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FLEXURAL BEHAVIOUR OF BEAMS WITH POLYSTYRENE AS PACKING MATERIAL WITHIN THE REINFORCEMENT

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Abstract:

This paper investigates experiments the use of expanded polystyrene beads that can be used to replace coarse aggregate partially and completely inside the reinforcement thereby aiming to reduce the self-weight of the structure. Polystyrene is a hazardous waste which we are reusing only inside the reinforcement keeping in mind that overall performance should not get affected so that we can reduce the self-weight of the structure along with a solution for the management of polystyrene waste which cannot be degraded by micro-organisms. Reinforced cement concrete is one of the important components in the construction industry. Now a days, the use of concrete increased very much. In this study an attempt is made for reduction of concrete and self-weight of the beam by replacing the concrete below neutral axis. Concrete therefore has poor tensile strength and when a concrete component is exposed to flexure. As cement is very costly, reducing the usage of cement will also help to bring down the total cost, also carbon dioxide production reduces which in turn is good for the environment. The overall weight of the structure will reduce as the density of concrete is 2,400 kg per cubic meter where as the density of EPS beads is between 960-1050 kg per cubic centimetre.

Keywords —Expanded polystyrene beads, Reinforcement, Self-Weight

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I. INTRODUCTION

Concrete is still one of the most commonly produced materials in the world and its total annual production is estimated to be more than two billion cubic meters. It is made from a hardened mixture of asphalt, water, fine, and coarse aggregate. As we all know that the beam being rectangular in shape and the materials used inside includes cement, water, fine aggregate and coarse aggregate.Steel reinforcement is used concrete in order to prevent the cracking of the structure. Concrete is strong incompression and weak in tension. When a point load is applied to the middle of the beam there is a compressive force developed at the top part of the

reinforcement and a tensile force is developed at the bottom of the reinforcement.Reinforcement section being present at the middle of the beam, there is no structural importance and does not get affected by the force that is given to the beam, so instead of using concrete inside the reinforcement, in this experiment we make use of some waste called as Expanded Polystyrene beads (EPS).

Waste management being one of the powerful topics in recent years, rigorous researches are being done to use the same in construction industry. Various works have been carried out to replace Coarse aggregate. In this context, expanded polystyrene beads were used to replace Coarse aggregate partially and completely. Expanded polystyrene beads are advantageous as lightweight concrete. It mainly reduces the dead load, self-weight and mainly improvises the thermal insulating property of a structure. Polystyrene being top second non – biodegradable waste next to plastic, using polystyrene in construction helps a part of waste management. Concrete is said to be lightweight when it's density ranges from 160 – 1920 kg/m^3. With reduced density of concrete and minimum required strength, Polystyrene concrete has a greater impact on economy in construction.

II.LITERATURE REVIEW

1. *ABDUL MANNAN* "**FLEXURAL BEHAVIOUR OF LIGHTWEIGHT REINFORCED CONCRETE BEAMS MADE WITH PALM OIL SHELL"** (NOVEMBER 2010, JACT)This paper presents an investigation on the flexural behaviour of reinforced beams produced from the waste oil palm shell. Using oil palm shells in the production of concrete not only solves the problem of disposing the waste which is coming from the palm shell and also helps to conserve natural resources. The results from this paper includes the deflection characteristics, cracking behaviour, ductility and end rotations. This use of lightweight concrete in the construction industry has been gaining popularity in the last few decades. Although there have been many works done on the structural performance of lightweight concrete, these are mostly confined to naturally occurring aggregates. Use of this OPC in the concrete shells to bring down the cost of production of structure. From this paper we come to know that the flexural behaviour of OPS concrete is comparable to that of other types of light weight concrete.

2. *ADRAIN JEFIMUK* **"FLEXURAL BEHAVIOUR OF REINFORCED CONCRETE BEAMSCONTAINING EXPANDED GLASS AS LIGHTWEIGHT AGGREGATE"** (DECEMBER2011, SJCE)Recent research has shown that the replacement of sand with lightweight concrete has shown similar

results as that of the conventional concrete beams. The replacement of recycled fine aggregates up to 20% or recycled coarse aggregate up to 30% produced an acceptable concrete. This paper deals with the flexural properties of concrete beams containing expanded glass as a partial fine aggregate(sand) replacement. The fine aggregates were replaced with 10%,25%,50% and 100% by volume.

