DESIGN THINKING APPROACH FOR THE STUDY ON PREVENTION OF STAGNATED RAIN WATER

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Abstract: —The removal of stagnated rain water in cities is very important to overcome the problems like traffic jams, breeding of mosquitoes, etc. that are faced by people during the rainy season. Stagnation is also causes discomfort and nuisance to passengers using the area. Stagnation occurs due to improper drainage system, improper slopes to the road pavement, improper maintenance of ground. This study is restricted to the market area, local roads, and streets of a city. A design thinking approach has been implemented to understand the situation and propose a viable solution to eradicate the difficulties faced by public. A detailed primary survey is carried out to understand the situation of streets, local roads of Visakhapatnam city. A secondary survey is also done to know the extent of work carried out in the present problem. Based on the responses of primary survey and literature survey a prototype model is proposed as part of this study to reduce the water stagnation on the streets and roads. Proposed prototype seems have low economical impact on the system and easily implementable. Some of the proposed prototypes are change in slope of roads, constructing the convex roads, Permeable pavement material, introducing a mesh like structure in market place, etc. These changes will definitely make users comfortable.

Key words*:* — drainage system, road, market place, stagnated rain water

1.0 INTRODUCTION

During the rainy season, most of the people in cities/towns are very much worried about stagnated rain water. The passers are concerned about the difficulty in moving on roads due to heavy rains which causes the stagnation of rain water. During heavy rains, the roads are damaged due to improper maintenance of roads. Many pockets/pills can be observed on the roads and they are clogged with rain water. In India during each monsoon, there is a problem of deterioration in bituminous pavement due to various factors like poor drainage, low quality of pavement materials that let the rain water to penetrate through the pavement causing various distresses like cracks, potholes, depressions, rutting, raveling takes place. Deterioration of the road affects the serviceability, riding quality and safety of the road up to a large extent. In the localities, the people are scared of mosquitoes because stagnation of water causes the breeding of mosquitoes. One of

the major reasons for stagnation of water is overflow of drainages which may contain household wastes. The drainage systems of various cities in India are not adequate as population has increased dramatically but the drainage system is still old due to which the sewers become unable to handle the rain water and water flows over roads which penetrate through pavement and make it weaker. This also stops the people from moving on the streets and roads. Many people in market areas, such as consumers and sellers are badly affected due to stagnated rain water. The sellers in the markets also get worried about the insects that attract the stagnated water because they may damage the vegetables/fruits.

Drainage lines are laid with sealed joints in the road easement with runoff coefficients and characteristics adequate for the land zoning and storm water system. Drainage systems must be capable of carrying the ultimate design flow from the upstream catchment with approval for the outfall from the appropriate authority to a watercourse, creek, river or the sea for drainage discharge Drainage quality is an important parameter which affects the highway pavement performance. The excessive water content in the pavement base, sub-base, and subgrade soils can cause early distress and lead to a structural or functional failure of pavement. Drainage is the most important aspect of road design. Proper design of drainage is necessary for the satisfactory and prolonged performance of the pavement. In designing drainage, the primary objective is to properly accommodate water flow along and across the road and conveniently transport and deposit the water downstream without any obstruction in the flow.

These are some problems and their solutions taken all over the world by the people. Firstly, vertical rainwater zoning drainage system, The high-zone rainwater disposal facility comprises an overflow gully in the concave green area, a water collecting basin and an emergency rainwater discharge pump set; the overflow gully is connected with the water collecting basin; the water collecting basin is connected with the emergency rainwater discharge pump set; a delivery outlet of the emergency rainwater discharge pump set is communicated with an urban flood drainage channel or a ravine or a depression.(Ref: Patent from Vertical rainwater zoning drainage system CN103184761B).

