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Strength Analysis of Cement Concrete Cube with Partial Replacement with Polymer Trash

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Abstract

As an increment of customers taking place worldwide, industries compete to make their products cheaper, more durable, appealing, and easy to be transported. Most industries use plastic without considering its environmental and health risks. Different Plastic create massive waste worldwide. This non-biodegradable garbage is a long-term issue that threatens human health and the environment. In this paper the traditional material cement is replaced with the discarded waste material in order to make construction activities as environment-friendly. Polymer Plastic Bag Waste (PPBW) is taken for study experimental analysis, this material has fibrous performance. Many of researchers have depicted in their experimental studies that with utilisation of such discarded waste in the preparation of concrete, enhances the characteristics of the concrete. In this experimental work the investigation conducted on the M20 grade of the concrete, the mixture prepared with the utilisation of PPBW. For the preparation of the mixture, the substitution doses were kept from 0 to 10%, whereas the Ordinary Portland Cement (OPC) has been considered for the incorporation in mix preparation. To analyse the performance of the concrete both durability as well as the mechanical characteristic has been investigated. The comparison of modified mixture has been made with the conventional mix by keeping the procedure of analysis in accordance to the Indian Standard Codal provisions. It has been observed in the results of testing that overall mechanical characteristics were found to be enhanced. Whereas, some of the durability properties are found to be altered when compared with conventional mix at varied level of substitution. It has been observed in the experimental testing that optimum results are achieved when the PPBW substitution has been kept at a level of 6%, and similar observed were also noted for the M20 grade. The result obtain justifies that polymer plastic bag waste can be utilized in the preparation of the concrete enhances the properties. The proposed work is an effort towards making sustainable and eco-friendly construction.

Keywords: Ordinary Portland Cement (OPC), Polymer Plastic Bag Waste(PPWB),Concrete, Eco-friendly Construction, Sustainable, Plastic .

1.Introduction

Society must ensure a clean and sustainable environment for all human-being. Due to increased urbanization and industrialization, the practices of waste dumping and land filling the recycled product has increased steeply and it poses a serious hazard for human as well as for other creature's health and the environment. Bakelite, the first synthetic material created from phenol and formaldehyde condensation, is dangerous. Bakelite is one of the polymer-based thermosetting plastic. E-elements has been produced in a high manner since the thermal and non-conductive properties of Bakelite are used and dumped [1-3]. Now-a-days, electronic components, heavy metals, glass, polymers, ferrous-nonferrous metals, hazardous chemicals, telephone casings, kitchenware, pipe stems, plastic toys, and other plastics use synthetic polymer plastic bag waste[1-4]. Polypropylene fibers tend to absorb no water at all since these are hydrophobic in nature. Hence, these are meant to be properly mixes during the concrete preparation to ensure their proper dispersion in the concrete matrix. However, it is not specified to completely replace the structural steel in the concrete[3-5]. Monofilament fibers are only able to inhibit the cracks tends to produced by the thermal as well as the shrinkage stresses and that too at the early ages. These are not able to inhibit the post-cracking in the concrete also there are no noted enhancement in the other characteristics of the concrete. The level of incorporation of these fibers as suggested by other researchers is 0.1% by volume when used in the preparation of paving mixes or the mixture used for other purposes. Whereas, it has been experimentally tested for a level of incorporation as 7%. However, volume beyond 2% is observed as the continuous fibre, which practically not accepted in the preparation of paving mixes due to the constructability issues[5-6]. The accepted level of incorporation of the fibers are suggested as 0.5% which enables to ignore the mix ratio adjustments. However, the need of admixtures as air-entraining agent as well as the water-reduction are aroused. Permeability tends to get increased which enables the ingression of water as well as the other ions

