Eco Friendly Cost Effective Earth bag House Construction

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Abstract:

High construction costs are one of the biggest drawbacks of constructing world houses. One of the most critical issues for people is the high cost of primary criteria for the building of houses in areas where people are below the poverty line. Earth bag technology, which constructs secure, attractive and cost-effective structures from ordinary soil. Earth bag construction is widely considered the most promising of sustainable building techniques, stronger, cheaper, and less detrimental to the environment than traditional building techniques such as brick and cement. But this approach is shunned by governments despite widespread support among environmental organizations and eco-builders, and remains virtually unknown to ordinary construction professionals and the public. Also known as "bagged adobe" "continuous bag stabilized earth" "earth bag building" or "Earth-filled bags" the super adobe is a construction technique in which bags filled with earth, stacked and reinforced, with barbed wire between them are essentially constructed of the walls.

The technique was developed as a potential solution for building on the moon, and then extended to solve the problem of social housing, and it is now possible to find buildings with multiple uses and other constructive technological connections in robust super adobe.

The paper aims to address the use of Earth bag construction technologies and to provide an alternative to their topological classification, backed by constructions that have already been implemented, in order to enable future research to identify and resolve the limitations and variations of the construction technique.

Keywords: *Poverty line, Super adobe, Sustainability, Earth construction, Conventional Material, Sustainable techniques.*

Introduction:

Today urbanization is very rapid in its way. The urbanization delivering modernization for human life but changing the environmental aspects. Construction of earth bags is an economical way of building structures that are both solid and can be constructed rapidly. It is a natural construction technique that developed from historic techniques of construction of military bunkers and temporary methods of construction of flood-control dikes. The cost of the foundation typically amounts to around 10 to 15 percent of the total building and generally 3 to 4 ft of the foundation diameter. As one of the key barriers to better housing quality, the shortage and cost of durable building materials is frequently reported. Professionals did not actually design or build the vernacular architecture that ascribes to a specific idea and its own aesthetics.

Another important motivation is that there is not much scientific research about super adobe. The super adobe technique was created by the architect Nader Khalili in 1985. It was a contribution for NASA research aiming at finding out a way to build houses on the moon, associating high tech with the use of local materials (KHALILI 1989). Earth bag construction has proven stronger and safer than conventional construction. It is noted for the ability to endure earthquake, fire, flood, wind, vermin, and even bombs and bullets.

Millions of new buildings are being built every year and new construction materials are being introduced in the name of modernity. Today, the planet has undergone global warming and climate change. In addition to other contributors, natural resource mining absorbs resources as construction materials themselves, causes environmental degradation and leads to global warming. In both developed and developing countries, buildings are the main energy users and emitters of greenhouse gases. Earth bag housing is a simple type of earth-based construction in which large sacks, compacted and lay horizontally in a running bond, are filled with granular material to form the center of a wall structure.

The objective of this paper is to introduce characteristics of this technique and respective benefits in building construction. Construction of the Earth bag consumes the least energy of any robust form of construction. Unlike concrete, brick or wood, there is no need for energy other than to collect soil to generate the required materials. With on-site soil being used, virtually no energy is spent on transportation and no energy is needed to compact the soil, unlike rammed earth construction.

Compared to other forms of building, the energy-intensive materials used in plastic (for bags & twines), and steel wire, and perhaps the outer shell of plaster are used in comparatively limited amounts. The buildings last for a long time; but when they are no longer useful, they may simply erode or even be recycled into new Earth bag-built buildings without serious environmental hazard.

STUDY OF LOCAL CONSTRUCTION MATERIALS AND TECHNIQUES TO ACHIEVING THE AFFORDABLE HOUSING

1. Need for Study:-

1.1 Building Materials for Low Cost Housing Construction

The use of low-cost building materials for low-cost housing construction improves the access of low-income groups to buildings. Low-cost housing can be accomplished by the use of effective planning and project management, low-cost materials, cost-effective building technology, and the use of available alternative construction methods.

- **Selection of Low Cost Building Materials for Low Cost Housing**

The first step in choosing low-cost construction materials is to choose eco-friendly building materials. The sustainable design theory is also reinforced by this.

