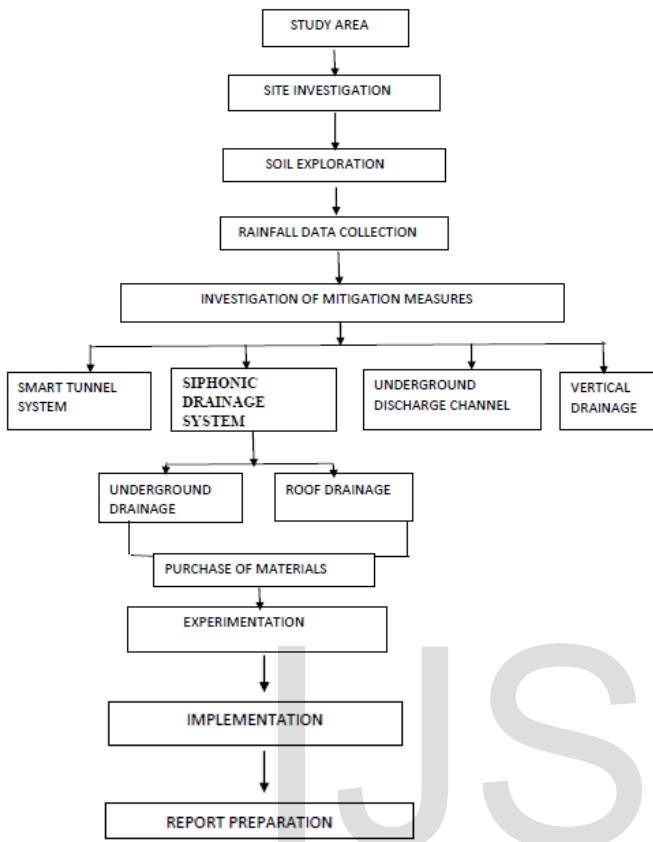

Fig 6 Smart tunnel.

IV. METHODOLOGY AND STUDY AREA

The objective of the study is to find solutions for quick and effective drainage of storm water. This chapter lists the sources of data to be collected and describes the methodology in detail to achieve the objective. Fig 7 shows the methodology in detail.

Flow chart 1. Methodology

V. STUDY AREA

Ponneri is a town, north of Chennai in Thiruvallur district in the Indian state of Tamil Nadu. It is located in Ponneri taluk. The neighbourhood is served by the Ponneri railway station of the Chennai Suburban Railway Network. Ponneri is located at 13.32°N 80.2°E. [1] It has an average elevation of 16 metres (52 feet) Figure 8, shows the study area.
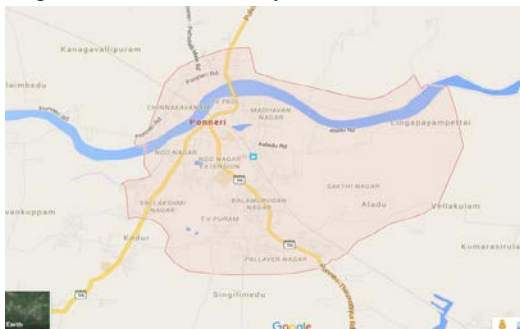

Fig 7 Skeleton map showing Ponneri Town

Soil exploration: Soil sample has been collected from five areas and tests such as sieve analysis, test for moisture content, test to find atterberg limits etc., are carried out and the type of soil of are study area has been found. The permeability level of the soil is found by testing the soil using constant head and falling head permeability test.

Collection of rainfall data: The maximum and minimum depth of rainfall is obtained.

A detailed investigation is done on the suitable mitigation measures. And few suggestions have been put forth which is already in practice in other countries. A model of siphonic drainage system is done for both roof drainage and underground drainage and the time taken for drain of certain amount of water is noted and is compared with normal gravity flow for drain of same amount of water and results are tabulated. Thus these steps are implemented and Siphonic system of drainage is design for our civil block, cost analysis is done for both systems and finally report is prepared.

The samples of Ponneri were taken from few areas like Gnayiru, Aladu, Pallaver nagar, Chinnakavanam and were tested in laboratory. Properties of soil like moisture content, specific gravity, permeability, Atterberg limits were determined. Soil particles have water between them. This water affects various properties of the soil. Moisture may be present as adsorbed moisture at internal surfaces and as capillary condensed water in small pores. At low relative humidity, moisture consists mainly of adsorbed water.