2.0 LITERATURE SURVEY

Boast, C. W., & Baveye, P. (1989) described a method for determining the location of the stagnation boundary for a porous medium with “jump to proportionality” threshold gradient behavior, and the method is used to solve the “flow at a corner” boundary value problem. Vlotman,

et al. (2007) describes the latest technological advances in drainage, flood management and water quality control. Ye, X et al. (2010, March) studied clogging mechanisms and control methods of artificial recharge. The present paper analyzed the mechanism and characteristics of different clogging types, and introduced the common methods for clogging control. Based on lots of experiments, a new method emphasis on engineering structure was proposed to prevent spread basins from clogging. Jiang, X et al. (2011) studied the existence of stagnation points in nested flow systems is relevant to a range of geologic processes. There has been no analytical study on the characteristics and locations of stagnation points in nested flow systems. Analytical solutions for hydraulic head and stream function have been derived in basins with isotropic and depth decaying hydraulic conductivity. Jaykumar, A., & Padmanabhan, S. (2011) presented a conceptual model of a system to prevent the clogging of drainage water and avoid spill over onto the roads by utilizing a graduated mesh based automatic solid waste separator. The main purpose is to automatically segregate garbage in flowing drainage water, identify and separate plastic using x-ray spectroscopy, collect it and recycle it instead of letting it flow into larger water bodies and causing pollution. Nobel, A. J., & Talmon, A. M. (2012), measured the stagnation pressure in the center of a cavitating jet. The stagnation pressure at a certain distance from the nozzle is important for the erosion/ cutting capacity of a submerged jet in dredging. The decay of the stagnation pressure with jet distance is well known in the case of non-cavitating jets. To fill this lacuna, carry out jet tests at various ambient pressures in both fresh and saline water. Gallen, R., et al. (2013) proposed a novel approach to computing a safe speed profile to be used in an adaptive intelligent speed adaptation (ISA) system. Liu, H et al. (2017). “Sponge city” concept helps solve China’s urban water problems. The idea behind sponge city is to promote the renovation of drainage systems, the improvement of connectivity of water systems, the division of rainwater and sewage pipe networks, and other modern engineering measures to enhance the city’s ability to cope with water problems. Brears, R. C. (2017) presented an overview of a case study that analyses how Hamburg's water utility uses a portfolio of demand management tools to modify the attitudes and behavior of water users to achieve urban water security. Pregnolato, M et al. (2017) studied the impact of flooding on road transport: A depth-disruption function. During extreme weather events transport infrastructure can be directly or indirectly damaged, posing a threat to human safety, and causing significant disruption and associated economic and social impacts. The function that describes this relationship has been constructed by fitting a curve to video analysis supplemented

by a range of quantitative data that has been extracted from existing studies and other safety literature[cement, aggregate, water in the construction of roads in different proportions, by this invention can solve the natural ecology problems of hardened ground in cities, atmospheric circulation as well as soil and water moisture retention, thereby forming a high-quality natural ecology environment and maintaining urban ecological balance. The previous concrete consists of two previous surface courses and two macadam bases in different particles so as to provide a water storage structure which can store the water until the water penetrates into the soil. Kodali, R. K., & Ramakrishna, P. S. (2017) proposed a new Internet of Things based drainage architecture as an innovative solution to address drainage clogging. Lintsen, H. (2018) paper describes the stagnation and dynamism in three supply chains: agriculture and foods, building materials and construction, energy. At the time, extreme poverty could be fought by, among other things, economic growth. That demanded another approach to the exploitation of natural capital and accordingly to innovation in the three main supply chains. Grace et al. (2019) proposed a system to identify and detect the location of leakages in the pipelines during water distribution using IoT. In this system a raspberry pi is used as the master device to collect the data from different slave nodes and send the data to the cloud. A notification will also be received on the mobile through an app whenever a leak is detected and located. Ben-Adour, M., & Sayad, A. (2020) published an article on the impacts of water use on human activities and vice versa. Proctor et al. (2020) discussed the chemical and microbiological contaminants in stagnant water that can pose potential health risks to nearby occupants. Health officials, building owners, utilities, and other entities are rapidly developing guidance to address this issue, but the scope, applicability, and details included in the guidance vary widely. Shaikh et al. (2020) discussed a case study in Dammam - Proactive Priority Based Response to Road Flooding using AHP. The study first introduces the proposed web-based road flooding management system which utilizes a variety of different information including real-time and historical weather data, digital terrain data and descriptive road parameters to provide flood response teams with clear information on the real-time status of roads. It then proposes the AHP based multi-parameter decision analysis solution which analyses the significance of the road parameters with respect to each other and assigns a specific response priority to each road section. This final priority will allow flood response teams to expedite the response to road sections with a higher priority, thus improving the efficiency of flood responses. Sun et al. (2020) paper proposes the problems encountered in the transformation of the gray infrastructure of the sponge city to the

