

BUILDING MATERIALS FOR LOW COST HOUSING





Building Materials for Low Cost Housing Segments

Low-cost housing projects are characterised by an increasing demand mainly due to urbanisation. The selection of building materials should meet the needs of local conditions to improve quality of life for the most needed ones by building new structures and/or by improving existing structures. Sustainability regarding urban housing intends to develop new approaches to manage human settlements and integrate energy and environmental issues. To achieve a sustainable housing project is required a balance of environmental, economical and social issues with technical issues. Findings show that up to 60 % of the total cost of a low-income housing project is allocated to

engineering design and construction materials. Moreover, walls constitute up to 50% of the total cost of materials and up to 45% of total construction time. Material origin, production techniques and labour requirements all have major impacts on the selection of wall building material. The analysis of particular local conditions will determine where materials are most suitable for their use. Furthermore, the time when materials and techniques were / are mostly used will determine whether they could be classified as traditional or contemporary. The regularity of use will determine whether materials and methods could be classified as conventional or alternative.

Building components can be interrelated through different systems. There are three building systems considered in this study:

- Massive system; a solid construction based on one type of material.
- Frame system; vertical, horizontal and angular members joined together to form a load-bearing framework. The space between the members can remain open or be filled with different materials.
- Core system; a combination of materials with an inner, or core, part and an outer layer for cladding/reinforcement.

The advantages and disadvantages of each system is shown in Figure 1.

Various studies showed that a big variety of wall materials have been used in different building systems with traditional and modern construction methods, but only few of them (extruded clay bricks, hollow concrete blocks) have successfully been implemented in low-cost housing projects. Conventional materials (e.g. cement, steel, concrete) in low-cost houses

	Advantages	Disadvantages
Massive System	<ul style="list-style-type: none"> Reduced number of materials and components Materials could be manufactured in situ High thermal capacities (common in hot arid climates) Medium to high resistance to dampness Medium construction speed Accessible information for design, construct and maintenance 	<ul style="list-style-type: none"> High quantities of the same material needed It needs wall finished to perform well Needs support and centering during construction (verticality problems may cause the failure of the structure) Possibilities of insects and vermin attack
Frame System	<ul style="list-style-type: none"> Medium resistance to natural hazards High construction speed Medium innovative design and construction techniques 	<ul style="list-style-type: none"> Increase variety of Components, equipment and skills Intermediate level of accessibility of information for design, construct and maintain Compulsory use of wall finishing
Core System	<ul style="list-style-type: none"> Very high thermal performance High resistance to dampness Very high construction speed Lighter elements to erect Reduce site work High innovative design and construction techniques 	<ul style="list-style-type: none"> Partially or totally imported material Need industrialised production rises basic cost Needs Environmental control during manufacturing Special design and connections Less access information for design, construct and maintenance High skill workers Sophisticated and conventional equipment during construction Higher possibilities of insects and vermin attack

Figure 1: Building systems, advantages and disadvantages

constitute up to 98% of the materials used. Nonconventional materials (polymers, composites, recycled) have been left aside despite better thermal and condensation characteristics for local conditions. Alternative design including use of non-conventional materials have also been left aside despite reduction of construction time of more than 50%.

Some of the aspects/criteria most frequently considered in the comparison of technical advantages and disadvantages of building material are shown in Figure 2.

	Advantages	Disadvantages
Natural Raw Material	<ul style="list-style-type: none"> Traditional design High thermal resistance in semi-dry and dry places High fire, noise, impact resistances for soils and stones High biological attack resistance for soils and stones High importance aesthetic service life Long Physical service life High reparability High recyclability 	<ul style="list-style-type: none"> Low water penetration resistance Low condensation capacity Low fire, noise, impact resistance for fibers Low natural hazards resistance Low durability for fibers Low biological attack resistance for fibres
Processed Material	<ul style="list-style-type: none"> High thermal resistance Medium water Penetration resistance Medium to high fire, noise resistances Medium to high natural hazards resistance High noise, impact prooerties Long durability if maintained Medium to long aesthetic service life Medium to long physical service life Medium to long technical service life Medium to high reparability (need knowledge) Medium recyclability 	<ul style="list-style-type: none"> Professional design Low condensation capacity Low biological attack resistance short technical service life
Processed Material	<ul style="list-style-type: none"> Very high thermal and condensation resistance Medium to high impact resistance Medium natural hazards resistance Long durability if maintained Medium to high biological attack resistance Medium to long aesthetic service life Long technical service life 	<ul style="list-style-type: none"> Professional / Specialized design Medium to low fire resistance Medium to low noise properties Long physical service life Medium to low reparability Low recyclability

Figure 2: Technical advantages and disadvantages of materials

Materials for Low Cost Housing

Some of the materials used in low cost housing are described as below:

Cement Plant (capacity from 300tpd to 12000tpd) – It’s the mother of all the building materials and is required in every aspect of a building construction. Raw materials required limestone, clay, iron stone and gypsum. Schematic diagram of a typical cement plant is shown in Figure 3.