2. Profile of study area:-

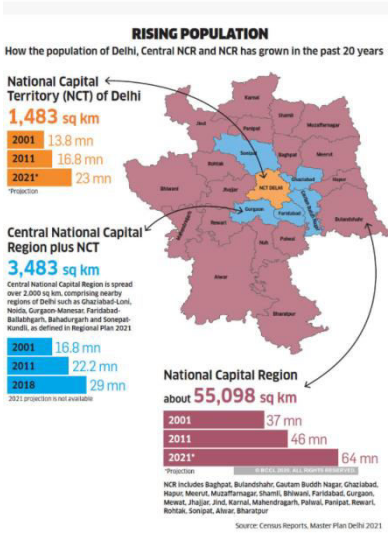
IDENTIFY THE RESEARCH AREA & POLICY OF AFFORDABLE HOUSING

To study the Problems of Poor Section Residing in Slums and Without Shelter, in Delhi and what are the issues of Direct and Indirect policy an affordable housing.

2.1 The Research Area and Housing in NCT of Delhi

Delhi, India's capital and officially called as the National Capital Territory (NCT) lies in North India, and is one of the fastest growing routes in the world. The population stands at 18.24 million that is very high and was reported as the third largest and most populous city in India. The state of Delhi is spread over an area of 1,486 sq. Km. Km, where the developed urban area forms 525 sq. Km. The entire Delhi area and urban extensions, as well as urban areas, make up 35% of the 1,486 sq. Km, equivalent to 961 sq. M. Km

Rapid growth of Delhi NCR and development has led to improved opportunities to support the lives of the urban poor. A new study suggests that if the current trend growth continues, perhaps “the city's population will reach from 18.24 million in 2011, 22 million by 2021 and 30 million by 2051” given Figure



Rising Population of Delhi according to Census Reports 2011

The pattern and framework of migration, which has a satisfactory effect on the economic and residential syst em of the city, is therefore important to understand.

"The percentage rate is different in urban migration rate is estimated at 83.9% of the population in rural areas, while 15.8% in small and medium-sized cities and 0.3% in the metropolitan area".

The majority community of migrants is in the southern parts of Delhi. Three districts are in Delhi, i.e. within the total population in that province, South-West Delhi, South Delhi and New Delhi have a 40% share of inter-state migrants. The lowest, just 17 percent, for the Central district, which includes the walled city, among the oldest habitations of the city-state.

3. Case Studies:-

To study all about local construction Techniques and community involvement in low cost Construction Housing?

3.1 10 X 10 Design Indaba, Low Cost-Sandbag Homes, Cape Town, South Africa

Architects: MMA Design Studio

Location : Mitchells Plains, Cape Town, South Africa

Number of Units: 490

Project Year: 2009

"Is it possible to develop a low cost house without using the conventional brick + mortar + concrete mix?" (Studio, 2009)

- ✓ This was the question raised by the [design Advocacy] organization based in Cape Town, Design Indaba, through the competition for the 10 x 10 housing project.

10xSouth African Architects were invited to work with 10xInternational Architects to apply design imagination to the design of a low-cost house for recipients in Mitchells Plein, Cape Town, in the Freedom Park neighborhood.

Figure 1: 10 X 10 Design Indaba, Low Cost-Sandbag Homes

➢ DESIGN CONCEPT

- The main and simple objective of this project Design Indaba 10 X 10 Houses is designing a dignified low cost house.
- In this project, the key challenge was to find the materials and construction technology that would be better for the allocated 50,000/- building budget for the 42 meter.Sq house area on the allocated 112 meter. Sq Erf. The design according to the urban contextual design of 10 X 10 houses on assigned sites for the projects is also determined by the architect in this project.
- Single free standing and semi detached units are proposed in Africa's design space. i.e. Design Response
- At the time of construction the Design space in Africa they are maximizing the allocated space for indoor/ outdoor use by the family that's why they are providing the double storey building or houses on a 27 meter. Square footprint.

➢ CONSTRUCTION (Materials and Technology)

1. In terms of building materials testing, a sandbag house designed with a timber frame ECOBEAM framework filled with sandbags and plastered over was found to react appropriately.
2. EcoBuild Technologies, in Epping Cape Town, produces the EcoBeam construction system locally. The good thermal characteristics of the sand and the simplicity of the building system, a low-energy

and sustainable product, make it a creative and genuinely South African design.

3. Sustainable materials that are also required to include people such as unqualified community members are also part of building their own homes at the time of construction, thereby contributing to the delivery of low-cost housing / affordable housing and at the same time it will be beneficial for communities.
4. The single unit building cost for the Design Space Africa 10 x 10 Design Indaba Low cost housing exceeded that allocated building budget of Rs 50,000/-. The economies of scale are accepted by Design Indaba housing project, the estimated amount is Rs. 80,000/- for Design Space Africa 10 x 10 houses was acceptable.

