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An Investigation into the Structural Suitability of Expanded Polystyrene (EPS) as an Innovative Building Construction Material

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Abstract: No one can deny the positive effects that rapid urbanization has brought in South Africa such as the creation of numerous economic, cultural and political interaction; but it has also, unfortunately led to some parts of the country turning into slums. Slums are mostly as a result of homeless people trying to create shelter for themselves in pieces of land which are closer to suburban activity. According to Homeless World Cup (2017), the last time a global survey was attempted in counting the number of homeless people; the United Nations in 2005 estimated that there were 100 million people who were homeless in the year 2005.

Slums differ in material composition according to the type of available resources to the 'builder' at the time of starting the building. Most of these structures are Hyper-permeable structures. According to Meth (2016) "Hyper-permeability is an extreme form of indefensible housing. It encapsulates housing that presents multiple forms of permeability, where apertures lack glazing, where construction materials cannot withstand force, walls and roofing are water-permeable, and basic construction elements such as joists, beams, insulation, and structural integrity are often not present, meaning elements of housing are poorly secured, and liable to easy removal. Housing with these material qualities eases criminal access."

The access to safe and affordable housing forms part of the 2030 Agenda for Sustainable Development as encapsulated by the United Nations Development Programme (UNDP). With a large proportion of citizens migrating to urban areas, the need for a model to address the low-cost housing market is imperative. South Africa is not insulated from this challenge. It is crucial for the South African government to address this challenge given the UNDP mandate and the country's historical background.

I. INTRODUCTION

South Africa is a beautiful country with a wealth of heritage and warmth since it is also the birth-place of a number of some of the world's greatest activists. However, great as it is, it still faces some tough challenges even after 23 years of democracy. Leader (2011) lists nine of South Africa's biggest challenges as follows:

1. Too few South Africans are employed
2. The quality of school education for most black people is sub-standard
3. Poorly located and inadequate infrastructure limits social inclusion and faster economic growth
4. Spatial challenges continue to marginalize the poor
5. South Africa's growth path is highly resource intensive and hence unsustainable
6. The ailing public health system confronts a massive disease burden
7. The performance of the public service is uneven
8. Corruption undermines state legitimacy and service delivery
9. South Africa remains a divided society.

Most of the above nine challenges are as a result of South Africa's history. The ills of the apartheid era have left South Africans with a terrible legacy of inequality. This inequality amongst citizens often times cause multiple service delivery riots and protests across all provinces. This is similar to what was experienced in the early 1940's where "The urban working class was growing rapidly, and small-scale riots and strikes bore witness to mounting African frustration over inadequate wages, housing and transport" (Gerhart, 1979, p.77).

According to Brand South Africa (2013), South Africa is an upper-middle-income country, but most South African households experience outright poverty or vulnerability to being poor. In addition, the distribution of income and wealth in South Africa is among the most unequal in the world, and multiple households still do not have access to clean water and adequate healthcare. The extreme inequality in South Africa is so bad that it allows other nations to see destitution, hunger and overcrowding side-by-side with affluence on a daily basis (Woolard, 2002).

Although South Africa is one of the many countries where poverty amongst its citizens is prevalent, but it also remains true that poverty is a huge global crisis that affects multiple other regions in the world. As Meyer (2016)

puts it, “Poverty is a global phenomenon and has proven difficult to resolve. Strategies to address it need to be focused on factors associated with poverty through local research as problems differ from region to region.”

A primary indicator of an impoverished country/community is the lack of adequate housing. There is an amazing psychological phenomenon that is evident when one looks at the lack of confidence of families who reside in informal structures as opposed to those that reside in formal structures. This ‘lack of confidence’ can be experienced when interacting and conversing with different individuals who are of informal structure residence. It is indeed true in the words of Achia (2010) that “the type of dwelling a family resides in, that is, a formal structure versus an informal one, contributes significantly to improved quality of life and poverty status”.

People seem to be more aware of their lack of financial resources if even where they reside is unsatisfactory and is in a terrible condition. It is therefore apparent that one of the first key issues that should be dealt with when attempting to bring aid to impoverished communities is resolving their lack and need for adequate housing. The SABC (2017) in reporting on the housing turmoil in Gauteng reported that the city as of May 2017 had a housing backlog of 300, 000.00. This turmoil-caused mainly by residents of Ennerdale, south of Johannesburg-saw Johannesburg experience waves of looting as well as other forms of criminality. Some people are of the view that it is only the poorest of the poor that need to be assisted with proper housing structures, but that is highly inaccurate because even the low income workers need assistance (Coley 2013).

