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SUSTAINABLE GREEN MATERIALS FOR BUILDING CONSTRUCTION

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Abstract

Because of increasing urbanization various tremendous environmental problems are rising. The increasing demand of houses consumes more energy, resources and raw materials which are directly or indirectly liable for causing a considerable portion of the annual environmental deterioration and harmful effect on human health. Usually building materials are selected upon their physical, chemical and mechanical properties whereas the selection and use of green materials depends on their functional, technical and financial properties. Green materials comprises of recycled and reused materials, sustainable production of products, locally available materials or use of green resources. The purpose of this paper is to describe some green materials in building construction and to highlight its beneficial aspects on lessening the impact of environmental degradation and generate healthy sustainable buildings which can be sustainable to the occupant as well as our environment.

Keywords: Raw materials, Environmental deterioration, Green materials, Sustainable building.

Introduction

In recent years, population growth and urban rapid development has been significantly increasing. To fulfill the occupied space demands, enormous number of buildings has been constructed worldwide. For the requirements of residential, industries and offices, supermarkets varieties of buildings are being constructed nowadays all around the country. Most of these buildings are designed without considering any hazardous impact on environment, human health and building life cycle. For constructing those buildings a lots of materials are being used without any planning. Building construction consumes 40% of the raw stone, gravel, and sand used worldwide annually, and 25% of the raw timber.[1] Because of extraction of those raw materials, the amount of raw material present in the environment is decreasing significantly. The manufacturing process of those of the materials used in buildings consumes huge amount of energy derived from the fossil fuels and the displacement of mega-tons of earth during the course of mining. The energy input in GJ/ton for aluminium is 190, plastics 80-100, steel and other metals 30-50, glass 20 and cement/concrete products.[2] But about 2 tons of raw materials must be mined for the production of every tons of cement; nearly one ton of CO2 and up to 6 kg of NO2gasses are produced at the time of the mining.[3] So we can see building contributes significantly to global ecological degradation and greenhouse gas emissions.

Most often bulk amounts of these materials are being extracted from their natural sources in unplanned and unscientific ways. As a result, natural abundances of these materials are reducing overwhelmingly day by day. Along with it, existing ecosystem is also getting at stake. After the demolition of old buildings a large amount of wastes are discharged into the local landfills as unwanted garbage.[4] Besides the byproduct of many industries are dumped as waste without any treatment. Most of these materials are non-decaying and largely contribute to the environmental pollution, acid rain and barrenness. But those wastes can be reused and recycled for many purposes. Some of these materials can be recycled and reused as building materials and others may serve as raw materials in several production engineering (e.g. cement, brick, glass industries) through recycling processes. Apart from these phenomena some green resources are naturally available to serve as raw materials in building construction, which is also prime concern of this paper.

In quest of alternative sustainable building materials and low technology methods large number of studies have been carried out by the research community worldwide, which results in a more sustainable and affordable construction adhering to the comfort standards. In order to meet this target, adopting green building materials is an excellent approach. Construction materials those have minimum environmental burdens can be selected because of its usefulness in the sustainable development of a country.[5] Selecting environmentally preferable

building products and reuse and recycle wastes as or to produce building materials is an excellent way to boost a buildings performance and lessen the impact on environment and human health.
The objectives of this paper is to review the previous works and literatures and find out the materials that include the usages of locally available and green materials, greening of concrete, minimization of waste disposal from brick kiln, recycle and reuse of by products in glass, ceramic, fiber, plastic industries as much as possible that possesses the capability of reducing CO_2 emission, alleviate the hazardous impact on human health and lessen the extraction of those materials from their natural pertaining. The mentioned areas covered fostering green resources, sustainable production of products and locally available materials for the selection of building construction materials.

Literature Review

Considerable literature was reviewed and gathered information on previous research and development of green materials. Previous literatures and experiments based on the speculation of reuse or recycling of construction garbage and demolished building parts have been studied. Along with this, researches that reveal the conversion of hazardous construction constituents to less vulnerable on environment and ecosystem have also been studied. The most inaugurating aspect of this paper is to accumulate these separate studies into a single frame so that the maximum benefits can be obtained at the time of selecting green materials simultaneously as all the available sustainable green materials are described. As one can get the concepts and resources of these green materials, it would be very easy for him to choose the most cost effective, environmentally and aesthetically suitable materials for construction operation. By adopting this practices replacements of conventional building materials can be accelerated by many folds.