Figure 2: Construction Phase of 10 X 10 Design Indaba, Low Cost-Sandbag Homes

3.2 Casa Hilo by Zeller & Moye, Mexico

Architect: Zeller & Moye
Location: Colima, Mexico
Year: 2019
Type: Prototype of rural social housing
Total size: 270 Sq.m.
House size: 90 Sq.m.
Garden size: 180 Sq.m.

- Casa Hilo is a housing prototype for living in rural conditions with heat / warm climate. supported

modules, the house takes kind from one box that may be increased and organized freely in line with the positioning, budget and desires of every family.

Casa Hilo by Zeller & Moye, Mexico

- After analyzing the current living situation of local people within the Mexican countryside, Zeller & Moye has designed 'casa Hilo' – a recent social housing type for a rural environment. The event relies on a modular system of volumes, with flexible arrangements and therefore the ability for homes to be extended in size. This project is focuses on external spaces because that is correlated with indoor and outdoor environments while also providing natural lights and ventilation in whole unit.

➢ CONSTRUCTION (Materials and Technology)

- The structure of casa Hilo is constructed from a concrete framework and adobe blocks to infill the frame that has been factory-made on website by locals.

- **Three materials are used for constructing Casa Hilo:**

1. Ferroconcrete Frame and Slabs
2. Custom –Made Adobe Blocks are used as Wall Infill's.
3. Custom-Made Bamboo Shutters & Doors

- Adobe blocks is using for constructing the low cost housing because it is easily available on the site and in hot climate as they help to absorbing excess humidity and maintain the temperature in interior with its thermal mass during the day, this resulting in a Sustainable construction type
- The concrete and adobe area unit offset by the bamboo lattice of the doors and windows. The lattice structure permits for air to circulate through the internal spaces, additionally to bringing a decorative element to the prototype.

4. Comparative analysis of all the cases.

- Comparative analysis based on low cost construction techniques.

PARAMETERS	**CASE STUDY 1 (10 X 10 Design Indaba, Low Cost-sandbag Homes)**	**CASE STUDY 2 (Casa Hilo by Zeller & Moye, Mexico)**
Location	Cape Town, South Africa	Colima, Mexico

Techniques	Sandbag Construction	Adobe blocks construction
Construction time	2 Year (2007-2009)	2 Year (2017-2019)
Type of material	Sandbag, Timber, Mud, Sand	Ferroconcrete Frame and Slabs, Custom – made adobe Blocks and bamboo shutters and doors
Material Characteristics	Low cost, Easy to use, Locally Available	Better Thermal insulation, Cost effective technology
Efficiency of material	Eco Friendly, high Strength	Energy efficient, eco Friendly technology
Cost of Unit	50,000/-	73,000/-
Transportation cost	No Transportation Cost	No Transportation Cost
Building Levels	G +1	G +1
Maintenance Cost	No Cost Required	No Cost Required

5. Design & Intervention

➢ Sandbag House Construction techniques

- The main objective of study these construction techniques are to construct low cost housing model using sandbags with minimum incorporation of other materials for walls and roof.

Figure 3: Sandbag House Construction process

- The mechanical behavior of this techniques is examined the full structure with roof system stability tests. This project proposes a reasonable or affordable, environmentally friendly and simple constructible housing unit which provides an adequate option for housing in informal settlements, slums, and areas.

- This technique consists in a very constructive system that uses polypropene, raffia or different luggage, wire and earth. This luggage square measure no heritable in rows, which might variant from thirty to sixty centimeters of length. They're stuffed with inorganic earth to form walls, domes and arches. the luggage is cut by the specified size and stuffed with a funnel victimization 20 percent humidness earth.