The results observed by this paper is that the compressive strength was decreasing linearly with the increasing amount of expanded glass and also the ductility of the concrete beam has also improved. The lightweight concrete containing recycled expanded glass as an aggregate can be used on its own in construction but not as a load bearing structure. It was found that the concrete made with expanded glass had very good thermal conductivity. Hence it can be recommended as a coating material during construction

3. *HAMID NIKRAZ* "**REINFORCED CONCRETE BEAMS WITH LIGHTWEIGHT CONCRETE INFILL"** (MAY 2012, IJCE) The lightweight concrete materials are used significantly because it reduces the weight of the structure without having compromise on its strength and service. A new lightweight sandwich concrete (LSRC) section has been developed using lightweight concrete as infill material. These light weight sandwich reinforced concrete section can be used as beams or as a slab member which has advantage due to its lighter weight. These lightweight concretes are affordable at cheap cost and also it reduces the construction time. This paper investigates the flexural test and shear test on normal concrete beam with light weight sandwich reinforced concrete beam. The stress and strain in normal concrete cross section are almost linear. In order to determine flexural capacity under bending theory a stress-strain and force diagram is drawn and analysed. Two types of concrete were casted, one is reinforced concrete with lightweight infill and other one is LSRC.These two sections were casted well and set for experimentation. After the experimentation the results were insignificantly different for the failure loads of solid and LSRC beams under flexural test, the main flexural cracks were developed within two-point loading with load increased. Under flexural test there was significant difference of less than 3% in flexural capacity between solid beams and beams within blocks. This result showed that LSRC sections perform well under flexure. For the beams tested in shear were somewhat similar for both normal concrete beam and LSRC beam. Small flexural cracks occurred in the first at the midspan region of beam. The cracks god widened up as the load increased. Based on the

shear test LSRC beam has lower shear capacity than the equivalent solid beam. This investigation is done as the first step for interested participants to gain more knowledge of LSRC performance of its use and an alternative lightweight concrete option.

4. *K H KONG* "**BEHAVIOUR OF REINFORCED CONCRETE BEAMS CONTAINING LIGHTWEIGHT AGGREGATE IN TENSILE ZONE**" (SEPTEMBER 2013, AJSE)Theapplication of using waste material in construction is likely to contribute towards to sustainable development. The lightweight materials are used to reduce the live load on structural elements. Here both normal concrete beams are compared in terms of strength and mode of failure. Two types of beams were casted with proper mix design calculations, one is of normal concrete beams and other is a type of lightweight concrete beams. These light weight concretes are taken in such a way that the depth of each beam is taken as 25%,50% and 75% of total depth of beam. After calculating the quantity of materials such as concrete, aggregate, sand and water per mix, the materials are weighed properly. Before casting, the workability of concrete is checked by slump test for each mix measured. After casting the beams are set for testing. Initially the beam was tested until yielding started. The loading continued until the failure, during that time the cracks were observed throughout the duration of the test.From the experimentation conducted above we conclude that with the increase in the depth of concrete, the failure load will decrease, which determine the strength of concrete beams. And thus, we could say that failure load in reinforced concrete beams tend to drastically decrease in lightweight concrete beams.

5. *ISMAIL MAT* "**FLEXURAL BEHAVIOUR OF FOAMED CONCRETE AS INFILL FOR REINFORCED CONCRETE"** (AUGUST 2016, JEAS) The advantage of any structure lies with ability to carry maximum load and at the same time being light in weight. In this experiment we make use of foamed concrete. Foamed concrete is a low-density cellular concrete with foam entrained into the plastic mortar. The density of foam concrete usually varies from 400 kg/m^3 to 1600 kg/$m^{3.}$ Whenever a dead load is applied to a concrete it increases the construction cost because it has to carry dead load along with its own self weight. It will be best to save the construction if the structure becomes light in weight. As the concrete becomes light in weight, the dead load applied by the concrete to the structure also decreases and as a result the load to foundation decreases.

