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Experimental Study on Light Weight Concrete by Partial Replacement of Cement by Flyash, Coarse Aggregate Pumice Stone and Thermocol Beads

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ABSTRACT- In today's world when focus is on reducing self-weight of concrete, light weight concrete has come with the high number of applications to reduce self-weight of concrete. In this study an attempt has been made to compare conventional concrete with the lightweight concrete which is made by partially replacing cement with fly ash and coarse aggregate with pumice stone and adding Thermocol beads using M25 grade of concrete. Lightweight concrete has been made by partial replacement of Coarse aggregate by pumice stone varying in the ratio of 10% 15% and 20% and Thermocol beads by 0.2%, 0.4% and 0.6%.Also cement is replaced by fly ash in the varying ratios of 20% 30% and 40% by weight of cement. In addition to that fine aggregate is replaced by Thermocol beads in the varying ratios of 0.2%, 0.4%and 0.6%.

KEYWORDS- Light weight concrete, Fly Ash, Pumice Stone, Thermocol Beads, Aggregates

I. INTRODUCTION

Concrete is one of the most popular construction materials used since hundred years ago. Because of its flexibility in usage it becomes more important and is preferred compared to timber or steel [13]. Conventional concrete is a composite mixture which is made by mixing cement, coarse aggregate, fine aggregate and adding water. Conventional concrete due to its higher self weight and density ranging from 2200kg/m3-2600kg/m3 is uneconomical to some extent. Concrete is a relatively brittle material, when subjected to normal stresses and impact loads. Tensile strength of concrete is approximately one tenth of its compressive strength, as a result of these characteristics; plain concrete members could not support tensile stresses that occurred on concrete beams and slabs [14]. In order to overcome the issue of tensile strength concrete is reinforced with continuous steel bars to induce ductility and comes up with the name of reinforced concrete also called as RCC. To reduce the self weight of concrete several attempts have been made one such attempt is light weight concrete [15].

The concrete made of lightweight aggregates which reduce self and density of concrete is called as lightweight concrete [16]. The density of lightweight concrete ranges from 1440 kg/m3 to 1840 kg/m3.It includes expanding agents which increase the volume of concrete thus reducing self weight of concrete . The minimum strength for structural lightweight concrete should not be less than 17 Mpa. Lightweight concrete reduces the self weight of concrete by about 25 to 35%.. In this study we have used pumice Stone and Thermocol beads as partial replacement for coarse aggregate and fly ash as partial replacement for cement in producing light weight concrete [17]. As we know that cement is obtained from non-renewable sources so replacement of cement is also a great concern in these days, so in this study attempt has also been made to replace to replace cement by fly ash [18]]. Fly ash is a waste product obtained by burning coal in power plants. It possesses cementitious properties which makes it a good binding material [19]. The type of fly ash used here is class C fly ash which is obtained from burning sub bituminous coal. There are two main classifications of lightweight of lightweight concrete [20]. On the basis of lightweight concrete suitable for structural purpose

A. Lightweight Aggregate Concrete

This type of concrete is made by replacing of aggregates either partially or fully. The common lightweight aggregates used pumice Stone, Foam slag concrete expanded clay Sintered Pulverized fuel ash aggregate.

B. Aerated Concrete

This type of concrete has the lowest density, thermal conductivity and strength. This type of concrete is used where less strength is required. Lightweight concrete used as structural material is usually high pressure steam cured. It can be only made in factory so it's available only as precast units.

C. No Fines Concrete

This type of lightweight concrete is generally made up of cement and coarse aggregate only. No fines concrete was introduced in 1923 in UK. The aggregates used in this type of concrete are in the size range of 10 mm 20 mm. On the basis of strength light weight concrete is classified as
Low density concrete: - This type of lightweight concrete is mainly used for insulating purposes. Its Unit Weight is too low not more than 800 kg\m3.

D. Moderate Density Concrete

This type of concrete falls in the mid way of low density and structural concrete. This type of concrete is usually used to fill concrete. Their compressive strength is approximately from 6.8 to 17 Mpa Structural concrete: - This is a type of concrete our experimental study is based upon. Concrete with full structural efficiency contain aggregates which provide compressive strength of more than 17.4 Mpa.

