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Research Article

SCOPE FOR UTILIZATION OF MELT PROCESSED PLASTIC PELLETS AS PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE

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ABSTRACT
Cement concrete is one of the most versatile materials in construction industry. The heavy demand has led to the depletion of raw materials available in nature.The present concrete making ingredients consume lot of energy during its production and at the same time release heat and greenhouse gases (creating environmental issues) directly or indirectly.
The dearth of fine aggregates warrants for some substitutes from the point of sustainability. The domestic plastic waste management has posed a challenge to present day engineers and scientists.
To overcome this menace, an attempt has been made here to exploit the scope for utilization of melt processed plastic (MPP) pellets as partial replacement of fine aggregates in concrete. This study reports strength variation in concrete with 5%, 10%, 15%, 20%, 25%, 40% and 60% replacement of fine aggregates by MPP pellets.

Key Words: *Eco Friendly Concrete, Melt Processed Plastic Pellets, Unconventional Materials.*

INTRODUCTION
Concrete is a widely-used man-made construction material on earth. However the availability of its ingredients is gradually decreasing with more and more demand for concrete.
Sand is one of the ingredients facing acute shortage since it is used for various other civil engineering works like mortar for masonry, cushioning for laying floor tiles and plastering, blocks for masonry and interlock pavement etc.
Even though manufacturing of crushed rock sand has gained momentum, it is depending on non-renewable source and in turn consumes energy in its production and release CO_2 indirectly.
The use of melt processed plastic pellet as partial replacement of sand in concrete acts as safe sink which lowers environmental burden and offer opportunities for significant reduction in energy and lower rate of carbon emission.
In this experimental investigation, the influence of partially replacing sand by MPP pellets on the compressive strength, split tensile strength and flexural strength of concrete has been critically evaluated.

MATERIALS AND METHODS
Materials
The Cement (C) used was 43 grade ordinary portland cement, Fine Aggregates (FA) were natural sand sourced from river and single sized pellets obtained by Melt Processed Plastic (MPP) waste i.e., recycled waste organic polymer called high density poly ethylene (HDPE).
The Coarse Aggregates (CA) were obtained by crushing natural granite rocks. The Water used for mixing was of potable quality. The particle size distribution of FA and MPP pellets are tabulated in Table 1.
Mix Proportions
Concrete with a nominal mix of C:FA:CA :: 1 : 1.5 : 3 with a water cement ratio of 0.5 was considered. For the same mix proportion keeping the volume of FA as constant, (to maintain the yield of concrete as one cubic metre) the sand was replaced volumetrically by 5%, 10%,15% ,20% ,25% ,40% and 60% of MPP pellets.

The target slump was targeted around 50 mm.

Table 1: Particle size distribution of Sand and MPP pellets

Sieve size (mm)	Percentage Finer	
	Sand	**MPP Pellets**
10	100.0	100.0
4.75	98.4	100.0
2.36	97.0	80.4
1.18	88.3	0.0
0.6	73.5	0.0
0.3	13.8	0.0
0.15	0.4	0.0
pan	0.0	0.0

Experimental Procedure

The concrete was mixed in a machine mixer and the fresh properties like slump, compaction factor and plastic density were measured. Three specimens comprising one sample were cast for each strength parameter and were tested after 28 days water curing. The compressive strength was measured by crushing 150 mm cubes, the split tensile strength on 100 mm cubes and flexural strength on prism of size 100 mm x 100 mm x 500 mm by 2 point loading. In addition to this, the dry densities at 28 days were also measured.

RESULTS AND DISCUSSION

Important results relating to mechanical properties is presented and discussed

Fresh Properties

The mix appeared normal by visual inspection and no segregation of MPP pellets was observed.

Strength Properties

Three types of strength tests were conducted after 28 days of water curing.

- Compressive strength as per IS: 516 1959.
- Split tensile strength as per IS 5816:1999.
- Flexural strength as per IS 516-1959.