II. OBJECTIVES OF THE STUDY

A. *The main purpose of this study was:*

To prove that Expanded Polystyrene (EPS) is structurally suitable to be used as an Innovative Building Construction Material.

B. *Study limitations as well as Housing Institutions governing Housing subsidies in South Africa*

This research is based within the borders of South Africa, but considers the application of any of its successes fit enough to be adopted on a global scale. There are a number of legislated housing institutions which undertake specific functions in the South African housing landscape. According to the Socio-economic rights of South Africa (2011), the four major institutions are:

1. The Housing Development Agency (HDA)
2. The National Home Builders Registration Council (NHBRC)
3. The Social Housing Foundation (SHF)
4. The Social Housing Regulatory Authority (SHRA)

1. The Housing Development Agency (HDA) is “a national public entity created by the Housing Development Agency Act 23 of 2008 in 2009.

2. The National Home Builders Registration Council (NHBRC) is “a national council established in terms of the Housing Consumer Protection Measures Act 95 of 1998 with the mandate to protect the interests of housing consumers, by providing warranty protection against defects in new houses, and to regulate the home building industry so that it delivers sustainable and quality houses.

3. The Social Housing Foundation (SHF) is “a nonprofit company set up in 1997 in terms of section 21 of the Companies Act 61 of 1973, in collaboration with the NDoH and in accordance with the Housing Amendment Act of 1999.

4. The Social Housing Regulatory Authority (SHRA) is “a new national regulatory authority created by the Social Housing Act and launched in August 2010.

C. *The Constitution of the republic of South Africa no. 108 of 1996*

In the Bill of Rights in Chapter 2 of the Constitution, section 26 outlines:

- Everyone has the right to have access to adequate housing.
- The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realization of this right.
- No one may be evicted from their home, or have their home demolished, without an order of court made after considering all the relevant circumstances. No legislation may permit arbitrary evictions.

III. ALTERNATIVE BUILDING TECHNOLOGIES

According to Engineering News (2012) the NHBRC provides the following definition for “Alternative Building Technologies”:

“Innovative housing techniques refer to any deviation from traditional construction methods that are specified within the limitations of SANS 10400- it does not necessarily have to be a material that has never been used before”

Some alternative building technologies include:

1. Futurehouse walling system
2. Futurehouse Slab System
3. Intermodal freight container housing modules

1. "The Futurehouse walling system is made of a pre-fabricated panel with a high density expanded polystyrene (EPS) core encapsulated in high tensile steel galvanized wire mesh. Panels are supplied in standard sizes; 1.2m wide x 2.5, 2.75 and 3m height. Custom heights can be made to order up to a maximum of 6m height/length" (Futurehouse, 2015).
2. "The Futurehouse Slab System comprises a panel with the same profile and mesh reinforcing as the walling panel but with two channels cut out of the EPS which, with additional reinforcing rebar, create beams when cast with concrete. The height of the slab panels varies by span of the slab and is determined by engineering requirements. A typical slab panel is 200mm high with two beams cut to 160mm deep and 120mm wide. There is then an additional 50mm of concrete poured above mesh height to give a finished slab thickness of 250mm" (Futurehouse, 2015).
3. The ISO shipping container is a 12.1m or 6.058m by 2.438m wide and 2.438m high box made of steel, with a minimum internal floor area of approximately 27.95m² and 13.6m² respectively dependent upon the manufacturer (Oloto and Adebayo, 2006). Below figure 1 shows a typical ISO container used for housing.

