Mechanical Properties of Concrete containing Plastic Aggregates: A Review

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Abstract: Plastic represents an environmental issue, as only 7% of it is recycled. The plastic remaining is either burned, disposed of in an uncontrolled manner or landfilled. Thus, in order to reduce the quantity of plastic which is disposed of, there is a need to increase the amount of the material which enters various product streams. This includes its use in the construction industry, and more particularly in concrete, which utilizes very large quantities of aggregate. As 100% replacement of natural fine aggregate (NFA) with plastic fine aggregate (PFA) is not feasible, partial replacement of natural fine aggregate weight by 10%, 15%, 20% with Plastic fine (PF) aggregate was done. Totally 24 cubes, 24 cylinders are casted to identify the compressive strength and split tensile strength respectively. Casted specimens are tested at 7 and 28 days. The identified results from concrete using plastic aggregate are compared with conventional concrete. Result shows reduction in mechanical properties of plastic aggregate added concrete. This reduction in strength is mainly due to poor bond strength between cement and plastic aggregates.

Keywords: Compressive Strength, Plastic aggregates,Split tensile strength, Flexural Strength.

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1) Introduction: The problem of disposing and managing solid waste materials has become one of the major environmental, economical, and social issues throughout the world. Among different waste fractions, plastic waste deserves special attention on account of non- biodegradable property which creates a lot of problems in the environment. In India approximately 40 million tons of solid waste is produced annually. This is increasing at a rate of 1.5 to 2% every year. Plastics constitute 12.3% of total waste produced most of which is from discarded water bottles. The plastic waste cannot be disposed off by dumping or burning, as they produce uncontrolled fire or contaminate the soil and vegetation and hence in civil engineering construction recycled shredded plastic aggregates can be used in a sustainable manner as a partial replacement of natural aggregates.

Past investigations suggest that partial replacement of natural aggregates in concrete with recycled waste plastic aggregates can improve properties such as abrasion resistance, impact resistance, ductility, shock absorption and thermal conductivity. It also shows that addition of plastic to concrete causes some reduction in mechanical properties such as compressive strength, split tensile strength, flexural strength depending upon ratio of replacement of aggregates. Polymer aggregate is significantly lighter than natural aggregate and therefore its incorporation lowers the densities of the resulting concrete. This property can be used to develop lightweight concrete. Thus, utilization of waste plastic materials in concrete as aggregates may be considered one of the most feasible utilization to overcome some disposal problems of waste plastic materials.

2. Past Investigations

The replacement ratios of Plastic aggregates and corresponding Mix design strengths from previous experimental studies are given in Table 1.

Table 1 : Replacement ratios of Plastic aggregates

Author	Grade of Concrete	Replacement Ratio	Type of Replacement
Praveen Mathew & Shibi Varghese	M20	20%, 22%, 40%, 60%	Coarse aggregates
MB Hossain & P Bhowmik	M20	5%, 10%, 20%	Coarse aggregates
B Jaivignesh & A Sofi	M25	10%, 15%, 20% & 15%, 20%, 25%	Fine aggregates along with Coarse aggregates
M. Guendouz & F. Debieb	M20	10%, 20%, 30%, 40%	Fine aggregates
Parvesh Kumar & Gaurav Kumar	M35	100%	Coarse aggregates
Md. Zakaria Habib & Md. Masud Alom	M25	5%, 10%, 15%, 20%	Coarse aggregates