Each sample consisted of three specimens.

Compressive Strength

The compressive strength will increase with decrease in water-cement ratio. Since w/c is kept constant for all the mixes, but with different MPP pellet proportion (replacement of river sand by volume), the change in strength will be the direct influence of presence of MPP pellets and its percentage content.

The results are plotted as shown in Figure1. Upto 20% of replacement and except for 5%, the strength is more or equal to that of reference concrete (without MPP pellets). It is observed that the strength increases upto 15% replacement and then drops till 25% with the same rate as that of strength gain rate. The strength then decreases at a lower rate with the increase in MPP pellet content. The optimum percentage replacement observed to attain maximum strength was with 15% MPP content, i.e., 11% more strength than reference concrete but numerically about 4 MPa.

The reason for gain in strength wrt to reference concrete could be more cement content available in matrix due to larger size of the MPP pellet compared to river sand. Whereas in higher MPP pellet content (beyond 20%), the following factors may overcome the beneficial part leading to loss of strength.

- Strength (elastic modulus) of MPP is lower than that of sand.
- The sharp edges of the cylindrical shaped pellets, which initiates crack growth.
- The smooth surfaces of the MPP pellet contributing lower bond strength.

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It can be concluded that compressive strength with MPP pellets prove equally strong as river sand in the range of 10 to 20 percent replacement, in general. However the best performance achievable is by 15% replacement.

