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Engineering & Technology in India www.engineeringandtechnologyinindia.com
Vol. 1:5 December 2016
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Managing Structural Raw Materials by Replacement of Concrete Materials with Fly Ash, M-Sand, Coconut Shell & Bamboo

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Abstract

Conventional Structural elements such as beams, slabs and columns may require strengthening during their service life period. The need for strengthening and rehabilitation of existing structures is, in general, caused by the following main reasons increase of service load levels; material degradation; design construction defects; new code requirements. The objective of this work is a systematic assessment of the performance of the RC by replacing the materials of the concrete partially. The assessment is focused on prediction of the ultimate axial strain of the concrete. Bamboo is a versatile material because of its high strength-to-weight ratio, easy workability and availability. Bamboo needs to be chemically treated due to their low natural durability. It can be used as Bamboo Trusses, Bamboo Roofs Skeleton, Bamboo walling/ceiling, Bamboo Doors and Windows, Bamboo Flooring, Reed Boards, Scaffolding. Properties of concrete with bamboo as reinforcement replacement were studied. Control concrete and coconut shell concrete with 20% coarse aggregate replacement with coarse aggregate were made. Three mixes with Fly ash, coconut shell, M-sand were also made to investigate the effect on partial replacement of bamboo.

Key Words: Material Degradation, Green Structural Elements, Alternative Raw Materials, Concrete Raw Materials, Fly Ash, Bamboo, Coconut Shell.

Introduction

General

Structural elements such as beams, slabs and columns may require strengthening during their service life period. The need for strengthening and rehabilitation of existing structures is, in general, caused by the following main reasons increase of service load levels; material degradation; design construction defects; new code requirements.

Composite materials are engineered or naturally occurring materials made from two or more constituent materials with different physical or chemical properties which remain separate and distinct within the finished structure.

Objectives

- The objective of this work is a systematic assessment of the performance of the RC by replacing the materials of the concrete partially. The assessment is focused on prediction of the ultimate axial strain of the concrete.

The Proposed work is plan to achieve the following:

- To investigate strength of replaced materials as a retrofit for cubes, cylinders and beams.
- To determine the compressive strength, tensile strength and flexural strength of M_{20} grade normal concrete and replaced materials concrete

History

Through research it has been found that some species of bamboo have ultimate tensile strength same as that of mild steel at yield point. Experimentally it has been found that the ultimate tensile strength of some species of bamboo is comparable to that of mild steel and it varies from 140N/mm2- 280N/mm2. Bamboo is a versatile material because of its high strength-to-weight ratio, easy workability and availability. Bamboo needs to be chemically treated due to their low natural durability. It can be used as Bamboo Trusses, Bamboo Roofs Skeleton, Bamboo walling/ceiling, Bamboo Doors and Windows, Bamboo Flooring, Reed Boards, Scaffolding.

I. Strength Properties of Bamboo

It has also been found that bamboo acts very well in buckling but due to low stresses than compared to steel and due to it not being straight it may not be very good. Further, it has been established that in seismic zones the failure of bamboo is very less as the maximum absorption of the energy is at the joints. Cellulose is the main component present in bamboo which is the main source of mechanical properties of bamboo.

Some specific properties of Bamboo are as given below:

- Specific gravity - 0.575 to 0.655
- Average weight - 0.625kg/m
- Modulus of rupture - 610 to 1600kg/cm2
- Modulus of Elasticity - 1.5 to 2.0 x105kg/cm2

Replacement of Steel by Bamboo Reinforcement

- Ultimate compressive stress- 794 to 864kg/cm2
- Safe working stress in compression - 105kg/cm2

Safe working stress in tension It has also been found that bamboo acts very well in buckling but due to low stresses than compared to steel and due to it not being straight it may not be very good. Further, it has been established that in seismic zones the failure of bamboo is very less as the maximum absorption of the energy is at the joints. Cellulose is the main component present in bamboo which is the main source of mechanical properties of bamboo.

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- Safe working stress in compression - 105kg/cm2
- Safe working stress in tension - 160 to 350 kg/cm2
- Safe working stress in shear- 115 to 180 kg/cm2
- Bond stress - 5.6kg/cm2

II. Selection and Preparation of Bamboo Selection

The following factors should be considered in the selection of bamboo culms (whole plants) for use as reinforcement in concrete structures:

