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Application on Partial Substitute of Cement by Bentonite in Concrete

M. Karthikeyan[1]*, P. Raja Ramachandran[2], A. Nandhini[3], R. Vinodha[3]

[1,3]Department of Civil Engineering, M.I.E.T Engineering College, Trichy-620007, TamilNadu. India.
[2]Department of Civil Engineering, Dr.M.G.R. University, Educational & Research Institute, Chennai – 600095, TamilNadu. India.

Abstract: To investigate the potential use of Bentonite to evaluate its impact on various strength of ordinary Portland Concrete (OPC). It was accomplished to raise cement concrete by partially replaced of cement. An OPC batch, properly mix designed was prime; aiming at strength admixtures was also introduced to attain high workability. Normal compressive testing was performed for this purpose and the quality of concrete was checked. It was seen from the results that Bentonite resulted in poor early stage and good later stage Compressive strength when compared with Conventional samples. The bentonite samples were characterized by the main variable proportion of bentonite in the natural and intercalated forms (0, 25, 30, and 35 % by weight of cement for a mix of M25) in the replacement mode whiles the amount of cementations material. At 30% substitute of clay has achieved 19.55%, 2.72% and 8.07% in compressive, split tensile and flexural strength for 28days.
Keywords: Cement, Bentonite, Compressive Strength, Split Tensile.

Introduction

The construction industry has taken considerable strides forward over the last two or three decades with regard to trials in the use of one or another cementitious materials generally identified as pozzolans, for the compounding of various cement based products. This have not only resulted an improving the compressive strength value attained thereby but also in qualities like ability to set and harden under water. Among these coal fly-ash, blast furnace slag, rice hull ash, silica fume, or metakaolin are the most common ones. Other like gypsum, gypsum fines, Portland cement, cement kiln dust, lime dust, stone dust, and calcined clay are also in use, due to economic and environmental concerns, different methods of making cement products are being considered. One method to achieve the goal of reducing carbon dioxide emissions and greenhouse gases is to formulate cements using a lower portion of calcinated material, thereby reducing carbon dioxide emissions per unit of product. Another approach is that of including a lower percentage of cement and or gypsum than it is common with standard cement or gypsum and to ensure an increased compressive strength and or flexural strength is yet attained thereby. This as one which is durable, and suitable for all types of applications, also benefits the environment. Additionally, a need exists for improved cement and gypsum products that permit the use of less expensive aggregates to reduce the cost of the cement product.

S.Targan (2002)[10] had result showed that setting time of cements was generally accelerated when bentonite replaced a part of the cement. Bentonite is a form of metakaolin clay (i.e. clay that has gone through heat process to be in its powder form) that consists of a primary mineral called montmorillonite which gives it

its properties. Metakaolin clay seems to have the greatest overall potential as alternative pozzolanic material for concrete due to its availability in large quanta and the relatively cheap price. Poon, C. S. et al., (2005)[7], had studied about mechanical and durability properties by used metakaolin clay and silica fume in cement concrete. Though the mineralogy of clays varies a lot, which may influence the reactivity, its interaction with CSH gel formed during ordinary Portland cement has been found beneficial to the final form of the hardened concrete. The benefit of it being used as partial replacement of a portion of the ordinary Portland cement has been found not only on strength improvement, but more on durability enhancement. Al-Akhras, N. M. (2006)[6] have investigated the effect of metakaolin (MK) replacement of cement on the durability of concrete to sulfate attack and also studied the experimental parameters were, water to binder ratio (0.5 and 0.6).

