Environment Friendly Building Materials for
Low Cost Construction Techniques

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***Abstract* —** This paper aims to present work on low cost sustainable alternative building materials with their impact on construction industry in India. Sustainable building materials are environmental friendly and economical in use. This paper addresses the challenges, scope and limitations of using the construction materials in low cost building industry. The broad spectrum of factors - physical, social, psychological, ecological & economic plays a vital role on human psychology and living conditions. Sustainable building techniques and materials are the future of construction industry.

Global warming has affected the earth in various ways. Climate change has dramatically changed and impacted the construction scenario over decades. Extraction of natural resources as building materials itself consumes energy which cause environmental degradation and contribute to global warming.

India has witnessed rapid urbanisation. Urbanisation has brought tremendous growth and development to the construction industry. Construction cost in India is increasing at around 50per cent over the average inflation levels. It has registered increase of up to 15 per cent every year, primarily due to cost of basic building materials such as steel, cement, bricks, timber and other inputs as well as cost of labour. As a result, the cost of construction using conventional building materials and construction is becoming beyond the affordable limits particularly for low-income groups of population as well as a large cross section of the middle - income groups.

Therefore, there is a need to adopt cost-effective construction methods either by up-gradation of traditional technologies using local resources or applying modern construction materials and techniques with efficient inputs leading to economic solutions. This has become the most relevant aspect in the context of the large volume of housing to be constructed in both rural and urban areas and the consideration of limitations in the availability of resources such as building materials and finance. Buildings are the largest energy consumers and greenhouse gases emitters, both in the developed and developing countries. This paper describes how the architects can decrease the amount of carbon footprint emitted from the building materials.

Keywords—low cost; sustainability; global warming; climate change, environmental degradation, green house.

I INTRODUCTION

The earth's climate has been constantly changing. India is a land of diverse climate, culture and heritage. India has witnessed adverse climate changes in the span of a decade. Urbanization has impacted the city growth in huge extent.

Buildings are constructed to shelter people from the worst effects of weather and climate, mainly uncomfortably hot or cold temperatures, wind and precipitation. As the climate changes there is a danger that current building designs will not be suitable for the new climate and the same is implied on building materials as well. However, it is likely that the effects would have to be rapid and therefore require severe substantial modification to the built structures.

Most experts agree that over the next few decades, the world will undergo potentially dangerous changes in climate. The impact of climate change and the consequences of it we have already witnessed (Chennai flood, Uttarakhand flood, cyclones, earthquakes, famines, etc.) This will have a significant impact on almost every aspect of our environment, economies and societies, which will even affect the built environment. It is widely known that buildings construction contribute to Climate change. But the main issue is that, how are we going to deal with the direct and indirect impacts of changes in climate on building and construction technology.

Today, it is widely accepted that human activities have contributed in a massive way to climate change. The buildings contribute as much as one third of total global greenhouse gas emissions, primarily through the use of fossil fuels.

II IMPACTS OF BUILDING CONSTRUCTION MATERIALS ON CLIMATE CHANGE

Cement is an important construction material. Cement itself produces 5% of global manmade CO2 emissions. The chemical processes and use of fuel/electricity are accountable for the major portion of the CO2 emissions. The highest impact of climate change is also on the mining industry. On-site construction of buildings has relatively low-impact on the CO2 emissions, mainly energy use; influenced by choice of building materials, construction techniques, and distances of transportation of building materials to the site plays a deciding vital role.

III MAIN COMPONENTS IN BUILDING CONSTRUCTION

1. **Building Material**: Building Material is the most important component of any building project. Climate change will effect the availability of building materials at local level and even in the construction techniques, directly and indirectly. For example, the cost of sand and bricks, which has risen threefold in past 10 years, will continue to rise as the government has started putting regulations on stone and sand mining. The cement, also the culprit here, and highly energy intensive material, will cost more as the green building councils and regulatory bodies all over the world are looking for a energy efficient alternate for cement.

2**. Machinery:** With the local labour getting costlier every year, people are opting for more use of mechanical and prefabricated construction technology, neglecting the vernacular construction techniques, which were labour intensive, and at the same time, efficient in cost and energy. The risen value of real estate, people want to finish the construction process as early as possible, which urges them to use prefabricated and mechanical technologies.

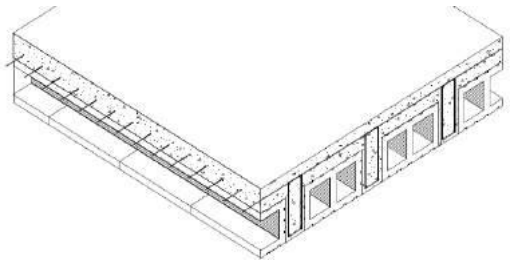
3. Manpower: Labour have been very cheap in India, as compared to western world. This is one of the major reasons of various infrastructure companies investing in India.
Firstly, high birth rate, post- independence, especially in the rural areas where most of people are poor. In short, economies of scale, in population. The utilization of skilled manpower very much required in the low cost construction.