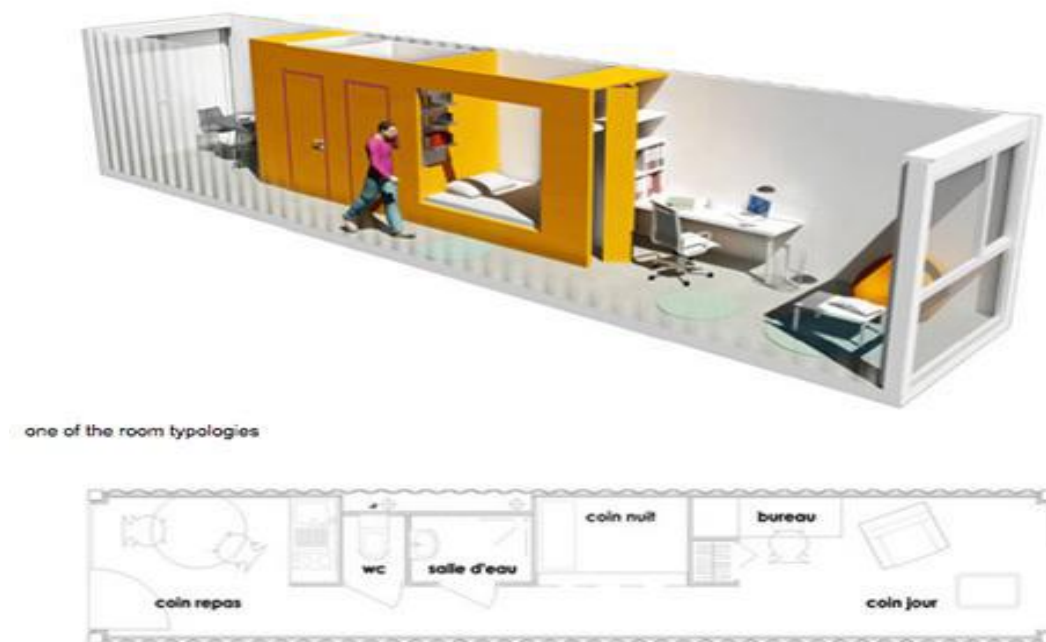


Figure 1 Oloto and Adebayo, 2006

IV. PROBLEM STATEMENT

The challenges that prevent a significant decrease in the housing backlog relate to six primary issues, namely subsidies and financing for beneficiaries, affordability of housing, quality of housing, settlement planning and suitable land acquisition. These problems relate to difficulties encountered in the political, social and financial sphere of the built environment. However, would it be possible to approach these problems from a different angle, namely the technical side of the built environment? Would a different technical solution be able to alleviate some of these challenges? Can modern expanded polystyrene architecture provide a possible solution?

It can be seen from the developed literature review that although alternative innovative technologies already exist for new housing models, but a more comprehensive model is needed in order to be able to combat the growing need of adequate housing. Therefore the researcher proposes the following research statement:

"How would the use of Expanded Polystyrene dome houses be a better alternative to conventional construction in low-cost subsidized housing in South Africa?"

This statement can be tested scientifically through the following:

- 1) Conducting various laboratory tests
- 2) Comparing laboratory tests results with existing results previously done on EPS
- 3) Gathering and analyzing data from an existing miniature model to test if the model replicates what can be found through laboratory analysis
- 4) Assessment of existing housing policy to determine an implementation plan of how EPS constructed houses can be initiated

V. EXPANDED POLYSTYRENE

The urgent need for innovative methods of construction is primarily based on the potential benefits thereof such as faster construction time, fewer housing defects, and reductions in energy use. Innovative methods of

construction will also offer significant potential to minimize construction waste and construction safety risks. Such benefits are possible with the adoption of Expanded Polystyrene as a new building model alternative.

A. Aspects of EPS as a building model

Expanded polystyrene is generally available in 3 types of densities, namely, 15, 20 and 30 kg/m³. With the use of materials such as EPS, the different shapes of a house can be moulded to form various inter-locking pieces that will be easy to assemble on-site.

The cost of EPS that can form the superstructure of a house that would comply to the minimum standard of 40m², is approximately R145,000.00 for a density volume of 15kg/m³ as compared to R110,947.00 for a conventionally built house in 2010 (Department of Human Settlements, 2010). In the year 2015, according to Stats SA (2016) the cost of building a 40m² house amounted to R237,280.00; which means that in the year 2017 this would be bordering quite close to R300,000.00.

A.1 Advantages of EPS as a building model

- Ultra-thermal insulating properties that enable energy savings
- Semi-permanent durability
- Gale resistant
- Earthquake resistant
- Ultra-short assembly time
- Ultra-low cost
- Environmentally friendly

A.2 The primary disadvantage: In many countries such as South Africa, people are still of the view that geodesic domes are a bit “strange” or “not fitting with the conventional buildings” and often object to their construction.

VI. CONCLUSION

It is easier to paint a picture that will reflect the true extremities of the housing situation in South Africa by considering both the past and the present. The vision of elected government leaders to tackle the housing issue needs to be one that remains paramount above all other visions in governance. This is mainly because housing not only gives citizens a sense of belonging but it also affirms their sense of dignity. Angel (2000, p.3) states that “public housing was the battle cry of paternalistic governments vowing to overpower monstrous housing deficits and dedicating themselves to providing decent housing for all those in need” and this should continue to fuel the need for adequate housing for all.

VI. RECOMMENDATIONS

Conventional building methods have gained popularity through their lengthy existence in the built environment; but if EPS is not adopted as an acceptable innovative building construction material then it will be difficult to introduce new building models in industry which will most likely bring far reaching benefits than conventional methods, such as being able to reduce the number of slums and informal settlements that South Africa currently has.

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