The main objective of this experiment is to know the flexural behaviour of reinforced foamed concrete lightweight beams with a compressive strength of 25N/mm^2 at 28 days. In

this experiment three reinforced concrete beams were cast which contained two lightweight foamed concrete beams and a normal weight concrete beam. Here two lightweight concrete beams with cement to sand ratio of 3:1 and 2:1 were developed to produce 25MPa compressive strength. These three beams were designed as under reinforced beam. From the results it was observed that the foamed reinforced concrete beams sustained lower ultimate load as compared to normal concrete beams by about 22% to 26%.

6. *INDRADI WAIJATMIKON* "**STRUCTURAL BEHAVIOUR OF BAMBOO REINFORCED CONCRETE WITH EPS INFILL PANEL"** (SEPTEMBER 2017, MSP) The main purpose of this study was to investigate the load carrying and flexural behaviour of the slabs. After the conduction of the experiment, the flexural analysis was in a good agreement with the experimental data and also the theoretical data. The slab with EPS infill panel had 6% drop on the ultimate load carrying capacity but 27% lighter compared to those of regular slabs. It can be considered as a good performance as the weight of the slab is reduced. The results showed that the flexural strength of the specimen decreased marginally of about 6%. Overall, the reinforced concrete slab with bamboo reinforcement and EPS infill panel showed reasonably good performance compared to slabs with steep bars.

7. *CHAITANYA KUMAR* "**EXPERIMENTAL ANALYSIS OF LIGHTWEIGHT CONCRETE AND FIBRE REINFORCED CONCRETE***"* (APRIL 2018, ISCEET*)* By using lightweight material like palm oil shell as aggregate will also reduce the self-weight of the structure which ultimately helps in lifting and carrying of pre cast structure. Steel and glass materials are used to increase the bonding. In earthquake conditions, the pumice concrete is elastic which will help in reducing the brittleness. Steel fibres are used in concrete so that it can resist the tensile stress which causes cracking.

The results show that no bonding failure occurs in Lightweight aggregate concrete (LWAC). According to the test done in this paper surface hardness is increasing slightly by adding steel and glass fibres and the normal weight concrete is slightly lesser than the fibre reinforced concrete (FRC) beams. Testing done on UTM also illustrates that the normal weight concrete has better compressive strength than the light weight reinforced concrete aggregate but the difference is very small which is about 7.6% to 8.8%.

8. *MUHAMMAD U RASHD* "**ANALYSIS OF LIGHTWEIGHTCONCRETE BEAMS***" (AUGUST 2018, SJCET)*In this experiment Lightweight

concrete beams were taken and casted as simply supported beams by using four-point loading. This experiment was done with an aim to know the flexural strength, deflection, stiffness and water absorption of lightweight concrete and to check its suitability to use inside the structure. We know that a normal concrete consists of cement, sand, fine aggregate and coarse aggregate as the materials, but in a lightweight concrete, the modulus of rupture seen is very low because of the weak lightweight aggregates used. Each of the beams were evaluated in terms of cracking, failure mode, flexural strength, ultimate deflection, stiffness, toughness, water absorption and energy absorption. It was found that the its water absorption is very high because of the large number of holes in the LWC beams. The more contact zone between the paste and aggregate and more water in the pores because of aggregates for continued internal curing in LWC reduces cracking in the concrete. So, it provides an advantage over the normal concrete as there is no need of continuously watering on the surface to maintain the moisture, the pores on the surface causes more water to be maintained. As the moisture content is preserved it is important to note that the cracking in the concrete reduces. Therefore, dead loads produced by the concrete reduces on the structure and hence it helps in saving the costs in foundations and reinforcement.