green infrastructure and the measures to be taken. The integrated indicator system is used to comprehensively evaluate the integration of the gray-green facilities.

3.0 DESIGN THINKING AND INNOVATION METHODOLOGY

This research work is specifically carried out to review literature on the effects of a poor drainage system on road pavement and in the streets of a city/town and also a prototype model to overcome the effects of stagnated water in market areas. This section provides the steps followed in the mapping review process like research questions formulation, sample selection strategy, inclusion and exclusion criteria and data collection process. The design thinking methodology is implemented for the solution of this problem. The design thinking methodology is carried out with empathy phase, define phase, ideate phase, prototype phase and test phase.

3.1 Empathy Map

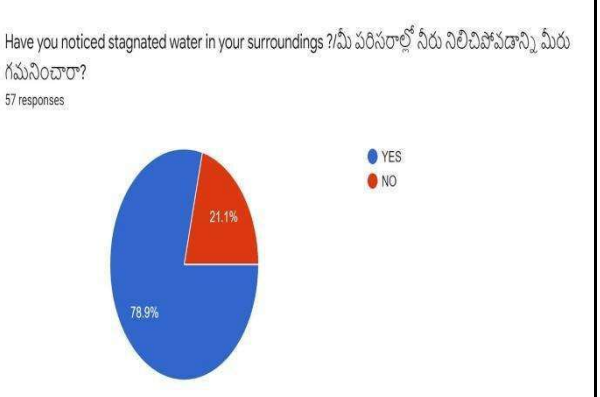
When there are heavy rains, most of the people suffer from stagnated water. Every affected person expresses his concerns about the problem. There are many questions that always arise in their minds. Table 1 is an empathy tool known as 5W+H. Fig.1 shows the data analysis on the responses that are listed from the primary questionnaire.

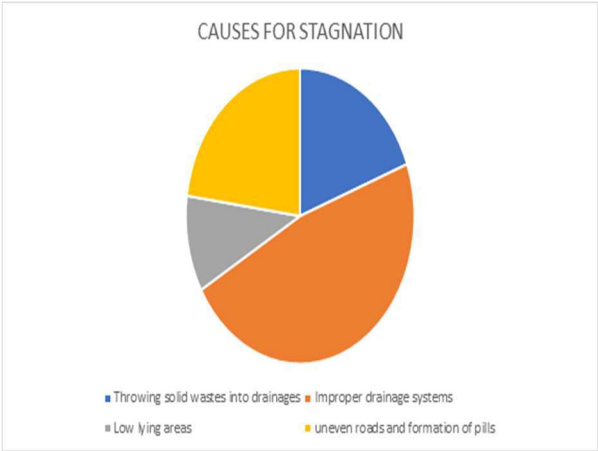
3.1.1 Empathy Tool

Table 1 Empathy Tool of 5W+H

Who?	*Who is facing the problem?*	*Who is suffering Majorly?*	*Who is feeling Unpleasant?*	*Who uses stagnant water for drinking purposes?*
What?	*What is the main reason for Stagnation of rain water?*	*What are the problems that the people are Facing?*	*What happens when you go out on a bike/car During the rainy season?*	*What are the health concerns that are faced Due to stagnation of water?*
When?	*When do we observe the Stagnation of Water?*	*When do people get irritated?*	*When does the road get*	*When will you observe the*