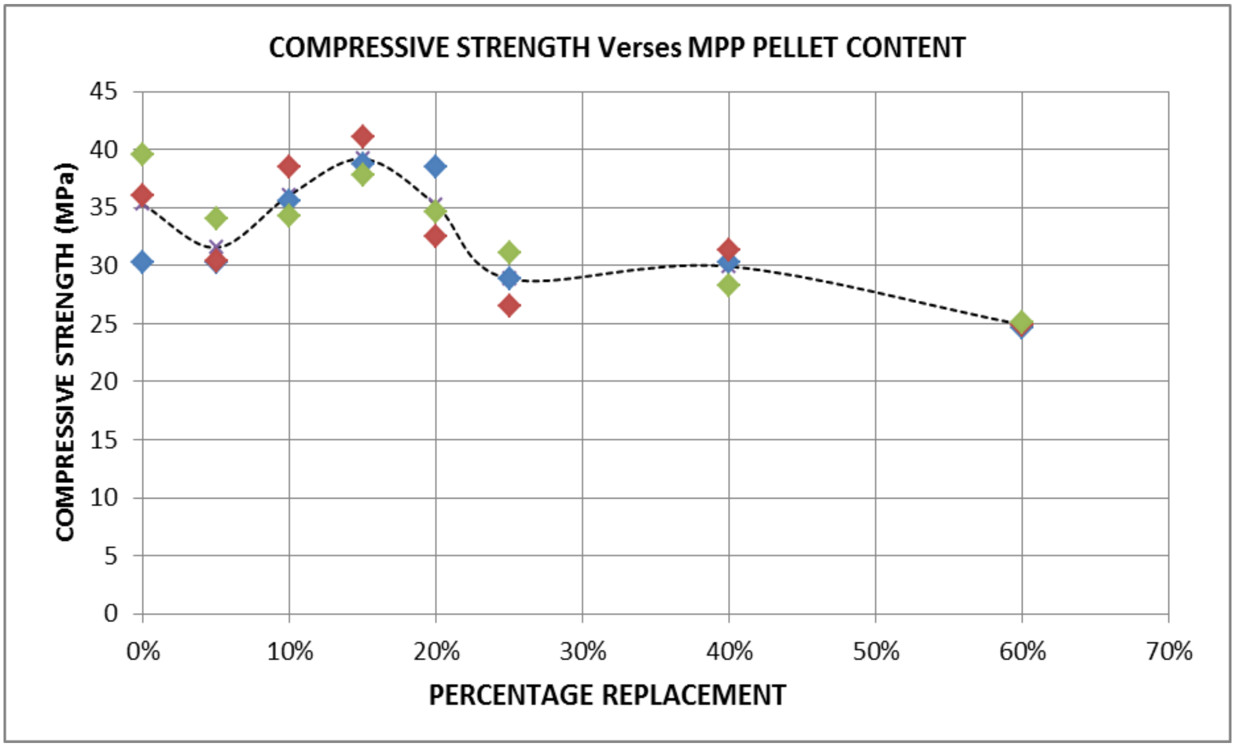

Figure 1: Variation of Compressive Strength with FA replacement

Tensile Strength

Tensile strength is a function of compressive strength but there is no direct relation of proportionality. In general, as the compressive strength increases, the tensile strength also increases but at a decreasing rate. Indirect tests such as split tensile strength and flexural strength are conducted in order to evaluate the tensile strength.

Split tensile strength

The results are plotted as shown in Figure2. Upto 20% of replacement and except for 5%, the strength is more or equal to that of reference concrete (without MPP pellets). It is observed that the strength increases upto 15% replacement and then drops till 25% with the same rate as that of strength gain rate. The strength then decreases at a lower rate with the increase in MPP pellet content. The optimum percentage replacement observed to attain maximum strength was with 15% MPP content, i.e., 55% more strength than reference concrete but numerically about 2 MPa.

The split tensile strength is found to vary from 1/10 to 1/19 th of its corresponding compressive strength and 1/3rd to 2/3rd of flexural strength.

All the values are found to be less than the estimated value computed from ft=0.23(fck)0.67(as per FIP), the ratio of actual by estimated is found to be less than unity except for 10% and 15% replacements.

Flexural strength (Modulus of rupture):

The flexural strength in all the cases is lesser than reference concrete and decreasing at a lower rate with increase in MPP pellet content (Figure3).

