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Research article

Proposing the Use of Plastic Bottle Waste for Low-Cost Housing under Government Guidelines in India

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Abstract

Despite increasing the efficiency of proper solid waste management in India, there are significant amount of non-biodegradable waste that are left untreated or dumped into the landfill. In developing countries like India, as landfill has been the major option of disposing solid waste, there would be ever expansion of landfill in future which might put constraints over finding land for further dumping of garbage, unless there is way to re-use those solid wastes which has significant potential to be utilized again for other purposes. Fortunately, many environmentalist and researchers have come up with new idea of utilizing these wastes in construction of building. Discarded plastic bottles are now being used for construction of dwelling unit in the form of building blocks replacing conventional bricks and concrete reducing the overall cost of construction drastically to at least 20% to 40% as compared to conventional method of construction. Depending upon the availability of plastic bottle waste in a certain location, an ample number of dwelling unit can be possibly built to provide housing affordable to urban poor in India where housing shortage is becoming an acute problem. According to different housing scheme of government, grants and subsidies are provided to specific group of households to build own house. This paper focuses on the financial assessment available from the government that can be provided to households from low-income groups (LIG) and economically weaker section (EWS) sectors who can avail a home with basic infrastructure subsequently controlling the excess volume of garbage that are being transported to already available landfills. A proper planning and management on financial assessment in accord to government guidelines using plastic bottle waste as construction material, is proposed in this research.

Keywords: Low-cost, affordable housing, plastic bottle, solid waste, scheme, construction, landfill

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1. Introduction

A significant percentage of urban populations are facing housing shortage which is becoming an acute problem in modern age of development. Migration, from rural to urban sector in search of better living condition and better employment opportunities, is yet one of the most visible factor leading to increasing urban density. But with unavailability of affordable housing in housing markets, most people face housing problems giving rise to squatting and slum settlements. The estimate of housing shortage in urban areas of Indian cities has reached to 18.78 million in 12th Five-Year plan according to the report by technical committee [1].

Most housing shortage are pertaining to economically weaker section (EWS) and Low-income groups (LIG) who have monthly income below the standard of living condition and they lack potential to afford basic amenities. Unaffordability by such households forced them to build slums comprising of scrap materials, shabby items, unhygienic and prone to harsh weather. Most houses which are congested, non-serviceable or obsolescent are administered as homeless. As shown in figure 1, almost 80% of houses are congested and need reconstruction or relocation, while 12% of houses are vacant or need to be destroyed and rebuild [2]. According to the policy of new government under Prime Minister NarendraModi, India is expected to be free from housing shortage by 2022. To take such action, new schemes and guidelines have been launched to encourage providing housing for all [3].

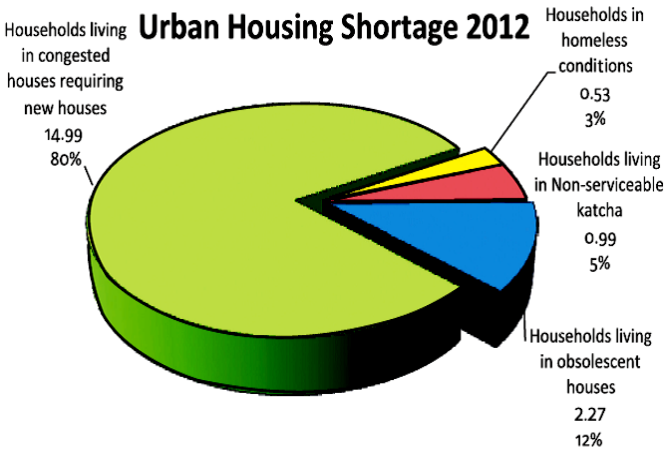

Figure 1: Housing shortage in urban India in 2012 [2]

2. Background of study - Plastic bottle waste as construction material

There is no denying to the fact that more the population density, more the generation of waste. Among all the solid waste, plastic waste constitutes around 0.62% of total household waste in Indian cities. Though the figure of percentage is deceivingly less, but it amounts to around 10, 000 tons per day (TPD) [4]. According to the estimates on production of raw plastic from the manufacturers, India is expected to have 150, 000 processing machines by 2020 and attain the position of being the third-largest consumer of plastics in the world [5]. Therefore, it is clear that there will be more generation of plastic waste in future due to the growing demand of plastics by the common citizens. Figure 2 indicates the variance of demands on different types of plastics as produced by manufacturer through 1956 till 2010.