			Damaged?	*garbage over The roads?*
Where?	*Where do we Notice stagnation of rain water?*	*Where does the stagnant water mix with Garbage?*	*Where can we observe the overflow of drainage water?*	*Where does the garbage come from to mix with stocked water?*
Why?	*Why is the problem a Problem?*	*Why is the environment Affected?*	*Why do mosquitoes feed on stagnated Water?*	*Why is stagnated water observed for many days?*
How?	*How is water Clogged?*	*How does stagnated water Irritate the owners and consumers in the market?*	*How do traffic jams occur due to water clement?*	*How do the garbage is mixed with stagnated Water?*





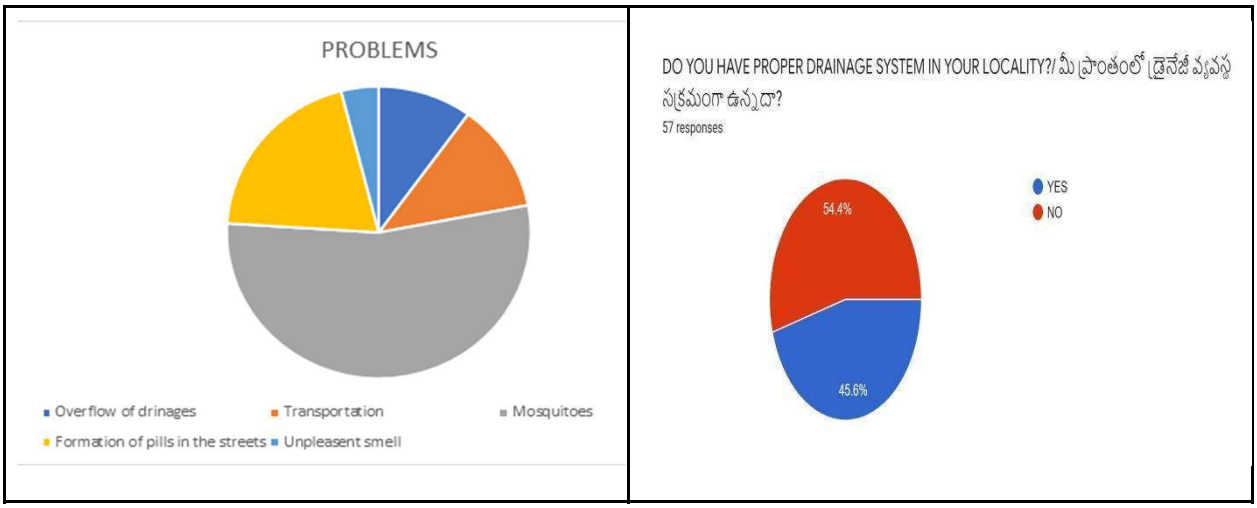


Fig.1 Data analysis on the responses that are listed from the primary questionnaire

3.2 Define Phase:

From the emphasize method, the problem is identified and that will give the clarity on what work have to do. In the define stage, the problem statement is analyzed and that goes through all the information gathered for defining the problem statement in a better way.

How Might We Questionnaire:

1. How might we improve our drainage systems?
2. How might we reduce the mixing of household wastage with drainage water/stagnated water?
3. How might we increase the resistance of roads against water?
4. How might we remove the stagnated water in streets?
5. How might we remove the stagnated water in markets?
6. How might we construct a drainage system in closed areas (having no drainage ways)?
7. How might we decrease the overflow of drainages?

POV Statement:

USER: People who live in low lying areas/near markets/Crowded areas in cities/towns and also the people near improper drainage management systems.

NEED: People need a permanent solution to get rid of stagnated water and also they need proper drainage systems

INSIGHT: Generally stagnated water is observed in the rainy season. During these days lot of people are suffering many problems like malaria, dengue, unable to walk freely, bad smell, etc. Improper drainage system is one of the main reasons for stagnated water. Due to this the overflowing water comes on to the road and stagnates there. So the people need a proper remedy

POINT OF VIEW STATEMENT: People need a solution to remove the stagnated water which is causing many problems to them and they also need proper drainage systems near their localities.

