



The use of Alternative Building Materials in Disaster Zone. A Case Study of Maiduguri North Eastern Nigeria

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Abstract: This study covers some of the alternative building materials used in disaster zone which is located in Maiduguri Borno State, North-Eastern Nigeria, and the materials are HAFAT bricks, Fiber bricks and hydra-form bricks. Samples from the casted bricks were collected and cured for 7, 14, 21 and 28 days before crushing to determine the compressive strength of the respective bricks. The results shows that each respective brick have an average of Hafat bricks 0.725N/mm^2 , Fiber bricks 0.263N/mm^2 and Hydraform bricks 0.815N/mm^2 . it shows that the alternative sources are reliable, cost effective and environmentally friendly.

Keywords: Hafat Brick, Fibre Brick, Hydra-Form Brick, Disaster Zone.

INTRODUCTION

Alternative building materials are those which can be used economically by replacing the conventional building materials. Alternative building materials are made from waste products and thus it even minimizes environment pollutions. These alternative building materials can be used when it meets the respective specifications in the code of practice. Here some new materials and technology is discussed as well and list many alternative materials for foundation, roof and walls are presented with details of each. The following are the new and alternate building materials used in construction works: Aluminum Bitumen materials, soil conditioning agents, Tempered Glass Fiber, Reinforced plastic Bamboo, Reinforced plastic and polyester Fiber.

According to Simon (2011), a disaster area is a region or a location, heavily damaged by either natural, technology or social hazards. Disaster area affect the population living in the community by dramatic increase in monetary interest, loss of energy, flood and services; and finally increase the risk of disaster for citizens. An area that has been struck with a natural, technological or sociological hazard opens the affected area for national or international aid.

According to Keenani (2012) terrorism is defined as the acts of violence and threats by a group against people or property with the intention of intimidating or coercing societies or governments, often for ideological or political reasons. Terrorisms occurs with

an unexpected attack on non-combatants to create fear and panic having a detrimental consequence. Terrorism attacks create a massive, costly negative impact on the society. Not only is there large amount of property damage that may not be able to be repaired, there is also a large negative impact on citizen. People lose loved ones and suffer ill health.

Conflict in northeast Nigeria has coursed a large scale humanitarian crisis with 8.5 million people in need of humanitarian assistance in 2017. In the north affected state of Borno, Adamawa and Yobe state. today nearly 1.6 million people are displaced in the three state in the northeast and livelihoods have been lost, commercial markets and trade have been disrupted, host community resources are depleted (reducing), and large area of Borno state remain inaccessible for humanitarian needs due to the volatile security situation. Since late 2015 access to the affected populations in the conflict areas has gradually improved, enabling humanitarian organizations responding to the crisis to scale up their operation, primarily to I.D.P and host communities Government Authorities. Insecurity, poor/damaged infrastructure and increased humanitarian activity have replaced significant demands on logistics capacity in the three affected state with Borno state being most affected. Movement of humanitarian assistance into key operational areas remains limited access for humanitarian staff is restricted, and some areas are inaccessible due to active hostilities.

NATURALLY OCCURING SUBSTANCES

According to Harries (3rdSeptember 2017). Sand is naturally occurring granular materials composed of finely defined by size, being finer than gravel and coarse than silt. Sand is used with cement, and sometimes lime, to make mortar for masonry work and plaster. Sand is also used with cement as part of the other uses of clay in building is combined with straws to create highly clay, wattle and mud plaster. Sand is also used with cement as the part of the concrete mix. An important low cost building materials in countries with high sand contents soil in the Sandcrete block, which is weaker but cheaper than fired clay block. The composition of sand varies, depending on local rock sources and conditions, but the most common constituent of sand in inland continental setting is silica (silicon oxide or SiO_2) sand is a non-renewable resource over human time scales, and sand suitable for making concrete is in high demand.

USES OF SAND

Concrete: sand is often a principal component of this critical construction materials.

Bricks: manufacturing plants add sand to a mixture of clay and other material for manufacturing bricks. Mortar: sand is mix with masonry cement or Portland cement and lime to be used masonry constructions. Paints: mixing sand with paint produces a textured finish for walls and ceiling or non-slip floor surface. Sand casting: caster moister or oil molding sand, also kwon as foundry sand and then shape it into molds into which they pour molten sand with high temperatures and pressures allow gases to escape, have uniform small grains size and be non-reactive with metals.

According to Ebert, et al. (31 august 2011). Clay is a finely grained natural rock or soil material that combines one or more clay materials with traces of metal oxide and organic matter, clay deposits are mostly containing variable amount of water trapped in the material structure. Clay are plastic due to particles size and geometry as well as water content and become hard, brittle and non-plastic upon drying or firing. Depending on the soils content in which it is found, clay can appear in various colours from white to dull grey or brown to deep orange red.