II. LITERATURE REVIEW

Mohamed Noaman Abouelnour, (2021) The work presents a study of fresh and hardener characteristics of Light Weight Concrete (L.W.C) using Polystyrene Beads and air entrained admixture [12]. This type of concrete classification as non-structural concrete. There is positive relationship between density of concrete & Compressive strength. Compressive strength decrease when using air entrained admixture than the same density using polystyrene because there is increase in air content.[1]
Pragati J. Jagtap1, Mayuri R. Rathod2, Sheikh Shahebaz Sheikh Murtuja3, (2020), the paper elaborates that the lightweight concrete has a desirable strength to be an alternative construction material for the industrialized building system [13]. The strength of aerated lightweight concrete are low for lower density mixture. This resulted in the increment of voids throughout the sample caused by the foam. Thus the decrease in the compressive strength of the concrete. The foamed lightweight concrete is not suitable to be used as non-load bearing wall as the compressive strength is 27% less than recommended. Nevertheless the compressive strength is accepted to be produced as nonload bearing structure.[2]
Miss Akshata A Mulgund and Dr. Dilip K Kulkarni (2019) had worked on the light weight concrete in which they shown the comparison of both the densities of normal concrete as well as light weight concrete. As per the density of light weight concrete is much more lesser than normal concrete, so the lesser density of light weight concrete is helps to reduce dead load of structure, increases the progress of building and it maintain the economy of structure.[3]
Dr. G. Elangovan (September 2015) Studied partial replacement of fine aggregate by fly ash and coarse aggregate by Thermocol. The study concluded that, by replacing fine aggregate by 60% with fly ash and coarse aggregate by 0.3% of Thermocol the highest strength of 23.5N/mm2 who was achieved and its percentage improvement was 47.2%.This experimental work proves that fly ash can be used as an partially alternative material for fine aggregate in the concrete and makes the concrete more economical and eco-friendly concrete as well [14]. In this study Cost Analysis was also done and they concluded that this mix ratio is comparatively more economical. In this study Cost Analysis was also done and they concluded that this mix ratio is comparatively more economical.[5]
Thousif Khan, et al (May 2018) Studied floating concrete using lightweight materials. In this study the coarse aggregate was partially replaced by Thermocol beads and pumice stone in varying ratios [15]. The study concluded that the mix ratio with 50% replacement of coarse aggregate pumice stone and Thermocol beads show best results for compressive strength and tensile strength. The compressive strength of 5.60 Mpa and tensile strength of 1.14 Mpa can be achieved using the materials chosen in the study. The volume of aggregates can be maintained in the range of 0.7 to 0.75 for achieving floating concrete.[6]
Kothari Akash and Chaudhari Balasaheb(April 2017) the study of lightweight precast concrete using Thermocol was done. This paper present of an experimental study on the effect of using industrial waste [16] Thermocol as a potential aggregate in light weight precast concrete panel. In this study Thermocol aggregate was used as replacement of natural aggregate at the level of 40% 50% and 60% by volume and Crush sand stone was replaced by Thermocol at the level of 10% 20% by volume. The replacement of 40% natural aggregate bipolar string beads and placement of 10% crushed sand stone showed maximum Compressive strength of 6.18 N/mm2. The cost of this panel is 30% - 40% less than conventional concrete panel[7]
Nagaswaram Roopa, K. Supriya and P. Rasheed Khan (March 2017) did the experimental Study on Light Weight Concrete by Partial Replacement of Cement and Fine Aggregate with Fly Ash and Thermocol [17]. This project focuses on investigating the characteristics of M25 grade of concrete with cement partially replaced with fly ash 35%, 40% and fine aggregate replace with Thermocol 0.2%, 0.3% respectively. The compressive strength of concrete is increases from 33.25 N/mm2 to 35.5 N/mm2 at 35% of fly ash and 0.2% of Thermocol replacement and increases from 33.25 N/mm2 to 36.8 N/mm2 at 40% of fly ash and 0.3% of Thermocol replacement. They concluded that the workability of concrete in terms of slump cone and compaction factor shows that Compaction factor changes slightly with increasing fly ash, Thermocol replacement and the slump cone also changes with the % increase in the replacement of fly ash, Thermocol content and the values falls within the value for normal range of concrete[8]
Lakshmi Kumar Minapu, et al (Dec 2014) did experimental Study on Light Weight Aggregate Concrete with Pumice Stone, Silica Fume and Fly Ash as a Partial Replacement of Coarse Aggregate. In this study, an attempt has been made to study the Mechanical Properties of a structural grade light weight concrete M30 using the light weight aggregate pumice stone as a partial replacement to coarse aggregate and mineral admixture materials like Fly Ash and Silica Fume [18]. They concluded that by using 20% of light weight aggregate as a partial replacement to natural coarse aggregate the compressive strength is promising. The density of concrete is found to decrease with the increase in percentage replacement of natural aggregate by pumice aggregate. The compressive strength of concrete is found to decrease with the increase in pumice content. With the addition of mineral admixtures, the compressive, split-tensile and flexural strengths of concrete are increased. Light weight aggregate is no way inferior to natural coarse aggregate and it can be used for construction purpose.[9]
Vinod Goud, et al (oct 2016) did the experimental study of partial Replacement of Cement with Fly Ash In Concrete And Its Effect. The research was done on M25 grade of concrete and the replacement of fly ash with cement was 10%, 20% and 30%. The research concluded that slump loss of concrete increases with increase in w/c ratio of concrete [19]. The 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days

and the 30% replacement of cement with fly ash ultimate compressive strength of concrete decreases[10]

