POST EARTHQUAKE HOUSING CONSTRUCTION USING LOW COST BUILDING MATERIALS

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ABSTRACT

There are several natural disasters occurring throughout the world round the year and one of them is Earthquake. The severe quakes wreak catastrophic havoc in the human community because of destruction of structures - houses and buildings, bridges, roads, railways and uprooting of transmission towers. Along with death the other distressing factor is collapse of dwelling units. Death and destruction can be prevented or vastly minimized if the houses are structurally sound. In a poor country severe earthquake occurs every now and then, the problem of appropriate ‘safe’ housing must receive adequate attention from architects, engineer, builders, and owners of property.

Nowadays the various waste products from big industries has been converted into useful building materials which can be used during post earthquake housing construction, solving the problem of disposal on the one hand and providing better construction material at low cost on the other hand. Similarly some agricultural wastes (as rice husk) have also been converted into building materials, which are very much useful during reconstruction phase as low cost building materials. In the present paper few low cost building material, which can be used during post earthquake housing construction has been highlighted.

INTRODUCTION

The impact of disasters caused by natural hazards such as earthquakes can have serious consequences. Vulnerable populations are faced with unforeseen hardships, misery and death if their housing and buildings collapse and supporting infrastructure is severely damaged. Works programmed with a focus on developmental efforts are severely disrupted, accompanied by destructions of strategic infrastructure. Furthermore, earthquake seriously limits the rate of progress in achieving desirable economic development and poverty reductions for vulnerable populations. Accordingly, many unfortunate people will continue to be faced with social setbacks until the worst outcomes of disasters can be addressed.

The basic needs of masses for food, clothing and shelter are required to be fulfilled on priority basis during post earthquake reconstruction phase. Supplying of food following the aftermath need not require much time and similarly there is no problem of clothing as immediate contribution gathers to get rid of shortages. The third need for providing shelter still a challenging task before the policymakers. The number of people who are under-nourished, under-roofed and who thus under-live in more than one sense goes on increasing. This evidently depresses the productivity level of these people taking away their will and initiative, psychologically and their working capacity, physically. Since, the means of income observed that if their living conditions are improved by better housing and sanitation, they gain back their

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self-confidence. The desired systematic changes required for a world order where economics, growth with equity and ecological balance can be brought about may begin with this first step.

Since, materials constitute 70-80 percent of the cost of the house, so the cost of building materials are required to be optimum during post earthquake reconstruction. Low cost building materials do not mean sub-standard materials, but the materials available/developed locally, cutting the transportation charges and manufactured applying civil engineering know-how for better service and economy.

FEW REASONS OF FAILURE OF EARTHQUAKE-PROOF HOUSES

It is commonly believed that some houses could be made earthquake proof. The reality however is that by taking up precautions, the earthquake resistance of the house is increased finitely, to make them resist quakes of specific magnitudes. These houses, too, may fail once they face quakes having more intensity than their design took care of. Following are the few reasons why earthquake proof houses may fail:

Vibrations

The movement within the earth’s crust manifests itself in the form of waves that reach earth’s surface and cause vibrations in structures. The structures fail and collapse under the action of these vibrations. These vibrations may be in horizontal direction, in vertical direction or combination of both, which generally is the case. The vertical component of seismic force creates repeated changes in the weight of structures while the horizontal component induces. These forces get commanded in each cycle.

Inertia Force

Houses collapse as a result of inertial forces. Under the action of earthquake the lower portions of the structures that are in direct contact with the ground tend to vibrate more; whereas due to inertia the upper portions of the structures tend to remain static. The resultant stresses build up fast with the increased frequency of vibrations leading to failure of the structures.

Poor Quality of Material

The Lature, Gujarat, India disaster came about when huge stone masonry walls gave way under the earthquake bringing down with them the roofs that were overlaid with thick clay. The walls and roofs were heavy; the masonry was badly made with round stones. The houses were not ‘engineered’ units, but more an assemblage of materials. The mud mortar used was weak and could not provide enough cohesion to sustain the walls on that fateful night. The huge mass of construction material led to a massive disaster.

Dead Load

The magnitude of the inertial forces increase as directly as the weight of the houses. The heavier the house, heavier is the destructive force. One important consideration in making a house more earthquake resistant is to reduce its mass and making it as light as possible.

SOLUTIONS TO PREVENT FAILURE OF EARTHQUAKE-PROOF HOUSES

Traditional poor man’s houses in the tropics have mostly wattle and daub walls with thatched roofs - these houses consume little material, and are light by weight. The inherent limitations of the houses do not permit higher storeys. Additional advantage these houses afford is that due to their lightness, the houses, even if they collapse, may not kill people.
Another way of improving earthquake resistance is by way of making the houses rigid, viz, making sure that the houses vibrate together as one unit. This prevents unnecessary absorption of energy by the structural members and improves the quake resistance of buildings. Schematically, in such houses the top portions of the houses are so joined to the bottom that all movements are transferred immediately from lower levels to the entire building and the entire house vibrates as one rigid body. Consequently no disharmonious stresses are set up and the house remains safe.