According to Thomas, et al. (2006). Thatch is one of the oldest of building material known, thatch is another word for grass; grass is a good insulator and easily harvested. Many African tribes have lived in homemade completely or grasses and sand year-round. In Europe, thatch roofs on homes were once prevalent but the materials fell out of favor as industrialization and improved transport increased the availability of other materials. Today, though the practice is undergoing a revival. In the Netherlands, for instance, many new buildings have thatched roofs with special ridge tiles on tops.

According to concise Oxford Dictionary Oxford university press, 1964. Stone or Rock, rock structures have existed for as long as history can recall. It is the longest lasting building material available, and is usually readily available. There are many types of rocks throughout the world, all with differing attributes that make them better or worse for particles uses. Rock is a very dense material so it gives a lot of protection too, its main drawback as a material is its weight and awkwardness. Its energy density is also considered a big drawback, as stone is hard to keep warm without using large amounts of heating resources.

MANUFACTURING SUBSTANCE

According to Malcolm et al (2011). A cement is a binder, a substance used for construction that sets, hardens and adhesives to other materials, binding them together. Cement is seldom used on its own but rather to bind sand and gravel (aggregate) together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregate to produce concrete. Cement used in construction are usually inorganic often lime or calcium silicate based, and can be characterized as being either hydraulic or non-hydraulic depending upon the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster) non-hydraulic cement will not set in wet conditions or under water; rather, it sets as it dries and reacts with carbon dioxide in the air. It is resistant to attack by chemical after setting. Hydraulic cement (e.g. Portland cement) set and become adhesive due to a chemical reaction between the dry ingredients and water. The chemical reaction result in mineral hydrates that are not very water soluble and so are quite durable water and safe from chemical attack. This allows setting in wet condition or under water and further protects the hardened material from chemical attack. The chemical process for hydraulic cement found by ancient Romans used volcanic (pozzolana) with added lime (calcium oxide).

HAFAT, HYDRAFORM AND FIBERBRICKS

HAFAT interlocking sandcrete Block (HAFAT block) is an interlocking sand Crete block newly introduced for use in Africa (Nigeria) for construction purposes. The HAFAT block is made from sand cement which is a mixture of fine aggregate, cement and water, and it highly resistance to temperature and thermal comfort and fine aggregate technology bricks compressed to form a high quality interlocking sandcrete block. Sandcrete and conventional block are similar materials but not compressed. HAFAT compressed earth block is very popular due to the cost savings that are involve during the construction process as only around 30% of the structure requires mortar between the blocks. Due to the interlocking nature of the stabilized sand Crete block, unskilled labour can be utilized in construction thereby empowering rural communities and creating jobs. The dry stacked HAFAT interlocking block (HIGHLY RESISTANCE AND FINE AGGREGATE TECHNOLOGY) masonry replaces the conventional bricks and mortar construction masonry by HAFAT interlocking blocks masonry construction. The other components of the conventional

building system remain largely unchanged. The system is a dry stacked HAFAT interlocking masonry but can be done with mortar/slurry/grout also that enables aesthetic and affordable building, speedier construction of high quality in stretcher bond, and as well as in the normal English /Flemish bond with mortar. The block has an extremely appealing face-brick/wash finish and provide a pre-pointed straight masonry. The wall may be left exposed, plastered/rendered or finishes with cement wash. The system has originated during the time of Egyptian pyramids construction and may be even before that period, and has extensively been in use over different continents. A number of constructions have been made, using interlocking building system in India over last decades. The interlocking brick masonry system is not uniform in India, and as per information available with the author, there are three types of interlocking block available (as per information available with author) in India. The Indian masonry design standard (IS 1905-1987) does not deal with dry, interlocking bricks masonry, hence does not prescribe the design values for this masonry like basic compressive strength, tensile strength and shear strength. However, the same code recognizes other type of masonry and recommends that a prism test of different masonry may be done and these values may be accepted for designing the masonry.

This block masonry by hydra-form interlocking has been tested in the field as well as by experiments and has been found to have better strength than the conventional brick masonry (burnt clay bricks in English bond) using cement sand mortar (1:6). The basic compressive strength is much more than the minimum values given in the India masonry design standard (IS 1905-1987). These block have low embodied energy compared to burnt clay brick, and can be specifically designed as per requirements, resulting in promotion of green construction technology. The addresses the technical specification, raw material options, construction procedure, structural performance, embodied energy and conformity with the building standards.

THE TOTAL COST OF BUILDING MATERIALS

In history there are trends in building material from being natural to becoming more man-made and composite; biodegradable to imperishable; indigenous (local) to transported globally repairable to disposable; chosen for increased levels of fire-safety, and improved seismic resistance. These trends tend to increase the initial and long term ecological, economic, energy and social cost of building materials. Economic costs: the initial economic cost of building materials is the purchase price. This is often what governs decision making about what materials is to be use. Sometimes, people take into consideration the energy saving or durability of the materials and see the value of paying a higher initial cost in return for a lower lifetime cost.