Among all the plastics, PET bottles production has been escalating in the plastic industries in recent years in India. With an alarming rate of demand and supply of PET bottles, which comes in the form of packaged water, soft-drinks, cold-drinks and other beverages, there is a significant challenge ahead on what to do with the used PET bottles once they have been thrown away as trash [6]. These days, PET bottles are visible in every corner of streets, parks, public space, railway tracks etc. which proves that they are not properly processed after use. Though 75% of PET bottles wastes are collected, but there seems to be an absence of involvement of government to effectively regulate the waste management in India.

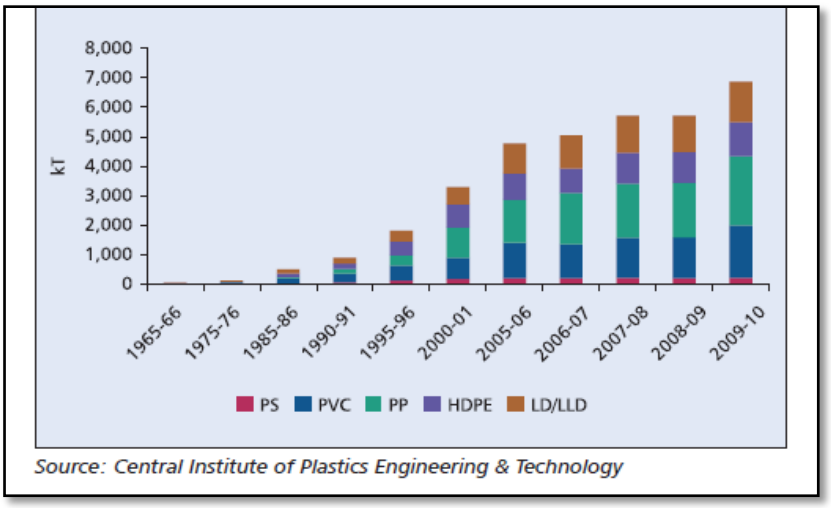

Figure 2: Demands of plastics in India [5]

According to Central Institute of Plastics Engineering and Technology (CIPET), there are around 35000 formal recycling units in India [5]. But recycling of PET bottle is not always a solution as the resulting product loses its raw ingredients in the process and with multi-use, it becomes toxic [7]. Moreover, a plastic of any form is injurious to nature if not taken care of, due to its non-biodegradability in nature. PET bottles, if not treated after use, usually end up at landfill; again subsequently causing a threat to the environment as they occupy the space unnecessarily and take years and years to degrade. With these concerns in the mind, the author felt it would be worthwhile to dispose PET bottle waste in the form of re-utilizing them for construction purposes, provided they are affordable in turn a favor to EWS and LIG.

3. Objectives

i. To study the relevant government schemes that support affordable housing for EWS and LIG;

ii. To evaluate the costing of dwelling unit constructed with plastic bottle waste and find the possible assessment available from government;

iii. To propose use of plastic bottle waste for construction under environmental frontline and housing asset under government

4. Limitations

This study is concerned towards the threat implied upon the environment due to inefficient solid waste management in developing countries like India. In this particular research, only plastic bottle waste has been taken as the main component to study how solid waste can be reused as construction material and reduce the total cost of dwelling units giving a clue for affordability for the deprived sections in India.

This study mostly comprises of secondary data and guidelines from government and earlier research done by the author with extensive research on potential use of solid waste for construction.

5. Materials and Method

In order to understand the advantage of utilization of solid waste in construction and its importance in curbing the environmental threat, it is important to draw implications and valued ideas from previous research studies. An extensive literature study was conducted to consider the pragmatic challenges towards affordable housing with use of plastic bottle wastes and encourage its implementation under government assessment.

6. Literature Study on previous research

6.1. Environmental concern from conventional method of construction

Since ages, use of traditional construction materials such as bricks, concrete, fly-ash bricks, hollow blocks, tiles and other conventional materials have been the integral part of construction of a house due to their strength and durability. Yet, there are many unseen consequences that take place while using these materials. During the extraction of raw materials from the nature, there is a subsequent cause of environmental degradation and depletion of natural resources which is now a global concern [8]. Apart from the exploitation of nature, there are atmospheric pollution through the process of manufacturing of construction materials like emission of carbon monoxide and other suspended materials which again contaminates water, air, soil, flora and fauna influencing human health [8]. Thus, it is necessary to bring down the frequency of using traditional materials for construction and promote other eco-friendly yet stronger and durable materials which can be cost-efficient as well.