Methodology and Materials

The key ingredient of any high-performance building effort lies in the application of stable, attractive and environmentally responsible building materials.[5] Materials having severe destructive impacts to the environmental affairs by releasing pollutants, toxicity and depletion of natural resources are to be avoided. To check these destructive impacts precautionary steps are initiated during acquisition of raw materials, their production and manufacturing processes and along with their transportation process. Pre building phase presents an opportunity to restrict the usage of materials that have harmful effects on human health and vulnerable to workers for its toxic exposure. The manufacturing processes of these green materials are to be conducted by taking some intensive cares (e.g. reservation of their natural resources, energy efficient, lessen up the pollutants disposal to nearest land and usage of additive chemicals, water etc)
Selection of the materials depends on some factors (e.g. aesthetically preferable to the habitants, cost effective in transporting and installing to the construction sites, repair workings are not laborious also most importantly durability and strength factors requirements are areas of consideration). Selection of Glassy and plastic materials are more dependent on their ease to recycle and reuse processes. In case of building's cardinal materials (e.g. concrete, bricks, cement and lime) strength gaining rates, durability, permeability etc requirements are to be served and their nominal acceptance values are desirable for the installation of these materials. Organic contents of green materials must be handled in a way that it doesn't create any nuisance to the occupants (e.g. obnoxious malodor, staining, water absorption and excessive moisture contents).

Bamboo, Wood & Straw bales

Bamboo, wood & straw bales are locally available materials in rural areas of Bangladesh. These three green materials are easy to find, transport and can directly be used as building construction materials.
Bamboo might seem trendy, but it has actually been a locally-sourced building material in some regions of Bangladesh. There are about 100 species of bamboo in Bangladesh where 19 species are commercially useable for as building materials or for interior designing. The combination of tensile strength, light weight, and fast-growing renewable nature makes bamboo such a promising building material for modern buildings.[6] Used for framing buildings and shelters, bamboo can replace expensive and heavy imported materials and provide an alternative to concrete and rebar construction, especially in difficult-to reach areas, post-disaster rebuilding, and low-income areas with access to natural locally-sourced bamboo**.**

Plain old wood still retains many advantages over more industrial building materials like concrete or steel because of its reasonable cost, ease of working, attractive appearance and adequate life if protected from moisture and insects.[6] Considering as building material if we cultivate more trees they do absorb CO2 as they grow and also they require much less energy-intensive methods to process into construction products. Properly managed forests are also renewable and can ensure a bio diverse habitat. Wood can be very flexible under loads, keeping strength while bending, and is incredibly strong when compressed vertically.[7] It contains highly-sought-after acoustic properties that can absorb sound and echoes.

There several tests have been conducted on high density rice straw elements plastered with cement skins.[8] Fire tests on cement plastered straw bales specimens sustained the two hour direct fire exposure without passage of the flame or even gases hot enough to ignite the internal straw to reach the opposite side of the plastered bales. In Bangladesh rice straw bales is locally available as an agricultural by product. A large scale usage of straw bales would minimize the cost of wall construction due to its easier accessibility as a recycled material (100% to 90%), at the same time making it more energy efficient. Besides proportion of environmental quality of straw bales specimens against ozone depletion effects during manufacturing phase and against toxic gases or waste construction phase is assumed 100%. When fire tests on cement plastered straw bales specimens were conducted, it was found that it could easily sustain two hours of fire exposure before deputizing the heat to the opposite of the walls. A saving of approximately 10% in the direct cost of the walls was achieved.[9]

Bricks

Brick is one of the major constituents in building construction operation. Burning of bricks requires an enormous amount of coal or fuels conflagration that adversely effects the environment by releasing proportionate amount of CO_2 and other Nitrogenous oxides (NO_x), responsible for Green- house effect, acid rain and other environmental calamities.

In recent years, experimental works and studies have revealed that usage of various types of blocks as an excellent alternative of red bricks that could be an optimizing solution for reducing environmental pollution and global warming.[10]

Autoclaved Aerated Concrete (AAC) is one of the eco-friendly and certified green building materials. AAC is porous, non-toxic, reusable, renewable and recyclable. Autoclaved Aerated Concrete also known as aircrete, is a lightweight, load-bearing, high insulating, durable building product, which is produced in a wide range of sizes and strengths.[11] AAC offers incredible opportunities to increase building quality and at the same time reduce costs at the construction site (AAC block). Its light weight and low thermal conductivity due to the presence of 50%-60% of air content. AAC has become a major building material in Europe and England. Moreover AAC consumes fly ash which is a waste product of thermal power plant. One square feet of carpet area with AAC blocks consume 1 kg of coal as fuel whereas consumption of coal for same amount of conventional clay bricks is 8 kg. From a comparison between AAC block and conventional brick, it has found that both materials have compressive strength of about 3 N/mm^2 ,also consumption of cement mortar by AAC block is 0.77 bag of cement/Cu.m[10] almost half of clay bricks consumption.