Ecological costs: pollution costs can be macro and micro. The macro, environmental pollution of extraction industries building materials rely on such as mining petroleum, and logging produce environmental damage at their source and in transportation of the raw materials, manufacturing, transportation of the products, retailing and installation. Energy costs: initial energy costs include the amount of energy consumed to produce, deliver and install the material. The long term energy cost is the economic, ecological and social costs of containing to produce and deliver energy to the building for the its use. Maintenance, and eventual removal.

Social costs: are injury and health hazard of the people, producing and transporting the materials and potential health problems of the building occupants. Aspects of fair trade and labour rights are social cost of manufacturing of global building materials.

Building materials are materials used for construction purposes. Many naturally occurring substances, such as clay, rock, sand, and even twigs and leaves, have been used to construct buildings. Apart from naturally occurring materials, many man-made products are in use, some are more and some are less synthetic. The manufacturing of building materials is an established industry in many countries and the use of these materials is typically segmented into specific special trades, such as carpentry, insulation, plumbing, and roofing work. They provide the make-up of habitats and structures including homes (home include I.D.P camps, residential), offices, schools, hospitals etc.

The history of construction overlaps many other fields like structural engineering and relies on other branches of science like history and architecture to investigate how the builders lived and recorded their accomplishment. Those field allow us to analyze constructed buildings and other structures built since pre-history, the tools used and the different uses of building materials. History of building is evolving different trends in time, marked by few key principles; durability of the materials used, the increasing of height and span, the degree of control exercised over the interior environment and finally the energy available for the construction process. The core of a construction project apart from its design is the materials used. Construction has always been highly related to its materials. Building and structures have been built since pre-history. Today, we see buildings made of bricks, concrete, wood, steel and glass.

The main aim of the study is to know the strength and durability of some blocks used, especially on I.D.P camps and schools. The objectives of the research are to: To establish a highly recognized company that architects, client and competitors alike will see the company as one of the first choice contractors in the construction industry. To how to produce bricks with local materials apart from normal materials used. To determine the durability of the bricks using different materials.

METHODOLOGY

STUDY AREA

Maiduguri is located north-eastern part of Nigeria. It lies within the latitude $11^{\circ}51'N$ and $13^{\circ}40'N$ and longitude $10^{\circ}0'E$ and $13^{\circ}40'E$ and has common borders with Chad and Cameroun nations. The land area of Maiduguri is about 543km^2 (Fig. 4.1: Google Earth map showing the study area and sampling points). The area falls under the Sahel zone of West Africa which is noted for its high climate and season variation (Alaku and Moruppa, 1983). The city practically experience two distinct climate seasons yearly. These are: a short rainy season usually from the month of June to September and a long dry season from October to May. March, April and May being the hottest months of the year having a temperature between $30^{\circ}\text{C} - 43^{\circ}\text{C}$ and a fall is experienced during the rains with a temperature between $25^{\circ}\text{C} - 30^{\circ}\text{C}$. There is a serious decrease in temperature during the harmattan months, which extends from October to February. In June, extreme temperatures of 43°C and 20°C have been recorded. Relative humidity is about 45% in August and decreases to about 5% in the drier season between December and January. Day length varies from 11–12 hours (Alaku and Moruppa, 1983, Umar et al, 2002).

TYPES OF DATA COLLECTION

The data's were collected from the research, based on field and laboratory experiments.

HAFAT BRICKS

This materials (HAFAT) comprises of the sand, aggregate, cement and water to give consolidated block of highly compressive strength.

MATERIALS USED

Fine aggregate: generally, consist of natural sand, or crushed stone. Stone dust: this is used in the molding of HAFAT bricks. Cement: cement is a binder, a substance used for construction that sets, hardens and adheres to other materials, binding them together. Water: is a tasteless, odorless, and nearly colorless. Water for production should be free from algae, salt and sugar. The materials are fine aggregate, sharp sand and stone dust which are found within Maiduguri metropolitan, Jere local government area and Konduga local government area of Borno state.

MACHINE USED

This is a motorize block molding machine.

METHOD/PROCEDURE

Measure the sample 1:3:4 (1 bag of cement, 3 head-pan of fine aggregate and 4 head-pan of sharp sand or stone dust, and the water cement ratio is 40%). Mix the sample three (3) times wet and three (3) times dry. Put the pallet inside the machine. Pour the mixed sample into the machine and label it. Allowed the jack hammer to fall on the labeled mixed inside the machine to compact it. Press the control units to vibrate both top and down on the mold. Used the control units to lift the jack hammer up. Used the trolley conveyor to moved out the block on the pallet to the place of curing. The capacity of the machine will produce: 6" HAFAT bricks 5000 blocks per day. 9" HAFAT bricks 3000 blocks per day.

