Environment Friendly, Fire-proof and Durable alternative to Conventional Timber Housing

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Timber has been the backbone of traditional housing construction for centuries. Even today, it is the most extensively adopted choice for the Structural framing, suspended floors and even external cladding in superstructure work all over North America. Primacy of dependence on timber can be attributed to ready availability, lighter weight, ease of working and availability of adept craftsmen, who execute timber-based projects pretty fast. However timber structures have major deficiencies. This paper attempts to highlight these and suggest suitable alternative.

1.0. CAUSES OF CONCERN IN TIMBER HOUSING

The major causes of concern for using timber in constructing homes include: -

- **Low fire resistance:** The inflammability of timber warrants extra care in laying & maintaining electrical/gas lines, extra caution by residents against smoke/heat creating actions or gadgets. Timber structures reduce to ash in no time in an internal flame or an external fire hazard. For instance the Colorado fire of June '02 not only destroyed over hundred thousand acres of precious forest, but also hundreds of homes. Can the damage be reduced in future?

- **Proneness to Decay and Insect Attack.** Termites are known to cause more than $2 Billion in damage in the USA each year. That's more than the combined damage caused by all fires, storms and earthquakes. Termite damage is more extensive in south, but even other states excepting Alaska are not free from threat of termites. These are so deadly that no attempts at termite-proofing timber constructions have succeeded so far. Timber structures therefore need special pre-construction treatment and regular maintenance to constantly protect these against termite damage and ensure a reasonable durability.

- **Depletion of Forest Cover**: The environmentalists, the world over, are pleading against depletion of forest cover, especially in the over populated developing world. Timber as a housing shell is almost unthinkable in that environment, because of prohibitive material cost. In many such countries like India, use of forest timber even for the construction of doors/windows has been banned. Such concern to preserve forests is bound to gain momentum even here in North America.

- **Dependence on Harmful Insulation Materials:** Thermal comfort of the timber houses in hot and cold climates is commonly being ensured by complementing timber shells with other high insulation in-fill or cladding materials like Expanded Polystyrene, Rockwool, Mineral wool, Man Made

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Fibers like Polypropylene etc. All these insulation materials emit toxic fumes and harmful gases under accidental fire conditions, thereby reducing the chance of safe escape or recovery of any trapped inmates.

2.0. CELLULAR LIGHTWEIGHT CONCRETE (CLC) ALTERNATIVE

It is in the context of the above, that the writer has been attempting to promote use of alternative construction technologies based on the use of "Cellular Lightweight Concrete"- (CLC) produced under ambient conditions. This version of concrete is lighter in weight, because the stone aggregate is substituted with minute and stable air bubbles provided by a non-chemical foaming agent. Some of the salient features of this material are: -

- **Easy to Produce:** It can easily be produced anywhere like ordinary concrete by any building contractor, concrete or prefab plant without a major investment or change of procedures. Gravity Mixers like the normal Truck Mixers are ideally suited for mixing, conveying and delivering CLC and are being extensively deployed for the purpose the world over.
- **Different from AAC**: It is very different from another version of lightweight concrete known as Autoclaved Aerated Concrete (AAC). This type of lightweight concrete is produced as a result release of gases through a chemical action in the mixture under controlled conditions and can be produced in the form of pre-cast elements only. It warrants establishing high investment stationary plant, equipped with high-pressure steam curing autoclaves.
- **Wider Density Range:** It is feasible to produce CLC in a wide range of controlled densities varying from 400 kg/m^3 to 1,800 kg/m^3. *(The normal range for AAC is 400-1000 kg/m^3)*
- **Low to High Strength:** The 28-day cube crushing strength of the material increases with density. It varies from 0.5 N/mm^2 for a density of 400 kg/m^3 to over 25 N/mm^2 for a density of 1,800 kg/m^3. Higher densities are good enough for structural applications, while also offering better thermal insulation.
- **Lower Water absorption:** In view of the intrinsic minute air bubbles in CLC being segregated from one another, the water absorption of this material is relatively lower. It is 8.5% for a density of 800 kg/m^3 and 3.75% only for the density of 1,400 kg/m^3. This compares much better than ordinary brick, which has water absorption of around 13.5% and AAC blocks, where it may be as high as over 50% by weight.
- **Superior Thermal Efficiency:** The cellular structure of the material ensures far superior thermal insulation efficacy as compared to alternative building materials like dense concrete, bricks etc. While the dense concrete has a thermal conductivity value, expressed in Kcal/m^2h^{o}C, of 1.3, the corresponding values for CLC density 1, 800 kg/m^3 is 0.52, CLC density 1200 kg/m3 is 0.37 and that of CLC density 400 kg/m^3 is 0.08 only.
- **Makes Productive Use of Industrial Waste**: The primary raw materials needed for its manufacture are Cement, Sand, Water & Pre-formed Stable Foam. The author has succeeded *(since 1995)* in improving the intrinsic environment friendliness of this material by deploying FLY ASH - a nuisance