The bamboo construction in North-East India follows this principle of rigid house. Bamboo being light gives added natural advantage. In these houses rigidity is achieved by means of cross bracing and triangulation. All joints are strengthened by means of cross members that can transmit earthquake forces directly to the remaining portions of the house.

Reinforced concrete ‘frames’ are rigid by design and their rigidity can be improved further by small increases in steel used. The ‘framework’ of such beams and columns can be made to resist earthquake-induced vibrations of considerable magnitudes. Almost all the multi-storied buildings in towns and cities are framed, thus the structure finds great support. It must be noted here that though the RCC frames take care of major portions of earthquake induced forces, the forces generated in the non-load bearing walls could still lead to damages byway of wall collapses. In places like rural India where concrete technology has little reach, masonry in brick and / or in stone takes major share in the form of lead bearing walls.

The strength of masonry depends to a great extent on the strength of the mortar joining them to distribute the earthquake-induced forces equally throughout. One modern method ‘Foamed Concrete’ construction combines principles of structural masonry together with the advantages of lightweight foam concrete. Foam concrete is prepared by aerating the concrete profusely as it is mixed to create a highly fluffy, lightweight substance. Building blocks and units made out of this material lead however to centralization and are subject presently to patent laws.

Masonry when properly construct, possesses good resistance to seismic forces. Bad construction, however, means disastrous consequences. Improving the rigidity of load bearing masonry by way of three RCC bands one each at plinth, lintel and roof levels is the most common technique employed in a country’s earthquake resistant housing programmes today. These houses, when constructed under supervision can resist earthquakes of moderate intensities quite efficiently.

**TYPES OF BUILDING MATERIALS**

The various building materials available can be divided into two types and they are:

**Traditional materials**

These materials serve the basic needs of the majority of the population. These have very useful properties, however, there is a scope to modify these through appropriate changes in the process of production as well as in the techniques of application, so that these are made structurally and functionally acceptable.

**Conventional materials**

The conventional materials are those, which have been obtained by using the modern technologies and can be mentioned as fruit of research and adopted to indigenous requirements.
BRIEF DESCRIPTION OF FEW LOW COST BUILDING MATERIALS, WHICH CAN BE USED DURING POST EARTHQUAKE HOUSING CONSTRUCTION

Improvement of Mud

During post earthquake reconstruction, mud houses are most effective since they are environmental friendly, cool in summer and warm in winter. Mud is only a material available everywhere in abundance free of cost and is being used as building material from centuries. But such types of houses are temporary in nature, prone to erosion by heavy rains. The disadvantages of mud can be overcome by suitable improvement in design and construction techniques.

Stabilization

The strength of mud is improved by adding cement, lime, bitumen or fibers and it also becomes resistant to water, its main enemy.
Cement stabilized mud blocks, using 3 to 10% cement by weight molded in mechanical machines are better than adobe mud bricks.

Non-erodable mud plaster

Central Building Research Institute, India has developed an economical but effective process to protect mud walls by applying non-erodable mud plaster. Non-erodable mud is prepared by mixing bitumen cutback (Bitumen & Kerosene oil mixture) with a specified mud plaster. Soil should consist of clay 20-25%, sand 40-45% and remaining part may be silt, peat, loam etc, but it should be free from organic matter. Bitumen of 80/100 grade penetration and kerosene oil are mixed in the proportion of 5:1 (by weight) for preparing cutback. 64 kg of cutback is required for one cubic metre of soil. Non-erodable mud plastered walls are resistant to water erosion.

Terra-cotta skin to mud walls

Center for Science for Villages, Wardha, India has developed technique of providing potter made tile lining to mud-walls protecting them from rain and moisture. In place of potter made tiles, Kiln-fired brick or tiles may also be used to protect mud walls from rains. These tiles/bricks can be fixed with mud mortar & pointed with cement mortar.

Improved Thatch Roof

An effective treatment for rendering the thatch roof fire resistant and water repellent has been evolved by Central Building Research Institute. It involves plastering of thatch layers by the specified mud plasters. Top & bottom of the thatch roof is plastered with non-erodable mud plaster, which makes it durable & fire resistant too.