3.3 Ideate Phase:

In this ideate phase the NABC method has been choose to find some solution for the prevention of stagnated rain water. The main idea of the project is to remove the stagnated rain water in the areas where there is no drainage and also having poor drainage management systems including markets. Table 2 represents NABC (N-Need, A- Approach, B-Benefit and C – Competition) method.

Table 2 NABC method

NEED:	**APPROACH:**
1. Stagnated water is to be removed in the streets where there are large houses. 2. The people living in market areas need a solution which is a temporary one to get rid of stagnated areas. 3. The people live in closed areas where there are no drainage systems. 4. The people need to get rid of mosquitoes. 5. The people need to go out freely during the	1. The government through municipal workers should remove the stagnated water manually. 2. The siphon pipes are available in the markets. So the people who can afford those should use them to remove stagnated water near their locality. 3. The government should build underground basins near markets,

rainy season where stagnated water is found majorly. 6. To remove the stagnated water at road junctions in cities. 7. To improve drainage systems. 8. To decrease the overflow of drainages. 9. To decrease the damage of roads. 10. To decrease the mixing of household waste with stagnated water.	closed areas in order to reduce the amount of stagnated water which can be removed manually with great ease. 4. The government should improve the drainage systems in all areas through the construction of Jalam Jeevam which was introduced recently. 5. The people should give the household wastage to the municipal department instead of throwing it into drainages. 6. The drainage systems should be deeper to stop the overflow of drainages.
BENEFITS: 1. Due to this project many people lead a healthy and happy life even during the rainy season. 2. People can get rid of mosquitoes. 3. People can go to markets without any hesitation during the rainy season. 4. People can keep their surroundings clean so that no diseases can attack. The people who have 2/4 wheelers can go out happily.	**COMPETITION:** 1. More awareness should be created on the removal of stagnated water through digital media. 2. The construction companies should come up with a feasible solution so that the government will encourage that. 3. The engineers should take it as a chance to come up with a perfect solution to help society.

From this, the three ideas have been proposed for the prevention of stagnated rain water.

Proposed Research Method:

Idea-1: Correction of slopes of the roads

Features:-

1. This idea is mainly an informative and suggestive idea to the government.
2. Find the roads where more water is stagnated.
3. Analysis of the road about its slope.
4. To stop the clogging of water that needs to modify the slope of the road by adding sand and aggregate.

5. This idea is to change the straight roads into convex roads.
6. Due to heavy rains, there is a great chance of formation of pockets/pills on flats.
7. To avoid the formation of pockets that contain stagnated water can use convex roads so that the water will go down the edges.

Idea-2: Making a mesh like structures in closed areas like markets. (Fig.2 shows the proposed mesh structure**)**

Features:-

1. First we should check a place in the market in order to put the mess structures so that maximum rain water will go into the mess structures.
2. For this, we need to dig the ground with a certain depth which allows the water flow and make a path to the nearer drainage system so that the rain water will go into that.
3. Now put the mess structure on the surface of the ground so that people also can walk on them instead of blocking the paths.
4. This will help the people to go to markets during the rainy season