Blended cements containing higher amount of natural pozzolans shows excellent ability to reduce the alkali-silica expansion and yields almost equal strength to Portland cement at the age of 91 days. Research has also been carried out on the use of bentonite clay as replacement of cement. Hassan et al. (2003)[9] found out the reactivity index of mortar cubes containing Jehangira bentonite as replacement of cement. He concluded that 40 per cent replacement of bentonite in mortar and 25 per cent replacement in concrete yielded satisfactory results when used as such (without any heat treatment). Badshah (2003)[8] found out the optimum replacement of Jehangira bentonite as pozzolana on the basis of XRD diffraction analysis and compressive strength results. He also studied the sulfate resistance of concrete utilizing Jehangira bentonite. He concluded that 20 per cent of Bentonite replacement in concrete yields satisfactory results but any further addition reduces strength drastically. Sulfate resistance of concrete increases as the pozzolana replacement increases. At 20 per cent of bentonite replacement, a maximum resistance to sulfate resistance of mortar in 2 per cent sulfate solution is achieved. The mixture including 10% bentonite + 90% sand is the most economical solution that satisfies the limits values needed for clay core of earth fill dams and clay liners of solid waste storage areas was studied by Devrim Alkaya(2011)[5].

Materials and Method

The cement used is an Ordinary Portland Cement (OPC) of 53 grades. The tests were conducted on cement; some of them are Fineness as 285m^2/kg, Normal Consistency is 32.5%, Standard Consistency range is 40-9mm of 400gm cement, Initial and Final setting time of cement is 35min and 300mm respectively as per recommendation of IS standards. The initial setting time should not be less than ±30 min and final setting time should be less than 600 min given in IS 456: 2000. Ordinary Portland cement of 53 grade having specific gravity is 3.35, specific gravity of Fine aggregates is 2.68 with fineness modulus of 2.50, coarse aggregate 2.58 with fineness modulus of 3.22 and Bentonite is 2.32. The impact value and crushing value of aggregates is 24.6% and 24.73% respectively. The Physical and Chemical Properties of Bentonite are given in the below Tables 1 and 2.

Table 1. Physical Properties of Bentonite

Colour	Light Yellow
Size	Pass from 70 microns
Free swell	60% by volume
Nature	Pozzolanic

[Source: Junaid Akbar et al.,(2013)]

Table 2. Chemical properties of Bentonite

S.No.	Chemicals	Test Results
1	Al_2O_3	21.118
2	SiO_2	49.634
3	Fe_2O_3	3.235
4	TiO_2	0.498
5	Na_2O	0.449
6	CaO	0.65
7	MgO	3.591
8	K_2O	2.091

Mix proportion

The mix design for obtaining the amount of cement, fine aggregate and coarse aggregate are calculated based upon the code IS 10262: 2009 to achieve a compressive strength of M25 grade. The maximum size was 20mm; water content is 186 kg/m3, water/cement ratio of 0.432, slump of 68mm and compaction factor of 0.905 was observed and shown in Table 3.

Table 3. Mix Design Proportions

Sl. No	% Replacement of Bentonite	Actual W/C Ratio	Water Content (l/m3)	Mix Proportion			
				Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregates (kg/m^3)	Mix Proportion
1	Conventional	0.432	191.50	443.60	537.27	1180.40	1:1.21:2.66
2	Bentonite-25%	0.576	191.50	332.70	537.27	1180.40	1:1.61:3.54
3	Bentonite-30%	0.616	191.50	310.82	537.27	1180.40	1:1.73:3.80
4	Bentonite-35%	0.664	191.50	288.34	537.27	1180.40	1:1.86:4.09

Result and Discussions

The compression test was conducted on the concrete cubes and is shown in graphical representations of the results are also shown. A.A. Elsayed and N. Amer (2015)[1] has found that for initial water content has no effect on the mixture containing 10 percent bentonite, whereas a significant effect is noticed for 20 and 30 percent bentonite mixtures. The mixed properties and the result are indicated in Fig.1 which showed that the compressive strength for 7 and 28days of 0, 25, 30 and 35 percent are replacement of cement by used bentonite were attained results as 17.45, 16.88, 19.62 & 7.26N/mm2 and 25.24, 21.68, 30.1 & 9.66N/mm2 respectively. The compressive strength for 7 and 28days of 30% replacement is increased strength by 12.43% and 19.25%. The 35% was suddenly attained very low strength when compared to conventional concrete. Low cost concrete can be produced by substituting Bentonite as partial replacement of cement in concrete without compromising on strength parameters by Shazim Ali Memon et al., (2012). By the usage of bentonite powder, we can increase the compressive strength and decrease the cement content in concrete up to 30% was concluded by J. Chamundeeswari (2012)[4]. The test results from 7 and 28days Split Tensile strength of 0% replacement of Bentonite used 1.34 and 2.25N/mm^2. The mixed properties and the result are shown in fig.2, which showed that the Split Tensile strength for 7days and 28days of 25% and 30% replacement is raised 1.67N/mm^2 and 2.72N/mm^2 when compared to conventional concrete and gradually decrease after added 35%. Fig.3 Shows that the flexural strength is gradually increased for 28days of 25% and 30% replacement is increased strength by 4.76% and 8.07% respectively when compared to conventional mix.