IV ADOPTION OF SUSTAINABLE TECHNOLOGIES

Number of innovations has been made in the field of low cost construction technology, it is now possible to achieve an overall saving to the extent of 10% to 30% in the total cost of construction compared to the cost of traditional construction techniques. Various technologies adopted are mentioned below: materials like cement and steel adopting sophisticated technologies with increasing demand in the construction industry, the value addition to these material has became faster and the technology with shorter obsolescence period seemed to be more dynamic.

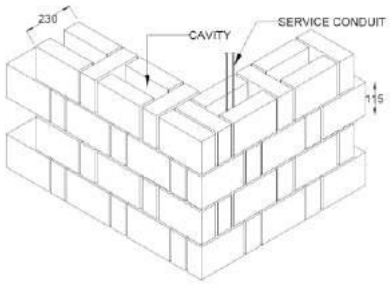
Filler slabs
Filler slabs are normal RCC slabs in which bottom half (tension) concrete portions are replaced by filler materials such as bricks, tiles, cellular concrete blocks, etc. Filler Materials are so placed as not to compromise structural strength; they replace unwanted and non-functional tension concrete, thus resulting in economy. These are safe, sound
And provide aesthetically pleasing pattern for ceilings. An additional advantage of filler Slabs is that they do not need plastering.

Low-cost and light weight filler materials, which will reduce the dead weight as well as the cost of the slab to 25% (as 40% less steel is used and 30% less concrete). Makes saving on cost of this slab compared to the traditional slab by about 23%.



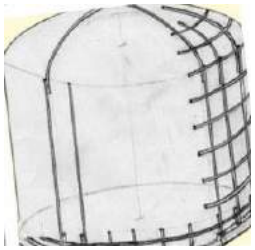
Filler slab using Hollow concrete block

Rat-trap bond
This an economical and innovative bonding systems in brick masonry to build walls. The bricks are placed on their edges in 1:6 cement mortars and after the first layer of bricks has been laid, a gap is left between the bricks in the remaining courses. This means that compared to a 230 mm thick solid brick wall, the amount of bricks required to build the wall is reduced by 25 per cent hence reduction in the 10to 15% of the masonry cost.



Rat –trap bond masonry

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. It can be used for constructing pre cast toilet units, water tanks, cycle sheds etc. As it is pre casted and then manufactured, it can play a major role during post disaster housing requirements which is economical and easy to build. The various ferrocement components are Ferrocement based sanitation units/cladding, Ferrocement water tanks, Ferro cement roofing elements, ferrocement doors and window frames, ferrocement shutters



Ferrocement water tank (Source: Google images)

Precast building elements

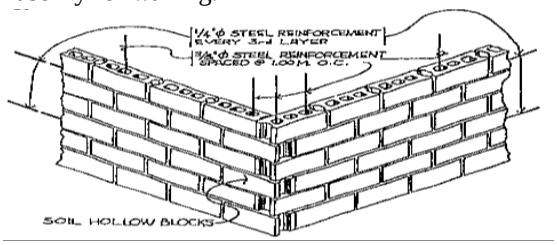
Adoption of precast building elements has many merits in the context of availability of materials, labour and technical skills. In precast construction, as the components are readymade, self supporting, shuttering and scaffolding is eliminated with a saving in shuttering cost. In traditional construction, the repetitive use of shuttering is limited, as it gets damaged due to frequent cutting, nailing etc. On the other hand, the mould for the precast components can be used for large number of repetitions thereby reducing, the cost of the mould per unit. There is saving of time as the elements can be casted before hand during the course of foundations being laid and even after laying slab, the finishes and services can be done below the slab immediately. While in the conventional in-situ RCC slabs, due to props and shuttering, the work cannot be done, till they are removed. Saving of time means saving of money. In precast construction, there is better quality control, shape and size of precast elements. Therefore, in structural design, full advantage of properties of cement and steel can be exploited. There is disciplined use of scarce materials like cement, steel and timber. In precast construction, similar type of components is produced repeatedly, resulting in increased productivity and economy in cost too.

The construction is not affected due to weather, rain, wind etc. Pre cast construction, the work at site is reduced to minimum and therefore, work is qualitatively better, more reliable and clean. The precast building. The various building elements are Thin precast lintels, Thin ferrocement precast shelves, Precast well rings for water wells, Precast sanitation unit rings, Precast septic tanks, Ferrocement bio-gas units, Precast tree guard, Precast poles for street lighting, Precast posts for boundary walls, Precast cellular concrete roofing unit, RCC channel units, Precast joist for hollow block construction, Precast RCC solid planks/joists, Precast/factory-made walling units using light weight cellular concrete, recast plate floors, precast door and window frames

V MATERIALS FOR LOW COST CONSTRUCTION

The usage of vernacular materials is most effective for these areas, both from the climatic as well as the recycling point of view.