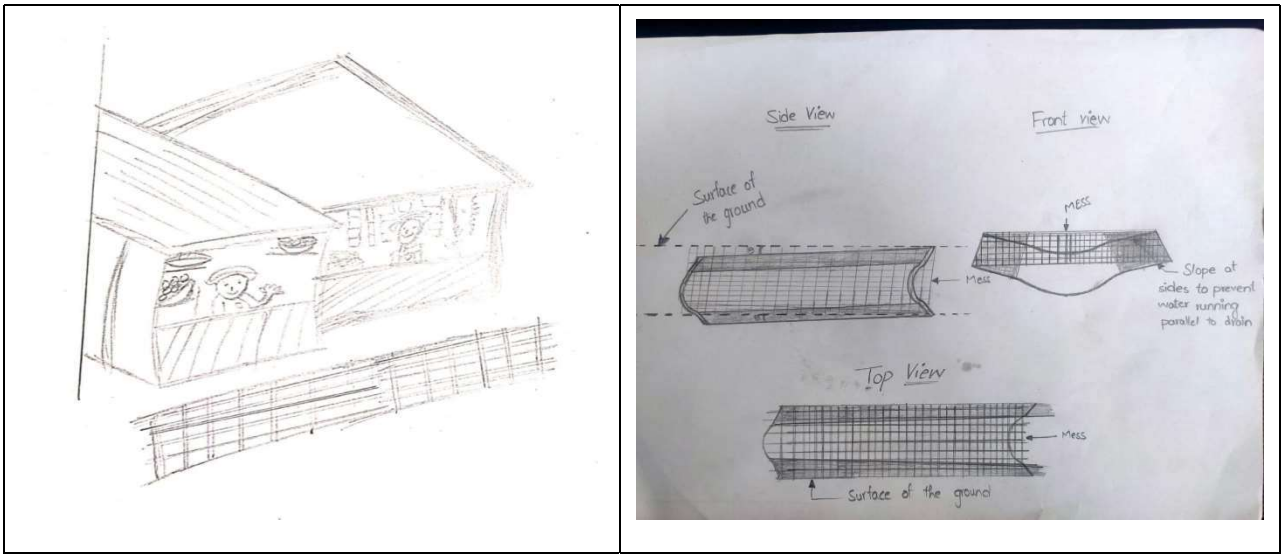


Fig.2 Proposed mesh structure

Idea-3: Maintaining accurate drainage gradients (Fig.3 shows the drainage gradient of a road)

Features:-

1. Due to flat pipes with no inclination, blocks the flow of drainage wastage.
2. Due to the block of drainage wastages, the rain water cannot flow further through the pipes.
3. The drainage overflow.

4. To overcome this, a perfect gradient has to be maintained whose slope is between 2 percent and 5 percent, which equates to 2 to 5 inches of drop-off for every 10 feet you measure as you move away from your home.

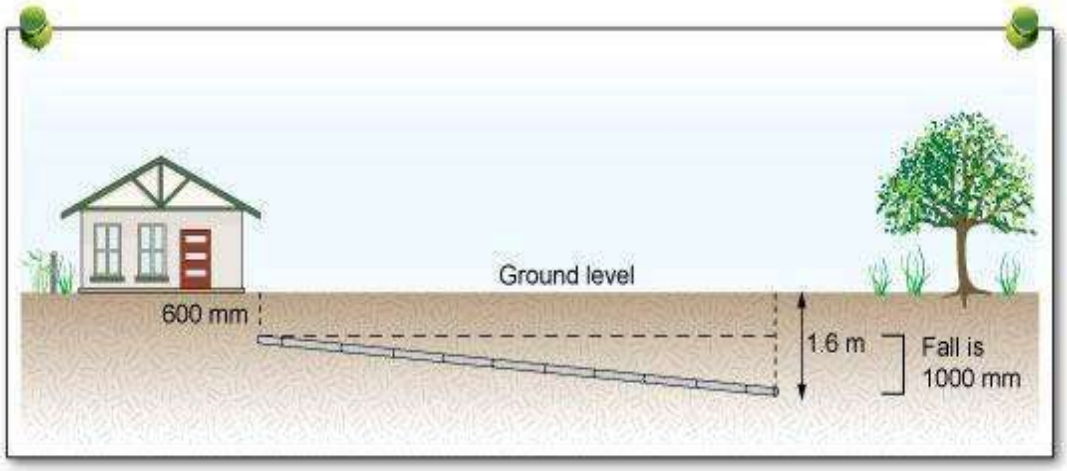


Fig.3 Drainage gradient of a road
(https://images.app.goo.gl/NRYjfqqc7zQZaBnV8)

4.0 CONCLUSION

A systematic methodology from the first stage of design thinking and innovation is adapted and a proper research has been made. The information has been gathered through literature survey. The problem has been understood through the empathy phase, analyzed in the define phase and some ideas are developed in ideate phase. Finally, two informative ideas and one model type idea has been identified. One of the informative ideas is to provide the basic information about how the slopes of roads should be and the other is to provide clear information about the drainage gradients. The model type idea is mess structure that has been proposed to prevent the stagnated rain water near the markets.

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