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FLEXURAL STRENGTHENING OF R.C BEAMS HAVING PLASTIC AGGREGATE THROUGH REDUCED W/C

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Abstract— **Due to the greater availability and low biodegradability plastic wastes become a great concern for the researchers worldwide, because these wastes are one of the main environmental issues. Nowadays these harmful industrial wastes can be helpful in place of conventional aggregate in concrete mix, which in turn will also save natural resources. A similar effort have been made in this research study for making concrete having replaced percentage of plastic aggregate along with plasticizer and reduced water cement ratio. Six beams were cast, and after curing period, these were tested for flexural strength. The strength of beams in flexure increases by 57% through reduction of W/C from 0.68 (normal concrete/fc'=3000psi) to 0.3, and with further replacement of 40% plastic aggregate the increase in strength as compared to the normal concrete was still 3%.**

Keywords— **Plastic Aggregate, Concrete, Flexural Strength, Water Cement Ratio, Plasticizer**

I. INTRODUCTION

A significant increase for aggregate demand is just because of increase in population day by day. The changed life style of human being adds many solid wastes to the environment. We can reduce some of the problems caused by these solid wastes through productive use of these wastes and thus we can benefit our world in the form of reduced environmental pollution, saving and sustaining natural resources and recycling energy products. Nowadays many research works are conducted to determine the possible disposal of these waste plastic to be replaced in place of mineral aggregates, especially in situations where the main concern is dead weight reduction rather than strength.

Many research work have been conducted to modify the concrete mix by replacing some of the components of concrete such as coarse aggregate, fine aggregate and cement with different industrial and solid waste materials. In concrete, these wastes are beneficial to be added either as a part of mineral aggregate or as a partly replacement of fine aggregate. Due to heavy weight of concrete, it can be used in skyscrapers because use of plastic aggregate will make the concrete light and then eventually the entire structure [1].

The investigation of Choi et al.(2005) clarify the result of plastic aggregate as a fine aggregate replacement in concrete mix. 2–6% reduction in weight is possible through the addition of plastic aggregate as related to that of ordinary weight concrete. Although, the reduction of strength in compression was about 33% as compared to that of conventional concrete [2]. The same results were obtained from the experimental investigation of Batayeneh et al.(2007) in which the decrease of strength in compression was directly proportional to the increase in the addition of plastic aggregate [3].

Another research work investigated the physical, chemical and mechanical behaviors of concrete mix incorporated with plastic aggregate. Their findings showed that there would be no substantial alteration in the concrete mechanical behavior if we incorporate plastic aggregate in quantity less than 10% by volume in the concrete matrix [4].

In one of the research polyethylene, terephthalate fibers were used in order determine the concrete mechanical properties; with the main concern to measure the effects of different dimensions and geometries on the concrete mechanical properties. His conclusions declare that the workability effected by a very small amount by changing the fibers geometry [5].

Another research work was carried out in which they replaced various percentages of sand in concrete mix with the waste plastic. They investigated concrete both in hardened state as well as in wet state with the main concern on the toughness index test. Their research declared that with the replacement of sand through waste plastic the generation of micro cracks can be arrested because a fabri form shape is provided by plastic wastes to concrete mixture [6].

The basic assumption, which is supported by experimental data reveals that the strength of hardened form of cement paste is the main agent that control the structural concrete strength, which in turn is in the control of W/C and is defined as the quantity of water present in the fresh concrete mixture to the quantity of cement. Thus, it is clear that the relation between water cement ratios versus concrete strength is the base for modern concrete technology.

Concrete produced with 10%, 20%, 30%, 40% and 50% plastic aggregate. The plastic aggregate addition up to 20% in place of mineral aggregate will still give strength value with in permissible range. Beyond 20%, replacement of mineral coarse aggregate with that of plastic aggregate will reduce the density of concrete [7].

The concrete mechanical properties, such as flexural and compressive strength having polymer based on recycled Polyethylene terephthalate, and the results showed that energy saving along with reduction in material cost is possible [8].

Plastic aggregate are lightweight aggregate and incorporation of plastic aggregate in concrete mixture will give much better results than the addition of other naturally used lightweight aggregate. The poor mechanical properties in most of the studies is because of reduced bond strength between cement paste and plastic coarse aggregate [9].