Figure3. Plastic bottles refilled with sand [11]

Figure4. Plastic bottles being laid during construction [10]

6.2. Potential of solid waste in construction

Generating solid waste has become daily life routine of human beings. It is inevitable that the materials after its use will become a waste and will be disposed according to the policy of planning and management by the local government bodies. It is lesser known to mass population that some of solid waste has potential to be re-used in other form, such as construction material for building low-cost dwelling units. In this study, plastic bottle waste and construction waste has been chosen as the most convenient and reliable form of solid waste that can be used in construction. In developing countries where citizen face inadequate housing, there have been use of PET bottles to replace conventional materials to build a very low-cost house that are eco-friendly yet sustainable, strong and durable. An example can be derived from Nigeria, Africa, where PET bottles used to be thrown or dumped into waterways and landfills causing pollution, erosion and health problems. According to ECOTEC-Africa, these PET bottles were used as construction materials [9]. In another example, Andreas Froese, the founder of ECO-Tec has researched on use of PET bottles in various purposes that includes the stability of structure and durability [10]. Similarly, in India, there are certain NGOs, who have built institutes like hospital, school and other small units in remote areas where villagers have little access to basic amenities. The institutes are built with recycled PET bottles that are collected from at the proximity around the village [11].

The PET bottles are usually filled with either dry sand, dry soil or construction waste depending on the availability of type of content as shown in figure 3. Similar to the layout method of bricks construction, the bottles are laid accordingly with different pattern as per the different size and shapes of the bottles as shown in figure 4. To further strengthen the structure, nylon fishnet was used as a replacement to steel rods [10] [11].

A study on unit compressive strength test of Plastic bottles has revealed to be varying between 10.9 N/mm^2 and 23.1 N/mm^2 [12]; whereas, the unit compressive strength of brick falls in the range between 3.5 N/mm^2 to 10.5 N/mm^2 [13]. Therefore, it is evident that when Plastic bottle is filled with either sand, dry soil or construction waste makes it stronger than an average burnt brick.

According to the test launched by founder of Samarpan foundation, a non-profit organization, a prototype plastic bottle masonry withstood an intensity of 9.8 on Richter scale and such experiment helped torebuild homes for Nepal citizens after an earthquake hit the cities of Nepal in April 2015 which destroyed millions of homes [10].

6.3. Planning and cost benefits

In previous research, an extensive study was carried out to estimate the cost of a single dwelling unit using plastic bottle waste in place of bricks. Since the trash have no commercial values as they are disowned in one or other way. Hence, the cost of plastic bottle was kept as **zero** against the average cost of a brick at Rs.5 (Indian Rupee) per brick according to present market rate [14].

Following the rules and guidelines on permissible carpet area of single dwelling unit for EWS (21-27 sq.m) and LIG (28-60 sq.m), a protocol design for a household size of 4 was drafted [15]. The plan included one drawing room, one bedroom, one kitchen-cum-living room and one bathroom with toilet. There was a 14% reduction of total cost of superstructure on estimation of plastic bottle masonry compared to brick masonry [14]. The planning and estimation was further refined with an aim to minimize the space and requirements for suitable budgeting as shown in figure 5 and figure 6 for EWS and LIG respectively [16].

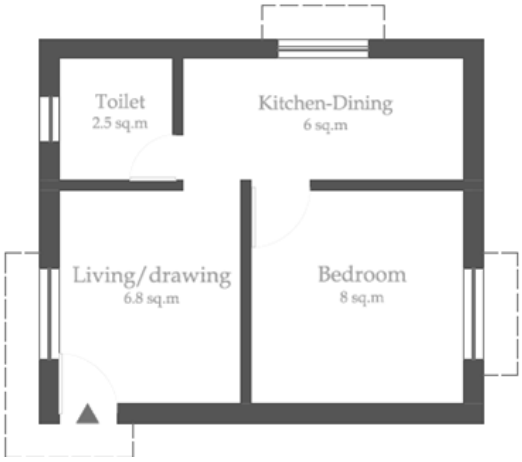

Figure5. Single floor plan for EWS with carpet area = 23.2 m^2 [17]

Figure6. Single floor plan for LIG with carpet area = 33 m^2 [17]

Moreover, use of construction waste such as broken tiles, crushed concrete, broken bricks, excavated soil, sand and pebbles were adopted to replace the cement as an adobe, for bindingone plastic bottle to another and plastering of wall as well. There was again significant 36% reduction of cost as compared to conventional construction provided that the cost of construction wastes remainsto be zero [16].

