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Investigation on Strength of Ternary Concrete Beams Retrofitted Using Chicken Mesh

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Abstract: Industrial and agricultural wastes produced by industrial processes has been the focus of waste reduction research for certain technical reasons. Replacement of cement by blended proportion of agro-industrial waste product of particular percentage can reduce the emission of greenhouse gases to a great extent. Typically, concrete structures are very durable, but sometimes they need to be strengthened. The reason may be cracking due to environmental effects, that a damage resulting from earthquakes. Here ternary beams are strengthened by chicken mesh provided in two layers on three faces of concrete beams. Both strengthened and non-strengthened beams contain 20% cement replaced by 40% Bagasse Ash and 60% GGBS blended combination and beams of M30 grade concrete were cast. This paper mainly compared ternary concrete beams with strengthened ternary beams using chicken mesh in terms of its strength carrying capacity and deflection characteristics.

Index Terms: GGBS, Bagasse Ash, Ternary beams, Chicken mesh

I. INTRODUCTION

Concrete is a composite material composed of water, granular material (the fine and coarse aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together. Admixtures are defined as materials other than aggregate (fine and coarse), water, fiber and cement, which are added into concrete batch immediately before or during mixing. Additive is a material which is added at the time of grinding cement clinker at the cement factory. They are used to modify the properties of ordinary concrete so as to make it suitable for any situation. Today concrete is most widely used construction material due to its good compressive strength and durability. It is estimated that the present consumption of concrete in the world is of the order of 10 billion tones every year. As GGBS is a by-product of iron manufacturing industry, it is reported that the production of one ton of GGBS would generate only about 0.07 tonnes of CO_2 equivalent and consume only about 1300 MJ of energy and similarly bagasse ash is a byproduct of sugar cane industry. The utilization of bagasse ash and GGBS result in cement saving, energy saving and cost saving, environmental and socio-economic benefits due to the decrease in energy and resource consumption during manufacturing of Ordinary Portland Cement. Utilization of GGBS and bagasse ash is a solution for sustainable development.

Here a particular proportion of blended agro industrial waste ie 40% Bagasse ash and GGBS (Ground Granulated Blast furnace Slag) is used as supplementary cementitious material in concrete. Concrete structures often have to face modification and improvement of their performance during their service life. The main contributing factors are change in their use, corrosion, contact with external aggressive environment and earthquakes. In such circumstances there are two possible solutions: replacement or retrofitting. Full structure replacement might have determinate disadvantages such as high costs for material and labour. When possible, it is often better to repair or upgrade the structure by retrofitting.

In this work ferrocement jacketing technique is used to strengthen the ternary beams.

II. MATERIAL DESCRIPTIONS

A. Cement

The Ordinary Portland Cement [OPC] (43 grade according to IS8112:1989) used in the present work is of Dalmia brand. The term cement is commonly used to refer the powdered materials which develop strong adhesive qualities when combined with water.

B. Aggregate

Coarse aggregate of 20mm size is used whereas M-sand is used as fine aggregate.

C. Bagasse ash

Bagasse ash used in this project was sieved through 300 micron sieve and the ash passing through 300 micron sieve was rolled on abrasion testing machine with steel charges. Bagasse ash was sieved through 300 micron sieve to remove the unburned particles. The rolled Bagasse ash was then sieved through 90 micron sieve to make the fineness of Bagasse ash as same as cement. The Bagasse ash for the project was collected from Ponni sugar industry, Erode, Tamilnadu.

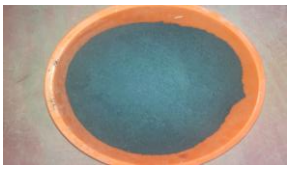

Fig. 1. Bagasse ash

D. Ground Granulated Blast furnace Slag (GGBS)

Ground granulated blast furnace slag is obtained by quenching molten iron slag from a blast furnace in water or steam to produce a glassy granular product that is then dried and ground in to fine product. GGBS is used to make durable concrete structures in combination with ordinary Portland cement and other pozzolanic materials.

Fig 2. GGBS

E. Chicken Mesh

Chicken mesh here used is hexagonal in shape. This chicken mesh is provided in two layers in three faces of cracked beams for strengthening purposes.

Fig 3. Chicken mesh

F. Superplasticizer

The use of superplastisizers permit the reduction of water to the extend upto 30 percent without reducing workability. These polymers are used as dispersants to avoid particle segregation and to improve the flow characteristics of suspensions. Their addition to concrete or mortar allows the reduction of water to cement ratio, not affecting the workability of mixtures and enables the production of self-consolidating concrete and high performance concrete. In this work we use the super plasticizer Master Glenium sky 8233, it is a high performance super plasticizer based on polycarboxylic ether for concrete.it is used in high performance concrete where highest durability and performance is required.it is free of chloride and low alkali.

