

Site Produced Cellular Lightweight Concrete

– A boon for Housing

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Housing is one of the primary human needs. All of us in the Asia- Pacific, Middle East and the African region face massive shortage of shelter for our people. We, despite limitation of appropriate resources, are trying our best to meet this challenge by using ingenious methods/ techniques. The paper discusses one such approach, which is being adopted by increasing number of institutions/ organizations in the Indian sub-continent for their housing projects.

1.0. Criteria, which an appropriate Housing Technology should satisfy in our environment?

- 1.1. Technology to be simple and easy to execute.
- 1.2. Should not warrant heavy Capital Investment.
- 1.3. Require minimum skilled workforce and primarily deploying unskilled labour.
- 1.4. Should be environment friendly - neither wasting natural resources nor creating pollution.
- 1.5. Economise on Energy Consumption.
- 1.6. Should result in faster execution.
- 1.7. Finished dwellings to be weather-proof, thermally comfortable and durable.
- 1.8. Provide solutions for Hurricane/ Earthquake –proof constructions.
- 1.9. Should try and make productive use of industrial waste products.
- 1.10. Be cost effective in comparison with conventional alternative

2.0. Site Produced Cellular Lightweight Concrete (CLC) & It's versatility

2.1. What is this Cellular Lightweight Concrete?

Cellular Lightweight Concrete is produced like normal concrete under ambient conditions, unlike the plant-produced version, which needs to be autoclaved in high-pressure steam chambers. It is a type of concrete, where the coarse aggregate is substituted with pre-formed stable foam. The same infrastructure, plant and equipment, as available at ordinary construction sites, supplemented with a small Foam Generator, is suitable for producing CLC.

The wet mix slurry is either poured or pumped into assembled moulds of blocks or formwork of reinforced structural elements or poured onto flat roofs for thermal insulation or for filling of voids. The foam imparts free flowing characteristics to this slurry due to ball bearing effect of foam bubbles, enabling it to easily flow into all corners. It levels and compacts in the moulds/forms by itself, without requiring any kind of external vibration or compaction.

The foam produced using Foam Generator is stable for a time duration far beyond the final setting time of Cement, thereby creating permanent voids in the finally hardened mass thus imparting lightness. The entrapped air bubbles are very fine in size and segregated from each other, because of which the water absorption of the material is even lower than clay bricks. This CLC can be produced in a wide range of controlled densities varying from as low as 400 kg/m³ to 1,800 kg/m³ and may either be poured in-situ or be made into pre-cast elements.

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2.2. *International Version of CLC and the Indian Contribution*

This CLC technology originated from Germany over three decades ago. As mentioned above, the primary constituents of this CLC are: Cement, Sand, Water and Preformed Stable Foam. This version is currently being exploited in over 50 countries of the World. More than 2,00,000 dwelling units and other structures have already been constructed with this in diverse climatic conditions.

The author has been responsible for bringing this technology into India in 1995. He is also glad to share that, as a result of a great deal of investigative work done, we have been able to incorporate Fly Ash as a new additional constituent in its manufacture. Fly ash constitutes more than 25% (*ranging between 26% to 33%*) of the solid material constituents of CLC mixes for different density outputs. We have thus not only found a productive use of a waste industrial product, but incorporation of fly ash also saves nearly 40% on cement content, otherwise needed for the corresponding Cement + Sand only mixes, thereby also leading to substantial reduction in the cost of manufacture.

3.0. *Diverse Range of Applications*

The material in different density ranges is suitable for specific types of application in civil construction projects.

3.1. *Higher Density Range*

The density range from $1,200 \text{ kg/m}^3$ (*Having 28-day cube crushing strength of 65 kg/cm²*) to 1800 kg/m^3 (*Crushing strength 250 kg/cm²*) is reckoned as structural grade material. It is utilized for the construction load carrying structural elements like walls, slabs, pre-cast blocks or of any other types of Reinforced Pre-cast elements like cladding units etc.

3.1.1. *SINGLE STOREY POURED IN-SITU HUTMENTS*

An example of a **single storey construction** for Economically Weaker Section Housing constructed at a fast pace with hardly any skilled input, has been shown in the Illustration –“A”. This depicts a completed house with the formwork for the second having been assembled next to it.