Lime-Sand Brick - This is used for load bearing walls of low-rise buildings and is a good substitute for clay brick. Raw materials required are lime and sand. Refer Figure 4.



Figure 3 : Cement Plant

Cement-Waste Slag Brick – This is used for load bearing walls of low rise buildings. The main feature of this is that a lot of waste slag can be recycled and either natural curing or steam curing for bricks can be adopted. Raw materials required are waste slag (80%) (fly ash, coal gangue, slag, etc.), Aggregate (stone powder or river sand) and Bonding agent (20%) (Cement or gypsum). Refer Figure 5.



Figure 4: Lime Sand Brick



Figure 5: Cement-Waste Slag Brick

Concrete Hollow Block - This is used for walls. The main features are:

- Wide source of raw materials
- Simple manufacturing process
- High construction speed
- The same process for Fly ash concrete block
- The same process for Lightweight concrete hollow block

The raw materials required are:

- (a) For Concrete Hollow Block: Cement, sand, aggregates
- (b) For Fly ash concrete block: Cement, fly ash, aggregates and
- (c) For Lightweight concrete hollow block: Cement, lightweight aggregate, such as, fly ash, ceramsite, pumice, furnace slag, cinder, pearlite and other waste slags. Refer Figure 6 below.

Decorative Concrete Block – These blocks come with a combination of structural and decorative function and are used for decoration of exterior walls. The raw materials required are sand, stone, admixture and pigment. Refer Figure 7.

Lightweight Concrete Block (3E) Panel – This panel is used for

walling system of steel reinforced concrete - lightweight panel system. Main features are:

- 3E panel (Ecological, Extruding Process, Economical)
- Specially designed for low-cost house
- 3E house (Easy, Energy-saving, Ensure) can be installed and rapidly constructed with 3E panels
- Excellent shock resistance: post-casted stem, panel and ring beam form an integrated structure

The raw materials used are cement, fly ash (optional), glass fiber or steel wire, aggregate (optional: sand, stone, blast-furnace slag, pearlite, ceramsite, pumice, and other slags). Refer Figure 8.



Figure 6 : Concrete Hollow Block and production machine

Foam Concrete Panel – This is used for concrete panel for partition wall, EPS sandwiched external wall panel, reinforced hollow floor panel, EPS sandwiched roof panel. The main features are:



Figure 7: Decorative Concrete Blocks

- Easily worked and rapid on-site assembly
- Light weight
- Fire resistant
- Energy efficient: 80%
- Excellent acoustic performance
- Designed for inner comfort: cooler in summer, warmer in winter

Raw materials required are Fly ash (50-70%), cement, forming agent, reinforced materials. Refer Figure 9.

Hooking Panel – This panel can be used for wall of low-rise and high-rise buildings. Main features are :

- The wall is assembled by concrete hooking panel and concrete or steel hook.

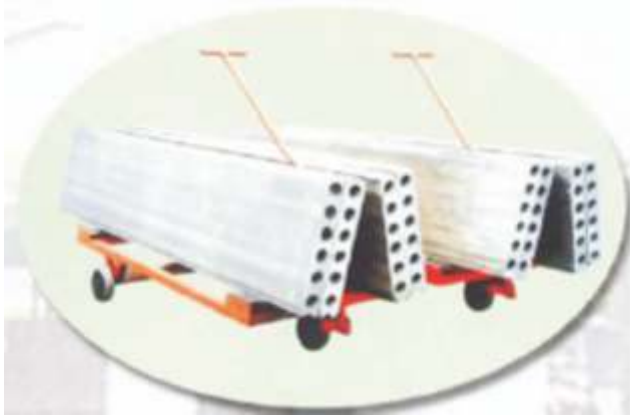


Figure 8: Lightweight Concrete Block (3E) Panel

- No auxiliary materials are needed for assembling. No need for bonding or anchoring for the panel.
- The house built with hooking panel is quake-proof and fireproof
- The machine can produce many kinds of panels
- Low-cost: US\$40/m² building area

Raw materials required are cement, sand, waste slag, glass fiber (for non-bearing wall) or steel wire (bearing wall). Refer Figure 10.



Figure 9 : Foam Concrete Panel

Glass-fiber Reinforced Concrete (GRC) panel - Suitable for load bearing wall of 1 to 2 stories buildings and non-load bearing wall of high-rise buildings. Main features are :

- Easy and quick construction: all the building materials needed for a 280m² house can be transported by a truck; 8 workers can complete the house in 2 weeks
- Light weight: 35-50kg/m²
- High shock resistance
- Good heat insulation
- High durability
- Low-cost house: building cost is only US\$60/m².

Raw Materials required are Cement, EPS panel, reinforced materials, sand, blast-furnace slag, perlite, ceramsite, pumice, and other slags. Refer Figure 11.

