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Low Cost IN Sustainable Building Materials

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Abstract: *Low cost or affordable construction technologies and materials are always in the ever growing demand for rapid housing delivery in developing economies like India. From the global trends in rural to urban migration, most of the developing countries are facing an enormous service backlog and massive delivery challenges in addressing its millennium development goals in the provision of housing and shelter. With growing concern over global warming and climate change, global responsibility in the consumption and production of renewable energy becomes not only a vital necessity, but a moral imperative also. This has imposed a thrust towards the use of eco-friendly materials and sustainable architecture in both developed and developing countries. This paper focused on some of the ecofriendly materials used for construction industries with low cost.*

Keywords *–construction techniques, low cost materials, sustainable building, efficient construction, eco-friendly material.*

I. Introduction

Building materials and technologies, and building practices have evolved through ages. Housing and building conditions reflect the living standards of a society. Stones, mud, thatch/leaves and timber represent the earliest building materials used for the construction of dwellings. Quest for durable building materials is an on-going phenomenon ever since man started construction activity.

Sustainable materials are the key to limiting the impact on the ecological system. Local techniques and technology, resources and materials are a good starting point when researching or implementing projects. Housing models should determine the sustainability of the building materials through lifecycle analysis, and occupational use of building including renewable energy, water, land and use of resources. Appropriate technology goes hand in hand with the design and building materials. It should correspond to local conditions, reflect and respect climatic conditions and demand a minimum of maintenance.

II. Low Cost Sustainable Materials

1. Introduction

The Industrial Revolution introduced many foreign substances which were the by-products of industries like fly ash and rice husk and created problems for their disposal. But on further research into their properties it was observed that these materials possess excellent pozzolonaic properties. Hence these can be used as alternative building materials.

1.1 Polymer-bamboo Reinforced Concrete

The problem of bamboo reinforced concrete includes high volume change, low bond strength between bamboo and concrete, low modulus which precipitate cracks at service loads in tensile zone of concrete beams, and decay. Bamboo can be used for secondary structures when steel is not available.

1.2 Pozzolona Material(fly ash/slag/calcined clay) as Blending Material with Cement Up to 35% of suitable fly ash can directly be substituted for cement as blending material keeping the structural considerations. Addition of fly ash significantly improves the quality & durability characteristics of the resulting concrete.

1.3 Recycled Steel Reinforcement Steel reinforcement can be made entirely of recycled scrap iron. This material is salvaged from automobiles, appliances, and steel-reinforced structures, which include reinforced concrete pavements, bridges, and buildings.

1.4 Ferro Cement and Precast Components

Precast Components are 85% recyclable, have low carbon dioxide generation and are energy efficient. They are eco-friendly, cost effective and easy to install. With use of precast components, wastes during operations are minimal, curing is not required, and structures are waterproof due to less water cement ratio, plastering is not required from the inner side of slabs and the components are corrosion proof.

1.5 Foundation

Folded strip footing as an alternative foundation system instead of the conventional rectangular strip footing are:

- Minimizing the cost of foundations through reducing the ratios of steel reinforcements.
- Introducing foundations with higher load carrying capacity and less soil settlements than the traditional rectangular strip footings, (up to ten floors).
- Performing a comparative economical study for the costs of both foundation types.
- Minimizing or even eliminating the tension zones in the folded strip footings.
- As a consequence of achieving previous point, the needed ratio of steel reinforcement will be minimal.

1.6 Precast R.C.C. / Ferro-cement Frames

Precast R.C.C. frames are concrete doorframes with welded reinforcement. These are manufactured according to Indian Standards. These are economical, environment friendly and durable. They are termite proof, fire resistant and corrosion proof. There is no bending or twisting, no warping, no shrinkage and no cracks.

1.7 Bricks & blocks

Need for building materials is growing at an alarming rate and in order to meet the demand for new buildings, new ways and techniques must be evolved. Manufacturing of building materials like bricks/blocks, cement, steel, aggregates, etc. consumed in bulk quantities, puts great pressure on natural resources (raw materials) and energy requirements. The use of alternative materials for bricks should be encouraged in order to preserve precious fertile top soil.