Rajeswari S, Dr. Sunilla George (May 2016) did the experimental study of light weight concrete by partial replacement of coarse aggregate using Pumice stone using M25 grade of concrete. The light weight concrete was made by partial replacement of coarse aggregate by Pumice stone in the varying percentages of 50%, 60% and 70%. They concluded that at 60% replacement the strength of concrete was maximum 22.14Mpa as compared to 50% and & 70% replacement where strength was 13.32Mpa and 8.85Mpa respectively after 28 days of curing. They also concluded that this type of concrete can be utilized in wall panels of non load bearing type for use in precast panels.[11]

M Praveen Kumar, Dr. K Rajeskhar (Sept 2016) investigated light weight concrete by partial replacement of coarse aggregate by pumice stone and cement by GGBS using M30 grade of concrete. The light weight concrete was made by partial replacement of coarse aggregate by Pumice stone in the varying percentages of 25%, 35% and cement by GGBS in varying percentages of 5%, 10%, 15%, 20%, 25% and 30%. The researcher concluded that strength decreases with the increase in light weight aggregate. 25% of light weight aggregate gives higher values for compressive, split tensile and flexural strength [20]. They also found that density is also reduced by 695kg/m3.At 20% GGBS and 25% pumice stone the compressive and split tensile strength was highest valued as 38.25Mpa and 4.86Mpa respectively at 28 days.[12]

III. MATERIALS AND METHODOLOGY MATERIALS USED

The detailed methodology involved in this study is described below. These works have been completed after a series of work steps done in their sequential manner. This sequence of procedure to accomplish the project work is given below as:

This chapter gives the theory and formulation procedures involved in the study. The detailed methodology involved in this study is described below. These works have been completed after a series of work steps done in their sequential manner. This sequence of procedure to accomplish the project work is given below as:

- Study of research and review papers to gain the deep knowledge on the topic.
- Material collection and knowing the properties of materials to be used.
- Mix proportion calculation and calculation of quantity of materials to be used.
- Preparation of recycled concrete and collection fly ash, Thermocol beads and pumice stone.
- Inception for the analysis of their properties.
- Ultimate step to optimize the use of fly ash, pumice stone, Thermocol and recycled concrete for the optimized strength and workability.
- Casting and Physical tests for strength values.
- Analysis and conclusion the project.

IV. MATERIALS USED

The products or materials used in this research paper are fly ash pumice stone and Thermocol beads. These are all lightweight materials and can be used in formation of lightweight concrete and these all these products are economical than conventional concrete. Fly ash being a byproduct from burning of coal in power plants is easily available and very low cost product and is very cheaper than cement. The design mix of M25 grade of concrete has been calculated using IS 10262 with water cement ratio of 0.45. The proportion which was used for experiments was 1: 1.58: 2.63; 0.45. The tests done in the lab were compressive strength test flexural strength test. For compressive strength test cubes of size 150*150*150 mm were casted and for flexural strength strength beams of size 150*150* 700 mm were casted. The casting of 3 samples each with the replacements 20%, 25% and 30% cement with fly ash and 15% pumice stone and 0.3% Thermocol beads will be fixed throughout the project except for nominal mix of concrete where conventional materials will be used. Till now 3 cubes and 2 beams of nominal mix were casted and there compressive strength and split tensile strength was checked respectively for 7 days and 28 days.

V. CEMENT AND AGGREGATES

Ordinary Portland cement of grade 43 of Birla cement was used throughout the project. The cement was purchased from Harjas steel knowledge park II Greater Noida. Crusher sand of size less than 4.75mm confirming to zone II from table 4 of IS 383:1970 was used and coarse aggregate of 20 mm nominal size were used for this research study. Both types of aggregates were purchased. from Balaji construction materials jagat farm market.

Figure 1 shows the cement Bag, Figure 2 shows the fine aggregate, Figure 3 shows the coarse aggregate and Figure 4 shows the Fly Ash.