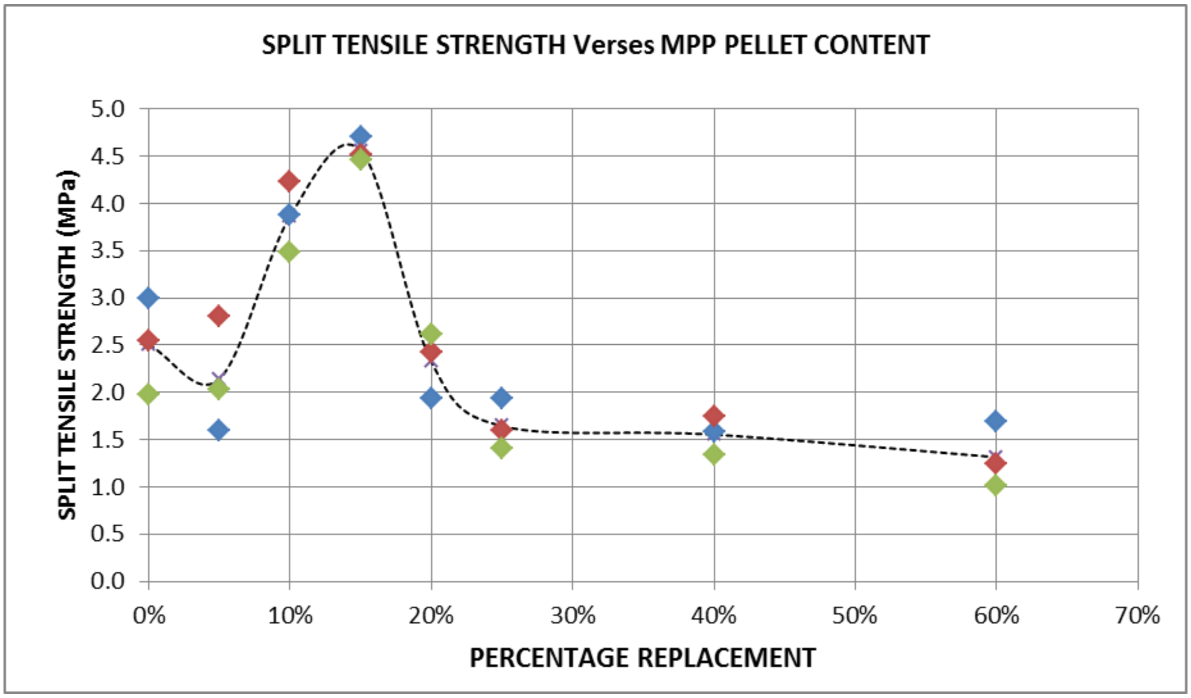

Figure 2: Variation of Split Tensile Strength with FA replacement

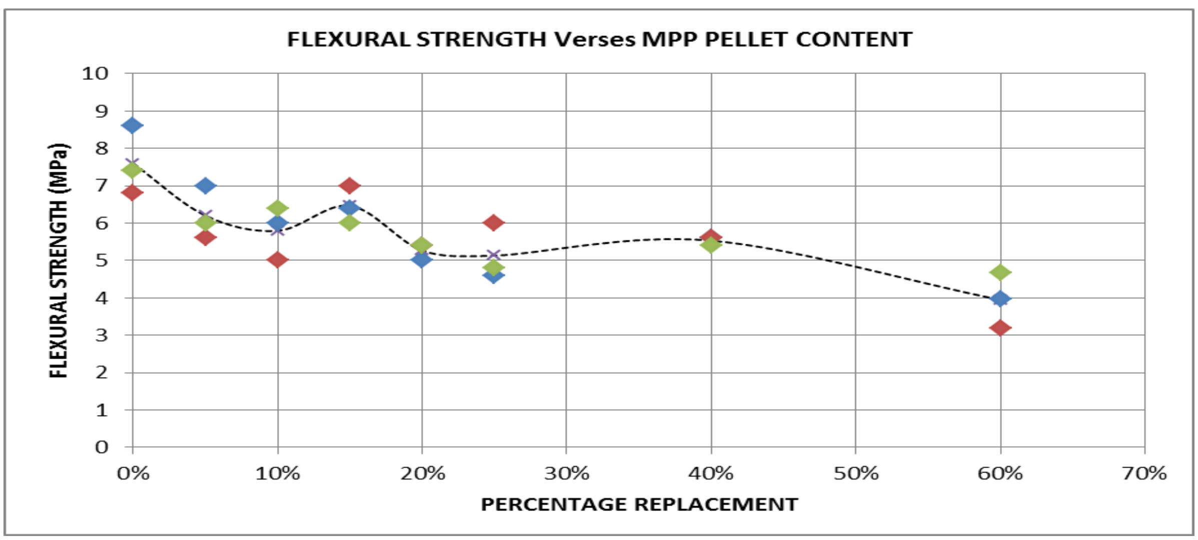

Figure 3: Variation of Flexural Strength with FA replacement

There is clear indication on loss of flexural strength by the addition of MPP pellets with minimum loss of 15% strength at 15% replacement compared with reference mix.

All the values are found to be more than the estimated value computed from fcr=0.7√fck(IS 456-2000), the ratio of actual by estimated is found to be more than unity.

It is a well-known fact that as the aggregate size increase, there will be drop in strength, which is true in this case as the sand is replaced by comparatively larger (and uniform) sized MPP pellets.

Again the orientation of cylindrical shape of MPP pellets may play an important role; the pellets with its axis parallel to longitudinal axis of prism may act as fibre (since short in length may fail by bond strength than tensile failure) and those pellets with its axis normal to the longitudinal axis of prism will not offer any resistance to failure, i.e., debonding takes place due to its smooth surface.