Furthermore, instead of using RCC slab for roofing; low cost roof construction methods were adopted to reprocess the overall cost of the dwelling unit. Cost-efficient roofing materials like Pre-cast RC plank roofing system, Un-reinforced pyramidal brick roof and Ferro-cement channel/shell unit helps in reducing the cost of roofs to a range of 25-35% as compared to RCC slab [17, 18].

Therefore, it is evident that using plastic bottle waste, construction waste and low-cost roofing materials can be used as important materials to cut the heavy cost of conventional construction to as much as 40% depending on the availability of the materials.

6.4. Study area - Bhubaneswar city

Bhubaneswar is the capital city of Odisha in eastern India having the current population of more than 881,988 (2011). A household survey was taken up in 2015, to find out average consumption of carbonated drinks and packaged water from plastic bottles by an individual [19]. Keeping view of quantity of plastic bottle waste being generated in the city, it was possible to estimate how many dwelling units can be possibly built with same carpet area as discussed in figure 5 and 6. It was observed that at least 6260 dwelling units can be built in a year (as in 2015) and would increase at a rate of 4.47% reaching at around 8073 dwelling units by 2021, with respect to current growth rate of urban population and rate of waste generation and collection of plastic bottle waste [19]. The number of dwelling units completely depends on the amount of plastic bottles used and type of roofing used. Since the plastic bottles come in many sizes; hence a fixed size of 1.5-liter capacity bottle was used to maintain the composure in the research [19].

The cost of one dwelling unit for EWS was estimated to be Rs.84480 and for LIG was Rs.112819 on superstructure using plastic bottle waste, construction waste and low-cost roofing.

According to the Bhubaneswar Municipal Corporation (BMC), there are more than 145 slum pockets in the city and around 30, 000 households are estimated to inhabit there [20]. Thus, it would be worthwhile to keep the increasing housing shortage on guard.

7. Study on initiatives taken by Government

7.1. Smart Cities and other schemes

In the year 2015, under incumbent Prime Minister-ship of ShriNarendraModi, the central government of India launched proposals of developing smart cities in which 100 cities were selected for proposal. Though there is no definitive meaning of smart city, as it differs from city to city, country to country depending upon the level of development. Therefore, it can be vaguely defined as a way to promote or transform a city with better infrastructure and provide quality of life to the citizens through employment generation, agriculture, housing, basic amenities etc. [21]. Bhubaneswar city has been adjudged as best proposed smart cities [21]. In view of planning and management of all kinds, it is necessary that a city accepts new type of innovative technology, ideas that help in shaping the city to better perspective in terms of housing, water supply, sanitation, solid waste management, low carbon footprint etc. to fulfill the requirements under smart city schemes.

Some of the noted schemes which had been launched by state government are still applicable and have been showing dramatic change in housing trends for poor. ValmikiAmbedkarAwasYojana (VAMBAY), Indira AwasYojana (IAY), Rajiv AwasYojana (RAY), Orissa State Housing Board (OSHB) are some of popular scheme that provides subsidies and grant to urban and rural poor whose incomes is less than Rs. 100,000 per annum. It generally helps them to build own homes with whatever grants they receive from the government.

As per RAY, only selected cities are eligible to receive the service under this scheme in which Bhubaneswar is one of them [22]. The beneficiary will be supported by the central government along with the scheme of Affordable Housing in Partnership (AHP), an amount of Rs.50,000 per dwelling unit or 25% of the cost of civic infrastructure whichever is lower [23].

7.2. Scheme for Affordable Urban Housing in Odisha, 2012

Under this scheme, the subsidies are provided to EWS and LIG based on their monthly incomes; where monthly income of EWS is up to Rs.7500 while that of LIG is ranging between Rs.7501-15000 [22]. Due to high land cost in cities like Bhubaneswar, the people belonging to weaker section do not have access to basic needs – Home. Thus it is important to provide affordable housing to the weaker sections that do not have potential to coordinate with the financial crisis. Under this scheme, the government is entitled to provide viable grant limited to 20% of the project cost or a ceiling of Rs.75000 per EWS dwelling units and Rs.100, 000 per LIG dwelling unit if built by private developer on government land with EWS being a beneficiary of this scheme for 20 years of period [22].

Hence, lesser the cost of construction of dwelling unit, better the affordability rate and lesser the use of own money.

7.3. Swachh Bharat Mission (SBM)

With effect from 2ndOctober, 2015 till 2nd October, 2019, this mission is being carried to ensure clean and green cities in every nook and corner of the nation. Literally, ‘Swacch’ is a Hindi term denoting ‘cleanliness’ and ‘Bharat’ means ‘India’. This mission promotes the implementation of Manual on Municipal solid Waste management, 2000 published by Ministry of Urban Development that refers to systematic process comprising of waste segregation, primary collection, secondary storage, transportation, secondary segregation, resource recovery, processing, treatment and final disposal of solid waste [24].