Figure 1: Cement

Figure 2: Fine Aggregate

Figure 3: Coarse Aggregate

Fly ash, pumice stone and Thermocol beads

Fly ash used in this research study is purchased from NTPC dadri and its properties will be checked before using in design mix, Thermocol beads were purchased ansal plaza greater Noida and pumice stone is purchased from N.M Enterprises banglore.

Figure 4: Fly Ash

VI. MATERIAL COLLECTION

Fine and coarse aggregate were purchased from Balaji construction materials Jagat Farm market in Greater Noida and cement was purchased from Harjas Steel knowledge park Greater Noida. Fly ash was brought from NTPC dadri Uttar Pradesh, pumice stone from N.M Enterprises Bangalore, Thermocol beads from Ansal Plaza Greater Noida. Except pumice stone all materials were available easily from local markets in Greater Noida and fly ash from dadri which is about from 20 kilometers from college campus.After the successful collection or preparation of all these required materials, then the properties check and tests on them were done respectively in order to know their characteristics. After a series of tests done, the final proportions of replacements were set according to their properties.

VII. RESULTS AND DISCUSSION

Chapter includes the results found after testing of materials, testing of concrete samples at 7 days and 28 days of curing. The result and information included here is approximate one that has been analyzed further in the conclusion of this report. The chapter includes the types of test done during the project and their results.

VIII. MATERIAL TESTING

This part of the report shows various preliminary material tests done and their results. Before proceeding to the design mix and for the experimental works we must know the properties of these materials. The materials have been tested and their results are given below.

A. Cement

It is the main constituent material of the concrete which helps in gaining strength in concrete. Almost 90-95% of cement contains four main minerals, which are tri-calcium silicate, di-calcium silicate, tri-calcium aluminate and tetra calcium alumino-ferrite. These four minerals play with different roles in the hydration process that convert the dry cement and hardened cement paste. The tri-calcium silicate and di-calcium silicate contribute virtually all the beneficial properties by generating the main hydration product calcium silicate hydrate gel. The quality and property of cement influences the quality and property of the cement. So,it is necessary that the cement should be tested very well and as much test should be performed before proceeding to the formal work

B. Fine Aggregate

Fine aggregate is also one of the important constituents of concrete which needs to be tested before using in experiments. Aggregates make concrete economical and provide strength to the concrete. They act mainly as filler material. Low specific gravity of aggregates generally indicates porous week and absorptive materials while as high specific gravity of aggregate indicate good quality. They do not react with cement and water but the cement paste coats and binds together with aggregates. The property of fine aggregate must be known before used in project. The type of fine aggregate used in this project was crushed stone fine aggregate. Coarse aggregate is one of the main and major constituents of concrete. They are used as filler and provide mechanical support to the concrete. They use they are used to make concrete economical. The dense coarse aggregate is best suitable than less denser one. The properties of coarse aggregate play major role in the properties of concrete. So it is necessary to check the properties of coarse aggregate. The type of coarse aggregate which is used in this research study is angular coarse aggregate.

IX. STRENGTH TESTS ON CONCRETE SAMPLES

As far as tests are concerned workability test was done on fresh concrete and on hardened concrete compressive strength test and flexural strength tests were performed. The results of these tests are shown below.

A. Workability Test

Workability is the east by which concrete can be mixed, placed, transported, moulded and compacted. Is also defined as the amount of energy required to counter friction while compaction. Slump cone test was performed to check the workability of concrete. The slump value for M25 grade of concrete with water cement ratio of 0.45 was found to be 65mm. In this research study mix design was calculated for slump value of 50-75 mm. So, the required slump was achieved for nominal concrete under normal conditions without use of any mineral or chemical admixture. Apparatus for Slump cone is shown in Figure 5.

Figure 5: Slump Cone Test

B. Strength Test

After the completion of tests on fresh concrete, certain tests were performed on hardened concrete samples which include compressive strength test and flexural strength test. The series of tests on the samples were done and calculated the value of strength that concrete can withstand the loads applied on compression and flexure on cube and beam respectively. Following are the tests done and their results are shown as below.