Therefore, the above reasons endorses the requirement of a study to promote the replacement of high percentage of plastic coarse aggregate in concrete. For which, this research has been planned to explore the concrete flexural strength having higher percentages of plastic aggregate.

II. SELECTION AND LABORATORY TESTING OF MATERIALS

The test conducted on all the material used such as coarse aggregate, fine aggregate and cement were having all the values within allowable limit according to the ASTM codes.

Additives are usually added to modern concert, which may be added either in chemical form or in mineral form. To improve workability of concrete mix we usually add superplasticizer and plasticizers, which are high range water reducers and reducers respectively, and both are chemical admixtures. There will be inverse relation between the concrete strength and added water or water cement ratio when the added water is not enough in the concrete mix. Plasticizer or superplasticizer will be required for greater workability when added water is too less for producing stronger concrete. Addition of 1-2% plasticizer by weight of cement is usually enough as higher percentages are not advisable because it will cause excessive concrete segregation [10].

Chemrite 520 BA-S was used as superplasticizer for W/C reduction. The slump test was carried out as per BS EN 12350 (2000) standard. The recommended range for superplasticizer used (Chemrite 520 BA-S) is 0.6-3% per unit weight of cement. From Slum test, we have defined the percentages of super plasticizer required for each type of concrete mix. Three trials were performed for each type of concrete mix to define the percentage of superplasticizer required. Thus, superplasticizer of 0.75% per unit weight of cement was defined to be added for a W/C of 0.5, 1% super plasticizer per unit weight of binder i.e cement for a

W/C of 0.4 and 2.5% superplasticizer per unit weight of binder for a W/C of 0.3. Table 1 shows Mix Design for Concrete Specimen.

Table -1 Concrete Mix Design

Ratios	Cement : Fine Aggregate : Coarse Aggregate : Plastic Aggregate	
	W/C = 0.68	W/C = 0.3
Normal concrete (fc' 3000 psi)	**1:3.13:4.35:0.00**	---------------------
0 % Plastic Coarse Aggregate (PCA)	--------------------	**1:0.92:1.92:0.00**
40 % Plastic Coarse Aggregate (PCA)	---------------------	**1:0.92:1.15:0.41**

Six beams were designed and cast for flexural testing with clear span equals six feet and cross sectional area of 6x9 in2. Among them two were controlled beams (fc'=3000psi and provided with flexural reinforcement based on minimum steel reinforcement as per the ACI-318-08), two beams with w/c of 0.3 and plastic percentage of 0% while the last two beams were having a w/c of 0.3 and plastic percentage of 40%. Slump tests were performed for each type of concrete mix for the determination of workability and thus a W/C of 0.68 was obtained for normal concrete and super plasticizer of 2.5% by weight of cement was specified for a W/C of 0.3. For beams design the average compression strength value fc'=6700psi was obtained from compression test conducted on concrete cylinders as per ASTM standard C470/C470M-15, shown in Figure 1 (a) and (b).

(a)

(b)

Fig. 1. (a) & (b) Compressive Test of Concrete Cylinder

The beams were tested for flexural strength as per ASTM C78/78M-10 using the third point loading criteria, as shown in Figure 2.

Fig. 2. Third Point Loading

The load application rate was 0.2 ton/sec by the loading cells having a total capacity of 100 ton. The data is tabulated in Table 2 and Figure 3, 4 and 5 shows flexural strength results.

Table 2: Flexural strength testing results

	Avg: Ultimate load (kips)	Avg: Deflection (mm)
Normal concrete (fc'= 3000 psi)	**10.40**	**25.16**
0 % Plastic Aggregate, W/C=0.3	**16.40**	**38.23**
40 % Plastic Aggregate, W/C=0.3	**10.73**	**53.08**