Fig. 4. Master Glenium sky 8233

G. Concrete mix proportion

Concrete mix proportion of M30 grade is shown in Table I.

TABLE I
MIX PROPORTION

Water	Cement + pozzolana	Fine aggregate	Coarse aggregate
186	511.50	581.19	1054.40
0.3636	1	1.136	2.061

III. DETAILING OF NON-RETROFITTED BEAMS

Size of non-retrofitted beam is 100mm x 100mm x 500mm. Cement is replaced by 0%,10%,20%,30% by 40% and 60% bagasse ash and GGBS blended pozzolana. Detailing of non-retrofitted beam is shown below.

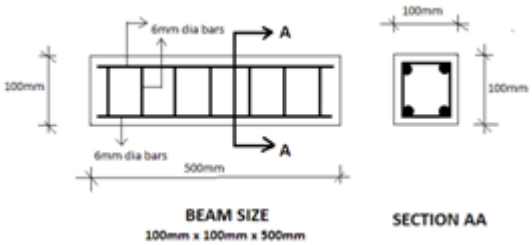

Fig. 6. Non-retrofitted beams

IV. DETAILING OF STRENGTHENED BEAMS

Size of non-retrofitted beam is 100mm x 100mm x 500mm whereas 1:2 ratio of cement mortars of blended proportion (40% is applied along with two layer chicken mesh. Then new dimension of retrofitted beam is 150mm x 150mm x 500mm. Detailing of retrofitted beam with chicken mesh is shown below.

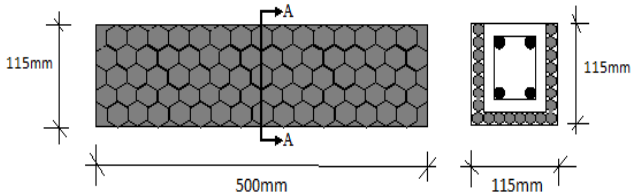

Fig. 7. Retrofitted beams

V. CASTING OF NON-RETROFITTED BEAM SPECIMENS

Beams have the dimensions of overall length 500mm and cross sectional area of beam is 100mm x 100mm. Two 6mmΦ HYSD bars of Fe415 grade were provided at bottom as tension reinforcement and two 6mmΦ HYSD bars of Fe415 grade at top as stirrup holders. Two legged 6mmΦ stirrups were provided as shear reinforcement.

Fig. 7.Casting of beam specimens

VI. STRENGTH OF NON-RETROFITTED BEAMS

Flexural tensile strength test is conducted to determine the flexural tensile strength of reinforced beam of size (100mm x 100mm x 500mm). Procedures are as follows:

1. The specimen of (control mix, 30%, 20%,10% replacement specimens) from curing tank were taken and cleaned the surface.
2. Center, supports and one-third distance from either support were marked.
3. Placed the specimen in the testing machine and apply load at the rate of 1.8 kN/min without shock.
4. Noted down the breaking load and appearance of the fractured faces of concrete.

Fig. 8.Testing of beam specimens

Flexural strength of steel reinforced beam was studied by flexural test and results obtained are reported in table. Here we can see that maximum flexural strength test is obtained in 30% replacement of cement (T30). So this T30 beams are again cast for strengthening tests.

TABLE II
ULTIMATE LOAD CARRYING CAPACITY OF NON-RETROFITTED BEAMS

Specimen	**Cement replacement %**	**Glenium sky dosage (% mass of binder)**	**Average Ultimate load (kN)**
T30%	30%	0.6%	48
T20%	20%	0.7%	45.66
T10%	10%	0.5%	43
Control Mix	0%	0.3%	44

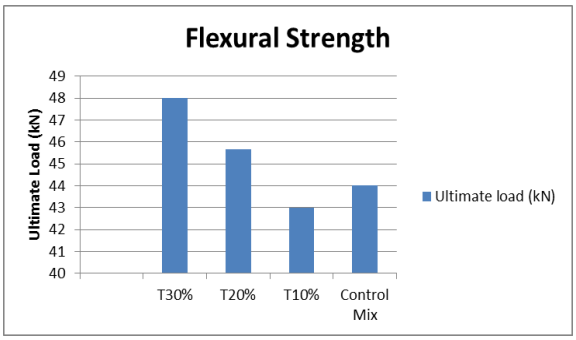

Fig. 9.Graph showing ultimate load of non-retrofitted beams

VII. RETROFITTING PROCEDURE

The beams are stressed up to a specified limit as above and then retrofitted by applying steel chicken mesh shown in Fig 3.34 and then plastering it with cement mortar up to the thickness of 15mm. Effect of two different stress levels has been studied to see their effect on the strength of retrofitted beams with chicken mesh placing it over the free surfaces of beam. First of all surface of beam is cleaned and after cleaning of the surface, doubled layers of chicken mesh stretched and raped to three faces on beam with cement mortar for bonding between beam and mesh. One after that plaster in the form of 1:2 cement mortar is applied on three faces of beams. After this the beam is cured for 28 days. Then with the same procedure as of control beam, testing of beams is done under two points loading in order to calculate ultimate load and corresponding deflections.