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from outside to inside formed cracks, which leads to the damage to the concrete [7]. Creation of cracks and their propagation can be inhibited by the incorporation of Polypropylene Fumarate (PPF) in the preparation of the concrete, since these fibres tend to create 3 dimensional dispersion in the concrete matrix creating a random fibre network [8-11]. This phenomenon enhances the durability characteristics of the concrete by inhibiting the water along with the ingression of other deteriorating ionising the concrete [4, 12-14]. Since the better performance of the PPF, these have wide acceptance to be utilised in the paving purposes as well as in the hydraulic and architectural works [7, 15-17]. Furthermore, the formation of cracks are efficiently inhibited by the utilisation of the PPF, and this phenomenon leads to the inhabitation of the permeability [12]. Along with this, the toughness of the engineering structures like pavement can be improved with the incorporation of the PPF [7].Deteriorating ions along with the possibility of water ingress are too much prone in the hydraulic engineering works, and the PPF are able to resist the ingress of these in concrete in an effective manner along with the inhibiting crack formation, all these phenomena tend to enhance the overall performance of the concrete [14]. Many of the achievements of the PPF utilisation in concrete has been studied by various researchers in their experimental works. As, Rashid [14] have assessed the durability characteristics of the PPF modified mixes, and it has been observed in their study that overall durability characteristics of the concrete has been found to be enhanced for the PPF modified mixes. Furthermore, Wang et al. [13] have also assessed the durability characteristics of the macro-synthetic PPF modified mixes, and it has been observed in their study that overall durability characteristics of the concrete has been found to be enhanced compared to the conventional mixes. Also, it has been depicted by the numerous researchers that, the incorporation of the PPF in the preparation of the concrete can also enhance the mechanical characteristics of the concrete [9, 10].

This paper has 4 section. Section 1 includes brief introduction of work carried out by different researchers.

Properties of material and methodology is discussed in section 2. Result and outcomes are depicted in section 3, followed by conclusion in section 4 .

2.Properties of Material and Methodology

In accordance to the IS 383, the constituting materials of mix preparation are selected, such as coarse and fine aggregates confirming to zone-II and OPC has been adopted for the binding purpose. Whereas, the coarse aggregate incorporated in the mix preparation are as crushed quartz stones. The procurement of all these incorporating materials are made from the native Jaipur market. The doses of the PPBW are kept at a varied level of different mixes. The chemical as well as the physical properties of the constituting materials are represented in the tables 1 and 2 respectively.

Table 1 Cement and Polymer Plastic Bag Waste's Chemical Composition

Composition	WPPB
SiO_2	20.34
Al_2O_3	6.02
Fe_2O_3	2.97
CaO	63.13
MgO	1.23
SO_3	2.12
Na_2O	0.34
K_2O	0.56

Table 2 Physical properties of raw material

Property	Cement	Fine Aggregate	Coarse Aggregate (10 mm)	Coarse Aggregate (20 mm)
Consistency (%)	27	-	-	-
Initial Setting Time (minute)	120	-	-	-
Final Setting Time (minute)	241	-	-	-
Specific Gravity	3.15	2.62	2.70	2.70
Water Absorption (%)	-	1	0.4	0.41
Fineness Modulus	-	2.67	5.79	7.02
Compressive Strength (MPa)				
7 days	34.6	-	-	-
28 days	44.8	-	-	-

2.1 Mixing Strategy Adopted

To accomplish the purpose of the study M20 grade of the concrete adopted to inspect the behaviour of PPBW in concrete. Individual six mixes were prepared for each grade. Polymer plastic bag waste was replaced with cement at 2% interval till 10%. All other characteristics of the mixes are kept as per the standards of IS 10262.

2.2 Testing Process Adopted

To experimentally analyse the mechanical characteristics of the mixes the standards of the IS 516:1959 and IS 5816: 1999 has been adopted for the testing procedures. The shape and sizes of the prepared specimens were kept as per the Indian Codal standards, for flexural, compressive as well as tensile strength testing, total six specimen were prepared, whereas for each test three samples were made.

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3.Results and Outcomes

3.1 Compressive Strength

This characteristic is the key factor to test feasibility of incorporation of any foreign material in preparation of concrete mix. The testing of specimens was conducted for 7, 28 and 56 days intervals. The grade of the concrete adopted to tested was M20 for PPF modified mixes. Figure 2 represents the outcomes of the testing results. It has been observed in the experimental testing that optimum outcomes were observed at 6% incorporation of PPBW in the mix preparation, whereas, beyond this level of dose the outcomes tend to go decreasing manner. This phenomenon takes place due to the consumption of more hydration products (C-H-S gel), which would be a tremendous improvement as shown in the results.

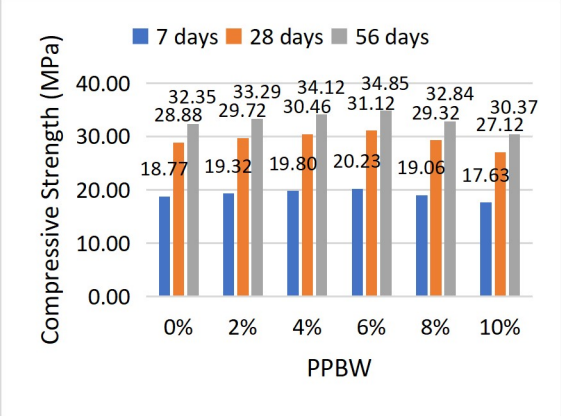

Figure 2 Compressive strength outcomes of PPBW modified concrete

3.2 Split Tensile Strength

The testing of specimens was conducted for 28, 56 and 90 days intervals.