But the problem persists when there is a lack of space and land to dispose the solid waste that are non-biodegradable and unnecessarily occupies the landfill. With rampant growth of population the amount of waste generation will later look for more space to be disposed if not treated properly and efficiently.

Under SBM if segregation helps in collecting plastic bottle specifically for construction, it would help in reducing the bulk of garbage being transported to landfill or for recycling.

8. Results and Discussion

As discussed in the section 6.3 and 6.4, the construction of a single dwelling unit of 23.2 m^2 of carpet area for EWS using conventional materials would cost around Rs.132000 and LIG, Rs.176280 [19]. This implies that per square meter carpet area of dwelling unit for EWS would cost around Rs.5689 and for LIG it would cost around Rs.5341. Whereas, the plastic bottle masonry with same carpet area for EWS would cost only Rs.3640 per square meter and for LIG, it would cost Rs.3418 per square meter. It should be kept in mind the cost of dwelling unit will vary depending upon the carpet area followed under government guidelines.
In section 7.1, under RAY, central government provides a grant of Rs.50000 per dwelling unit or 25% of the cost of civic infrastructure whichever is lower,to the beneficiary.

8.1. Analysis:

In this study, if the beneficiaries are provided Rs.50000, the total amount of money to be spent for the conventional constructionby the;

EWS would be Rs.(132000 – 50000) = Rs.82000 and
LIG would beRs.(176280 – 50000) = Rs.126280

On the contrary, using **plastic bottle masonry**, the cost of construction for: -

EWS will beRs.(84480 - 50000) = Rs.34480 and;
LIG will be Rs.(112819 – 50000) = Rs.62819. **……eq.(1)**

If the beneficiaries are provided 25% of the total cost on conventional material, then the cost of construction which government must provide for: -

EWS will be = 25% of Rs.132000 = Rs.33000 and
LIG will be = 25% of Rs.176280 = Rs.44070

On the contrary, using **plastic bottle masonry**, the cost of construction which the government must provide for: -

EWS will be = 25% of Rs.84480 = **Rs.21120 (**< 50000)and
LIG will be = 25% of Rs.112819 = **Rs.28205**(< 50000) **……eq.(2)**

Since, according to the government guidelines under RAY scheme, the government will grant lesser amount among the two equations. Therefore, the beneficiaries will be eligible to afford the budget as per the equation 2. Assuming the average expenditure of EWS to be Rs.5000 [25], it can be estimated that out of total monthly income of Rs.7500 for EWS, they save around Rs.2500 per month which equals an average of Rs.30000 per year, which they cannot afford to pay and falling over the debt.

Therefore, plastic bottle masonry can prove to be significant method of construction which challenges against problems on both contexts – housing and solid waste management. Instead of using conventional material, government should include the use of plastic bottle waste for construction of dwelling units for only EWS and LIG under various schemes which reduces their risk of falling into debt.

Conclusion

Rajiv AwasYojana (RAY) and AHP scheme is very essential and suitable type of scheme which can provide an opportunity to those deprived of basic infrastructures and improved living condition. With ever increasing population growth and urban density, improper solid waste management and housing shortage has always been increasing together hand in hand.

Utilizing solid waste, mainly plastic bottle in various aspects, reduces the unnecessary expansion of landfill and improves the economy in terms of housing provision.

It is evident from the study; plastic bottle has the potential to be used in construction and reduces the total cost of construction by at least 25-35% depending on the availability of resources and type of labor exploited. With Swachh Bharat Mission in effect, it is arguably possible to expect more efficient collection and segregation of plastic bottles in hand which would help in building more dwelling units.

The central government and State/Urban local bodies must take following initiatives to include this practice under the guidelines and help in improving the housing scenario and waste management strategy as well:

i. Collect and segregate the plastic bottles from the rest of solid waste

ii. The budget used for transporting waste to landfill, which are usually far and at the outskirt of the city, should be instead used for transporting plastic bottles to the nearby construction site; hencesaving fuel price.

iii. EWS and LIG groups should be given the privilege to build dwelling units with government support on financial basis and also supply of plastic bottles and other materials.

iv. Skill development should be provided to the weaker section to save labor cost and encourage self-employment.

v. At grant of Rs.50, 000 there is a lesser risk of falling over debt from loan and encourages EWS and LIG to take upon the practice of using solid wastes for construction.

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