C. Compressive Strength Test

This test is done on cubes with nominal mix ratio and the lightweight concrete samples. The test results for the nominal cube mix cubes after 7 days and 28 days was found to be 22Mpa and 31.36Mpa respectively. The values of the lightweight concrete cube samples after 7 days and 28 days compressive strength is shown in table 1 and Figure 1 below

Table 1: Compressive Strength Test results

Sample	7 days strength	28 days strength
Cube 1	18.26 Mpa	27.56Mpa
Cube 2	21.28 Mpa	30.96Mpa
Cube 3	17.2 Mpa	25.8Mpa

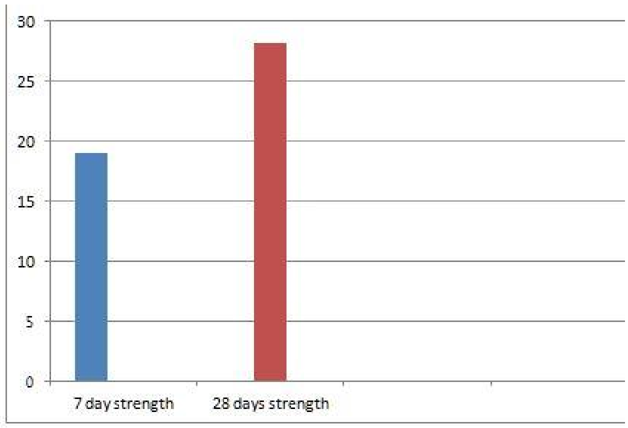

Figure 6: Compressive Strength

The 7 days compressive strength should be approximately 65% of required designed strength which in this case should not be less than 16.25 Mpa. So, the strength of cubes above satisfies the required designed strength.

D. Flexural Strength Test

This test is done on sample beams with nominal mix ratio and the lightweight concrete samples. The test results for the nominal mix sample after 7 days and 28 days was found to be 2.66Mpa and 3.67Mpa respectively. The values of the lightweight concrete samples after 7 days and 28 days of curing for flexural strength is shown in table 2 and Figure 2 below:

Table 2: Flexural Strength Test results

Sample	7 days strength	28 days strength
Beam 1	3.48 Mpa	5.15 Mpa
Beam 2	3.64 Mpa	5.35 Mpa

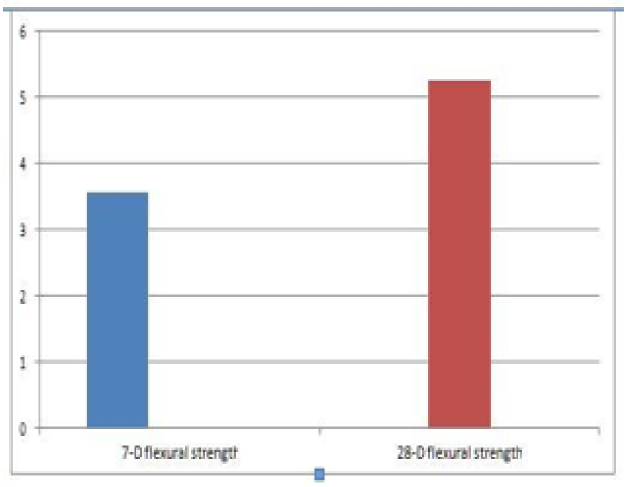

Figure 7: Flexural Strength

The flexural strength is calculated from the formula $0.7\sqrt{fck}$ which in M25 grade of concrete should not be less than 3.5 Mpa for 28 days strength and 2.275 for 7 days strength. The above values satisfy the required criteria for the flexural strength of concrete.

X. CONCLUSION

This chapter gives us a conclusion of the study and work that has been done so far. Since conclusion is the terminating chapter of any research work it has to conclude all the aspects related to the project and its results, Hence this research is all about the strength of concrete which has been casted not only by traditional constituent materials. The concrete has also some percentage of fly ash replacing cement, Pumice stone Thermocol beads replacing coarse aggregate. Till now we have concluded the nominal mix of concrete and tested its properties on fresh and hardened concrete. We found that the concrete satisfies all the desired properties that we need, like workability of fresh concrete and compressive strength and flexural strength on hardened concrete. After concluding these results we fixed the ratio of the materials that we are to replace in the nominal concrete mix we fixed the ratio of fly ash as 20%, 25% and 30%, and The ratio of pumice stone and Thermocol beads will be fixed as 15% and 0.3% respectively

After studying the research papers it is expected that create which we will make after replacing the normal concrete materials will be 25 to 30% lighter and will have strength equal to that of structural concrete. Fly ash being a waste material will make concrete economical as it is a waste product from burning of coal in power plants. Fly ash being a cementitious material will impart binding properties to the concrete and will enhance its strength looking forward with these research studies we hope that we will get our desired concrete with all the properties that are useful for structural concrete. Thermocol being lighter and insulating materials will also help in reducing the weight of concrete and enhance the insulating properties of concrete thus making concrete more useful and lighter.

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