industrial waste product from thermal power plants- as another constituent material to an extent of 26% to 33% for different density mixes. Introduction of fly ash results in over 25% to 40% reduction in the consumption of Cement, thereby making CLC even more cost competitive.

- **Feasible to Produce in Density Range of Glass wool:** In a plant-produced version, this CLC is also being manufactured in Germany *(using Cement, Sand, Water & same preformed stable foam)* in a density of less than 100kg/m^3. This low-density mineral product has thermal insulation properties comparable to that of Polystyrene/Poly-urethane or Mineral wool, but without their demerits. It is a non-flammable, non-toxic, not damaged by water and totally environment friendly alternative.
- **Can be Pre-cast or Poured In-situ like Ordinary Concrete:** The freshly mixed CLC slurry can either be: -

  -Poured in-situ into depressions or onto a flat surface or into assembled formwork of reinforced structural walls, suspended slabs or even a complete house. or

  -Cast into pre-cast blocks for walling masonry or pre-cast reinforced structural cladding, partitioning, flooring or roofing elements.

3.0. MERITS IN OPTING FOR CLC BASED CONSTRCTIONS

There are quite a few merits in choosing to use CLC instead of conventional building materials:

(i) **Fire Resistant**: CLC is non-flammable. A 100mm (4") thickness of CLC density 1200 kg/m^3provides over 4 hours of fire endurance.

(ii) **Proven Durability:** Being normally cured cement based product, it continues to gain strength with time so long as some moisture is available in the environment. Structures built over three (3) decades ago are still sturdy requiring little maintenance. This is unlike timber constructions, which deteriorate with time.

(iii) **Insect Resistant:** CLC, unlike timber is impervious to attack by any kind of white ants, termites or pests.

(iv) **Thermal Superiority.** It has much superior thermal insulation characteristics than dense concrete, concrete block, as indicated above.

(v) **Weather Resistant:** CLC structures have proven to withstand all types of severe weather conditions in dry hot desert, rainy and windy coastal or cold hilly areas in over 45 countries in the world.

(vi) **Environment Friendly:** This material does not produce any pollutants or toxic substances either during its manufacture or it's use in the structure.

(vii) **Acoustically Efficient:** CLC reduces transmission of sound. CLC finds extensive application for filling over structural slabs and below floor finish.

(viii) **Easy to work on:** CLC can be worked on like timber. Nails can easily be driven into it and would stay in position. Un-reinforced blocks can easily be cut with a wood saw or chases for service lines easily and quickly cut with the help of a mechanized chase cutter.

