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BEHAVIOURAL STUDY ON RC BEAM WITH SEA SHELL AS A FINE AGGREGATE SUBJECTED TO REVERSE CYCLIC LOADING

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ABSTRACT

Concrete is the widely used material after water in the world. The word concrete denotes the coarse aggregate, fine aggregate, water and cement. There are much research going on in the present world in the field of concrete technology. This project aims to find a solution for the exploitation of river sand and to replace with the other abundant and cost-effective material as the fine aggregate for the betterment of our society and the construction Industry. The viability of using grinded sea shell as the fine aggregate are investigated in the project. The grinded sea shell is replaced in the place of river sand in the percentage of 20,40%,60%,80%,100%. There is promising increasing in the strength of the specimen in all the percentage when compared to that of the conventional. The maximum strength is obtained for the replacement of 80%. The further investigation is carried with the aid of RC Beam subjected to Reverse cyclic loading. The optimum percentage (80% Sea shell + 20% river sand) is found out and the beam is cast and subjected to loading and the corresponding deflection is noted down. The parameters like ultimate load carrying capacity, energy absorption, ductility factor, stiffness and the maximum deflection is studied.

Key Words: Sea shell, River sand, Ductility, Energy absorption

I- INTRODUCTION

India is a developing country and its population is increasing day by day. This causes the cities and town to develop and change into concrete buildings. The development causes the depletion of the ingredients of the concrete which are available naturally like river sand (Fine aggregate) and stones (Coarse aggregate) beneath the earth. The exploration of gravel or coarse aggregate causes several associated problems like minor earth quake, landslides, land subsidence etc. [Chakravarthy and Mutusva, 2015] The depletion of river sand causes day to day problem in our lifestyle and habits. It is roughly estimated by government of India that about 90% of the construction works happening in India are using river sand as the fine aggregate. The forceful depriving of river sand causes the water to runoff without infiltrating into the surface. The illegal mining of sand causes revenue loss for the government. Moreover, the process of accumulation of sand on the banks of river are million years old, the greed of development causes to deplete the invaluable resource within a short time-frame. There is a popular saying "*Anything in the world is enough for man's need but not for man's greed"*. It is turn of Engineers to suggest an alternative for the river sand. It is feet that, this this project will serve as an alternative for the river sand.

The project attempted to replace the grinded sea shell as the replacement as a fine aggregate in concrete. The sea shell obtained is taken from the coast of Arabian sea at Kerala, India. The appearance of sea shell before grinding are shown in the figure-1.

Fig-1 Sea shell before grinding

Sea shell is the dead remain of the living beings in sea. It found naturally as a deposited along the coast and carried by tides and waves. Most the shell which are taken are in the recent age of geological period. These shells are of family Mollusca and Lamella branch. The shells which we used are mostly Bi-Valved shell (Arca, Mericrix, Venus) and some shells are uni-Valved (Puritella). Puritella shells are the shells which are in cone shape [Agbede and Manasseh, 2009]. The shell we have used is washed to remove the chlorine ion which gets stick to it due to the constant contact of sea water. We have managed to grind the shell at a rice mill.

II- EXPERMENTAL PROGRAM

The grinded sea shell is made to size below 4.75mm. The colour of the shell after grinding is of **dirty white**. The texture observed after grinding is **Flaky and elongated** and not round as in the case of river sand. The sieve analysis test is carried and it is found that the grinded sea shell confining to Zone-II aggregate. The other parameters like Specific Gravity, Fineness Modulus, percentage of Water absorption are 2.21, 2.95, 1.3% respectively. The chemical composition of the grinded sea shell obtained are given below:

Composition	Percentage of weight
CaO	63.21
SiO_2	18.55
Al_2O_3	6.13
Others	12.11

Table-1: Composition of Sea Shell

Generally, the sand is used to fill the voids of the bonded coarse aggregate and acts as the filler materials in concrete. The elongated shape of the grinded sea shell helps to fill the internal voids of the concrete in the effective way. On considering the chemical properties of the sea shell, the major portion of the weight is made up of calcium oxide. As the proportion by weight of the grinded sea shell is largely composed of CaO, it helps in the reaction with water (H_2O), forming the C-S-H gel thus in turn help in the increase in the strength of the concrete. Yet there is the fact that size of the particles is inversely proportional to strength developed due to the formation of C-S-H gel [Mageswari, et al., 2016]. It is believed that there will be considerable increase in the strength of the specimen on replacement.