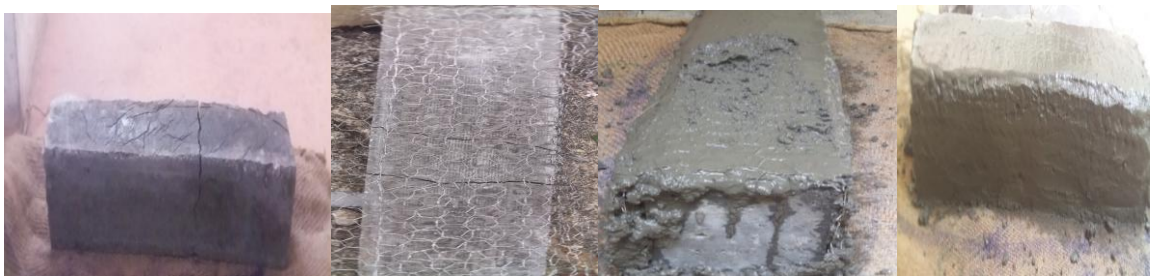

Fig. 10.Retrofitting procedure

Fig 11. Retrofitted beam specimen

VIII. TEST ON RETROFITTED BEAMS

Test conducted similar to that of above flexural strength test of beams. Firstly beams of size (100mm x 100mm x 500mm) are tested up to failure and the data corresponding to it is recorded. Then out of four (T10, T20, T30,Control beam), optimum load carrying beam is obtained as T30.Then another sample of T30 beam was stressed 80% of the safe loads of non-retrofitted T30 beam.

The beams are tested again with the same method as the non-retrofitted T30 beam was tested initially and the corresponding results are recorded are shown in Table. These retrofitted beams were then loaded to failure and the data was recorded in the form of load and deflection. The Table also presents this data for the non-retrofitted beams and beams retrofitted using specified chicken mesh.

Graph shows the load deflection behaviour of the T30 as well as beams retrofitted with chicken mesh. It is observed from the curves that with an increase in load there is a considerable increase in deflection for all the beams. It was also noted that the average Ultimate load carrying capacity was 55kN for retrofitted T30 beam specimen.

The results indicate that the beams retrofitted with chicken mesh 80% stressed beams. The increase in ductility ratio of beams retrofitted using ferrocement jacket having chicken mesh at different stressed level as reinforcement are makes the retrofitted beams suitable for dynamic load applications.

Fig 12. Test on retrofitted beam specimen

TABLE III
COMPARISON OF LOAD CARRYING CAPACITY BEAMS

Specimen	Size of specimen (mm)	Average ultimate load of failure (kN)
T30	100x100x500	48
Retrofitted T30	115x115x500	55

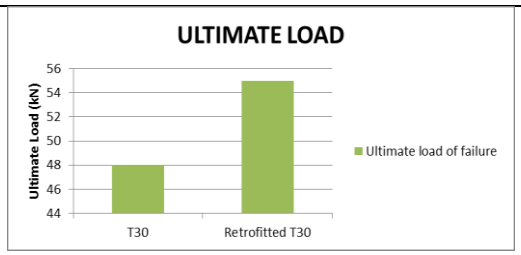

Fig 13. Ultimate load of non-retrofitted and retrofitted beam specimen

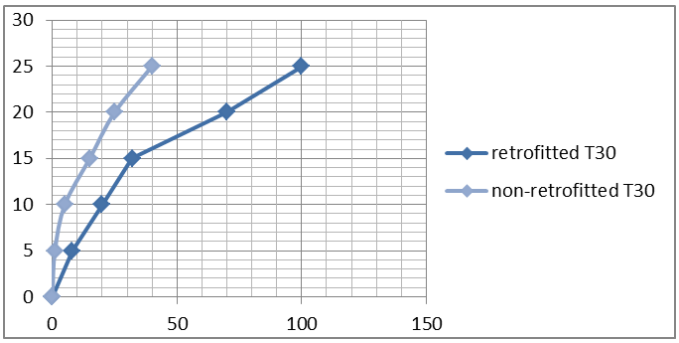

Fig 14. Load-deflection curve of non-retrofitted and retrofitted beam specimen

IX.CONCLUSIONS

The following conclusions were drawn from this experimental study:

- 30% replacement (T30) shows high flexural strength and T20 as well as T10 replacement show higher flexural strength than control mix.
- The load- deflection characteristics show that strengthened beams with Ferro cement (chicken mesh) improves the load carrying capacity.
- Based on the comparison between non retrofitted and retrofitted T30 beams, the latter gives significant confining and hence improves the strength.

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