HYDRAFORM BRICKS

The hydra-form block is made from soil and cement which is a mixture of soil, cement and water. The technology originates from UNIDO (United Nation Industrial Development Organization). Tanzania, South Africa and other Sub-Saharan countries.

MATERIALS USED

Clean laterite: this are clean soil free from organic materials. Cement: is a binder, a substance used for construction purpose, that sets, hardens and adheres to other materials, binding them together. Water: is tasteless, odorless, and nearly colorless. Water for production should be free from algae, salts and sugar. The clean laterite is found in Damboa local government area, Biu local government area and Yobe state (Dapchi and Potiskum local government area). But due to insecurity Damboa local government is not accessible, the location is from Yobe state, just behind Dapchi local government area.

MACHINE USED

This machine consists of a pump, compressor and mold.

METHOD/PROCEDURE

Measure the sample 1:10 (1 bag of cement and 10 head-pan of clean laterite, and the water cement ratio is from 25%-30% because it does not require much water). Mix the sample three (3) times wet and three (3) times dry. Pour the mixed sample into the machine and label it. Allowed the compressor to compress the bricks. Press the control units to pump out the bricks out from the mold. Take out the bricks to the place curing by using hand. The capacity of the machine will produce 3000 to 5000 bricks per day.

FIBER BRICKS

Fiber Bricks: is a mixture of small quantity of sand, cement, fine aggregate and saw dust.

MATERIALS USED

Saw dust: this is normally obtaining from sawmill. Fine aggregate: generally, consists of natural sand or crushed stone. Cement: is a binder, a substance used for construction that sets, hardens and adheres to other materials, binding them together. Water: is tasteless, odorless, and nearly colorless. Water for production should be free from algae, salts and sugar.

MACHINE USED

This is a motorized block molding machine.

METHOD/PROCEDURE

Measure the sample 1:2:3 (1 bag of cement, 2 head-pan of fine aggregate and 3 head-pan of saw dust, and the water cement ratio is 40%). Mix the sample three (3) times wet and three (3) times dry. Put the pallet inside the machine. Pour the sample into the machine and label it. Allowed the jack hammer to fall on the label mixed inside the machine to compact it. Press the control units to vibrate both top and down on the mold. Used the control units to lift the jack hammer up.

Used the trolley conveyor to moved out the block on the pallet to the place of curing.

RESULTS DISCUSSION

S/N	Weight (kg)	Load (KN)	Density (Kg/m ³)	Area of the block (mm ²)	Compressive strength (N/mm ²)	Average compressive strength (N/mm ²)
1	12	45	1,942.7	51,475	0.87	
2	11.9	45	1,926.5	51,475	0.87	0.725
3	12	45	1,942.7	51,475	0.87	
4	11.8	15	1,910.3	51,475	0.29	

Table 1: showing the compressive strength of the HAFAT bricks.

S/N	Weight (kg)	Load (KN)	Density (Kg/m ³)	Area of the block (mm ²)	Compressive strength (N/mm ²)	Average compressive strength (N/mm ²)
1	9.8	60	1683.3	50,625	1.19	
2	10	45	1717.7	50,625	0.89	0.815
3	10.1	35	1734.7	50,625	0.69	
4	10.1	25	1734.8	50,625	0.49	

Table 2: showing the compressive strength of the Hydraform bricks.

S/N	Weight (kg)	Load (KN)	Density (Kg/m ³)	Area of the block (mm ²)	Compressive strength (N/mm ²)	Average compressive strength (N/mm ²)
1	21.5	35	1123.8	101,250	0.35	
2	19	25	1001.1	101,250	0.25	0.263
3	18.5	25	974.1	101,250	0.25	
4	19	20	1001.1	101,250	0.20	

CONCLUSION

In conclusion, the alternative building materials used in disaster zone, Maiduguri Borno state being a case study. The materials used for producing HAFAT bricks, Hydraform bricks and fiber blocks are reliable, cost effective and also environmental friendly. The machine used can produce a large quantities of blocks per day. So that they can be used to substitute or replace the normal (hollow) sandcrete blocks that are in use. For the Hydraform bricks, it is molded with clean laterite and small quantity of cement to reduce the cost of production and develop the country. And then for this HAFAT bricks, it has molded with sand and cement but in highly compressive strength and it can withstand harsh weather. And for the Fiber brick it is molded with sand, cement and saw dust to reduce the cost of production and develop the economy of the country. The curing of the HAFAT bricks and Fiber brick is done by applying water from 7 days to 28 days .While the curing for the hydra-form bricks is done under humid condition by using trampoline to cover the bricks because it does not required water for hardening as well as sun light.

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