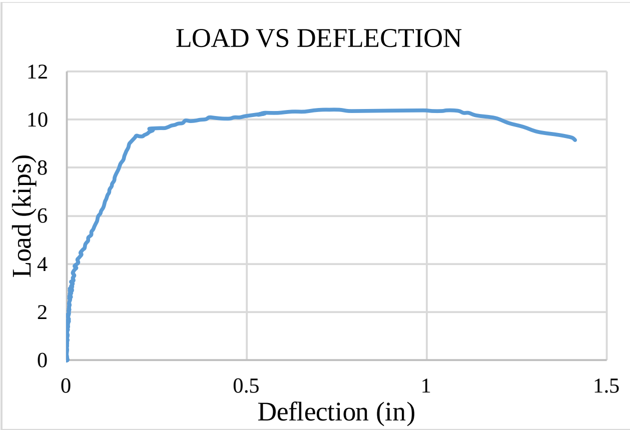

Fig. 3. Average Load vs. Deflection curves for beams having W/C=0.68, PCA=0%

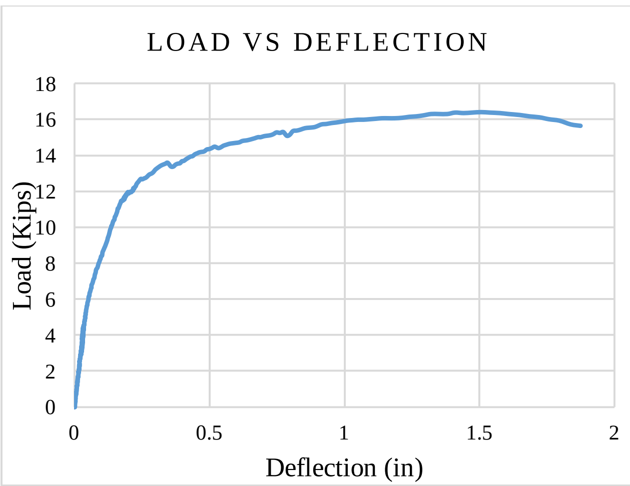

Fig. 4. Average Load vs. Deflection curves for beams having W/C=0.3, PCA=0%

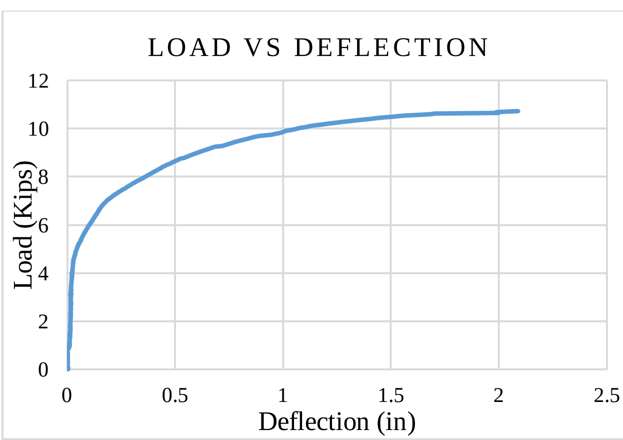

Fig. 5. Average Load vs. Deflection curves for beams having W/C=0.3, PCA=40%

The specimens with the plastic coarse aggregate replacement of 40% took more load than the specimens having W/C of 0.68, with the increase in flexural strength equals 3% only. Although the increase in flexural strength of specimens with 0% plastic aggregate and W/C 0.3 was 57% as related to that of traditional concrete.

Since all the specimens were designed for maximum shear, therefore no shear cracks were observed. All the cracks observed were purely flexural cracks as shown below in Figure 6.

Fig. 4. Crack pattern in 40% PCA specimen

III. CONCLUSIONS

From this research work, following decisions were made.

- The reduction in slump value because of plastic coarse aggregate addition best suits this concrete mix for situation where we need lower workability.
- Weight reduction of 25-30% is possible through replacement of 40% plastic aggregate.
- Concrete beam cast using plastic coarse aggregates replacement of mineral coarse aggregates increases ductility.
- The increase in ductility as a result of plastic aggregate addition can help to stop the cracks that can be generated during concrete mechanical failure.
- The strength of beams in flexural increases to 57% by lowering of W/C from 0.68 (normal concrete) to W/C of 0.3.
- Furthermore, the addition of plastic course aggregate of 40% to the mix having the same W/C of 0.3, the strength in flexural decreases, and the obtained average value of flexural strength is only 3% more than that of normal concrete mix having W/C equal to 0.68.
- Thus, increasing the percentages of plastic aggregate with reduced W/C gives equal or even

better performance in flexural strength than conventional concrete and thus can be used where dead load reduction is of prime concern.

IV. CONFLICT OF INTEREST STATEMENT

The authors of this research paper, whose names are listed on title page, certify that they have developed this research entirely on the basis of their personal efforts made under the sincere guidance of the supervisor.

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