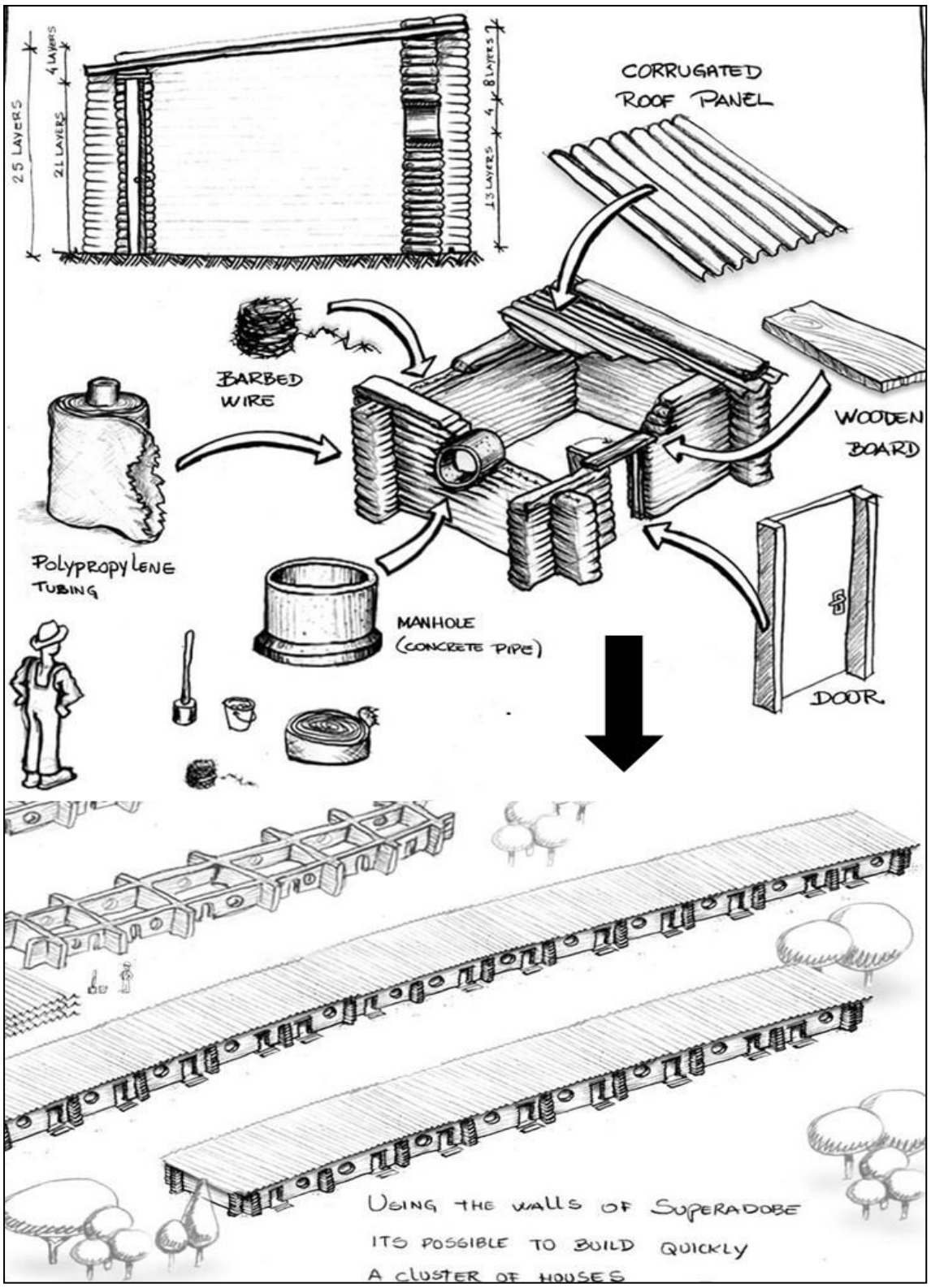


Figure 4: Sandbag House Construction materials and techniques required

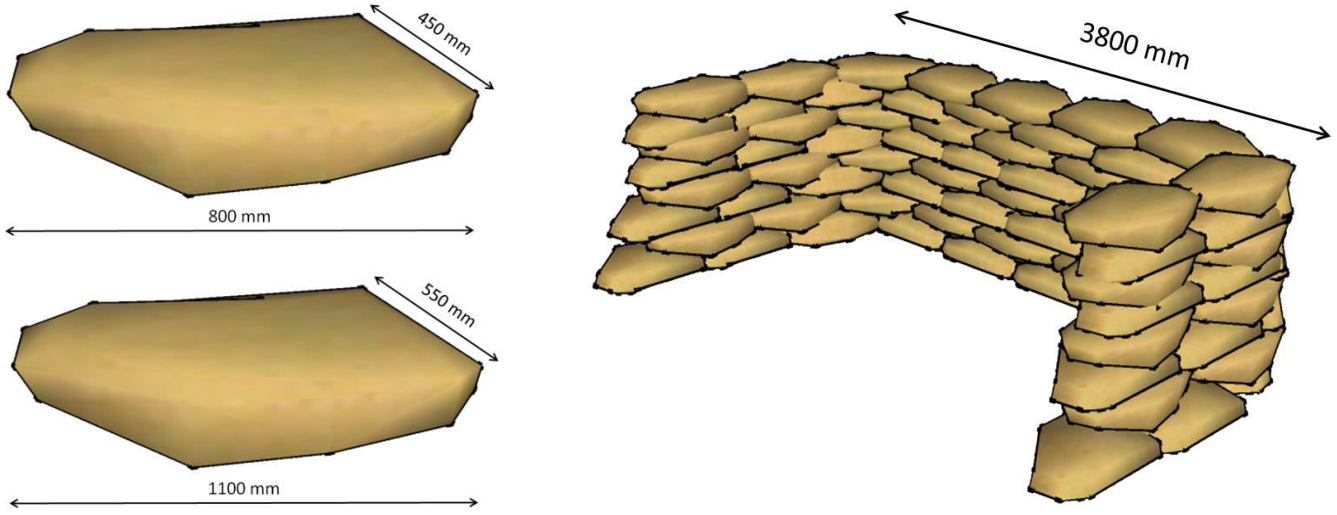
- Many variations of soil are often employed in this system attributable to luggage retention (Holding) capacities, but it's recommended the mixture of roughly half-hour of loamy soil and seventieth of sandy soil. This mixture was adopted by most of the recent buildings of rammed earth within the world which will still be seen these days.