Straw Panel – This is used for wall of low-rise buildings and partition wall of high-rise buildings. Main features are:

- Green Building Material - 70% straw
- Low-cost: 35%-50% of gypsum product 10%-20% of wood product
- Lightweight – 33kg/m²
- Non-radiative
- Waterproof, Fireproof, Crack resistant



Figure 10 : Hooking Panel & Applications



Figure 11: Glass-fiber Reinforced Concrete (GRC) panel

Raw materials required are (i) Straw (wheat straw, rice straw, maize stalk), sawdust, maize stalk, sawdust, sugarcane pole, husk, etc, (ii) Bonding and anti-burning agent and (iii) Reinforced material: mainly glass fiber. Refer Figure 12.

S Panel (Steel Wire-EPS Composite Panel) – S Panel system is a composite construction system. It is used for load bearing walls for low-rise buildings and non-load bearing walls for high-rise buildings, also for floor board and roofing board; It consists of S Panels -three-dimensional welded wire mesh and a built-in expanded polystyrene insulation core. The panels are erected over steel reinforcing bars embedded in a concrete foundation, then fastened to one another with wire - splice mesh. Concrete is sprayed to both sides of the panels to the desired thickness. The result is a homogenous structure with excellent thermal and acoustic properties. Main features are:



Figure 12: Straw Panel

- Fast and simple erection, creating a monolithic structure
- Cost effective way of creating a quality, plaster finished structure
- Light weight - only 3.9 kg per m², 110 kg with cement mortar of 30 mm thick on both sides, easy to handle and suitable for area with soft foundation
- High energy efficient system - Efficient thermal barrier, thermal resistance (50 mm in thickness) is 0.825 m².k/w
- Excellent Sound Insulation - STC rating up to 52.6 dBA
- Superior fire resistance - tested to 2 hours fire rating
- Earthquake resistance - As a monolithic structural element with superior strength and ductility; it is ideal solution for high seismic areas. Also hurricane and typhoon proof design, even at the highest wind loads
- Long life, high durability, low maintenance, strong and modern
- Healthy and secure - Insect, termite, mildew and fungi resistance
- Greater design flexibility, easily to be adopted to curved/

arched application. S Panel System is stronger than rock and more versatile than timber.

Raw materials are Steel wires: Ø2.0-2.2mm and EPS resin: density 15-20kg/m³. Refer Figure 13.



Figure 13: S Panel (Steel Wire-EPS Composite Panel)

Colored Cement Tile for Roofing – Colored cement tile is an ideal roofing materials used for residential and industrial buildings.

Main features are

- High flexural strength
- Low water absorption
- Waterproof and good impermeability durable

Raw materials required are cement, sand and pigment. Refer Figure 14.

Concrete Paving Block – Used for road paving. Main features are:

- Flexible design of shape and size;
- Good abrasion resistance
- High compressive strength

Raw materials are cement, fly ash, sand and stone etc. Refer Figure 15.

Hollow Gypsum Board & Blocks – Used for interior wall. Main features are:

- Lightweight, fireproof and heat – insulative;
- Easy & quick construction

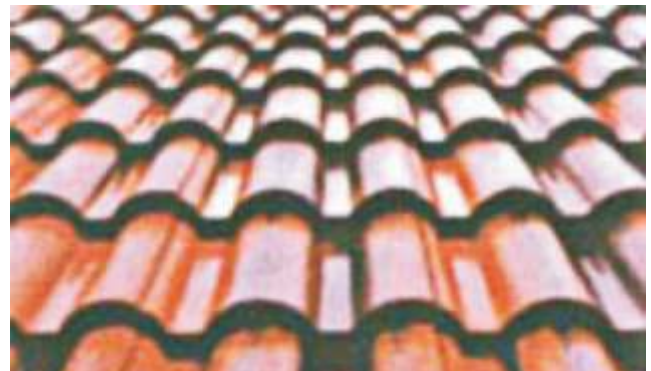


Figure 14 : Colored Cement Tile for Roofing



Figure 15: Concrete Paving Block

Raw materials required are Building gypsum, supplementary materials, such as, lightweight aggregate, fly ash, filler, etc. Refer Figure 16.



Figure 16: Hollow Gypsum Board & Blocks

Wall Plaster – Used plaster for interior wall. Main features are :

- Good workability and micro-expansion;
- Easy & quick construction;
- Good adhesion with basement;
- Lightweight, fireproof and heat - insulative



Figure 17: Wall Plaster



Figure 18 : Paint for Interior & Exterior Wall

Raw materials required are building gypsum, supplementary materials, such as, lightweight aggregate, fly ash, filler, etc. Refer Figure 17.

Paint for Interior & Exterior Wall – Used for decoration for interior and exterior wall. Main features are :

- Easy construction
- Convenient maintenance
- Wide color option upon demand

Raw materials required are Polymer emulsion, titanium white, filler, additive. Refer Figure 18.

Conclusion

The selection of building materials can promote better quality of structures, faster construction solutions and foster new economical development. This selection will have to deal with “appropriateness” and “adequacy” within energy efficiency and environmental approaches for local conditions (social, economical, financial, institutional, environmental, etc.). Both concepts will need to be clarified through interviews and literature investigations from many publications regarding building materials properties.

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