Wardha Tumbler Tiles

These tumbler tiles are cast by potters and used as roofing. These have been developed by Center for Science for Villages, Wardha. This kind of roof keeps the heat & cold out. These tiles require no under structure, yet can bear the weight up-to 1-0 tonne/m². Life is about 50 years & requires no repairs. Being light in weight (135kg/m²), the roof is safe even in future earthquakes.
**Ferro-Cement**

Ferro-cement is 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. The desired compressive strength of ferro-cement is generally 25 N/mm$^2$ at 28 days & mix ratio recommended is 1:2 to 1:2.5 ;(cement: coarse sand) and water/cement ratio should be 0.4 by weight. It can be used in the construction of pre cast toilet units, water tanks cycle sheds.

**Flyash-sand Lime Bricks**

These are produced from flyash and sand and lime used as binder. These bricks are cheap, and have good crushing strength.

**Clay Flyash Burnt Bricks**

These are produced from flyash and clay and are stronger than conventional clay bricks. These consume less energy, provide better thermal insulation and solve the problem of disposal of waste material flyash & thus are environmental friendly.

**Flyash Based Light Weight Aerated Concrete Walling and Roofing Blocks**

A process of mixing flyash, quick lime/cement and gypsum, foaming agents such as aluminium powder, produces these. These are cheap and lightweight blocks mostly used for non-load bearing partition walls.

**Cement Bonded Fiber Roofing Sheets**

Cement bonded fiber roofing sheets are made by profitably utilizing coir waste coconut pith, wood wool etc., in combination with cement as binder for production of corrugated or plain roofing sheets. These sheets require less cement and so they are cheaper than other roofing sheets available in the market.

**Clay Red Mud Burnt Bricks**

These are produced from alumina red mud or bauxite, an industrial waste of aluminum producing plants in combination with clay.

**Gypsum Based Ceiling Tiles, Panel Blocks and Door/Window Shutters**

There are manufactured from calcined gypsum obtained by processing phosphogypsum an industrial waste of fertilizer plants. The panels are strong, lightweight, resistant to fire and works as a thermal insulative and cost of the product is cheaper.

**Precast Stone Blocks**

These are of larger size than brick and are manufactured by using waste stone pieces of various sizes with lean concrete of 1:3:6 mix.
Precast Hollow Concrete Blocks

These are manufactured by using lean concrete mixes through block making machines. The cavity in blocks provide better thermal protection and these also do not need external or internal plastering.

Precast RCC Door and Window Frames

These are cheaper, stronger fire resistant, termite resistant and sustain temperature & humidity.

Precast Plank and Joist Flooring/Roofing

These are precast RC planks, supported over precast RCC joists. Cost saving is up to 20% and time saving in construction is up to 12%.

Holo-Pan System

The holo-pan system can be used only in six standard pre fabricated components and they are

- Wall
- Roofing/floors
- Door/window
- Collar units
- Parapet units
- Partially precast beams

Overall cost of hollow pan system is less and speed of construction is more. A flat can be constructed in 1.5 days time. They are useful for post earthquake reconstruction phase. One crane is required to lay the prefabricated panels at respective positions.

Rice Husk as Building Material

India alone produces about 20 million tones of rice husk annually. Rice husk ash has been found to be a useful building material. It can be mixed with cement up to 20% without affecting strength and thus cost of construction can be reduced and problem of disposal of this ash can also be solved by using it.

CONCLUSION

A study of the construction methods used by various agencies in the disaster affected areas points to the growing use of local resources and talents in present day relief and reconstruction measures. In case of rural areas, the houses can be constructed by using traditional and locally available raw materials of bamboo, cane, reeds, rattans, willow, timber and leaves of some particular trees, and has been designed to suit the traditional living habits of local people and maintain their socio-cultural heritage. Further there has been a growing feeling amongst the rural peoples that the old bamboo-thatch or leaf houses may be constructed with newer materials of RCC, precast-components etc., using better engineering information and thereby, achieving more durability as well as extra living comfort in the process. Under these growing innovative concept, concrete blocks, cement, wooden frames, and tiles that are locally made are most useful and thereby encouraging many small-scale enterprises in the process. Although there seems to be a strong emphasis on the use of local resources in present day relief aid, the important issue is not just the use of local resources, but how local manpower can be created. In most developing countries, the challenge is to organize and initiate measures that promote talent building.
So many new building materials for low cost housing has been developed by various research agencies but so far these new technologies has not been transferred to the community effectively. Local artisans, masons are required to be trained in the use of new low-cost building materials and techniques.

Creating better resistance to earthquake today involves access to steel and cement concrete if not to ultra modern aerated concrete blocks. There have been several attempts at local levels to make use of bamboo and mud instead. These attempts have not all stood the test of time; most of them have not got the chance to face further quakes of high magnitudes - but these attempts have always met with criticism by the scientific fraternity. In our rural housing, local materials have to play an important role. Even poor man’s materials can be used to provide extra strength to a dwelling unit with incorporation of a few simple engineering principles. Total safety cannot be assured even by use of high technology - but all dwelling houses, big and small, can be made safer.

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