2.1 Compressive Strength:

Past investigations suggest that incorporation of plastic aggregates in concrete reduces the compressive strength of concrete. Praveen Mathew & Shibi Varghese (2013) replaced Natural Coarse Aggregates (NCA) with Plastic Aggregates (PCA) with a replacement ratio varying from 20% to 60% and reported that a percentage replacement of 22% NCA with PCA was found to have superior concrete compressive strength. The experimental studies carried out by MB Hossain & P Bhowmik (2016) found that the compressive strength of concrete containing different proportion of PCA was different but the compressive strength at 10% volume of PCA provided higher compressive strength which allowed it to be used in structural applications. The investigation of B Jaiviganesh & A Sofi (2017) includes replacement of fine aggregate weight by 10%, 15%, 20% with Plastic fine (PF) aggregate and for each replacement of fine aggregate 15%, 20%, 25% of coarse aggregate replacement with Plastic Coarse (PC) aggregate. They concluded that the compressive strength of concrete containing Plastic aggregates was lowered by the addition of plastic. The reduction is being in the range of 9 to 17 %. This loss may be attributed to the poor bond strength between plastic aggregates and concrete. In experimental study of M. Guendouz & F. Debieb (2016) Various volume fractions of sand (10%, 20%, 30% and 40%) were substituted by the same volume of plastic aggregates, and various amount of plastic fibres (0.5%, 1%, 1.5%, 2%) were introduced by volume in sand concrete mixes. Their investigation found the increase in compressive strength at 28 days of age of about 30% and 25% when 20% of plastic powder or 1.5% of plastic fibres added respectively. They concluded that for an optimal utilization of this type of concrete, the level of substitution should be limited to 20% and 1.5% for plastic powder (LDPP) and plastic fibres (LPE) respectively.

2.2 Split Tensile Strength

Past investigations suggest that incorporation of plastic aggregates in concrete reduces the Split Tensile strength of concrete. Praveen Mathew & Shibi Varghese (2013) found about 22% reduction in Split tensile strength in 22% PCA replaced concrete with respect to conventional concrete and concluded that with regard to its tensile behaviour the bonding strength of PCA with matrix

needs more attention, since PCA concrete has shown a substantial reduction in split tensile strength and elastic modulus. The experimental studies carried out by MB Hossain & P Bhowmik (2016) found that the nature of increasing tensile strength is similar to the compressive strength. There is a decrease in the splitting tensile strength with respect to the fresh concrete independently on the size of the PET aggregates added. The investigation of B Jaiviganesh & A Sofi (2017) found that the split tensile strength of concrete by addition of Plastic aggregates was lowered. The reduction was being in the range of 10 to 24%. The reduction in strength is mainly due to weak bonding strength between the surface of the plastic aggregates and cement paste. The hydration of cement is also restricted by means of using plastic aggregates as it is a hydrophobic material. Md. Zakaria Habib & Md. Masud Alom (2017) concluded that the tensile splitting strengths were decreased from 6.7% to 30% for concrete containing 5% to 20% recycled plastic aggregates respectively.

2.3 Flexural Strength

Literatures found that replacement of aggregates in conventional concrete by Plastic aggregates reduces the Flexural Strength of concrete. According to Karthikeyan M. & Balamurali (2019) the flexural strength decreases with increase in the percentage replacements of plastic waste aggregates at the age of 14 days however the reduction in flexural strength at the age of 28 days is less as compared with early strength of concrete. MB Hossain & P Bhowmik (2016) observed that the flexural strength was decreased as the amount of PET aggregate increased in concrete. The investigation of B Jaiviganesh & A Sofi (2017) found that the flexure strength of waste plastic used concrete was lowered by the addition of plastic. The reduction was being in the range of 20 to 30 %.

3. Conclusion

For producing environment friendly and sustainable concrete products, incorporation of recycled plastic aggregates in conventional concrete has gained lot of importance. In previous studies tests were conducted on concrete containing Plastic aggregates to determine mechanical properties of concrete containing Plastic aggregates which concluded that there is considerable reduction in compressive as well as splitting tensile strength of concrete containing plastic aggregates. Past investigations also suggest that replacement of fine aggregates causes less reduction in strength of concrete than replacement of coarse aggregates.

From the study of past experimental investigations we found the optimal ratio of replacement of fine aggregates ranging between 10 to 20 percent utilization of waste plastic materials in concrete as aggregates may be considered one of the most feasible utilization to overcome some disposal problems of waste plastic materials.

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