1.8 Fly Ash

The mineral residue produced by burning coal and the fine glass powder recovered from its gases is called Fly Ash. The major constituents of fly ash are silica, alumina and iron. Fly ash bricks are energy efficient, mercury pollution resistant, lower water penetration, light weight, thermal insulation and cost effective the only major disadvantages of using fly ash brick is that there is very less information on its toxic fume emission.

1.9 Bricks from Coal Washery

The residual waste from the coal washery plants is a hazard to the environment and needs to be disposed or utilized in a manner which lessens its harmful effects on the natural surroundings. These bricks are eco-friendly and waste utilizing. They reduce air, land and water pollution, are energy efficient and cost effective.

1.10 Building Blocks from Mine Waste and Industrial Waste

It is eco-friendly, utilizes waste and reduces air, land and water pollution. It is energy efficient and also cost effective. Majority of the large-scale industries and thermal power plants generate solid wastes in bulk quantities. Red-mud, coal ash, slag, fly ash, etc. represent such wastes unutilized for several decades. Such wastes can be utilized for the manufacture of bricks/blocks, substitute for fine aggregates in concrete, partial replacement of cement in concrete, lime–pozzolona cements, etc.

1.11 Aerocon Panels

Aerocon panels are the inorganic bonded sandwich panels made of two fibre reinforced cement sheets engulfing a light-weight core consisting of Portland cement, binders and a mix of siliceous and micaceous aggregates.

1.12 C-Brick

These are bricks manufactured using the C- brick Machine developed by CBRI. The machine is available with BMTPC and is used for production of quality bricks using fly ash –sand –lime, fly ash –sand – cement and cement-sand aggregate.

1.13 Ferro-Cement

Ferro-cement can be defined as a thin walled versatile high strength cement based composite material made of cement mortar reinforced with one or more layers of wire mesh closely bound together to create a stiff structure unit with high performance, lightness of structure and strength.

1.14 Cement Concrete Hollow Blocks

Cement Concrete Block is a recently developed masonry unit of concrete. They are cost affective and better alternative to burnt clay bricks due to their good durability, fire resistance, partial resistance to sound,

thermal insulation, small dead load and high speed of construction.

1.15 Low Cost Sand Crete Block

The rice husk ash produced using charcoal from rice husk is pozzolonaic and therefore is suitable for use in block making. In Concrete the rice husk ash is a highly siliceous material that can be used as an admixture in concrete if the rice husk is burnt in a specific manner.

1.16 Calcium Silicate Plaster

Calcium silicate refractories are usually derived from calcium silicate. Wollastonite is a naturally occurring form of calcium silicate commonly used as filler. Portland cements are also based on calcium silicate. Calcium silicate plasters are economic, eco-friendly, produce less wastage, have wide usage, give a smart finish, are less energy consuming, do not emit VOC and other toxic fumes and gases after application and are recyclable. They are safe in handling and usage, do not need skilled man power, are fast drying, durable, and have less water consumption.

1.17 Fiber reinforced clay plaster

Clay Plaster can achieve better sticking properties by reinforcing it with fibers. These fibers can be natural plant (cellulose) fiber or artificial fibers of polypropylene. Plant fibers in fiber reinforced plaster act as reinforcement and create voids thus controlling cracking due to drying shrinkage and thermal movements.

1.18 In Floor and Roof

Structural floors/roofs account for substantial cost of a building in normal situation. Therefore, any savings achieved in floor/roof considerably reduce the cost of building. Traditional Cast-in-situ concrete roof involve the use of temporary Shuttering which adds to the cost of construction and time. Use of standardized and optimized roofing components where shuttering is avoided prove to be economical, fast and better in quality. Some of the prefabricated roofing/flooring components found suitable in many lowcost housing projects are:

i. Precast RC Planks.
ii. Prefabricated Brick Panels
iii. Precast RB Curved Panels.
iv. Precast RC Channel Roofing
v. Precast Hollow Slabs
vi. Precast Concrete Panels
vii. L Panel Roofing
viii. Trapezon Panel Roofing
ix. Unreinforced Pyramidal Brick

1.19 Micro concrete roofing tiles

Micro Concrete Roofing (MCR) tiles are a durable, aesthetic and inexpensive alternative for sloping roofs. Micro Concrete Roofing (MCR) tiles are made from a carefully controlled mix of cement, sand, fine stone aggregate and water.

