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Design of Sustainable Toilets for Rural Areas

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Abstract: The objective of this project is to design and build a self-sustaining toilet for implementation in rural areas of India, while meeting the design requirements set by the project sponsor, Mr. Sandeep Nhavle. The toilet will be built out of low cost and readily accessible materials. A successful design will ultimately reduce the transmission of disease caused by waterborne pathogens, improve the health and way of life of the rural community members, and be marketable to other impoverished areas of the world lacking adequate sanitation. India is still lagging far behind many countries in the field of environmental sanitation. Our project deals with construction of low cost sustainable toilets in rural areas. The components like wall, roof will be constructed using some sustainable material like bamboo which will decrease the cost of construction and which is easily available nearby place , also we are going to use solar panels for generating of electricity . our first priority is that to provide sustainable low cost toilets .

Environmental sanitation is a major public health issue in India. It envisages promotion of health of the community by providing clean environment and breaking the cycle of disease. It depends on various factors that include hygiene status of the people, types of resources available, innovative and appropriate technologies according to the requirementof the community, socioeconomic development of the country, social factors including behavioral pattern of the community and others.

The Indian government's Swachh Bharat mission includes a plan to spend $31 billion on building over 100 million toilets in rural areas over the next 5 years

I. INTRODUCTION

As of 2008 there are more than 545 million Indians without access to toilets which is more than half the population. Around 50% of the population does not have proper sanitation facility. Apart from poverty and lack of lavatories, one of the reasons is old practices which lead to open defecation in India. Consequently, open defecation cause major diseases like as diarrhea, cholera and typhoid.

Arguably low-tech, bamboo toilets are cheap and practical. As the name suggests, bamboo toilets are those whose structures are built with bamboo – fast growing woody evergreen plants that have strength comparable to steel. Bamboo toilets represent an eco-friendly and potentially sustainable solution in the quest for building toilets in areas that still do not have access to modern amenities.

Though from time immemorial, bamboo has been part of the housing scene, the advent of new building materials and increasing industrialisation has edged out the plant species from the construction sector. In fact, bamboo, once the housing mainstay of the rural and the poor population, is now the least used material. Keeping in mind the country's need for urban and rural sanitation options, the government plans to develop various models of public and community toilets using bamboo, natural, treated or engineered bamboo as construction materials. Recently, two prototype bamboo toilets were set up in Nagaland where Bamboo is readily available. This initiative was an outcome of a five-day training on "bamboo toilets for private use and for the community", jointly organised by Nagaland Bamboo Development Agency (NBDA) and South Asia Bamboo Foundation (SABF) in partnership with Building Material Technology Promotion Council (BMTPC), Ministry of Urban Development & Poverty Alleviation.

A. Objectives

1) To study the situation of toilet in rural area

2) To design sustainable toilet for rural area.

II. LITERATUREREVIEW

A. .Perceptions and Attitudes toward Eco-Toilet Systems in Rural Areas: A Case Study in the Philippines BY: -Jonathan Jared Ignacio, Roy Alvin Malenab, Carla Mae Pausta Publishing Year: -15 February 2018

Death due to diseases from poor sanitation is a serious global issue and it has become one of the priorities of the United Nations' Sustainable Development Goals (i.e., SDG6). This SDG6 aims to provide adequate improved sanitation facilities to over 2.3 billion people around the world who have no or limited access to sanitation, wherein more than two-thirds of these un-served people live in rural areas. One of the strategies for addressing this global issue is through emerging sustainable sanitation technologies such as the Eco-Toilet System (ETS), which uses small amounts of water or is even waterless and recovers nutrients from human waste thereby promoting water-energy conservation, improved sanitation and supplement nutrients essential to plant growth. Social acceptance, however, remains a key barrier in deploying the ETS

B. Development of water saving toilet-fushing mechanisms. By: -Roubi A. Zaied, Publishing Year: - 2 April 2018

Wasting water in toilets flushing is the largest source of water wasting through the use of old siphon boxes. It occupies the first place in domestic consumption.

This study reports two trial approaches for optimizing the flushing system design. The first one employs a rotatable blade in the bottom of the bowl.