The walls of such constructions are poured in-situ in CLC density $1,400 \text{ kg/m}^3$ using storey high formwork. The walls may be nominally reinforced, though in this case of construction in Indonesia, the 65mm thick walls have polypropylene fibre reinforcement only. The door/window frames, service lines and boxes etc. for electrification, water supply or communication are pre-placed in position before assembly of forms and pouring of concrete in the forms. The shutter finished wall surfaces are smooth enough to receive finishing paint directly, dispensing with the necessity of plaster and good enough to withstand weathering.

Although the roofing has been shown to be of sheeting in this case, it is feasible to cast the roof in reinforced CLC in a second stage operation using large area slab forms. Such lightweight and rigid constructions, made out of this highly insulating material (*nearly 4-times more efficient than dense concrete*) are ideally suitable for cyclone or eath-quake prone hot, arid or even cold regions in the countries of this region.

This technology is ideally suited for industrialized application for major housing projects that need to be completed fast. The room sized storey high wall panels & large Area slab forms can be handled, assembled and de-shuttered with help of tower/mobile cranes. The concrete is mixed in centrally located Batching Mixing plant, supplied to site in transit mixers and placed in position either with the help of concrete pumps or buckets handled by cranes.

3.1.2. ASSEMBLY OF PRECAST WALLING PANELS

Another system of applying this technology is initially pre-casting standardized – say 900/1000 mm wide 150/200 mm thick fibre reinforced or un-reinforced storey high hollow core panels in density $1,200/ 1,400 \text{ kg/m}^3$, then assembling and grouting the same to form walls on readymade floor pads for the houses. The roofing generally is of sheeting. This system is popular in Malaysia and Taiwan.

3.1.3 4-STOREY HIGH Poured IN-SITU GROUP HOUSING

An example of 156 EWS Group Housing units has been shown in Illustration “B”. These units were constructed using this technology in twin blocks of four storey high apartments in DLF City, south of Delhi in 1997. The nominally reinforced Cellular Lightweight Concrete cross walls of the dwellings have a uniform thickness of 150mm throughout. The density of material reduces from 1600 kg/m^3 in ground floor walls to 1200 kg/m^3 in the top floor walls. The minor partition and cladding walls were masoned using site produced pre-cast CLC blocks of size $500 \times 250 \times 100 \text{ mm}$ in density 1000 kg/m^3 .



The strip footings and the plinth walls were made in cast in-situ reinforced concrete. All the cross walls in the superstructure serve the purpose of carrying load as also serve to divide spaces. These were made of structural grade Cellular Lightweight Concrete, which was either pumped or poured in-situ in storey high, assembly of plywood faced formwork. The suspended floors were cast in normal reinforced concrete using large area ply faced slab forms. The shutter finished walls were paint finished directly without need of plaster.

3.1.4. USE OF CLC BLOCKWORK FOR LOADBEARING MASONRY

This is another option of using CLC blocks of this density range for load-bearing walls for walk-up apartments up-to 15m high constructions. Illustration “C” shows a project where CLC blocks of density 1,400 kg/cum have been used in a housing project at Haldia (W. Bengal).



3.2. Medium Density Range

CLC in dry density range of 800-1000 kg/m³ is utilized for making pre-cast blocks for non-load-bearing walling masonry for internal and/or external walls in framed structures. The size of blocks for the party/external walls may be 500x250x200 mm and the internal partition blocks may be 500x250x100 mm nominal size, although any desired size as per requirements, may be produced.

Substitution of brick walls with such CLC masonry cuts down dead weight of walls by over 50%, thereby resulting in substantial saving in the design of structural elements and foundations. These savings become more pronounced with rising height of dwelling blocks and when earthquake forces are the governing design criteria. Illustration – “D” shows use of such blocks in one amongst many such group housing towers rising up-to 27- floors above ground, in large-scale constructions south of Delhi. Moreover replacement of 230mm/115mm brickwork with 200mm/ 100 mm block-work improved carpet/plinth area efficiency by nearly 7%. Working with these large sized lighter blocks is much faster, substantially saving on mortar consumption for masonry and plastering. These blocks can also be cut and nailed like wood. Chase cutting for service lines is fast and easy. They also make it feasible to do dry fixing of door/window frames, thereby saving substantially on input of skilled labour and time spent in fixing and grouting holdfasts.