Inter-relationship between Compressive strength split tensile strength and Flexural strength

Figure 4 shows the variation of compressive, split tensile and flexural strength with increase in MPP pellet content (replacing the river sand by volume), shown in same scale. The interrelationship among the strengths was similar to that of normal concrete, i.e., tensile strength was proportional to compressive strength and flexural strength lesser than compressive strength and split tensile strength lesser than flexural strength.

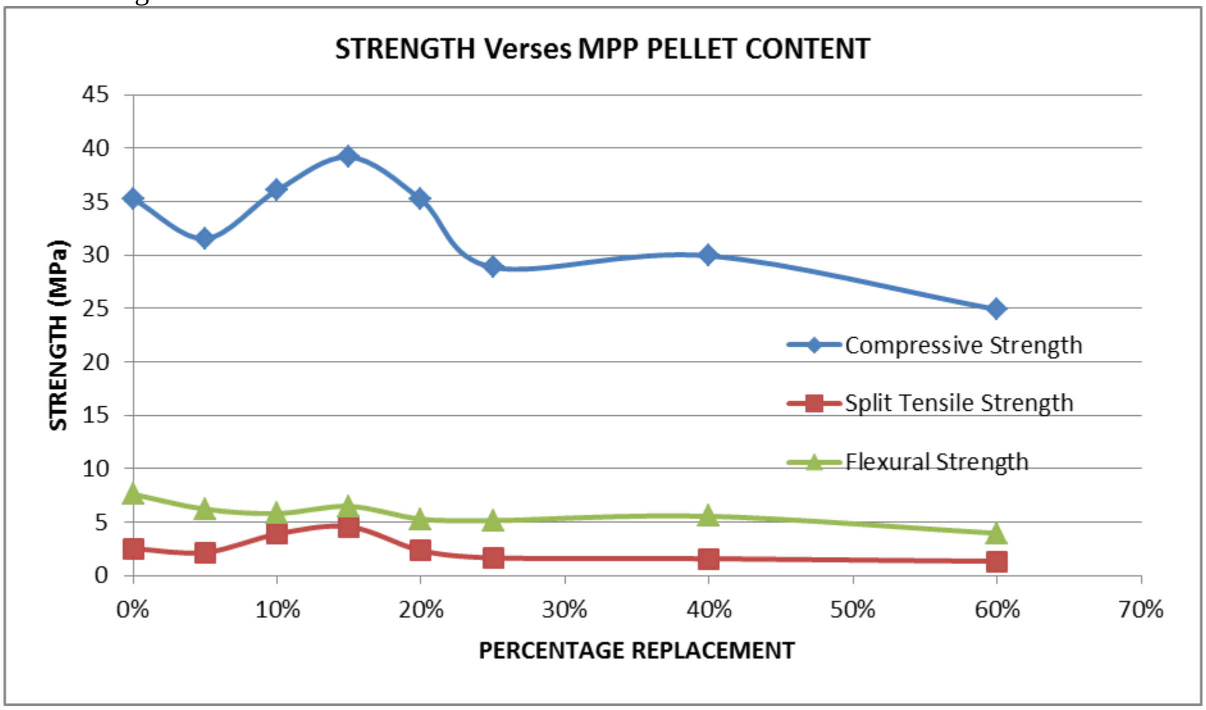

Figure 4: Inter-relationship among Average Strengths with change in FA replacement level

Conclusion

The following conclusions are deduced from this study:

1. There is no segregation of MPP pellets in concrete even though it is lighter than water.
2. The strength variation patterns in all the three types of strengths are following a similar trend/pattern, i.e., they together increase or decrease (Figure4).
3. It can be concluded that percentage replacement by MPP pellets are equally strong as river sand for the following cases:

Upto 20% replacement barring 5% replacement, there is no drop in compressive strength as well as split tensile strength. The optimum percentage replacement with gain in all the three type of strengths is found to be 15%.

The use of recycled materials incorporated to concrete is a technology that can constantly be improved, regarding technical and environmental conditions. Therefore, studies in this area are promising to its dissemination in the construction field.

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