This blade pushes materials in the bowl to cross the trap way thus; less toilet flushing water can be used. The second approach depends on using a rotatable trapway such that it can be tilted down to enable discharging materials in the bowl directly by its gravity. This facilitates the discharge and reduces the flush water amount which is just used to overcome friction and to clean the passage. Both are mechanical systems actuated by an external pedal mechanism that triggers the water flushing valve system.

C. Clogging potential of low-flush toilet branch drain system By:-Muhsmedaubuakar M., Publishing Year:-10 Nov 2017

Water scarcity is a global issue. In residential buildings, water closet appliances share the biggest portion of water consumption. Therefore, they are targeted for improvements to consume less water while keeping acceptable performance. Low-flush toilets consume a significantly smaller amount of water compared to their predecessors. However, lower water flows pose challenges like unreliable waste transportation and frequent clogging in old drainage systems.

Furthermore, it is not economic to upgrade an entire drainage system to adapt to the new generation of toilets. In this study, the clogging potential for two toilet modules is investigated and the effect of hydraulic parameters on clogging is quantified. Finally, the results of this investigation are used to develop clogging potential charts for the toilets under study. Real-world application of such charts is presented.

D. Urine diversion dry toilets in eThekwini Municipality, South Africa: acceptance, use and maintenance through users' eyes By: - NosiphoMkhize, Myra Taylor, Kai M. Udert, Teddy G. Gounden and Chris A. Buckley Publishing Year: - Journal of Water, Sanitation and Hygiene for Development | 07.1 | 2017

This study was part of the VUNA project aimed to develop an affordable sanitation system that produces a valuable fertilizer, reduces pollution of water resources and promotes health. Urine diversion dry toilets (UDDTs) simplify the on-site hygienisation of faeces and allow for nutrient recovery from urine.

Social acceptance is vital for the implementation of the UDDT, because sanitation is only effective if the system not only provides a well-designed toilet and effective waste management, but also offers users a facility that caters to their needs and is sensitive to their cultural lifestyle.

This study used qualitative and quantitative methods to investigate acceptance, use and maintenance of UDDTs. Key findings indicate lower levels of acceptance of UDDTs among the elderly, who are accustomed to traditional pit toilets. The users aspire to own a flush toilet, perceived to be indicative of household wealth.

A dominant concern was emptying the pit and the quality of the building material. Community interventions are required that will promote acceptance, understanding and encourage proper use and maintenance of the UDDT, and may need some technology modification

E. Better Toiletsfor a Better World BY: - JACK SIM, Publishing Year: - 2016

Inadequate sanitation is estimated to cause 280,000 annual diarrhoeal deaths, transmit diseases (i.e. cholera, diarrhea, dysentery, hepatitis A, typhoid and polio), and contribute to malnutrition. Poor sanitation also significantly impacts mental health.

Limited access to sanitation often results in negative social and psychological impacts, especially for women. From 2000 to 2015, sanitation played a relatively minor role on the global agenda to halve world poverty despite the fact that inadequate sanitation disproportionately affects the poorest populations in low- and middle-income countries and perpetuates cycles of poverty and diseases.

III. METHODOLOGY

1) Phase 1

Situation of toilets in rural area

a) Data collection

b) Visit

c) Oral study

A. Study and Understand the situation of Toilets in Rural Area

1) Data Collection

a) Locations

Location no 1:-Dive

Fig. No. 3.1.1.1 Location of Dive village (Source: Google Earth)

Location no 2:-Kalewadi

Fig. No. 3.1.1.2 Location of Kalewadi village (Source: Google Earth)

Location no 3:-Ambodi

Fig. No. 3.1.1.3 Location of Ambodi village (Source: Google Earth)

Location no 4:-Sonori

Fig. No. 3.1.1.4 Location of Sonori village (Source: Google Earth)