III- TEST SPECIMENS

The plan is to replace the grinded sea shell as fine aggregate in concrete in 0%, 20%, 40%, 60%, 80%, 100% in the specimens like cube, cylinder and prism. The 0% denotes the conventional specimen used to compare the properties with the rest of the specimens. The cube specimen of size 150x 150 x150mm are cast to find out the characteristic compressive strength (f_{ck}) of concrete. The cylindriccal specimen of 300x150 mm (l/d ratio is 2) are cast to find out the split-tensile strength of the concrete. The prism of size 500x100x100 mm are cast to flexural strength of concrete. The optimum mix proportion is found out and that concrete mix is used to cast as the RC beam. The RC beam is of length 1.5 m, breadth 100mm and depth 150mm. The G+5 storey equal bay commercial building is analysed and designed using the software STAAD Pro and MS Excel respectively as per IS 456, IS 13920 and the loading conditions are as per the IS 875. The prototype is scaled down to $1/5^{th}$ of the size as per law of simulation to suit the specimen to be tested in the laboratory [Ramadevi and Deepa Shri, 2015]. The reinforcement diagram of the beam which are used are given in figure-2.

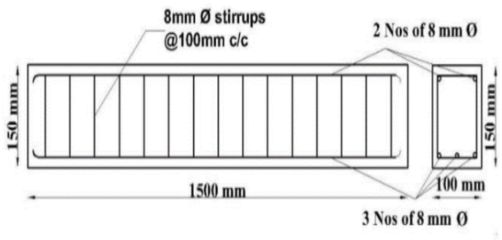

Fig-2 Reinforcement diagram of the beam

IV- TEST SETUP

The RC beam specimen is made to test under two-point loading in the loading frame of capacity 100ton. The mechanical method of loading is given to the beam. The mechanical jack is made to fix with the proving ring of 500 kN Capacity and the load is distributed to the length/3rd point of the beam by a I section placed under the proving ring and then the load from the I – Section is transferred by specially welded plate with the rein-forced bar. The deflection is measured by means of the LVDT and by dial gauge. The illustration diagram of the load setup and arrangement to note down the load vs defection is given in the figure-3.

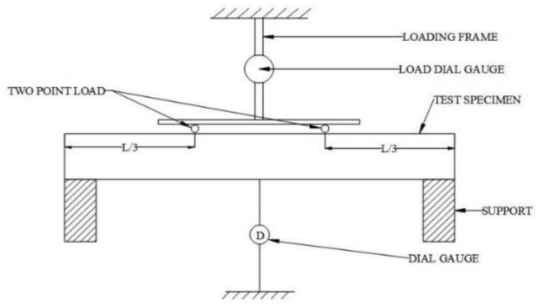

Fig-3 Test setup of the beam

V- CASTING AND CURING

The concrete mix of ratio 1:2.6:4 is arrived based on the mix design. To optimize the cost of the concrete the cement content is reduced to about 320 kg/m^3. The water/cement ratio is designed as 0.5. The grinded sea shell is replaced in 20%, 40%, 60%, 80%, 100% in the specimens of cube, cylinder and prism. The curing method adopted is water bath curing method. The look of the specimens at curing is given in the figure-4

Fig -4 Curing of cube specimens

VI- TESTING OF SPECIMENS

The cube, cylinder and the prism are tested and the optimum replacement value is found to be at the replacement of grinded sea shell of about 80%. The addition in the sea shell reacts with the concrete at minute quantity and thus showed the increase in the strength. Moreover, the angular aggregate help in the effective filler of voids of the concrete which can also be said as the reason for the increase in the strength. The testing of the Cylinder to find out the split-tensile strength is shown in the figure -5

Fig -5 Testing of cylinder

The test result shows that the 80% replacement of the sea shell in the place of river sand have acquired more strength than that of the other proportions. The RC Beam is cast with the 80% replaced sea shell as per the reinforcement details given in the figure-2. The real-time image of the beam testing under the loading frame is shown in figure-6.

Fig -6 Testing of RC Beam (80% Sea sand)

***Load- Deflection*:** The conventional beam and the beam with 80% replaced sea shell are cast and are made to test under the loading frame. The load is given manually and the corresponding deflection is obtained and noted down. This project aims to test the specimen to the abnormal loads hence the beam is tested for reverse cyclic loading subjected to earthquake. The load vs defection of the conventionnal beam under reverse cyclic loading for every cycle is marked with colour variation is given in figure-7.

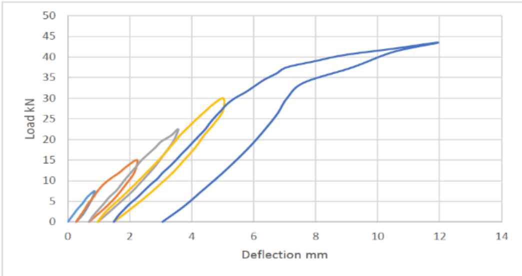

Fig-7 Load- Deflection curve for conventional beam under reverse cyclic loading.

