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Is dilution of Standards in housing using conventional materials as against using alternative materials like bamboo a solution to increasing affordability among the urban poor?

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Abstract--"Anything less than a 'pucca' (Permanent) house, is not a house at all", is the myth which is rampant among the urban poor, even while they continue to live in a "kuccha"(Temporary) house for decades.The myth is such because even the providers of housing believe in it. A "kuccha" " (Temporary) house is rendered valueless, hence remains temporary, subserviced and figures as an inhabitable house in the national surveys. So much so that it is a house that attracts political and national attention in the form of an "unauthorised construction" because it sits on a piece of land which was meant for some other purpose. A "Pucca" (Permanent) house uses conventional materials, which have a history of becoming costlier over time; a "kuccha" house is valueless. Under the circumstances the urban poor are left at the mercy of local bodies for their survival, on urban land.
Index terms- affordable housing, alternative materials, bamboo, low cost, mass housing, standards, urban poor,

1. Introduction

THE paper goes on to establish the importance of using alternative materials like bamboo to make houses affordable rather than to dilute standards to accommodate conventional materials for mass housing for the urban poor. The material has the potential to offer durability safety and habitability that matches that of a pucca house, thus transforming a value less house into one which can be termed as valuable and therefore equivalent to a pucca house.

2. The Census Definition of a Pucca House

2.1 Pucca House:

A pucca house is one, which has walls and roof made of the following material.

Wall material: Burnt bricks, stones (packed with lime or cement), cement concrete, timber, ekra etc

Roof Material: Tiles, GCI (Galvanised Corrugated Iron) sheets, asbestos cement sheet, RBC,(Reinforced Brick Concrete), RCC (Reinforced Cement Concrete) and timber etc.

Kutcha House: The walls and/or roof of which are made of material other than those mentioned above, such as unburnt bricks, bamboos, mud, grass, reeds, thatch, loosely packed stones, etc. are treated as kutcha house.

Semi -Pucca house: A house that has fixed walls made up of pucca material but roof is made up of the material other than those used for pucca house.

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3. An Alternative Like Bamboo Can Be Upgraded to a Material Meant for a Pucca House

3.1 Bamboo as an Alternative material

Land is a scarce resource, and its intensity of use has to increase. All housing solutions have to be geared to ensure efficient use of land. The low rise concept is now out dated. This appears to be the main limitation of bamboo, as high rise is not possible with it. Hence it will not be accepted readily in the urban context.

There is also a great deal of resistance in the society for the use of bamboo, which has to do a lot with the Perception of a bamboo house. It is regarded as a poor man's house in India.

The Government's policy of looking at the potential users, that is the urban poor, is also totally transformed. Currently the Agenda is to have Slum free Cities. So how does this material fit in?

Bamboo has its own set of serious limitations, and the reduction in construction cost is only notional, since it will mean a disproportionate increase in the land cost due to the low rise nature of bamboo construction.

Also Land cost is to be seen against the potential market cost which further discourages any low rise housing solution.

It is recognised that using whole bamboo for construction has limitations relating to social acceptability and is therefore focussing on bamboo construction in non housing projects like schools and colleges, rain shelters, kiosks, guest houses, rooftop structures.

For housing the interest has shifted to processed bamboo in composite / prefabricated earthquake resistant green construction.

Various models have been developed. Also used in construction of school laboratories and libraries, educational insti-

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tutions campus buildings, canteens, residential schools, health centres, resorts, guard house, toilets etc.

In all the structures Social acceptability has been dealt with specifically to make the structures appear as close as possible to conventional structures.

It has also been observed that most typologies where NMBA (National Mission for Bamboo Applications) has used bamboo (whole or engineered) require low rise structures.

Testing of Bamboo involves installation of very expensive machines. Deflection control universal testing machine costs Rs. 50 lacs to Rs.1.2 crores .

Also testing is very difficult due to a) many varieties of bamboo b) Within the same variety itself again there are many variations. So the thinking is to use less expensive testing methods even if they are not as accurate. (Accuracy vs Affordability)

The most popular varieties of bamboo are Dendro Columus Strictus and Arundanacea which are widely available, nearly 60% of the entire stock of the country.

Funding is now being made available for constructional use, by the Ministry of Rural Development –National Wasteland Development Board, which has been identified as the most efficient way of conserving soil. Potential of Bamboo needs to be harnessed

3.2 Structural Qualities

The bamboo structure can be generally viewed as a Functionally Graded composite material constituted by long and aligned cellulose fibres embedded in a lignin matrix. Analysing the transversal section of a bamboo culm, one can observe that the fibre distribution is variable through its thickness. The non-uniform distribution of fibres prevents the direct application of equations used to model the behaviour of composite materials, as the rule of mixtures equations for strength and modulus of elasticity. In bamboo, the fibre distribution follows an organized pattern with a higher concentration of fibres on the outer surface of the culm. These groups of fibres are responsible for the bamboo strength. The veins are responsible for the transport of sap from the soil to all parts of the plant. The cellulose micro-fibres around the veins keep them straight along the whole culm.