9. *LING JEN HUA* "**ANALYSIS OF TRADITIONAL AGGREGATES REPLACED WITH LIGHTWEIGHT AGGREGATES**" (FEBRUARY 2020, MSP)In this experiment the author presents a topic where traditional aggregates are replaced by light weight aggregates which render the concrete lighter than normal concrete. They made many comparisons of the weight of cement between standard cement concrete and lightweight concrete with different amounts of aggregates, pumice stone, and aluminium material. They also made three different light weight mixtures using various proportions of pumice stone and light weight aggregates. From the experiments done they came to know that the use of pumice stone as aggregate would create a floating and a happy strength concrete. It was also observed that light weight aggregates can reduce the dead load in concrete mixture, but the only problem they found is that, this process decreases the concrete strength. But due to this they don't turn out to be useless. This low weight concrete was found to be used as separation walls which has enough strength to carry loads.

OBJECTIVES

1)To understand the flexural behaviour of concrete beam filled with polystyrene beads.

2)To study the mechanical properties of concrete beam filled with polystyrene beads

METHODOLOGY

1)Literature survey was one of the most prominent work carried out on various topics such as Lightweight concrete, polystyrene concrete, chemical admixtures, mix design, testing methods etc

2)Mix design for M25 grade concrete was carried out

3) Design of Steel Reinforcement for standard beam size 150×150×700 mm was done and carried out.

4)Next Raw materials like Cement, Water, Aggregates and super plasticizers are added in the required proportion.

5) Casting and curing of polystyrene beams was done accordingly

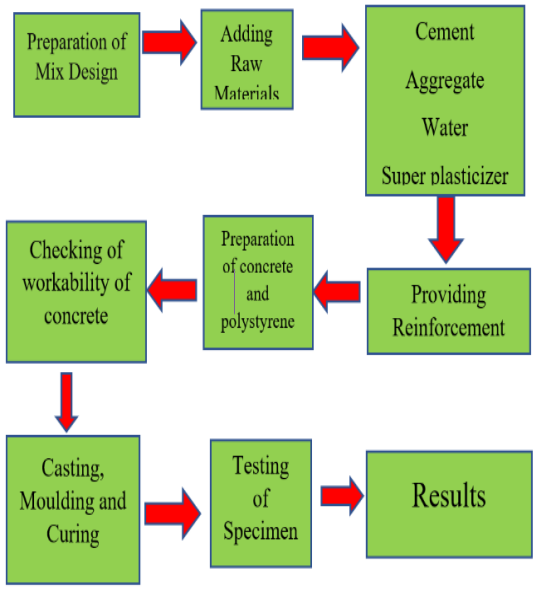
6) Mechanical strength property tests are carried out for 7, 14 and 28 days respectively for beams.

7) Six beams with steel reinforcement were cast out of which three are conventional and three are polystyrene.

8) De-moulding and curing of the beams were done for 7, 14 and 28 days.

9) After curing the beams were tested for Flexural Strength after 28 days.

10)Results are tabulated and conclusions are drawn.



II. CONCLUSIONS

This paper has presented the use of lightweight concrete inside the reinforcement so as to reduce the weight of the overall structure. Various materials like expanded glass, traditional aggregates, palm oil shell has been used in different experiments as a replacement for coarse aggregate partially, thereby aiming to reduce the self-weight of the structure and keeping in mind that the overall performance of the structure should not get affected. Following conclusions are made from the above studies

1. Expanded polystyrene beads are advantageous as lightweight concrete. It mainly reduces the dead load, self-weight and mainly improvises the thermal insulating property of a structure. Polystyrene being top second non-

biodegradable waste next to plastic, using polystyrene in construction helps a part of waste management.

2. The compressive strength was decreasing linearly with the increasing amount of expanded glass and also the ductility of the concrete beam has also improved.
3. Using oil palm shells in the production of concrete not only solves the problem of disposing the waste which is coming from the palm shell and also helps to conserve natural resources.
4. By the usage of lightweight concrete, the dead loads produced by the concrete reduces on the structure and hence it helps in saving the costs in foundations and reinforcement.

RESEARCHNEEDS

In the present century there is a wide use of concrete for making the structures and most of the structures carry heavy loads. In our experiment we have tried to reduce the self-weight of the structure by using expanded polystyrene beads as a partial replacement inside the reinforcement. Many comparisons are made between normal concrete and lightweight concrete. Our experiment also serves an example of natural resource conservation as polystyrene beads cannot be degraded hence it can harm the environment, so we have used in our experiment thereby reducing the content of unwanted EPS in the environment

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