1.20 Bamboo matt corrugated roofing sheets

Roofing is an essential ingredient of any house and in India several roof cladding materials are in use including burnt clay / Mangalore tiles, thatch, corrugated sheets of galvanized iron, aluminium and asbestos cement, etc. Of these, for semi-permanent structures corrugated sheets are preferred.

1.21 Cellular Concrete

Cellular concrete is a lightweight cement-based material, containing many gas bubbles evenly distributed in the volume, produced by blending and maturing of a mixture of cement, filler, water, agent generating cells. By the method of generating the air or gas cells there exist foam concrete and gas concrete. Cellular concrete is a lightweight cement-based material, containing many gas bubbles evenly distributed in the volume, produced by blending and maturing of a mixture of cement, filler, water, agent generating cells. By the method of generating the air or gas cells there exist foam concrete and gas concrete. Gas concrete is presented mainly in the form of pre-cast blocks, the majority of its applications however demand it to be cast-in-place.

1.22Filler Slabs for Ceilings

These are the normal RCC slabs where the bottom concrete is replaced with filler materials such as bricks, tiles, cellular blocks, etc. But they do not compromise the strength of ceiling in any ways, thus it is

economical, reasonable and safe to use.

1.23 Sand-lime brick

Sand-lime brick is a product that uses lime instead of cement. It is usually a whitebrick made of lime and selected sands, cast in moulds and cured. Production is limited, with greater use in the United States and Germany. Sand-lime brick, as now known to the trade, consists essentially of sand, which is bound together by a hydrated calcium silicate. It has about the same hardness and porosity as common clay building brick. It is naturally white in colour, or nearly so, this being determined by the colour of the sand from which it is made, although a few artificially coloured sand-lime brick are being sold. The individual specimens are much more nearly uniform in size and shape than clay brick of the same quality.

III. Benefits Of Using Low Cost Sustainable Building Materials

The environment friendly building materials are composed of renewable, rather than non-renewable resources. Use of these materials provides the following benefits.

- **Resource Efficiency** – benefits like high recycled content, naturally available, efficient manufacturing processes, and locally available, high salvage potential, reusable and highly durable.
- **Indoor Air Quality** – Selection of the materials with benefits like low/ non-toxic, minimum emissions, low VOC content, moisture resistant and healthfully maintained.
- **Energy Efficiency** – Selection of the materials with benefits like reduction in energy consumption in buildings and facilities etc.
- **Water conservation** – Selection of materials with benefits like reduction in water use in buildings and conserve water in landscape areas.
- **Affordability** – Is considered to compare the eco-friendly building materials to conventional materials within a defined percentage of the overall budget of the building.

Apart from the above benefits, using these materials have the following advantages also:

- These have similar or low price compared to conventional building materials when total life cycle cost is assessed.
- These do not exhaust the existing supplies of finite materials.
- These materials save energy and reduce harmful emissions. These materials help in reducing environmental degradation.
- These materials are encouraged by building promotion council, so planning/ building permissions are easy to get.
- They are less harmful to occupants; they make healthier and safer buildings.

IV. Conclusion

While many sustainable building materials and technologies do cost more, it has been demonstrated that many green strategies and technologies actually cost the same and some even cost less than traditional "not-so-green" technologies.

It is understandable that economic growth leads to rise in income but this has led to even faster rise in property prices leaving it unaffordable for majority of population. Affordable housing is expected to have a positive impact by improving basic quality of life. While the concept of affordable housing seems to be a simple solution to current housing woes, its execution remains complicated due to the unclear policy framework. To make affordable housing work in India, it would require "will" from all the stakeholders by slightly adjusting their interests towards a wider social cause. The first step towards making low cost housing should be making available low cost sustainable building materials for common people.

"The future looks green for low cost sustainable building materials as they contribute towards a more sustainable future on our resource limited mother earth"

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