(ix) **Versatility:** It is a versatile material, which has been used in constructions in a diverse range of applications:

- The lower density range of 100 kg/m^3 to 600 kg/m^3 has most effectively been used for providing thermal insulation over roofs or external walls.
- Medium density range from 800 - 1,000 kg/m^3 is ideal for use in the form of pre-cast blocks for non load-bearing walling masonry work in high-rise buildings or as an infill in plastic partition panels.
- The higher density range from 1200 kg/m3- 1,800 kg/m^3 is termed as structural grade material and utilized for: -
  (a) Production of pre-cast reinforced structural elements for cladding, partitioning or suspended slabs.
  (b) In-situ casting of entire houses in one go or load-bearing walls in one operation and suspended floors in another operation. CLC in such a case can easily be designed to serve the dual purpose of carrying load as also providing adequate thermal insulation as per local bylaws, thereby dispensing with the necessity to use potentially harmful synthetic fibers like EPS, Glass wool etc. for insulation.
  (c) Pre-cast blocks of such higher density material can be used for construction of load-bearing walls for low-rise buildings.

4.0. WIDELY ACCEPTED & PROVEN ALTERNATIVE

In view of various merits enumerated above and the ease of construction, the material has since been used in the construction of over 100,000 dwelling units and other types of structures in around 45 countries of the World. The fact that it has proven in the diverse range of climates is evident from the list of countries, which include Egypt, South Africa, Nigeria, Tunisia, Botswana, Libya, Saudi Arabia, Iraq, Brazil, Mexico, India, Nepal, Malaysia, Singapore, Thailand, Indonesia, Vietnam & various European countries.

5.0. A FEW APPLICATIONS:

The author, as President &Chief Executive of one of the largest Real Estate companies in Asia, has personally been responsible between 1995-1998, for using the fly ash version of this **Neopor©** based CLC in the capital region of New Delhi (India) for the construction of over 4.0 million sft. of group housing rising up-to 27-floors above ground. Illustration –**"A"** shows typical residential towers of that project, where CLC blocks of density 1000 kg/m^3 were used for non-load-bearing wall masonry of all internal and external walls. These pre-cast blocks were produced at respective project site in size of 500mmx250mmx200mm for external and party walls and 500mmx250mmx100mm for the internal partition walls. Illustration **"B"** shows a group of 156 units of Economically Weaker Section dwellings in two four-story high blocks constructed with Cast in-situ Load-bearing Reinforced Cellular Lightweight Concrete walls of 150 mm thickness and poured in-situ RCC slabs. The walls were cast storey high in CLC density 1600kg/m^3 for the ground floor, while reducing the density to 1200 kg/m^3 for the top floor.

Illustration – "A"

Hamilton Court & Regency Park using CLC block walls in DLF city near New Delhi (India)

Illustration – "B"

156 units of EWS dwellings with Cast in-situ Load-bearing Reinforced CLC walls of density 1200kg/m^3-1,600 kg/m^3 in DLF city near Delhi (India)

Illustration-**"C"** shows a neighborhood of 80-Townhouses *(Basement plus two upper floors)* in BASEL (Switzerland) constructed using 3,600mm wide storey high Pre-cast Reinforced Cellular Lightweight Concrete wall panels, starting from basement and 1,800mm wide 6,000mm long suspended floor elements. The shutter finished walls were directly applied finishing paint at site.

Illustration – "C"

A neighborhood of 80 townhouses at Basel (Switzerland) constructed in CLC density 1400 kg/m^3

6.0. CLOSING REMARKS

The author has been engaged since 1998 in sharing his gainful experience with the use of fly ash based CLC with other builders in the Indian subcontinent. It is matter of satisfaction that by now over a dozen agencies, including the largest contracting company in India, have since started exploiting this technology to their own advantage and for the benefit their clients. It is expected that considering major advantages of easy implementation, freedom from termites, fireproof-ness, durability, superior thermal efficacy, environment friendliness and above all economy, even the builders in North America would also like to explore such alternatives for the benefit of their potential housing clients. It is amply evident from the above, that CLC technology apart from taking care of negative attributes of timber constructions offers additional merits.

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