Location no 5:-Vanpuri

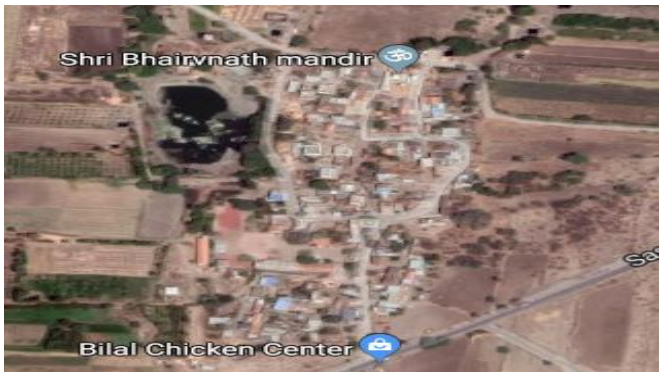

Fig. No. 3.1.1.5 Location of Vanpuri village (Source: Google Earth

B. Population

First of all we need to know the population of each village because without knowing the population we can't understand the need of toilets in that particular area or villages.

Table no 3.1.2.1 Population of villages

Sr. no	Village	Population
1	Dive	3484
2	Kalewadi	1404
3	Ambodi	1202
4	Sonori	2409
5	Vanpuri	1079

2) Phase 2

According to research papers dome sustainable materials are as follows

1. Bamboo

2.Ferro cement

3.solar panel

A. Bamboo

By the study of above research papers, we decided bamboo reinforced concrete construction for sustainable Toilet. Bamboo is a building material, it can be used in various forms.Bamboo reinforcement as replacement of steel reinforcement is gaining immense importance today.It investigates mechanical properties of bamboo reinforced concrete member with the experiment of reinforced concrete member. from these experimental works, effective using of bamboo is discussed.

1) Properties of Bamboo

a) Mechanical Properties – It perform very well in buckling because of low stresses as compared tosteel.Cellulose is the main component present in the bamboo which is main source of mechanical properties of bamboo

b) Tensile Strenght –It Varies between 140N/mm^2 to 280N/mm^2 the fibers of bamboo run axial.In outer zone are highly elastic vascular bundles that have a high tensile strength.

c) Compressive strenght – Slimmer tubes have higher compressive strength value and bigger tubes have moderate.

d) Elastic modulus - Colossal elasticity makes bamboo an useful building material in regions where risk of earthquakes is high.Outer parts of the tube walls work positive in connection with elastic modulus.

e) Anisotropic Properties – Bamboo is anisotropic material.Cellulose fibers are in continuing direction which is strong and stiff and in transverse direction it is lighnin which is soft and brittle.

f) Fire Resistance – Due to more content of silicate acid fire resistance is very good.

2) Benefits

a) Extremely strong fiber.

b) Extraordinary versatile material.

c) Totally Flexible.

d) Extremely Lightweight

e) Sustainable and renewable alternative

f) Cost effective

g) Long lasting

B. Ferro Cement

Ferrocement can be effectively used for various water supply structures like well casings for shallow wells, water tanks, sedimentation tanks, slow sand filters and for sanitation facilities like septic tanks, service modules and sanitary bowls. Ferrocement water tanks of 20 to 2000 gallon capacity are mass produced in India.

In Thailand and Indonesia, ferrocement and bamboo-cement rainwater colloection tanks are being built on a self help basis by villagers under the supervision of an apprapriate technology group to provide clean drinking water. Ferrocement water tanks over multistory buildings in Singapore, Bangladesh and the Solomn Island. Bamboo-cement well casings have been built in Indonesia to prevent contamination of the water.

Prefabricated service modules have been developed and constructed in the Solomn Islands and India. A service module is a unit which provides water supply for drinking and washing toghethe with toilet facilities. Ferrocement septic tanks have been in used in Thailand, India, Indonesia, Philippines and Papua New Guinea while ferrocement toilet bowls have been developed and constructed in Thailand and Bangladesh.

1) Advantages

a) Basic raw materials are readily available in most countries.

b) Fabricated into any desired shape.

c) Low labour skill required.

d) Ease of construction, low weight and long lifetime.

e) Low construction material cost.

f) Better resistance against earthquake.

IV. COST ANALYSIS

The costs of the individual materials were based off the prices found in the India . This estimate must be adjusted once prices for the same materials sold in India can be determined. The total budget for this project is below 17000 , to be spent on materials for prototyping of the total amount, $500 is specifically for transportation.