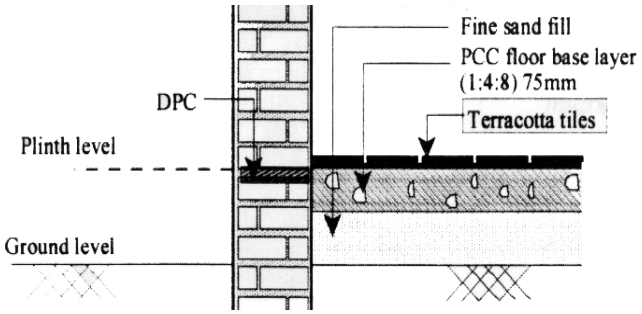
Hollow concrete block saves 20% of total cost of construction against conventional solid masonry. Hence 37% of users adodt to this material in the construction technique. Private builders are taking recourse to use hollow concrete block masonry for walling.



Hollow concrete block masonry (Source: Google images)

Many of the building centres countrywide are also able to contribute to the increased use of hollow concrete blocks as building material

Terracotta represents one of the most ancient technologies developed by humankind. Dust pressed Terracotta tiles in combination with oxide floors keep the floors at the same temperature as room temperature. Terracotta floor tiles are locally available & are extremely cost effective. Terracotta tiles are easy to maintain. The cost of terracotta floor tiles are very less compare to other flooring tiles.



Terracotta flooring (Source: Google images)

Stone and brick walls have been used for beautiful buildings worldwide. Earth buildings last well when maintained, and are less subject to overheating and dampness than stone or concrete. Earth walls don't get hot or cool very quickly because earth insulates better than concrete.

Raw earth buildings need to be protected from rain and flooding to work well in humid climates. Solid earth walls will receive less condensation than concrete because they are less dense, and because they absorb more humidity. The raw earth buildings are healthier than concrete in high humidity. Materials are comfortable in hot, damp weather if they don't hold much heat or if they are very well insulated.

Light earth, like cob and mud block, modifies humidity. It can be formed into blocks, used in rammed earth walls, or in what has been called the cheapest building method on earth, in earth bags, a construction technique like sandbags.

Light earth contains lightweight gravels like pumice or scoria. These broken volcanic rocks are available at reasonable costs in many areas with active or dead volcanoes.

Low-fired bricks absorb more water than common fired brick. They can be used for inside walls, or outside with special finish coats. Brick can be formed into beautiful openwork “jali”, as Sri Laurie Baker created in India.. Small scale jali keep driving rain out, but may cost only 10% as much as a window.

Solid walls earth, stone, brick are good materials in hot-arid zones, combined with few openings and light colored outer surface. Takes best advantages of time lag, with heat emission at night. In warm-humid zones only useful for daytime rooms.

Burnt clay bricks are good thermal resistance, depending on the porosity. Medium to high heat storage capacity, good humidity regulating property.

Unburnt clay bricks have better thermal resistance and humidity regulating property than burnt bricks.

Timber is good thermal resistance, high heat storage capacity, and good regulation of humidity. The main advantage of using wood for construction in warm humid area is that it is hard, resistant to moisture and has poor thermal conductivity. In a two-storied house, the first floor is raised from the ground by brick masonry. The first floor is completely constructed of wood.

Fly ash bricks

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 can be substituted for many constituents in building materials making it the ideal choice for alternate building material.

Fly ash bricks (Source: Google images)

Fly Ash Brick is a construction material, masonry unit comprising of Class C Fly Ash and water. Due to the high concentration of calcium oxide in Class C Fly Ash, the brick can be described as self-cementing These properties make fly ash bricks energy efficient, mercury pollution resistant, lower water penetration, light weight, thermal insulation and cost effective. It costs 20% less than traditional clay brick manufacturing.

CONCLUSION

The report provides information on the low cost materials and efficient construction techniques which can comfortably be used in the present scenario.

It also speaks about cement replacement and their cost reduction with its utilization materials and techniques

The selection of proper low cost housing material will be eco friendly and also enhances the sustainable design principle. As building materials cost 65-75% of the total cost of construction. Hence there is strong need of cost effective materials which reduce the cost up to 30%.

In developing countries, the challenge is to organize and initiate measures that promote these materials as well as train local artisans and masons in the construction techniques adopting these materials. These attempts are done in the housing sector still it failed in the other types of construction because of lack in scientific precision. A positive approach and initiatives taken by government agencies, leading engineers and technologists, end users and entrepreneurs can bring sustainable development process in the construction industry. There is a strong need to put in organized efforts in the direction of developing newer eco-friendly materials in cost effective construction.

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