Concrete

Another major constituent of building construction or any another construction operation is concrete sometimes defined as ordinary portland cement concrete (OPC). 10 billion tons of concrete is produced in every year around this civilization.[12] Concrete itself is a very eco friendly material, but the problem lies in cementitious materials mixed with it. Almost one ton of CO_2 emits in the air for producing each ton of portland cement. Worldwide, the cement industry alone is estimated to be responsible for about 7% of all CO_2 generated.[13] Most often the debris of concrete demolition's proper disposal appears another challenging matter to deal with. Fly ash can conveniently be used as an important pozzolan with portland cement. Significant attributions of fly ash when used in concrete mixtures are- low heat of hydration, enhanced strength and durability properties, less expensive, proportionate reduction in CO_2 emission.[12]

Recycling concrete as aggregate offers a solution to the problems encountered with the quarrying of natural aggregates and the disposal of old concrete. The use of recycled aggregates is being practiced by numerous agencies. But the most concerning issues in case of using these materials is the quality control. For example, when recycled glass particles are used as substitution the chemical reaction between silica and alkali in the pore solution creates undesirable atmosphere.[14] However the problem of alkali- silica reaction (ASR) can be mitigated by using small sizes particles.[15] Along with it crushed concrete aggregate can be reused through proper recycling process for manufacturing new concrete mixes. Due to the higher water absorption of crushed concrete than brand new coarse aggregate the slump value of recycled concrete mixtures reduces significantly. Irregular shape of surface of recycled aggregates also affects workability of the mixtures. The above mentioning problems eradicates in a large quantity when a super plasticizer is used with concrete mixture. The reduction of compressive strength with a 20% substitute of recycled crushed concrete is about 13%, which might be tolerated as long as it is taken into consideration in the design stage.[4]

Recycled plastic

Recycled plastic is helping tremendously to save energy and landfill spaces. Recycled plastic can be blended with virgin plastic (plastic that has not been processed before) to reduce cost without sacrificing performance of Green building. Such recycled plastic are used to make polymeric timbers for making furniture or fences.

Columbian company " Conceptoplasticos'' recycles plastic into LEGO like building blocks that family can use to easily construct their own homes. With the building blocks locals can build their own houses, emergency shelters, community halls, and classrooms. Only 5 or 4 days are enough to assembly those blocks, and no construction experience is necessary.[16] By using some additives "ConceptosPlasticos" have made it as an earthquake and fire resistant building material easy to deal with. Due to heavy monsoon rainfall and melting of glacier in Himalayan regions, major rivers of Bangladesh reach beyond their capacity and overflow and so Northern country sides are severely affected by flood. Thousands of institutional buildings, schools, offices suffer by weathering action of water whose repairing cost is very high. If these buildings are made with such plastic blocks the repair and construction phase would be very easy to undergo. Water repelling properties will also play a potential resistance towards damage done by flood water. Plastic materials also have very good aesthetical potentialities which make them a sophisticated equipment for interior and outdoor design, In Netherland framework of "Ludwig Mies van der Rohe'sFransworth house" structure consists of 40,000 plastic for decorating floor to ceiling, double walled corrugated sheets. [17] During daytime, the translucent mass of crumpled shapes illuminates the interior. By night, huge 'curtains' turn into an abstract lantern in landscaped described by the architects associated with the project.

Fly ash

The cementitious properties of fly ash have been known for some time [18]. The utilization rates of fly ash vary greatly from country to country, from as low as 3.5% for India to as high as 93.7% for Hong Kong [13]. Fly ash can conveniently be used as an important pozzolan with portland cement and in the production of AAC block. Fly ash contains trace levels of trace elements (like e.g. Arsenic , barium, beryllium, selenium, molybdenum, and mercury) and therefore the potential of the gas to pollute ground water needs to evaluate .So a proper management of fly ash by recycling process ensures control over groundwater contamination and environmental pollution. In Bangladesh, recently the construction work of Rampal power plant is on the verge of initiation. One of the primal from this power plant will be fly ash wastes, with a discharge rate of 7.5 lakh tons per year. This huge amount of fly ash wastes is hard to handle and would create hazardous impact on Sundarbans which is an environmentally susceptible area. If the wastes can be recycled for AAC production it would bring a tremendous solution by ensuring sustainable development and environmental restoring in multipurpose ways. The disadvantage of using fly ash concrete where high early strength is required is its relatively slow rate of strength development.[12] But in such construction which involving mass concrete structures where early rate of strength development is not required can be used.

Recycled tires

In old days when recycling was not a familiar phenomena, nobody could even think of using dumped tires as a part of building material. As a consequence they simply went to landfills as wastes. But today with the revolution of recycling process old tires are being recycled to make new ones. The most common ways of recycling tires in cement composites and concrete is to use it as shredded, chipped, ground, or crumb rubber.[12] Crumble rubber manufactured from recycled tires can be a proper solution for adorning different floor kinds. They can also be used on a large scale for roofing system by ensuring related technical performance.(e.g. moisture/vapour transfer, flammability etc).[19] But the most effective use of crumbed rubbers are as waterproof membrane/damp proof course against underground seepage.

Ground granulated blast furnace slag (GGBFS)

GGBFS is a by-product of the steel industry that is the glassy granular material formed when molten blastfurnace slag is rapidly chilled, as by immersion in water [20] which has cemntitious properties having specific gravity of 2.9. It is experimented the optimum cement replacement level is to be about 50% and sometimes as high as 70% and 80%.[12] As fly ash do GGBFS also generates less heat of hydration and improves many mechanical and durability properties of concrete. Comparing with concrete made with Portland cement, Concrete containing GGBS cement has a higher ultimate strength, a higher proportion of the strength-enhancing calcium silicate hydrates(CSH).

Silica fume

Silica fume is a byproduct of semi-conductor industries. It can be used in powder form, a slurry or either blending with cement mixtures. For use in the UK, it is normally supplied as slurry, consisting of 50% powder and 50% water.[21] Water demand of concrete mixtures tend to increase with the increasing usage of silica fume. Improvement of strength and workability is the major advantages of using silica fume in concrete mixtures. For placing concrete in a long distance vertical member (e.g. column) practice of adapting silica fume with concrete mixtures have been proved as a convenient solution for proper consolidation. Concrete was pumped in a single operation to a height of 601 metresat the BurjKhalifa project in Dubai.[21] Sometimes

excessive bleeding leads to the layer formation of water on the top surface of the concrete. This bleeding is responsible for producing layer of weakness by forming plastic settlement cracks. Usage of silica fume has been proved as a remarkable solution to get rid of excessive bleeding. Due to the increasing amount of silica fume, the surface area of concrete mixture increases which results in a higher rate of water absorption. However as silica fume reduces bleeding a lot, proper care should have been taken during the curing stages for attaining desired properties of concrete.

Other materials

Several other materials can serve as green building materials after proper modification in their chemical and physical properties. Rice husk ash (RHa), an agricultural by product derived after burning rise husk, millions of tons are produced in rural areas of Bangladesh. It can be used as an excellent supplementary cementitious material for its cohesive nature when wetted.[12] Discarded sand from steel and glass industries id available for recycled. If these sands can be reused after proper recycling, extraction of sand from rivers will decrease, which would help to restore the environmental balance. Recycled carpet fibre can also be used as fibre reinforcement. Prior that, more studies and experimental works are need to be conducted on this subject matter. Hempcrete is a similar material resembles the property of concrete which created from the woody inner fibre of hemp plant. Hempcrete is a lightweight material and easy to transport and placing. Ferrock is a new material being recycled from materials including steel dust from the steel industry to create a concrete-like building material. It is even stronger than concrete. The more is this unique material as part of its drying and hardening process actually absorbs and traps carbon dioxide.

Conclusion:

In this paper we have discussed about the green materials that are available in Bangladesh or may have the possibilities of manufacturing through the installation of proper technologies. Some of these materials are used directly as building components and some need to recycle prior using. Implementation of these materials depends largely on the conditions, facilities and services to be provided by the building itself. Usage of these green resources in building construction effectively reduces CO_2, saves energy and helpful for creating a green environment. Installation of green building materials lessen up the hazardous health issues to the habitants. Quantity of wastes disposes in landfills comes down to a large scale, when reused and recycle in building construction. Practices of adapting these materials in building construction needs to spread to construction agencies by creating awareness of destructive features of conventional building materials, still penetrating our environment. Green building will boost up the movement for sustainable development which is a talkative solution to restore environmental balance around the world. These initiatives greatly reduce the life cycle cost of buildings. Advanced approaches toward a contextual sustainable economical step is necessary nowadays for developing a community. The construction sector, directly and indirectly creating a sensitive portion of environmental destruction, are responsible for promoting sustainable development by inaugurating more environmentally susceptible approaches to construction and building.

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