The use of CLC block work instead of brickwork in these buildings not only saved wastage of agricultural land for brick making, saving on energy expended in baking & transporting bricks, enabled use of industrial waste material like fly ash, but also resulted in 10% to 15% saving in the cost of structures.

3.3. Lower Density Range

The lower densities of 400 to 600 kg/m³ are ideal for thermal insulation applications. CLC's fire proof-ness, termite-resistance, very low water absorption make it a far superior alternative to the commonly used synthetic products like Thermocole, glasswool, woodwool etc. or age old practices of using mud-phaska or Lime terracing.

The synthetic insulation materials, though lighter in weight and somewhat thermally superior, are far more expensive and lose their efficacy with slight ingress of moisture. These materials are also not environment friendly. Mud-phaska & Lime terracing are nearly four times heavier than CLC and around nine (9) fold thermally less effective than CLC. Moreover cellular lightweight concrete once placed would bond very well with concrete roof slab and last for the life of the structure. The mud-phaska and lime terracing treatments need repair/ replacement every few years. One of the institutional projects in Hyderabad city using such thermal insulation is shown in Illustration –“E”.

This range is also used in laying sound insulating layer over structural slabs of intermediate floors in high-class hotels and institution buildings to minimise transmission of noise between lower and upper floors. It can also be used as a filling in depressions in bathrooms or other floors due to up-stand beams etc.



4.0. Relevance for wider application

- All of us in the Asia-Pacific, Middle East & African region are facing a common problem of growing population. We therefore have to maximise our agricultural production to meet the increasing needs of food. We can therefore ill afford to waste any part of our fertile soil for making clay bricks? Any alternative to brick, especially if it offers additional merits, is certainly worth considering. Dense concrete blocks are another alternative choice, but they are relatively heavier, thermally inferior and not as easy to work with, as CLC blocks.
- CLC produced at project site saves energy expended in baking bricks, as also energy spent in transporting bricks/ dense concrete blocks to site of work. CLC blocks being lighter than bricks or Dense Concrete blocks save on labour deployed for on-site handling, masonry, cutting and filling chases etc.
- CLC is a far more versatile material than bricks or dense concrete blocks for its application even as a cheaper substitute for dense concrete as reinforced structural elements and as a thermal insulating product.
- It is not only that the production process of CLC is totally free of any environmental pollution, but it offers additional possibility of further reduction in environmental pollution by enabling Fly Ash – an industrial waste - to be used as one of the main constituent materials.
- Production process of CLC is even simpler than producing ordinary dense concrete for it also saves on labour and energy needed for vibration and compaction of dense concrete. Dense concrete elements could have honeycombs or voids on surface, but such internal/surface blemishes are ruled out in CLC units
- The capital investment in production of CLC is far far less (*in fact less than 0.05%*) than the investment needed for producing Aerated Autoclaved Concrete. Only one low investment Foam Generator needs to be added to Concrete making establishment.

- It has already been explained above that working with CLC is simpler, faster than brickwork (*and also dense concrete blocks*) and deployment of skilled manpower is also minimal in production, masoning, concreting or finishing.
- CLC being the typical concrete, it keeps gaining strength with time, so long as some moisture is available in the surroundings. It is therefore as weatherproof, termite resistant, fireproof and durable as any other concrete.

It would, therefore, be evident from the above, that the production and use of CLC satisfies all the desirable parameters listed in Para 1.0 above. The range of diverse applications to satisfy different structural/ non-structural functions in construction is another unique feature of this product. It is in view of such considerations, that the Indian national institutions like BMTPC, HUDCO, NTPC, Fly Ash Mission are promoting this material as one of the desirable alternatives for construction projects. This technology therefore, merits a very serious consideration for wide scale application, especially in housing projects, in all countries of the region for overall benefit of our society.