When the level of PPBW substitution was kept as 6%, the mixes were observed with the enhanced split tensile strength, whereas, when the level of dose taken beyond this limit the mixes strength observed with decrement, the same manner of the strength variation has been observed in the compressive strength in figure 3.

Compared to the control mix, the optimum gain of tensile strength was 2.51 MPa from 2.42 MPa. PPBW particles are in fibre form which provides additional reinforcement to concrete mixes. This interlocking of fibres with concrete mixes enhances the tensile behaviour concrete. Figure 3 represents the outcomes of testing.

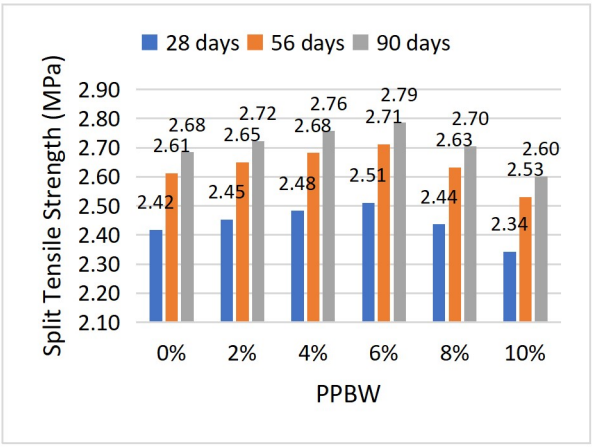

Figure 3 Split tensile strength outcomes of PPBW modified concrete for (a) M20 (b) M25

3.3 Flexural Strength

PPBW fibre particle provides addition reinforcement to concrete mixes which leads to increase in flexural strength. The testing of specimens was conducted for 28, 56 and 90 days intervals. PPBW modified mixes observed with the higher strength gain comparing to the conventional mix, the same manner of the strength variation has been observed in the compressive strength. The increment in strength is propagated due improvement in Interfacial Transition Zone (ITZ), this phenomenon leads to the more resistance to the loadings. Along with this, fibers act as additional reinforcing material, which enables mix to gain increment in the flexural strength. When the level of dose increased beyond optimum level, then mixes depict strength decrement, this phenomenon takes place due to the formation of increased voids as shown in the resultant graph. Enhanced interlocking of these fibre in concrete matrix enables mixes to gain better strength.

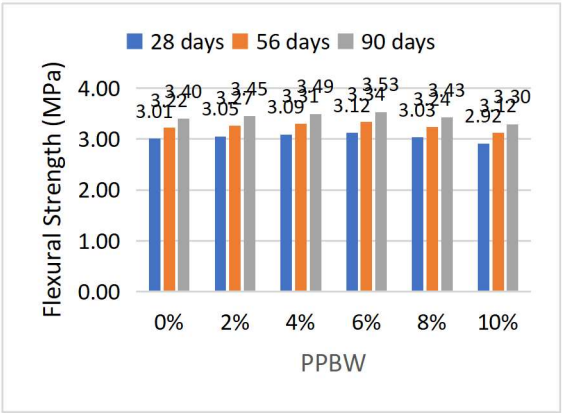

Figure 4 Flexural strength outcomes of PPBW modified concrete for (a) M20 (b) M25

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4.Conclusion

The resultant outcomes are concluded as follows:

Prepared PPBW modified concrete samples were experimentally tested for the durability performance.

- The optimum level of substitution was observed as 6%, at this level of substitution compressive strength was noted with the highest strength gain, when the level of substitution taken beyond this level, then mixes were noted with decrement in strength. Similar strength values were observed for the control mix and PPBW modified mix with level of substitution as 8%.
- Outcomes trend of tensile strength testing are identical to the compressive strength testing, the optimum level of substitution observed for PPBW was 6%.
- When the level of substitution of PPBW kept as 6%, then the mixes were observed with the highest flexural strength gain, however, when level of dose taken beyond this level, then samples were noticed with decrement in strength.

  Hence, overall it can be concluded that optimum dose of substitution of PPBW is 6%, at this level the durability of the mixes enhanced to the best level to be used for construction.

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