METHODOLOGY

- Selection of Polypropylene Sandbages Size
- Selection the amount of sand material to fillup Sandbages
- Material and structure tests
- Selection roof system
  The most suitable selection for roof system that is economical, avaiable in materials & high strength
- The arch sandbags roof system
  It used when construction of dome is done by using of sandbags
- High Density Polyethylene Sheets and Recycle Timber Purlin are Used

Figure 5: Arched sandbag roof system

Figure 6: High-density polyethylene sheet used on wooden frame roof system



The selected polypropylene sandbags of dimensions 450mm x 800mm, 550mm x 1100mm, 600mm x 1100mm, and 550mm x 1050mm were filled with different amount of sand namely; 20kg, 25kg, 30kg, 35kg, 40kg, and 45kg.

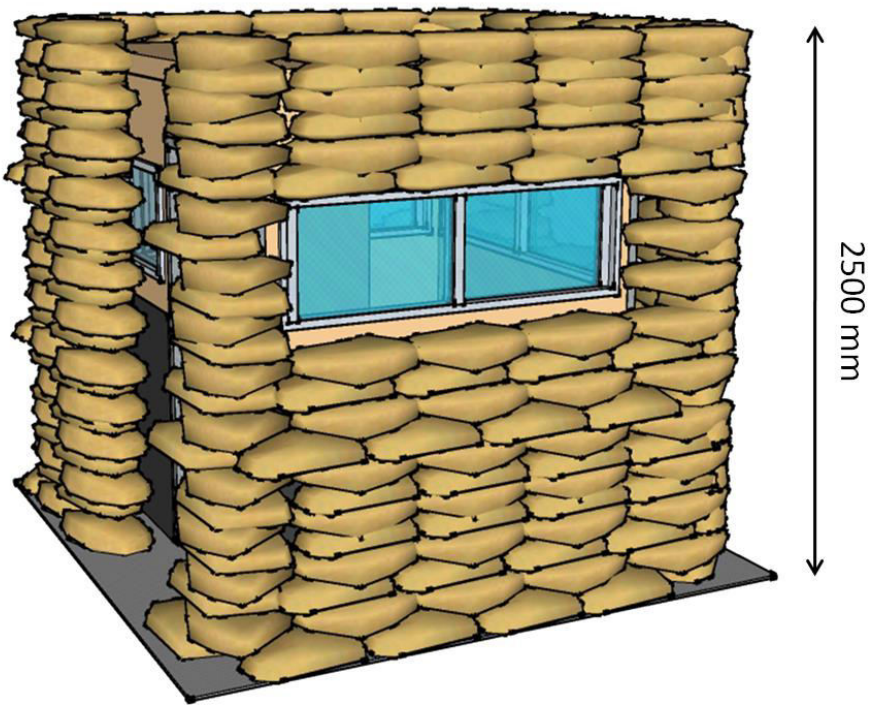
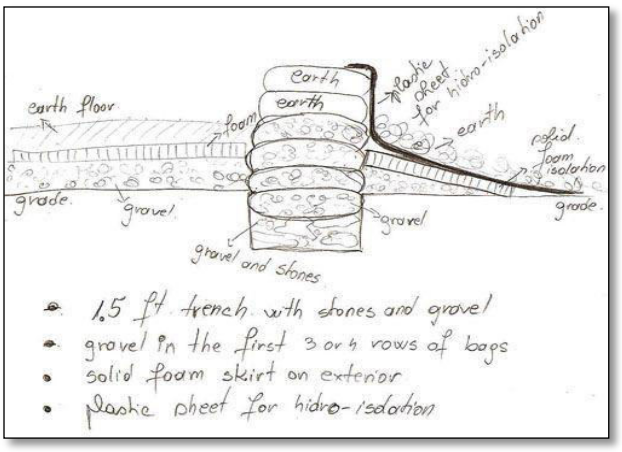