Increasing the application of bamboo as structural elements requires profound scientific knowledge about its behaviour in nature, considering its macro, meso and microstructures From the structural mechanics point of view, bamboo acquired several natural geometries mainly in order to counteract wind load and its own weight, These characteristics turn it into one of the best materials/structures for the requirements of compression-deflection.

A conical form along the culm, an approximately circular transversal section, a hollow form in most species, which reduces its weight, a functionally gradient rigidity of its cross-section to deflection in the radial direction, Through the application of the Digital Image Analysis (IA) appropriate equations were developed to present the fibre distribution across the thickness of the cross-section. These equations allow the designer to calculate the modulus of elasticity of bamboo with some degree of precision. A reliable method for establishing the meso-structure of bamboo is Digital Image Analysis (IA), providing fairly accurate results for structural designing.

4. BAMBOO NEEDS EXTRA TREATMENT FOR COUNTERING ITS LIMITATIONS

4.1 Durability

The density of the fibers in the cross section of a bamboo shell varies along its thickness. The thickness decreases from the base to the top of the bamboo shell. Fibre Distribution is more uniform at the base than at the top or the middle part, since bamboo is subjected to maximum bending stress at the base, owing to the wind and its own weight. A steel reinforced concrete column after 10 service years & the first bamboo reinforced beam tested at PUC-Rio in '79 were compared. The steel reinforced column is part of a tunnel structure of Rio's Metro. The bamboo reinforced beam after testing has been exposed to open air. The bamboo segment of the beam reinforcement, treated against insects, as well as for bonding with concrete, is still in satisfactory condition after 15 years.

The fibers are concentrated in regions closer to the outer skin. A mathematical formula, relating thickness (t), to the position of the inter-node (n), is established for all species. The equation for DG is as follows…..T= -0.0003n3 + 0.025n2 – 0.809n + 16.791 The International norm for the evaluation of the mechanical behavior of bamboo proposed by the International Bamboo Committee of the INBAR is being adopted by ISO and shall be available to the general public shortly.

The durability of bamboo depends on the Preservative treatment methods. Its chemical composition should not have any effect on the bamboo fiber, and once injected it should not get washed away by rain or humidity. The variation of the shell thickness (t), and inter-nodal distance (L), with height of bamboo (inter-node) for the species DG, shows that the internodal length is larger in the middle of the Culm. With the help of this equation the designer can choose the required thickness from the range of bamboo species DG. Drying bamboo is critical for its conservation. Bamboo with less moisture is less prone to mould attacks especially if the moisture content is less than 15%.

4.2 Water absorption

The main shortcomings for bamboo to be used as reinforcement or as a permanent shutter form with concrete are its water absorption capacity. The capacity to absorb water was found to be the least in the case of species like DG and VS. (Dendrocalmus Gigantius and Bambusa Vulgaris Schard). The Dimensional variation of untreated bamboo, due to water absorption can lead to micro and macro cracks in cured concrete as show in the figure. The dimensional variation of the transversal sections of these species reached up to 6% after 7 days of immersion in water

The main factors that affect this bonding are; adhesive properties of the cement matrix, the compression friction forces appearing on the surface of the reinforcement bar due to shrinkage of the concrete and the shear resistance of concrete due to surface form and roughness of the reinforcement bar.

ISSN 2229-5518

A reinforcement bar in concrete is prevented from slipping either by adhesion or a bond between them. The dimensional changes of bamboo due to moisture and temperature influence all the three bond characteristics severely. During the casting and curing of concrete, reinforcing bamboo absorbs water and expands, as shown. The swelling of bamboo pushes the bamboo away. Then at the end of the curing period, the bamboo loses the moisture and shrinks back almost to its original dimensions leaving voids around itself. The differential thermal expansion of bamboo w.r.to concrete may also lead to cracking of concrete

The swelling and shrinkage of bamboo in concrete creates a serious limitation in the use of bamboo as a substitute for steel. To improve the bond between bamboo segments and concrete, an effective water-repellent treatment is necessary.

4.3 Economical Spans for Mass Application

For a modest Dwelling Unit, an economical span of 10-12 feet is considered fairly appropriate and is found to be economical even if steel reinforcement were to be used. Large spans are not possible in bamboo; hence it would prove to be ideal for a small dwelling unit. Though Dendrocalamus Strictus is known to grow up to a height of 40 feet, it is the tapering of the diameter of the bamboo culm, with height, that makes it difficult to get splints of uniform cross-sectional area as reinforcement, for very long lengths.