1) Bamboo = 1) 16ft- 90rs 2) 18ft- 120rs
2) Aggregate = 68rs / CFT=68*16=1088 RS
3) Cement (M43)=270rs / 5 Bag =1350 RS
4) Toilet seat = 900 rs
5) Tiles = 230 Box = 460 Rs (18Ft)
6) Solar panel + Battery (4 watt) =350+1199(12v7Ah)=1550
7) Crushed sand = 4000/ Brass
8) Sand= 90/8.5 CFT=765 Rs

V. QUESTIONERIES

A. How many Toilets are currently there in your village?

Ans:- Every house in the village has got at least one toilet, but those houses located in farms or away from village have not got this facility yet.

B. Despite of having toilets, why don't villagers use it?

Ans:-

1) Because of old tradition of defecating in open ,people are now used to it. Since it has become their daily and a long term habit, they find it really hard to use toilets in their houses.
2) Houses are located in farms and besides them are canals because of which this year it has been a huge lose due to heavy rainfall. Because of flood due to canals nearby, houses are destroyed and farmers do not have enough money to even rebuild their houses. Even after complaining about this to Gram Panchayat, they have not taken any actions about this. So, because we do not have any other option left we defecate in open. (Farmer- Prapancha sonawane- Sonori village)

C. For every house in a village, government has issued a total amount of Rs. 15,000 for building toilets. Are you aware about it?

Ans: -

1) Yes, we are aware about this scheme of government. But to avail this scheme, we have to submit some documents in Gram Panchayat which are not available by everyone. We have told everybody to get those documents ready as soon as possible but there are still some people who are not aware about this. (Gram Panchayat- Vanpuri)
2) No, I am not aware about this scheme. I will go and check it myself today. (Farmer – Vanpuri) 3) Yes we know about this scheme, but the politicians have not distributed any of the amount to villagers. (Farmer-Sonori Village)

D. Are you aware about the health problems and diseases caused by open defecation?

Ans: -

1) Nevertheless yes, we know the outcomes but there are still some villagers who provide open space for defecation saying it can be used as fertilizers. (Villager- Dive Gaon)
2) Yes we know very well the outcomes of open defecation. So we are trying our best to carry out Swachha Bharat Mission in our village. (Gram Panchayat – Kalewadi)
3) No we are not aware about any of these outcomes but due to old traditions we defecate in open. (Villager- Kalewadi)

E. What are your thoughts about open defecation in your village?

Ans: -

1) It is very wrong. But as you the people do not take any action till they suffer because of it. (Gram Panchayat- Dive)
2) No, it is definetly bad to defecate in open. Therefore, we are carrying out the Swachha Bharat Mission.
3) Yes, we are aware about the problem caused by this to everyone in the village. (Vanpuri)

F. As per your saying children are facing problems because of open defecation, but what about elders of village? And females of village are allowed to defecate in open? Why so? Doesn't they face problems because of the same?

Ans: - Most the population of village is children and mostly children defecate in open and so they face problem whereas females of village they probably so after dusk and before dawn so they don't face problem because of this.

G. *.The project we are about to introduce to you will help you in defecating properly in toilets whereas you can use Methane gas for cooking produced from recycling human feces . So, after knowing this pros, will you like to make you of such toilets in future?*

Ans: - Yes, we will definetly like to make use of this as this is good for us itself.

VI. CONCLUSION

This design of a sustainable toilet system for India is the first iteration of a series of anticipated senior design projects. The subsequent design projects will be used to further develop, analyze, and test this design before its final goal of implementation in a village in India. The Bamboo has known qualities and an established reputation of being a wonder building material (eco friendly, regenerative, high tensile strength, low cost etc.). It is light in weight and offers a sustainable solution for construction. Due to its regenerating quality it falls under the category of being a renewable resource. It has high tensile strength. And that most of the demerits of bamboo construction can be countered.