OBSERVATION

Weight of pan = 0.258
Moisture content $w = [(W_{wet} - W_{dry}) / W_{dry}]$ x100
Where W_{wet} = Wet weight of sample
W_{dry} = Dry weight of sample

Table 1 shows the moisture content values tested

TABLE I
MOISTURE CONTENT

Particulars	Wet weight of sample	Dry weight of sample	Moisture content in %
Sample 1	0.060	0.056	7.142
Sample 2	0.070	0.067	4.477
Sample 3	0.087	0.083	4.810

CALCULATION
Moisture content $w = [(W_{wet} - W_{dry}) / W_{dry}]$ x100
$= [(0.060-0.056) / 0.056]$ x 100
$= 7.142$
RESULT
Average moisture content of soil = 5.67%

a) DETERMINATION OF SPECIFIC GRAVITY OF SOIL

SOLIDS

Specific gravity of soil solids is the ratio of weight, in air of a given volume; of dry soil solids to the weight of equal volume of water at 4ºC.Specific gravity of soil grains gives the property of the formation of soil mass and is independent of particle size. Specific gravity of soil grains is used in calculating void ratio, porosity and degree of saturation, by knowing moisture content and density. The value of specific gravity helps in identifying and classifying the soil type.

OBSERVATIONS AND CALCULATIONS

Determine the specific gravity of soil grains (G) using the following equation

$G = (W2 – W1) / \{(W2 – W1) - (W3 – W4)\}$
Where $W1$ = Empty weight of pycnometer.
$W2$ = Weight of pycnometer + oven dry soil
$W3$ = Weight of pycnometer + oven dry soil+ water
$W4$ = Weight of pycnometer + water

$W1$ = 615g , $W2$ = 1102 g , $W3$ = 1736 g , $W4$ = 1484 g
$G = (W2 – W1) / \{(W2 – W1) - (W3 – W4)\}$
   = (1102-615) / { (1102 – 615) –(1736 – 1484)}
   = 2.072

INFERENCE

The specific gravity of the soil sample from Ponneri = 2.072

b) DETERMINATION OF PERMEABILITY OF SOIL BY CONSTANT HEAD METHOD

The property of the soil which permits water to percolate through its continuously connected voids is called its permeability .Water flowing through the soil exerts considerable seepage forces which has direct effect on the safety of hydraulic structures. The quantity of water escaping through and beneath and earthen dam depends on the permeability of the embankment and the foundation soil respectively. The rate of settlement of foundation depends on the permeability properties of the foundation soil.

OBSERVATIONS AND CALCULATIONS

The coefficient of permeability of soil using the equation
$K = QL / Ath$
Where K = Coefficient of permeability
Q = Quantity of water collected in time t sec (cc)
t = Time required (sec)
A = Cross sectional area of the soil sample (sq.cm)
h = Constant hydraulic head (cm)

L = Length of soil sample (cm)

i) Length of soil sample (cm) = 18.5
ii) Area of soil sample (sq.cm) = 78.5

Table II shows the coefficient of permeability values were derived using constant head method from the site area

TABLE II
COEFFICIENT OF PERMEABILITY BY CONSTANT HEAD METHOD

S.NO	Hydraulic head h in cm	Time interval T (sec)	Quantity of Water collected(cc)	Coefficient of Permeability (cm/sec)
1	172	70	50	0.0007
3	172	71	50	0.0007
4	172	70	50	0.0007
5	172	72	50	0.0006

INFERENCE

Coefficient of permeability of the given soil sample = 0.0007 cm/s

VI. SIPHONIC DRAINAGE

Siphonic Rainwater Drainage Systems utilize special rainwater outlets and airtight pipe work to promote full bore flow during heavy rainfall. These systems are now becoming popular especially for larger projects due to the cost and design benefits available compared to conventional underground and roof drainage.