4.4 Technical Precautions

What are those precautions that are needed to be observed, while converting bamboo into a suitable reinforcement material in concrete for structural elements? The outcome of the detailed technical study by Prof. Falade of Nigeria made bamboo splices ready for reinforcement if the surface was treated to create friction to form a bonding key with concrete, an equivalent of tor steel, as against plain MS bars with hooks used in the early 80s for the same purpose, i.e. - prevent concrete to slip, on shrinking.

When comparing the equivalence of the quantity of reinforcement required for a beam or a column out of bamboo and steel respectively, it is observed that the former requires a larger proportion of cross-sectional area than the latter for a given factor of safety, load, load type, and span / height as the case may be.

At the next level of refinement of structural design, the same study concluded by recommending that the extra cross sectional area required for BRC, be compensated not by larger cross sectional area of individual bamboo splints, but a larger number of splints, each with a smaller cross-sectional area. This harnesses the full potential of the tensile property of bamboo splints. Slimmer the splint, larger is the tensile strength.

The overall cross-sectional dimensions of beam/column/slab using BRC are required to be larger than those in the case of SRC. While a remarkable saving in the quantity of steel used for the structure can be achieved, a resulting increase in the quantity concrete is indicative of some amount of marginalization in the monetary saving. However the environmental benefits cannot be ignored.

Friction issue is resolved by wrapping a layer of bitumen around the splints and tying a thin wire around them to create an undulated rough surface. It serves a dual purpose of preparing for effective strong bonding as well as waterproofing so as to prevent the dampness from the wet concrete mix from penetrating bamboo splits and causing decay.

Most bamboo culms available for building purposes have gone through some treatment. A slight modification to the process could render it appropriate, even if it means a slight increase in the market prices of treated bamboo.

Given its limitations and potentials, how can they be best countered or harnessed, as the case may be? Having achieved this, through technical research, a methodology for a systematic dissemination of the procedure from plantation to harvesting to the final availability of bamboo as a ready material for use in construction was worked out. As and when these are made known to prospective agencies that will be involved in low cost mass housing projects for the Urban Poor, bamboo will have succeeded in its utility as a construction material for mass housing.

5. Unaffordability Increases with Use of Conventional Materials

Escalation in prices of materials like steel cement makes pucca houses unaffordable for all sections. However the worst-hit are the poorest of the poor living in urban agglomerations. Use of alternative materials could contribute towards reduction of unaffordability.

"Cost reductions through the development of new materials and methods are difficult to come by. Often other costs - services, materials, land, energy, and skilled labor – rise fast enough to over shadow these savings. Clearly modern Technology by itself has not yet provided an answer, and very few realists now believe that it will". (Angel Shlomo and Stanley Benjamin [1])

6. Dilution of Standards

Simply because the contribution of alternative materials in cost reduction is marginal does not imply that they must be abandoned. However small the saving it will be enough reason to prevent dilution of standards of a "Pucca" house, which is detrimental to achieving the national target of having slum free cities or total eradication of homeless population.

Often the size of the house, number of rooms, provision of basic amenities and facilities are compromised, creating a favourable situation for catalysts to thrive for creation of slums rather than their eradication.

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6.1 Cost Cutting is not equal to Size, Safety and Quality Compromises

There cannot be a compromise in any of the three variables when addressing the issue of housing for the Urban Poor! The issue can only be resolved through the use of appropriate technology, local materials, to make it affordable for the poorest of the poor -in this case, the Urban Poor and the Homeless. Having established this, the stage is now set in place, to transfer innovative low cost technology and alternative materials from lab to land. However it is essential to define "poor, very poor" and other terms that often get misinterpreted by those in charge of translating missions, goals, objectives and policies into a reality.

There is a clear dilution of the content and intent of policies by the time they get implemented. At times ground realities are much harsher than what planners can comprehend. Affordable Housing gets defined purely in terms of what is "Possible to be supplied" in a given income range, and what a household in particular can pay for. This creates a gap between what is affordable, what is possible, and what is desirable as part of housing standards. This non convergence is noticed the most in the housing for the urban poor. Since their affordability levels are very low, the market provides them with housing which is characterized by insecure tenure, small size, unhygienic environment and non-existent infrastructure. Non-availability of Affordable housing is as much a problem of the middle income groups as it is of the lower income groups. In their inability to find appropriate abode many a higher income groups (belonging to middle and lower middle income groups) are constrained to opt for sub-standard housing. Many invade cheaper/subsidized housing provided by the state for the poor thus negating government efforts. The issue of Affordable Housing thus has to be looked at in an integrated manner.

7. Conclusion

With extra precautions bamboo can be used to bring down costs in order to make houses affordable among the urban poor so as to reduce the possibility of dilution of standards which accommodate larger population in smaller and sub-serviced houses. Bamboo structural elements and inner walls in the superstructure alone can bring down the costs up to 13.8 % which saves enough to prevent dilution of standards in a conventional house.

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