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Study the Effects of Tobacco Waste Ash and Waste Glass Powder as a partial replacement of cement on Strength Characteristics of Concrete

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Abstract

The environmental problems that are related to cement manufacturing makes the new studies to move forward to using materials having a less environmental impact, thus, in this paper, the authors were utilizing Waste Glass Powder (WGP) that has high percentage of silicon dioxide (SiO_2) along with Tobacco Waste Ash (TWA) in different concentrations. Utilization of these waste materials can be considered as keeping on resources. The objective of this study is to partially replace WGP (size 80 µm) and TWA at percentage of 5, 7.5, 10, and 12.5 respectively as replacing cement. The strength characteristics of this new type of concrete are compared with that of the conventional concrete. After mixing, casting, and curing in water for 7, 14, and 28 days respectively, with respect to the experimental results of compressive, flexural and split tensile strength tests values of the specimens were assessed. The experimental results reveal that the compressive and split tensile tests values of the specimens increases by adding at 10% of WGP and 10% of TWA , whereas flexural strength test values increases at the 12.5% of WGP and 12.5 % of TWA. The test results show that the partial replacement of the waste glass powder and Tobacco Waste ash combination can be a good substitute for cement. Apart from the strength, the new type of concrete helps to recycle the wastes of glass and Tobacco, and thereby protecting the environment and reduce the construction cost.

Keywords: Waste Glass Powder, Tobacco Waste Ash, Environmental Impact, Compressive, Flexural, Split Tensile Strength.

1. Introduction

Cement is a significant material that used for civil engineering applications all over the world. Though, the consumption of cement brings about some important ecologic problems. One of these problems is the large amount of CO2 emission resultant from the manufacturing process of the cement [9-10]. In addition to reducing cement consumption of the mineral admixture content also improves some important properties of the concrete in two ways. First way is the reaction occurs between calcium hydroxide and mineral admixture resulting with the generation of the extra Calcium Silicate Hydrate gel. Second way is the filler effect of the mineral admixture due to its fineness [11]. Mineral admixtures can also reduce material costs by providing less cement consumption [12].

Many natural and artificial mineral admixtures are used in the field of construction and concrete production for various purposes. The utilization of the industrial wastes and by-products in concrete industry as mineral admixture provides the industry to be eco-friendlier and sustainable. Industrial by-products and wastes, such as, recycled plastics, silica fume, fly ash and ground granulated blast furnace slag have been successfully used as mineral admixture in concrete technology for decades [13, 14]. The behaviour of these additives in concrete is physico-chemical. The physical part of this behaviour is originated from the shrinking of the size of the void in the interface between the cement and the aggregate. The main compounds SiO2, Al2O3 and Fe2O3 should constitute great rate of the total chemical composition of the mineral admixtures in order to be used in cement and concrete. The activity of these additives is dependent on the presence of oxides and minerals in amorphous or weakly crystalline states [15]. As we know that now day, most of developing country facing shortage of post consumers disposal waste site and it's become very serious problems. For this reason, regenerating and using waste product as resources and prevent environmental pollutions. Currently most of recovered waste glass is used by glass manufactured company in the production of new glasses such as bottle and etc. But only a limited amount from the waste glass collected is that can be used towards the production of new glass.

Since waste glass and Tobacco waste still gave us a problem, an attempt made to use it in the concrete mix and find the result whether because if the results gives us a good value, then it will benefit to our earth because we can reduce few portion of our waste that cannot dissolved by natural or normal recycling ways. The main reason of this study is to create a better environment that free from polluted space and also to find a better solution for concrete mixture that can give higher strength to concrete from the waste glass and Tobacco waste products .Even study may give less cost of using those kind of admixture rather than buying expensive admixture to get great and higher strength in concrete as now days it's the admixture that in market are very expensive and often increase the cost of the construction.

2. Materials and Methods

2.1. Materials

2.1.1 Cement

Cement is as important ingredient in the manufacturing of concrete and acts as a binding material i.e. having adhesive and cohesive properties. Cement is obtained by pulverising

clinker formed by calcining raw materials primarily comprising of lime (CaO), Silica (SiO_2), Alumina (Al_2O_3), and Ferric Oxide (Fe_2O_3) along with some minor oxides.

2.1.2 Fine aggregates and course aggregates

Fine and coarse aggregate make up the bulk of concrete mixture. Sand, natural gravel and crushed stone are mainly used for this purpose. For fine aggregates natural sand is provided with maximum size of 4.75 mm. Coarse aggregates are used with size between 20mm-4.75mm.

2.1.3 Waste Glass Powder

Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. The amount of waste glass is gradually increased over the recent years due to an ever-growing use of glass products. Most waste glasses have been dumped into landfill sites. The Land filling of waste glasses is undesirable because they are not biodegradable, which makes them environmentally less friendly. Glass powder shows that have a high content of SiO_2, CaO, and Fe_2O_3 in the powder, in the same of time Ordinary Portland Cement have almost the same content but with different percentages. These results encouraged us to utilize it as a partial replacement of cement. Composition of cement, Glass Powder and Tobacco waste ash are shown in Table 1.

2.1.4 Tobacco Waste Ash

Tobacco waste ash is a material that needs to be investigated with its potential to show puzzolanic activity due to its properties such as fineness, amorphous form and high silica content. So it can be said that tobacco waste ash may be used in concrete as a mineral admixture. The tobacco waste was collected from a local factories and shops, and the waste was primarily composed of tobacco stems. The waste was burned, and the resulting ashes were sieved through a 425 μm sieve to eliminate undesirable particles. The ashes were ground in a Los Angeles abrasion machine to reduce the particle size to below 60 μm.

Table 1: Chemical Composition of Cementing Material

S. No	Properties %	Waste Glass Powder (WGP) %	Cement %	TWA %
1	SiO_2	72	20.2	25.67
2	CaO	9	60.06	25.54
3	MgO	2.5	2.6	4.6
4	Al_2O_3	0.5	4.2	0.16
5	Fe_2O_3	3.5	3.0	0.31
6	SO_3	-	3.5	7.04
7	Cr2O3	1.00	-	-
8	Na_2O	8.9	0.19	0.49
9	K_2O	-	0.82	17.84
10	$CaCO_3$	-	2.3	-
11	Specific gravity	2.6	3.13	2.62

2.2 Methods

The ingredients of concrete consist of Cement, fine aggregate and coarse aggregates, water. When the reaction of water with cement takes place hydration process is done and a hard material is formed. Mix design carried out for M20 grade of concrete by IS 10262: 2009 yielded a mix proportion as shown in Table.2. Specimens were prepared according to the mix proportion and by replacing cement with glass powder and also replacing cement with both WGP and TWA in different proportion. The ingredients are used in proper proportion by replacement of cement at 10%, 15%, 20% and 25% by only waste glass powder. Even in the next stage both waste glass powder and tobacco waste ash replaced as cement at 5%, 7.5%, 10% and 12.5% respectively. To find out the Compressive strength, specimens of dimensions 150X150X150mm were used finally cast and tested using a compressive testing machine for 7, 14 and 28 days characteristic compressive strength.

Table2: Mix Proportions

Mix Base	**Water (ℓ)**	**Cement** (Kg/m^3)	**Fine Aggregate** (Kg/m^3)	**Coarse Aggregate** (Kg/m^3)
Weight	191.58	384	559.91	1219.3
Ratio	W/C=**0.5**	Ratio = **1 : 1.45: 3.30**		

3. Result And Discussion

In this chapter, the authors were discussed about the important properties of concrete such as compressive strength, Flexural strength and split tensile strength of conventional concrete in various mixing proportion such as glass waste powder and tobacco waste ashes.

3.1. Compressive Strength

At first, compressive strength is considered, because it is the most important and commonly used property of concrete, to study the strength behavior of the concrete. It may give an overall picture about quality and performance of test samples.

The concrete (test samples) is prepared with the combination of glass powder and Tobacco waste ash (discussed in last section), the test samples are compared with conventional concrete, the compressive strength of the test sample which gives a better characteristics than the conventional concrete for all ages, is shown in Figure 1. The compressive strength of the conventional concrete was in the range 13.92 N/mm^2 (at 7 days), 19.36 N/mm^2 (at 14 days) and 21.46 N/mm^2 (at 28 days). The compressive strength of the concrete mixed with only GWP was in the range 12.87–18.12 N/mm2 (at 7 days), 17.02–20.04 N/mm2 (at 14 days) and 18.94–23.07 N/mm2 (at 28 days). The compressive strength of the concrete mixed with both GWP and TWA was in the range 13.03–17.68 N/mm2 (at 7 days), 18.42–19.89 N/mm2 (at 14 days) and 20.62–24.32 N/mm2 (at 28 days). Table 3 shows the 7, 14 and 28 days compressive strength for Conventional, WGP, WGP+TWA concrete. For this three samples cube were taken and the average compressive strength is founded.

Table 3: Test Result for Compressive Strength Conventional, WGP and TWA Concrete at 7, 14 and 28 days

Compressive strength of concrete (N/mm^2)	Days	Cube Size (mm)	Conventional Concrete	Glass Powder Concrete				Glass Powder (G)+ TWA Concrete			
				10%	15%	20%	25%	5% G + 5% TWA	7.5% G + 7.5% TWA	10% G + l0% TWA	12.5% G + 12.5% TWA
			C1	C2	C4	C6	C8	C3	C5	C7	C9
	7	150	13.92	12.87	13.89	17.66	18.12	13.03	14.31	19.47	17.68
	14	150	19.36	17.02	18.88	20.27	20.04	18.42	18.42	21.22	19.89
	28	150	21.46	18.94	20.95	22.83	23.07	20.62	21.35	24.32	22.96

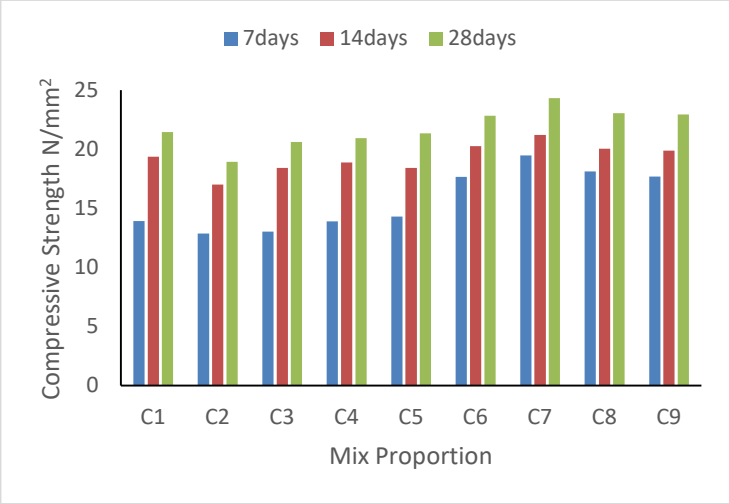

Fig.1. Optimum level of replacement of WGP and TWA for compressive strength of concrete

3.2. Flexural Strength of Concrete

Secondly, another important characterises, flexural strength is considered. Here, the concrete (test samples) is prepared with the combination of glass powder and Tobacco waste ash similar as compressive strength analysis (discussed in last section).

The flexural strength of concrete with the mixing of glass powder alone shows good strength when compared with the conventional concrete and the cement concrete with the mix of glass powder and tobacco waste ash shows small improvement in the flexural strength is shown in Figure 2.

Table 4 shows the 14 and 28 days flexural strength. For this three samples cube were taken and the average Flexural strength is founded

Table 4: ***Test Result for Flexural Strength Conventional, WGP and TWA Concrete***

Flexural Strength of Concrete (N/mm^2)	Days	Prism Size (mm)	Conventional Concrete	Glass Powder Concrete				Glass Powder (G)+ TWA Concrete(L)			
				10%	15%	20%	25%	5% G + 5% TWA	7.5 % G + 7.5 % TWA	10% G + l0% TWA	12.5% G + 12.5% TWA
			F1	F2	F4	F6	F8	F3	F5	F7	F9
	14	500x100x 100	6.41	5.92	6.12	6.44	6.79	5.77	6.07	6.74	6.79
	28		7.12	6.81	6.89	6.73	6.98	6.48	6.77	6.93	7.11

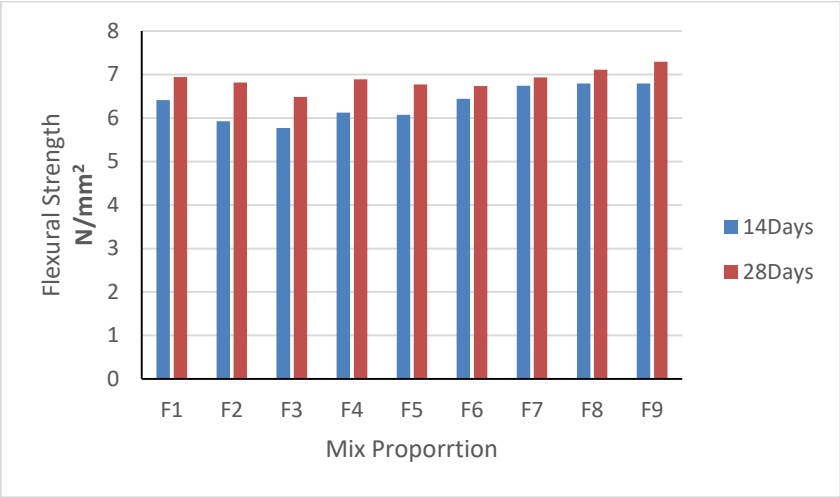

Figure 2: Optimum level of replacement of WGP and TWA for flexural strength of concrete

3.3. Split Tensile Strength

Lastly, another important characterises of concrete, split tensile test was done. Similar to previous section, the concrete (test samples) is prepared and considered for testing. The outcome of the test with the addition of glass powder and tobacco waste ash combination, not gives much variation in the split tensile strength. However, the partial replacement of WGP and TWA mixed concrete gains strength as the age of concrete increases is shown in figure 3.

Table 5*: Split Tensile Test Result for Conventional Concrete, WGP + TWA Concrete*

Split Tensile Strength of Concrete (N/mm^2)	Days	Prism Size (mm)	Conventional Concrete	Glass Powder Concrete				Glass Powder (G)+ TWA Concrete			
				10%	15%	20%	25%	5% G + 5% TWA	7.5 % G + 7.5 % TWA	10% G + l0% TWA	12.5% G + 12.5% TWA
			S1	S2	S4	S6	S8	S3	S5	S7	S9
	14	300x150	2.98	2.11	2.36	2.69	2.45	2.04	2.29	2.89	2.63
	28		3.16	2.54	2.61	2.84	2.61	2.36	2.57	3.12	2.90

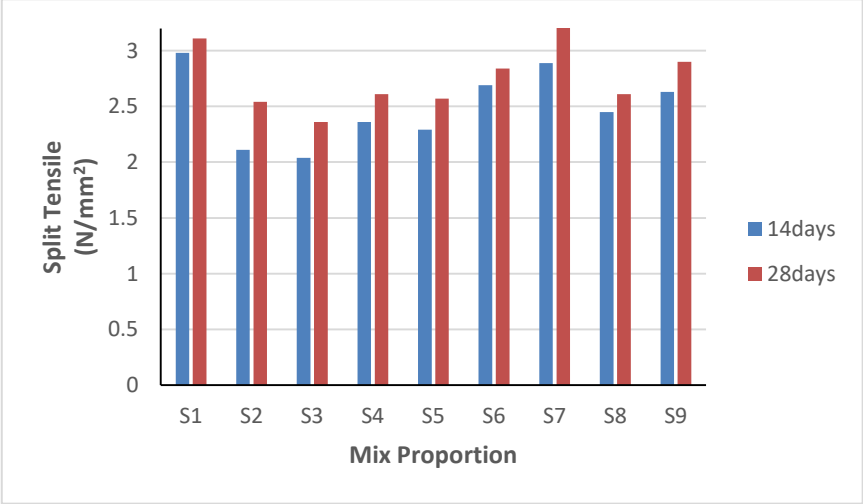

Fig.3. Optimum level of replacement of WGP and TWA for split tensile strength of concrete

4. Conclusion

Based on the experimental study and the analysis of the test results, the following points are summarized

- With the presence of silica in the waste glass which causes to increases the compressive strength of the concrete at an early stage of 28 days. It also helps to enhance the durability and toughness of the concrete. It is highly resistant to chemical attack. With replacement of small quantity of waste glass powder in the conventional concrete will not give a major effect in compressive strength properties.

- With the partial addition of tobacco waste ash, the compressive strength and Flexural strength increases day by day. It also increases workability thereby reducing the water requirement. It also help to reduce the heat generated during hydration and the tobacco waste ash may also prevents (ASR) in the concrete

- Whereas the compressive strength of the concrete mix with the partial replacement of 10% wastes glass powder and 10% of tobacco waste ash for cement was found as the best mixing proportion. And also the proposed mixing proportion will reduces the construction cost considerably, based on this study.

The waste materials like glass and tobacco waste can be used as cementing replacement materials; it may compensate the cost of environmental hazard from the discharge of the ash as landfill or any other activities.

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