The load-deflection curve for the reverse cyclic loading is obtained for the specimen with the 80% sea shell as the fine aggregate and it is given in the figure-8

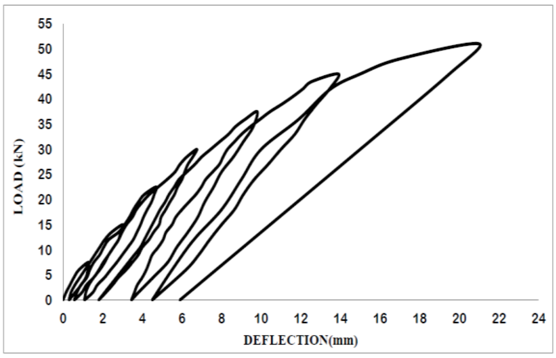

Fig-8 Load- Deflection curve for S80 beam under reverse cyclic loading.

The inferred values which are taken from the load vs deflection curve are made for easy comparison are given below:

The **Ultimate load** of

Conventional beam	: 43.5kN
S-80 beam	: 51kN

Initial crack load of

Conventional beam	: 20kN
S-80 beam	: 21kN

Energy Absorption: The area enclosed in the hysteresis loop is the measure to find out the energy absorption capacity. The cumulative energy absorption is given by the summation of the total energy absorption in each cycles.

The Cumulative energy absorption of

Conventional beam	: 258kN-mm
S-80 beam	: **382**kN-mm

There is a very good increase in the value of the energy absorption in the beam with 80% replaced sea shell. The chart showing the cumulative energy absorption for the beam with 80% replaced sea shell are explained in figure-9.

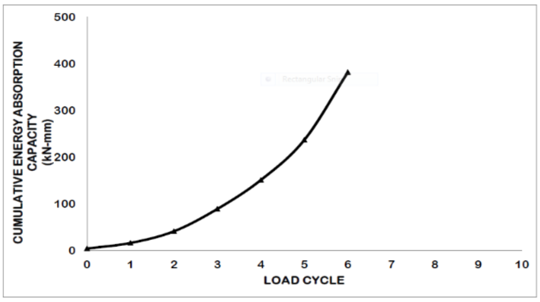

Fig-9 Cumulative energy absorption curve for S80 beam

Stiffness: Stiffness is defined as the load required to cause unit deflection. The stiffness is obtained by the slope of the load-deflection curve.

The Stiffness of Conventional beam: **6.1** kN/mm

S-80 beam: 5.7 kN/mm

Ductility Factor: Ductility is the ability of the material to undergo inelastic deformation after the yield point without the sudden failure. In the earthquake analysis the ductility plays an important role as it is the factor which gives amble warning for the people to come out of the house.

Ductility factor of Conventional beam : 9.08

S-80 beam : **9.83**

Deflection: Deflection is the strain that the specimen is subjected to when the load is acting on specimen the specimen.

Maximum Deflection of Conventional beam: 11.25mm

S-80 beam : **12.98** mm

Failure Pattern Study:

The failure pattern of both the case of the beam appear to be same i.e flexural failure [Thenmozhi and Deepa Shri, 2012]. The several flexural cracks start to appear after the initial crack load. On reaching the ultimate load the beam attained a concavity upwards bending. In both the cases the flexural crack dominated with very minor shear cracks starts to appear while reaching the ultimate load. The failure pattern of the conventional beam is shown in the figure-10.

Fig-10 Failure pattern of the conventional beam

VII- CONCLUSIONS

This project, replacement of sea shell as fine aggregate has finally resulted in the increase in the strength of concrete to a high extend. The strength increase in found not only in compression but it follows the same in split-tensile and in flexural strength. The max % of successful replacement is found in 80% which mark the maximum strength value in all three forms of strength (viz) compression, split-tensile, flexural. This increase in strength clearly shows, the sea shell not only acts as the binder in the concrete but it starts to react with the cement which is understood by the rapid increase in the strength. It is observed the specimens especially beam was subjected to calcination. It is being concluded that addition of sea shell increases strength in all replacement and this could be done practical solution to avoid the exploitation of river sand.

VII- SCOPE OF FUTURE STUDIES

The further studies on the combination of partial replacement of fly ash for cement and the partial replacement of sea shell for fine aggregate can be done, due to fact of less CaO in fly ash [Bharathi, et al., 2016] help to neutralize the calcium content in the sea shell.

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