Figure 7: Sandbag Construction model

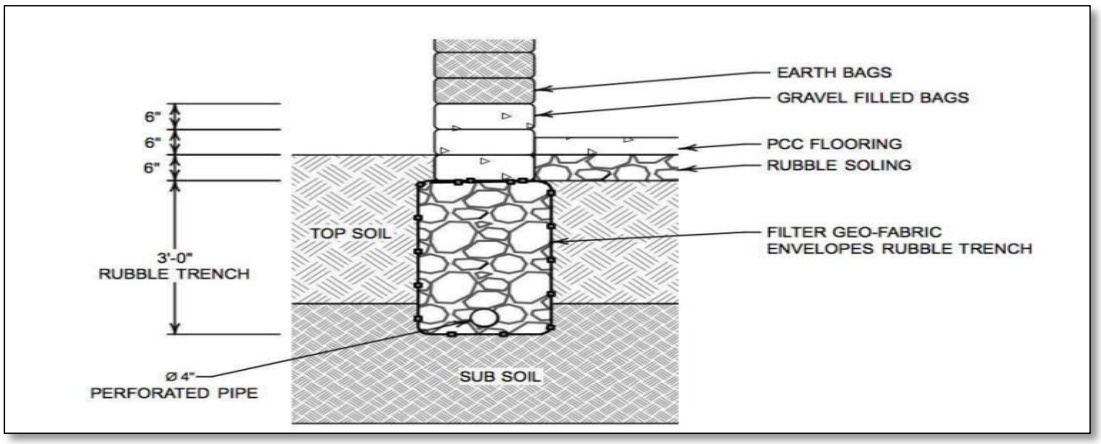
Construction of one single room unit with dimensions 3m is width, 3.8 m length, 2.5 m height according to the standard. The mechanical behavior of these techniques that will be examined the full structure with roof system stability tests.



4. Foundations of Sandbag Construction

In Sandbag construction one first creates a rubble trench foundation that will filled with coarse gravel, an innovation first popularized by Frank Lloyd Wright.

Figure 8: Rubble Trench Foundation



All the workers on site stuff ordinary soil gathered from the construction site into polypropylene bags. Staggered like masonry and tamped down, after that the bags become hard as brick in a month or two.

➢ Disadvantages and Advantages of Sandbag Construction

- Because of the natural material advantages, this system only was proposed to include small constructions to answer social housing problems. Just after was tried to use in buildings of various sizes and uses, like eco villas, hotels, exhibition pavilions, and others.

- The known disadvantages to use this material are just some, and most of those are associated with the unfamiliarity of the technique by the population. TABLE 1 summarizes these advantages and drawbacks.

Advantages	Disadvantages
Flexible Form	Unknowledge (architects, engineers, constructors, etc.)
Speed of construction	Legal issues
Thermal comfort	Social acceptance
Energy efficiency	Technical limitations
Low cost	Fragility of site construction
Structural strength	Specific Tools of Computer aided design
Self-supporting for up to 2 floors	
Low maintenance	
Recyclable and reusable resources	

Conclusion:

Sandbags construction may be considered as alternative method for constructing a low cost, small size unit for poor and disadvantaged areas it'd be beneficial for lower income group. The construction of 12 meter. Square sandbag room will be relatively easily conducted with the utilization of waste bags nearby using fine aggregates and little amount of polyethylene sheets which is definitely available on the positioning. This small scale project pinpoints a comparatively low cost housing for the poor sandbag that costs is cheaper. Evidence exists from our work that sandbag housing could be a step to a greener structure that involves less use of non-environmental friendly materials. The sandbag unit developed should be considered as an adaptable and versatile alternative unit during a sense that it is disassembled and reused with minimal to no loss of the initial materials and components. Compared to conventional steel and reinforced concrete structures, the benefits include high strength, light weight, increased resistance to corrosion and fatigue, superior damage tolerance and the potential to be adapted to suit particular applications.

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Imageography: