Locally available waste materials as partial Replacement in Construction Materials: A Review study

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Abstract - *This review paper chronicles the use of various natural materials in constructions of building as eco friendly. The use of eco friendly material for different components of buildings is discussed. Green buildings are one of the steps to relieve significant effects on environment and society. There is a rapid growth on number of studies on green buildings. This paper reviews about the available local waste materials and non-renewable resources which can be used in construction of building as replacement. Man made intercession has caused a gigantic impact on ecosystem. By this paper one can have knowledge about non degradable wastes in different regions of world like plastic, glass, fibres etc. This paper also consist some locally available materials like timber, bamboo etc as a replacement of reinforcements in buildings.. This paper focused on some of the eco friendly materials and non degradable wastes used for construction industries with low cost. Hence by this paper the researchers understand the use of waste in construction to make a sustainable, eco friendly and cost effective building.*

***Key Words*: Aggregates, compressive, tensile, rice husk ash etc.**

1. INTRODUCTION

Waste materials become real concern for humans in today's life. The main issue is to decompose these materials, as these are responsible for environment pollution. Because of this problem this has becomes the point of interest for researcher across the world. Therefore, utilization of non-biodegradable waste material in construction is rapidly growing. It was observed that these waste materials can be unchanged on earth for hundreds of decade without degradation and this issue of disposal of non-biodegradable waste will not solve itself and certain practical steps have to be taken for solving this problem. The construction of structure is increasing day by day. Hence it's a time of increasing strength and stability of structures by utilizing waste material and reduces the overall cost of structures.

1.1 BACKGROUND STUDIES

Several types of natural materials i.e., clay, sand & many more were used in concrete mix design by researcher across the world. It was observed that utilization of waste material as a partial replacement of materials in concrete results in mix which is eco friendly, less cost and leads to sustainable construction. Different guidelines were proposed by the researcher across the world regarding utilization of waste material & natural materials in different proportions which are discussed below.

Asamoah et al. [1] explores the ways of using bamboo reinforced concrete beams cost effective, efficient and simple for rural construction. In his study comparison of bamboo reinforced concrete beams with shear link which are made from different materials. The materials considered in this process are bamboo, rattan cane and steel. He tested sixteen (16) beams having two mix ratios cement: sand: coarse aggregates: water ratio) of 1:2:4:0.6 and 1:1.5:3:0.45. Concrete used by him for making of beams are made in cubes of size 100x100x100mm.he cured the beams at 25 degree room temperature for 28 days and at 100% humidity The study includes the cases of steel stirrups and no steel stirrups were recorded by him. He analyzed the cheapest way of providing shear reinforcement in bamboo reinforced beam by using a model. He concluded that the culms of bamboo which had been split along their horizontal axes show higher load capacity as compared to unreinforced concrete beam with bamboo. He also finds that to enforce the shear capacity of bamboo reinforcement one has to increase the amount of tension reinforcement and by adding additional web reinforcement. According to his BPI model he founds in his research that most economical method to provide stirrups in bamboo reinforcement is steel and most expensive are rattan stirrups. So he recommended the use of steel as stirrups in bamboo reinforcement to increase the load carrying capacity.

Maity et al. [2] compares the dwelling units made of bamboo as reinforcement in place of steel and evaluates the scope of using bamboo as reinforcement in place of steel. Various tests are conducted like two point test, tensile test and central loads test to examine the behavior of bamboo reinforced concrete members. He also estimates the cost of one and two bedroom dwelling units to get an idea of cost when bamboo used as reinforcement. The walls of dwelling units are made of bamboo mesh panels so that the walls are eco friendly and economical also. He used concrete which has high early strength cement so that crack obtained during swelling of bamboo can be reduced. In this process lean mixtures concrete with mix proportions of 1:2:4 of cement: fine aggregate: course aggregate and water to cement (43 grades PPC) ratio of 0.4, all measured by weight. Is used. Bamboo used in construction is allowed to dry for 2 to 3 days. Then he made the bamboo framework by cross linking the strips. Thick concrete of thickness 2,54cm is added in the framework and again another 2.54cm thick layer of concrete is laid on top of it. Then compaction of whole thing is done and cements sand and water mix finishing is done. Curing of this panel is done for 28 days to obtain a 70mm bamboo panel mat which is used as a slab. Foundation is made with cement concrete (1:2:4) pedestals over which timber columns rest. Columns are made of made of square section timber. Walls of thick asphalt, sand and aggregate (1:2:4) mortar coated bamboo mat panels are made. For holding the bamboo Sand panels vertically in position, an cross sectional timber section are used horizontally as well as vertically. Stone stolling which is smoothly finished by thick plain cement concrete (1:2:4) is used as flooring. Bamboo mesh slabs or tin is used as roofing material. After considering the cost of all members and their quantity he concluded that Cost of construction with Bamboo concrete mesh wall is Rs.26/ft2, brick wall has cost of Rs.40/ft2 and mud wall have Rs.5/ft2.he concluded that bamboo concrete panels have quite higher strength then mud walls. He also recommended using bamboo in flood prone areas because mud walls easily washed away in flood areas. .he also finds that by using asphalt coating increases the bond between bamboo and concrete.

Sakaray et al. [3] compare the properties of bamboo as reinforcing material with steel. He conducts following test (1) Tensile test, (2) Modulus of Elasticity „E", (3) Compressive test (4) Water absorption test. To find out the mechanical properties of bamboo he suggested to use 3 years old bamboo (brown in color) .he used well seasons culms of bamboo in this research. for reducing swelling of bamboo , "ALGICOAT RC-104 is used as waterproofing agent . Hysd bars are used to compare the bond strength of bamboo. M30 (1:1.5:3) grade mix concrete used in the present study as per IS-456:2000 specifications. The average Modulus of elastic value is 1.5 x 104 N/mm2 while steel is 2 x 105 N/mm2.. From present study the average tensile strength of moso bamboo is 125N/mm2, which is half the strength of mild steel. Compressive strength of bamboo is 108.19N/mm2 which is nearly same to steel. Due to surface smoothness of bamboo the bond strength of bamboo as compared to steel with concrete is very low. Waterproofing agent is recommended as Water absorption of bamboo is very high .from all experiments in this research, he concluded that bamboo can be used in place of steel reinforcement. By using bamboo which is an eco friendly material, carbon dioxide emission due to steel can be limited; he recommended the use of bamboo in green building.

Sethy et al. [4] examine the use of aerated concrete in place of normal concrete. He prepared Aerated concrete by using:-

1) Cement:-OPC 53 which provides high strength and durability to structures (As per IS: 12269)

2)sand- natural sand having silica content not less than 80% and sieved properly through 4.75 mm sieve to take out the pebbles or organic matter (as per IS 383-1970)

3) Lime: class c lime is used **(**As per IS 712-1973)

(4) Aluminium Powder: - used as a foaming agent in aerated concrete production. Aluminum powder with grain size less than 100μm and particularly with fractions less than 50μm is used.

5) Water:- free from alkalinity and acidity.

Mould size of (150×150×150) mm is taken and weighing of the raw materials is calculated as per the proportion as per IS 2185 (Part-3).he mixed cement sand and lime in a tray for 3-4 minutes and mixing is done by adding alumina powder in the mixer. Then addition of water is done and mixed for 2-3 minutes. Slurry was pounder in the mould up to one third height of mould on reaction of alumina with cement and lime hydrogen bubbles were formed, to reduce it volume of mixer was increased within 10 to 15 minutes. Demoulding of mould is done after 8-10 hrs. by this research he concluded that with the help of aluminium powder Aerated concrete blocks of strength between 4.84-5.98 (N/mm^2) can be prepared .he also said that replacement of bricks can be done with Aerated concrete blocks.

Nagaraja et al. [5] investigates the production of compressed earth blocks With stabilized laterite soil for construction of low-cost housing construction. Some chemicals like Algiplast 210N, Conplast SD110 and red soil is used in this study. Manufacture of compressed stabilized earth blocks by using chemicals is examined in this study. For compressive test specimen is examined under CTM machine. Soil is mixed with suitable proportion of lime, fly ash, cement and chemicals and compressed manually. He concluded that soil stabilized with 10% of Algiplast 210N and cement SD110 is of 1.0% & 0.3% respectively, water absorption of 21.54% was achieved which is high but the highest compressive strength of 4.949N/mm2 was achieved .thus from this study, it was concluded that Stabilized compressed earth blocks can result in less waste, faster construction and also eco friendly.

Ahmad et al. [6] studied the locally available earth material in Awantipora, Jammu and Kashmir which is famous in pottery is taken and different percentages of OPC is mixed in production of Cement stabilized earth blocks. In this research curing of CSEB's sample and compressive strength under wet and dry conditions, water absorption, compaction characteristics was tested to determine the strength and to find out the optimum dosage of cement (opc) required. locally available sand is taken and opc 53 confining to IS 8112 was used throughout the work .mixing of ingredients is taken out with varying proportions and mixed is placed in block mould and then curing of 28 days is carried out. Strength determination without curing ie. Dry Compressive Strength (DCS) and with curing i.e. Wet Compressive Strength (WCS) on UTM/CTM from this study it can be concluded that when cement content is increased up to 10% increase there is corresponding increase in optimum moisture content and after that optimum moisture content remains constant. He also found that 70% to 80% of strength is achieved within 14 days.

Bharath et al. [7] carried out a work to make adobe blocks using locally available soil in banglore as blocks are made up of soil so they are prone to shrinkage. In this study an attempt is made to make the blocks stabilized using lime and cement in varying proportions. In general adobe means stabilized sundried mud brick. soil having specific gravity of 2.55 is used in this study which is obtained from BEML LAYOUT site in Banglore. Hydrometer analysis on this soil showed the presence of 21% clay and 29% silt particles.opc 53 with 50 minutes of initial setting time and 200 minutes of final setting time is used. Slaked powdered limestones are used in this study. Mould of dimensions 230mm X150mm X 100mm is used to fill the mix and then soft compaction is done by dropping small smooth balls from height of 0.5 m so that voids are not produced and in last compaction is done by hands to avoid honeycombing. Levelling of mould is done by trowel and demoulding is done by tilting mould upside down, and then in first ejection of plate is done. Curing of blocks are done by covering them with gunny bags. as per IS1905 minimum strength required for building block to used as masonry is 3 Mpa .in this study average wet and dry compressive strength of adobe blocks are 4.4mpa and 6.083 which is more than required. Also water absorption is less than 20% which is less than the codal provision .hence by this study comparison of these blocks can be made with ist class bricks, hence making it an alternative and eco friendly source for building blocks rather using burnt bricks.

Muthadhi et al. [8] studies the identification the effect of RHA (which is produced under controlled conditions) on performance characteristics of the concrete.10% to 30% replacement of opc is done with RHA. This study include the investigation of compressive strength, chloride permeability, water absorption of RHA blended concrete. Materials used in this experiment are:-

1. OPC 53(IS 1987)
2. 2. Locally available river sand with fineness modulus of 2.62
3. 3. Crushed granite stone aggregate of 20-mm (maximum) size was used as fine aggregate and coarse aggregate, respectively
4. 4. Locally available rice huskis put in electrical box under controlled conditions.
5. Polycarboxylic ether polymer (super plasticizer) used as the water-reducing agent in concrete mixtures.

Four concrete mixtures consisting of partial replacements of cement with RHA by 10, 15, 20, and 30% by mass. The dose of super plasticizers' was adjusted in each sample to achieve a slump in the range of 75 to 100 mm. In this study Compressive strength of RHA-blended concrete cubes was determined at 3, 7, 28, and 60 days. According to ASTM C1202(ASTM 2001). Resistance to chloride ion penetration in terms of total charge passed in coulombs through RHA-blended concrete is measured after 60 and 90 days of curing. According to ASTM C642 (ASTM 2006) Water absorption of RHA-blended concrete is measured after 28 and 90 days of curing. Based on the results found by him he concluded that there is increase in compressive strength with addition of RHA up to 20% in partial replacement of ordinary Portland and beyond 20% there is reduction in compressive strength. Also as per ASTM C1202 (ASTM 2001) addition of RHA reduced the chloride permeability of concrete from a low to very low rating (≤1,000 coulombs). For 30% RHA maximum reduction in water absorption was achieved. as per laboratory conditions The production cost of RHA arrives to be Rs. 16.50 per kg. This study lead to fact that strength of concrete at all ages can be increased with addition of rice husk ash. And upto 30% replacement of RHA with cement shows no change in strength and durability.

Kou et al. [9] studies the use of recycle aggregates with 0, 20, 50, and 100% by weight replacements of natural aggregate .in this study authors took water-to-binder W/B_ ratios of 0.45 and 0.55 to make to prepare two mixtures. He used ASTM Type I Portland cement and ASTM Class F low-calcium fly ash in preparing the mixture. Aggregates used in this study are recycled concrete aggregate with nominal size of 10mm and 20mm.fine aggregate used is river sand. sulfonated naphthalene formaldehyde condensate is used as a superplasticizer to control the slump value between 100-150mm.in this study use of 150*300 mm cylinders are used for creep test. Additionally,100*200mm cylinders for tensile splitting strength, static modulus of elasticity, and resistance to chloride ion penetration of concrete. Curing of specimens are done at a temperature of 27±1°C up to the testing age. at the ages of 1, 4, 7, 28, and 90 days. Compressive and splitting tensile strengths were measured. at the ages of 28 and 90 days modulus of elasticity of concrete was determined. By conducting test authors found the decrement of compressive strength, tensile splitting strength, and modulus of elasticity when there is an increment in the natural recycled aggregate. Also he founds that with addition of fly ash in natural aggregates as partially replacement of cement there is again decrease of strength. But founds the decrement of drying shrinkage in this case. Also he concluded that partiall replacement of fly ash in place of cement increased the creep of concrete which results in long development of strength .due to pozzolanic reaction of fly ash.

Achal1 et al. [10] investigates the study of compressive strength of mortar with addition of bacterial cells. This study includes the Addition of Bacillus sp. CT-5 in cement mortar and finds the water penetration level. The materials used in authors study are opc cement, naturally available sand from local areas having 2.89 as fineness modulus, isolated Bacillus sp. CT-5 from commercial cement by serial dilution technique. the ratio of 1:3 (cement to sand) by weight is taken and 0.47 (water to cement).Authors used 70.6mm of cube as mold as per IS 4031-1988.then addition of Bacillus sp. CT-5is done in sand cement mixture with a optical density of (600 nm) of 1.0.then compaction and vibration of cubes are done and demoulding is done. Curing is done in a NBU medium at room temperature and compression test was carried out after 3 , 7, and 28 days on COMPTEST 3000 (AIML Ltd. New Delhi, India).then the control specimen is prepared in which there is a replacement of bacterial culture in NBU medium. Also sorptivity test is performed to determine the water penetration. The mortar specimens are covered with 2 layers of polysiloxane and 1 layer of silicon paint at the four edges which are adjacent to the treated side and then cured at 45 degree in oven. In last authors founds the result that the cubes which are incubated in CT-5 shoes higher compressive strength (31 MPa) then those which are incubated in water (23MPa).this is due to fact that caco3 is deposited within the cement-sand pores and on cell surfaces. Also this experiment shows that six times less water absorption occurs in cubes which are treated with Bacillus sp. CT-5 .this is again due to the deposition of layer of caco3.hence in last authors concluded that Bacillus species can remediate the cracking of concrete and found an alternative of high-quality concrete sealant which is eco friendly and less expensive.

Rissanen et al. [11] studied the replacement of fly ash from fluidized bed combustion with cement .the residue left after combustion of peat and forest industry contains fly ash is used in this study. natural sand(Puhallushiekka, Fescon, Hyvinkää, Finland)is used in this study. Before it is used as cement replacement it was milled to the same particle size as cement with a tumbling ball mill, resulting in milled sand .aggregates used in this study was of CEN standards. Cement used in this study is of CEM II/B-M (S-LL) 42,5 N [designation according to cement standard EN 197-1 (SFS 2012)]. This cement contains 6–15% limestone and 15–25%blast furnace slag. when 40% of the cement was replaced by biomass fly ash for maintain the consistency of mortar mixtures A polycarboxylate-based superplasticizer agent (SemFlow ELE 20, Semtu, Kerava, Finland) was used. Samples were prepared with replacing CEN stand sand with 10, 20, and 40% of the cement. Similarly milled biomass fly ash is replaced with cement with 10, 20, and 40%(includes addition of superplasticizer).curing of specimens is done at 22.5°C. by this experiment, authors conclude that with replacement of milled fly ash (10%and 20%)with cement same compressive strength(more than 90%) is achieved. While the replacement of milled sand as cement there is decrease in flexure strength at 40%,and at 20% replacement of both milled sand and milled fly ash specimen shows the same flexural strengths as at 10% replacement.

Subramaniaprasad et al. [12] investigated the tensile strength behaviour of plastic-fiber-reinforced soil using the split tensile strength test so that it can be used in soil masonry blocks. Author used OPC 43 as a stabilizer, two types of fibres are used - polyethylene terephthalate (PET) bottles and other is carry bags (pick up bags) . Chopping of plastic bottles is done up to minimal width of 2mm and 2cm of length. 0.1 and 0.2%(by weight of soil) of fibres were taken .compaction pressure is regulated by digital compression testing machine(capacity of 1000kn) and least count of 100N and molding pressure interval of 1.25-MPa (from 1.25-MPa to 7.5-MPa).before mixing ,limps of natural soil is to be broke ,and then sieving is done to remove larger particles. During mixing fibres are added by hand in order to achieve homogeneous soil cement- fiber matrix. Then the mix is added in a cylindrical specimen (101.5 mm as dia. 117 mm as height, and 50mm as collar height on top) and conventional method of tapping is done and in last removal of mould is done. Then curing is took place with moist jute bags for 28 days. And air drying is done in laboratory before testing of specimen. By this study, authors concluded that increasing rate of spilt tensile strength with molding pressure is found to be same irrespective of the cement content but soil containing no fibre this rate is very low as compared to soil containing fibre. Author also seen that in non stabilized raw soil if fibres is added show some amount of increment in tensile strength at low moulding pressure. While due to bond strength between soil and fibre at high molding pressure there is a huge increment in tensile strength. This is due to the function of cement. Thus author concluded that for increment tensile strength in plastic soil fibre and to improve ductility ,the soil should be stabilized with cement.

Durante et al. [13] assessed the use of sewage sludge in manufacturing of soft mud bricks. Authors determine the maximum percentage of sludge that can be incorporated in soft mud bricks that resulted in environment friendly and technical bricks. The authors took two clays clay A(high plastic) and clay B and treated sludge(containing 50% less sio2 then clay) which is drained from a dry bed. Clay had lower percentage of CaO and KO2 and high percentage of Al2O3 and SiO2.author finds out the best proportion of 2 clays i.e. 2:3 before manufacturing of bricks. Then the bricks(220 × 105 × 45 mm) are manufactured in kiln with 5,10,15,20,25,30,35,40% sludge. The results obtained from observations showed that bricks containing more than 25% of sludge exhibits cracks, damaged corners and edges. He also examined that the bricks made with 35% of sludge are very brittle while more than 40% of sludge made bricks are fractured. So they are removed from the experiment. Bricks with 10 and 25% sludge showed dramatically change in the dimensions. This study also showed that bricks made with 25 and 30% meet the required standard. Bricks manufactured with 5% sludge showed the loss of 45% strength, while there is decrement of reduction in strength of bricks which are made from 10 and 20% , but still these bricks attained the minimum strength according to the norms. He also examined that the bricks made from sludge percentage of 15 and 20% are characterized as 2nd class brick. So in lat this study showed that the maximum percentage of sludge that can be added in a mass to meet the desired standard is 20%.

Kazmi et al. [14] examined the study of using waste glass sludge (WGS) in clay bricks as a secondary material. The wGs used in this study was collected from the glass industry while polishing and scaling of glass. Manufacturing of brick specimens is done by various dosages. (i. e. 5, 10, 15, 20, and 25% by clay weight) of WGS in kiln. Clay used in this study was collected from local kiln located in Mirpur Azad Kashmir, Pakistan.WGS is white colored residue which is obtained from lass industry while polishing process.mix is prepared by adding WGS and clay with different ratios. Then adding of water is done and mixing is done until homogenous mixture is achieved. then mix is added in a specific mould to make a brick of size 228 × 114 × 76 mm. then bricks are dried for 3 days in sunlight under a rain protected shed and then dried bricks are burn in kiln at 850°C for 36 hrs. In this study chemical composition of raw materials was determined using X-ray fluorescence (XRF), which shows that clay composed of 58.35% of silica and 2.71% of alumina and WGS composed of 62% of silica and some amount of sodium oxide, calcium oxide, magnesium oxide, and aluminum oxide. Authors found that loss of ignition is higher for WGS (24%) than clay(4%) which can increased porosity of bricks. By this experiment authors founds that due to addition of WGS shrinkage reduced to a great extent i.e. brick specimen without WGS shows 5% of shrinkage and with WGS addition reduced to 3%.Also with addition of WGS there is a decrement of Weight per unit area of brick which leads to lighter weight of bricks. by this he concluded s that WGS added brick leads to eco friendly bricks and economical. When bricks are tested for compressive strength, it was found that compressive strength without Wgs have 10Mpa strength while With Wgs shoes 13Mpa strength. Hence in last authors concluded that with addition of WGS shrinkage reduced, compressive strength increased, porosity decreased, weight of bricks decreased, water absorption decreased, efflorescence decreased. Finally based on the above study, it can be concluded that WGs can be added in clay bricks in large production level leads to more sustainable, eco-friendly and economical construction.

Munir et al. [15] examined the study of using recycled waste Marble powder (WMP) as secondary product in eco-friendly burnt clay bricks. In this study WMP was collected from local industry and added in clay bricks with a dosage varies from 5 to 25% (by clay weight).clay and WMP used in this study was collected from Mirpur (Azad Kashmir), Pakistan.mix is prepared by adding WMP in dry clay, and then wet mixture is prepared by adding water as per ASTM D4318.then the bricks are placed into 228 × 114 × 76-mm brick molds, Bricks were sun-dried for 3 days and then burnt at 800°C for 36 h. after 45 days bricks are retrieved for testing. By experimenting bricks author concluded that there is reduction in shrinkage of bricks which incorporates 25% of WMP, reduction in weight of bricks, reduction in compressive and flexural strength of bricks but the bricks which had 10% addition of

WMP meets the minimum requirement of strength according to the standards. also there is increase in porosity of bricks by addition of WMP but bricks having 5% of WMP(water absorption less than 22%) can be used in moderate climate .hence in last authors concluded that addition of 5% of WMP leads to non-hazardeous, eco friendly and economical construction. Also solve the problem of decomposition of this by-product (WMP) in landfills

3. CONCLUSIONS

On the basis of past studies, several methods were identified for utilizing different waste materials i.e. Plastic waste, agriculture waste, industrial waste and many more in structural construction resultant in a sustainable environment. Use of different waste materials as the replacement of concrete compounds was found appropriate for the building construction as different properties of concrete were found to be increased or within the limit as specified by Indian standards. Therefore, waste material can be utilized in the construction for economical and sustainable construction. From the present study, it is revealed that the waste materials can be utilized to create a sustainable development without compromising the actual requirements (i.e. strength). From the future point of view, a study can be extended by proposing an alternative of concrete (based on waste material) for construction of structural elements or maximum utilization of waste material by mixing these wastes in the combined manner (by looking at their chemical properties) in order to replace the concrete partially or fully.

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