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A study on Portland cement concrete using demolished aggregate and silica fume

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Abstract
The aim of present study was to study on Portland cement concrete using demolished aggregate and silica fume. The High Strength concrete has become more popular in recent years owing to the extraordinary advantages it offers over the conventional concrete but at the same time strong enough to be used for the structural purpose. The aim of the present work is to study the attitude of coarse aggregate replaced with demolished aggregates in volume percentages of 10%, 15%, 20%, 25% and 30% cement replaced with the silica fume in weight percentages of 5%, 10%, 15%, 20%, and 25 %. The conventional mix has been designed for M40 grade concrete. In this research, cubes, cylinders and beams of standard size have been cast and tested after 3 days, 7 days 28 days, 56 days of curing period.

Keywords: Portland cement, demolished aggregate (DA), concrete, silica fume

1. Introduction

The fly ash, is similar to other pozzolans, affects the technical properties of the concretes and mortars by its pozzolanic characteristics and filler effect. It is known that the filler effect of the fly ash is more effective than the pozzolanic characteristics when affecting the properties of concrete. The fly ash have pozzolanic activity because they contain surplus amount of silica, alumina and iron oxide; they have a structure with very fine particles and amorphous. Materials with silica and alumina in the structure of fly ashes make additional calcium silicate hydrate (C-S-H) by reacting with calcium hydroxide occurring as a consequence of hydration of the cement.

Recycled aggregate is comprised of crushed, graded in organic particles processed from the material that have been used in the construction and demolition debris. The aim of this project is to determine the strength characteristic of recycled aggregates, for application in structural concrete. Coarse aggregate is important material in concrete for compressive strength, so there is utilization of demolished concrete in place of natural coarse aggregate.

Concrete is the largely used material in different types of construction, from the flooring of a cot to a multi storied high boost structure from pathway to an airport runway, from an underground tunnel and deep sea platform to high-rise chimneys and TV Towers. The last millennium concrete has challenging requirements both in terms of technical performance and economy while greatly varying from architectural masterpieces to the simplest of utilities. Concrete is one of the intelligent heterogeneous materials, civil engineering has always known. The arrival of concrete civil engineering has touched highest peak of technology. Concrete is a material with which any shape can be casting and with any strength. The material of preferred where strength, performance, durability, impermeability, fire resistance and abrasion resistance are required.

Kumar & Dhaka (2016) [1] write a Review paper on partial replacement of cement with silica fume and its effects on concrete properties. The main parameter investigated in this study M-35 concrete mix with partial replacement by silica fume with varying 0, 5, 9, 12 and 15% by weight of cement The paper presents a detailed experimental study on compressive strength, flexural strength and split tensile strength for 7 days and 28 days respectively. The results of experimental investigation indicate that the use of silica fume in concrete has increased the strength and durability at all ages when compared to normal concrete.

Bhattacharjee, Ujjwal, and Tara Chandra Kandpal (2002) [2] studied for potential use of Fly Ash in India. Out of the total energy generation in India 65% energy is contributed by coal thermal power plants. The Ash content produced in Indian Coal power plants tends to a higher content (25% - 45%). A huge amount of Fly Ash is generated across India causing disposal related problems, the level of fly ash utilization in the country was estimated to be less than 10% prior to 1996–97. World Wide less than 25% fly ash of yearly produced fly ash is used. In foreign countries such as Germany, Netherlands etc. more than 95% fly ash is used.

Chindaprasirt, *et al.* (2005) [3] investigated on class F Fly Ash of two different fineness, taken from Mae Moh Power plant in north of Thailand and replaced the Portland cement at 0%, 20%, and 40% by weight. It was observed that the compressive strength of classified fly ash (CFA) is higher than original fly ash (OFA) cement paste. It was also found replacement of OPC (ordinary Portland cement) with OFA increases the porosity and decreases the average pore size of the paste. In order to achieve higher strength it is therefore necessary to reduce porosity of cement paste. The blain fineness of OFA and CFA was taken as 300 and 510 m2/kg, and the specific gravities of these two were 2.33, 2.54 respectively. It was found that compressive strength decreases as the total porosity of blended cement paste increases.

Berndt (2009)[4] studied properties of concrete which were made by using partial replacement of fly ash, slag and recycled concrete aggregate. He made different mix by the use of fly ash and blast furnace slag. The results indicates that the concrete having 50% replacement as blast furnace slag provided improvement in mechanical properties and durability.

Ravina, D., and Mehta, P. K. (1986) [5] has studied the effect on workability, water requirement, setting times of fly ash (high amount) containing concrete and found that workability of fly ash concrete was better than the non-fly ash concrete at any content ratio of fly ash. The water requirement was also reduced in fly ash concrete by 5% to 10% but the setting time was increased or delayed in fly ash concrete.

Naik *et al.* (1994) [6] examined the abrasion resistance on high volume concrete and concluded that at 50% and 70% cement replacement by fly ash the compressive strength were lower than the normal concrete containing no fly ash though at 50% replacement gives enough strength for structural applications. He also concluded that the abrasion resistance in concrete containing no fly ash is relatively higher than the fly ash concrete containing high amount of fly ash.

2. Methodology

2.1 Cement: 53 grade (OPC – Ultratech Cement) was used in the experimental investigation. It was tested for its physical properties in accordance with Indian Standard specifications. The fine aggregate used in this investigation was clean river sand, passing through 4.75 mm sieve with specific gravity of 2.6. The grading zone of fine aggregate was zone II as per Indian Standard specifications. Machine crushed granite broken stone angular in shape was used as coarse aggregate. The maximum size of coarse aggregate was 20 mm with specific gravity of 2.60. Ordinary clean portable water free from suspended particles and chemical substances was used for both mixing and curing of concrete.

2.2 Fine Aggregate: The fine aggregate obtained from river bed, clear from all sorts of organic impurities was used in this experimental program. The fine aggregate was passing through 4.75 mm sieve and had a specific gravity of 2.44. The grading zone of fine aggregate was zone II as per Indian Standard specifications.

2.3 Coarse Aggregate: Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone, and trap rock. The last is a term used to designate basalt, gabbro, diorite, and other dark-colored, fine-grained igneous rocks. Graded crushed stone usually consists of only one kind of rock and is broken with sharp edges. The sizes are from 0.25 to 2.5 in (0.64 to 6.35 cm), although larger sizes may be used for massive concrete aggregate. Machine crushed granite broken stone angular in shape was used as coarse aggregate. The maximum size of coarse aggregate was 20 mm and specific gravity of 2.60.

2.4 Water: Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalies, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregates and cement.

2.5 Demolished Coarse Aggregate (DCA): The construction and demolition wastes are collected from a regional building that has been demolished and constructed. The aggregates passing over IS sieve 20 mm and retained on 12.6 mm are taken. The specific gravity of tile aggregates is 2.6 and fineness modulus of 7.358. The easy and compacted bulk densities are 1358 kg/m^3 and 1512 kg/m^3 respectively and water absorption of 0.50%. The aggregate crushing value (%) and aggregate impact value (%) of coarse aggregate is 36.3% and 35.20% respectively. Demolished waste is collected from residential building near Rewa (M.P.)**.**

2.6 Silica Fume: The American Concrete Institute (ACI) defines silica fume as "very fine non-crystalline silica produced in electric arc furnaces as a by-product of the production of elemental silicon or alloys containing silicon". It is usually a gray colored powder, somewhat similar to Portland cement or some fly ashes

3. Results and Discussion

The experimental program was designed to compare the mechanical properties i.e., Compressive Strength of Cubes & Cylinders of high strength concrete with M40 grade of concrete and with different replacement levels of Ordinary Portland cement (Ultra Tech cement 53 grade) with Demolished Coarse Aggregates and Silica Fume Compression testing machine was used to test all the specimens. The series of specimens were cast with M40 grade concrete with different replacement levels of Coarse Aggregates as 10%, 15%, 20% and 25% and 30% with Demolished Coarse Aggregates and 0%, 5% & 10% of Silica Fume.

Table 1: Average Compressive Strength for M40 using % of DCA

S. No.	Sample	Compressive Strength (MPa)			
		3 Days	7 Days	28 Days	56 Days
1.	10% DCA	21.75	23.41	27.47	31.87
2.	15% DCA	25.56	27.26	28.28	33.85
3.	20% DCA	26.91	28.47	29.33	34.94
4.	25% DCA	30.23	34.12	37.64	40.28
5.	30% DCA	32.22	36.08	40.28	46.63

Table 2: Average Compressive Strength for M40 (DA+SF)

S. No.	Sample		Compressive Strength (MPa)			
			3 Days	7 Days	28 Days	56 Days
1.	10% DCA +	0% SF	21.75	23.41	27.47	31.87
		5% SF	28.08	28.96	29.81	34.58
		10% SF	29.66	32.01	35.05	37.58
2.	15% DCA +	0% SF	25.56	27.26	28.28	33.85
		5% SF	31.56	34.65	36.47	39.11
		10% SF	32.23	36.04	37.46	41.26
3.	20% DCA +	0% SF	26.91	28.47	29.33	34.94
		5% SF	34.56	37.63	39.03	41.28
		10% SF	37.23	38.96	43.46	46.60
4.	25% DCA +	0% SF	30.23	34.12	37.64	40.28
		5% SF	38.24	40.15	44.13	47.92
		10% SF	41.23	45.15	48.46	52.93

4. Conclusion

Based on the present experimental investigation, the following conclusions are drawn Cement replacement with 5% and 10% SF & Coarse replacement with 10% DCA leads to increase in Compressive Strength. For M40 Grade with DCA 30% the percentage increase in Compressive Strength is 14.76%, 4% and 6.4% respectively. 30% DAC appears to be the optimum in the Standard concrete mix like M40 without any admixtures. For M40 Grade with DAC 30% and Silica Fume 5%, 10% the percentages increase in Compressive Strength is 26.41%. There is an increase in Young's Modulus of Concrete for M40 with DAC 30% and Silica Fume 10% is 50.70% and 58.88% respectively higher than Conventional Concrete The Compressive Strength of Cylinders for M40 with Silica Fume 10% is 17.14% and 11.07% respectively higher than Convectional Concrete

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