- Use only bamboo showing a pronounced brown colour. This will insure that the plant is at least three years old.
- Select the longest large diameter culms available.
- Do not use whole culms of green, unseasoned bamboo.
- Avoid bamboo cut in spring or early summer. These culms are generally weaker due to increased fibre moisture content.
- Preparation
- Sizing- Splints are generally more desirable than whole culms as reinforcement. Larger culms should be split into splints approximately 3/4 inch wide. Whole culms less than 3/4 inch in diameter can be used without splitting. Splitting the bamboo can he done by separating the base with a sharp knife and then pulling a dulled blade through the stem. The dull blade will force the stem to split open; this is more desirable than cutting the bamboo since splitting will result in continuous fibres and a nearly straight section
- Seasoning- When possible, the bamboo should be cut and allowed to dry and season for three to four weeks before using. The culms must be supported at regular spacing‟s to reduce warping.
- Waterproof Coatings- When seasoned bamboo, either split or whole is used as reinforcement; it should receive a waterproof coating to reduce swelling when in contact with concrete. Without some type of coating, bamboo will swell before the concrete has developed sufficient strength to prevent cracking and the member may be damaged, especially if more than 4 percent bamboo is used.

Classifications of Fly Ash

Two classes of fly ash are defined by ASTM c618: class F fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned.

Class F Fly Ash

The burning of harder, older anthracite and bituminous coal typically produces class F fly ash. This fly ash is pozzolanic in nature, and contains less than 7% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime mixed with water to react and produce cementitious compounds. Alternatively, adding a chemical activator such as sodium silicate (water glass) to a class F ash can from a geopolymer.

Class C Fly Ash

Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, class C fly ash hardens and gets stronger over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike class F, self-cementing class C fly ash dose not require an activator. Alkali and sulfate (SO_4) contents are generally higher in class C fly ashes.

At least one US manufacturer has announced a fly ash brick containing up to 50% class C fly ash.

Experimental Work

General

A total number of 12cylinders and 12 cubes, 6 cylinders and 6 cubes are made by normal mix concrete and 6 cylinders and 6 cubes are made by GFRP wrapping. Here the thickness of wrapping is kept constant and to be tested to study the confining effect.

Material Properties

M_{20} grade of concrete is used for casting the test specimen with the following details.

- Cement - PPC 53 grade is used through out the thesis.
- Fine aggregate - natural sand (river sand) passing through IS sieve no 7(1.18).
- Coarse aggregate - crushed gravel (angular) maximum size of 20mm.
- Water - portable quantity.
- Fly ash
- Manufacture sand
- Coconut shell
- Bamboo

Mould

(i) Cylinder size : Asbestos cement pipeof diameter 100mmand length 200mm.

Fig 1

(ii) Cube size : 10mm x 150mm x 150mm.

(iii)

Fig 2

(iii) Beam size :150mm x 150mm x 700mm.

Fig 3

Experimental Work

General

A total number of 6 cylinders, 6 cubes& 2 beams, 3 cylinders, 3 cubes & a beam are made by normal mix concrete and 3 cylinders, 3 cubes& a beam are made by replacing materials. Here the percent of replacing materials are kept constant and to be tested to study the confining effect.

Details of Test Specimen

- Cylinders of diameter 100mm and length 200mm, cubes of 150mm x 150mm x 150mm and beams of.
- M_{20} grade concrete with 20mm and 60mm maximum size aggregate were used.

Test Setup and Test Procedure

Compressive Strength

Axial loading from the device are applied to the specimens (6 cube specimen), where the specimen should be placed at the center of the machine. Compressive from the machine is applied until fracture occurs at the ultimate strength of the specimen. The machine indicator indicates the compressive force of fracture, and from that the compressive strength of the specimen is calculated from the formula:

$$\textbf{Compressive strength} = P/A$$

Where,

P = Compressive load

A = Area of specimen

Tensile Strength

This test is held on the cylindrical specimens (6 cylindrical specimens), where the cylinder is placed in the same machine that is used in the compressive test but this time the cylinder is placed with its axis horizontal. Two pieces of wood are placed between the machine plates and the specimen so that the applied force is uniformly distributed.

The reading of the maximum load from the machine is taken at the fracture of the specimen, and from that the tensile strength of the specimen is calculated using the formula:

$$\textbf{Tensile strength} = 2P/(\pi LD)$$

Where,

P = Tensile load

L = Length of cylinder

D = Diameter of cylinder

Flexural Strength

Flexural strength also known as modulus of rupture, bend strength or fracture strength is a material property, defined as the stress in a material just before it yield in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross section is bent until fracture or yielding using a 3 point flexural test technique. The flexural strength represent the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol σ

Conclusion

Fly Ash, Coconut Scalp and Bamboo needs to be chemically treated due to their low natural durability. It can be used as Bamboo Trusses, Bamboo Roofs Skeleton, Bamboo walling/ceiling, Bamboo Doors and Windows, Bamboo Flooring, Reed Boards, Scaffolding. Properties of concrete with bamboo as reinforcement replacement were studied. Similar alternative raw materials for conventional methods will develop a better green environment for sure in the future for the betterment of the Human community and Society.

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