Siphonic drainage can be adopted for
1) Underground drainage
2) Roof drainage
The experiment is carried out for two cases.
1) Flow of water through pipe without bend
2) Flow of water through pipe with bend

Therefore, flow of water through pipe without bend is found to be effective. But due to installation of siphon and pipe in the building, bends must be provided in the installation of pipe in the building (Fig 8).
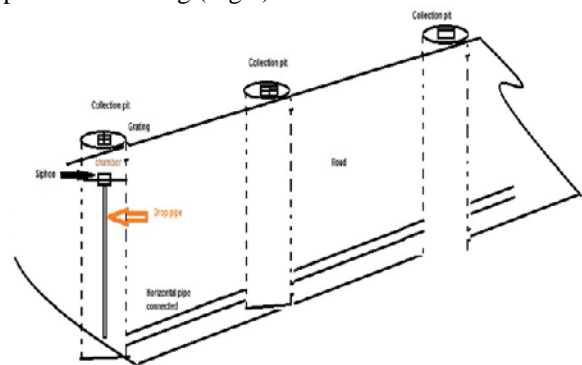

Fig 8 Installation at the side of the road

Therefore, bell siphon is installed at the bottom of the building or at the sides of the road under which collection pit is provided.

VII. SELECTING A ROOF DRAIN

To select the proper roof drain, the following information must be determined by the designer/specifier (Fig 9).

1. Type of roof construction and roof pitch
2. Maximum volume of expected rainfall and storm design criteria
3. Desired rate of drainage
4. Safety overflow requirements
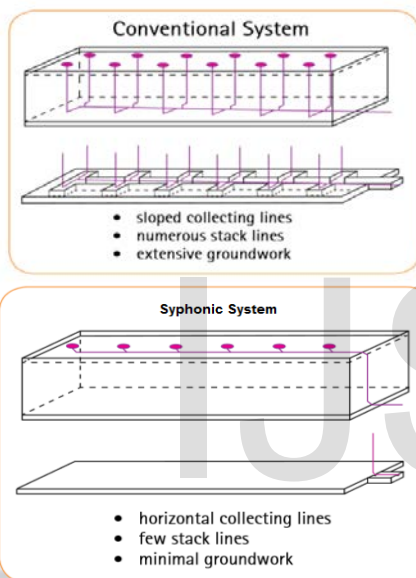5. Roof load
6. Location of drains
7. Size

Fig 9 Installation of Conventional and Siphonic System

VIII. PICTURES OF SIPHONIC DRAIN PROTOTYPE

Figures in 10, 11 and 12 shows the actual pictures of siphonic drain prototypes made and the results are discussed in the following section

10.(a) Bell pipe

10.(b) Full setup with Gravel guard

10. (c) Setup with soil

Figure 10 Pictures of Underground Siphon Prototype

IX.   ROOF SIPHON IMAGES

11. (a) Flow discharge

11. (b) Setup without bend pipe

11. (c) drain body without outlet

11. (d) setup with fins

11. (e) setup with baffle

11. (f) setup with bell cap
Figure 11. Final Design of Roof Siphon Prototype

X.   DESIGN PROCEDURE

The design procedure followed is as follows:
1. Calculate the total roof area.
2. Determine the maximum hourly rainfall in inches. (The figure can be acquired from your local weather bureau and/or local code authority.)
3. Select leader size.
4. Determine the number of square feet that can be drained by one roof leader at the local maximum rainfall rate.

5. Divide the total roof area by the area that one leader will handle. The above result is the number of roof drains required for the building. If the result is a fraction less, use the next higher number.

XI.   RESULTS AND DISCUSSIONS

Applying Bernoulli's equation at the top of the water surface in the tank and at the outlet of the pipe. Final value got with outflow volume vs. time with three combinations such as with natural gravity flow, siphon with bend and siphon without bend.

XII.   CONCLUSIONS

In this finding, the various possible ways of quick drain of water is investigated and suggested for Ponneri district. Modeling is done on siphonic drainage for both underground and roof drainage system. The time taken for draining of water under gravity and siphonic action are compared and found that time taken for gravity flow is more due to flow of water along with air that forms vortex and also by blockage of waste materials like leaves, twigs and other garbage items. To compensate this inconveniency, siphonic system provides far better results than conventional system which is found that it takes very much lesser time to drain off the storm water completely. A net profit percentage of siphonic action is found to be 50 percent more efficient than the conventional system. It is more economical.

Therefore, a suggestion of siphonic system of both underground and roof drainage are found to be a good method to achieve drain at faster rate. Other suggested methods of flood control system are also very effective and helpful to the public and surroundings. Thus we can save storm water for further or future use.

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