By providing the low cost sanitation system, not only the rural people but also the semi-urban and urban people saves time and increase their working hours thereby reducing the chances of having some dangerous diseases everyone can access the sanitation services. The low cost sanitation project approaches have inadvertently excluded the poor and rural people. This further increases inequity and makes achieving community water and sanitation outcomes, such as an open defecation free environment, impossible.

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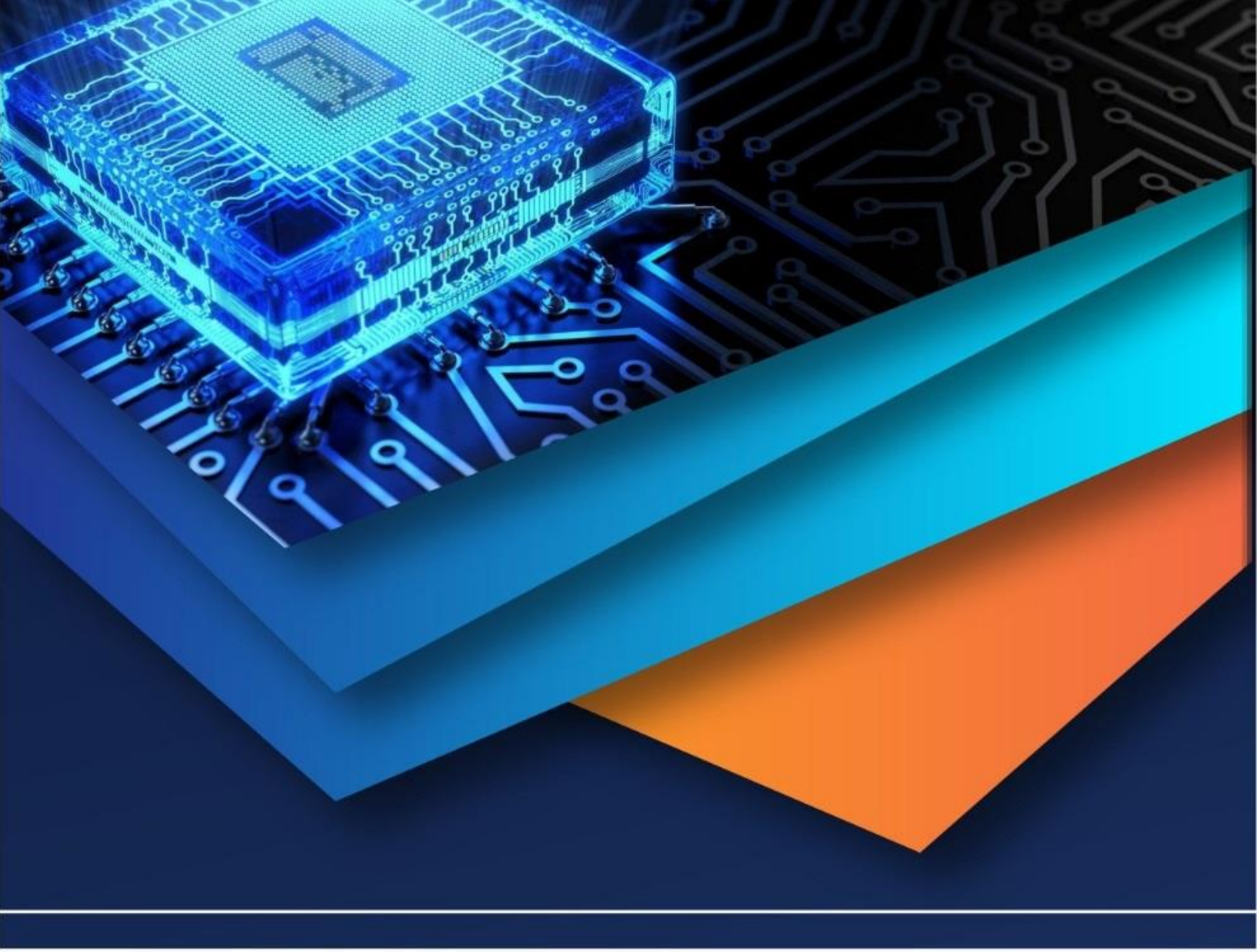

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