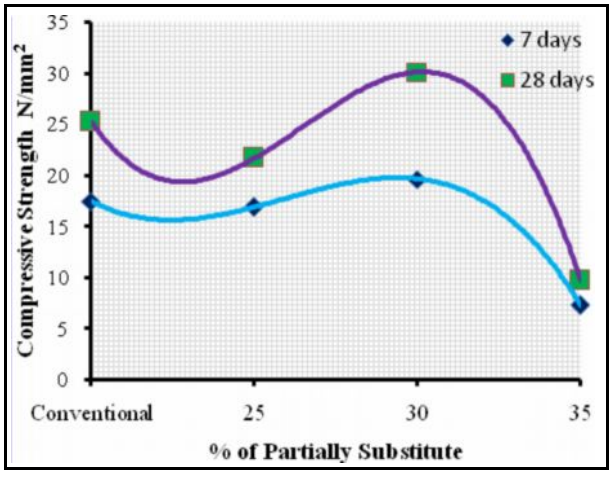

Fig.1. Compressive Strength

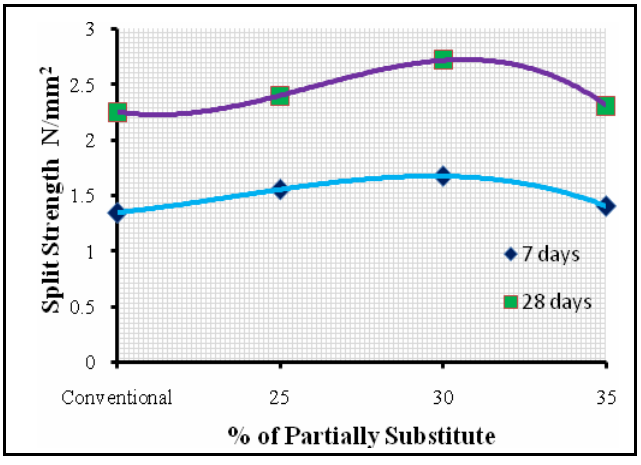

Fig.2. Split Tensile Strength

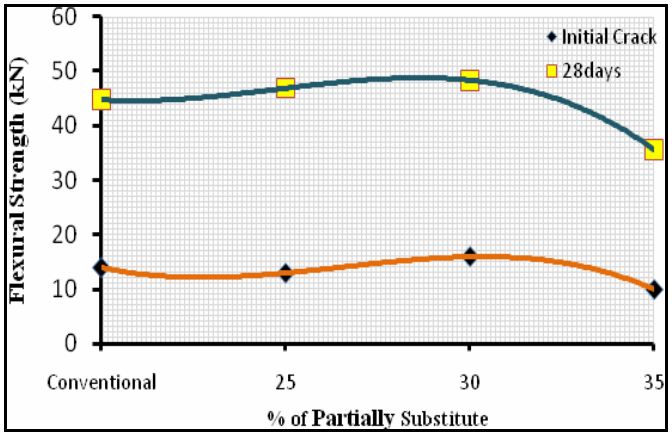

Fig.3. Flexural Strength

Fig.3 Shows that the flexural strength is gradually increased for 28days of 25% and 30% replacement is increased strength by 4.76% and 8.07% respectively when compared to conventional mix.

Conclusion

Cement is the most widely used construction material in the world and important product in concrete as compared to other. Based on the test results, the compressive strength for 7days and 28 days of 30% replacement is attained strength by 19.62N/mm2, 30.10N/mm2 respectively. The split tensile 7 and 28days of 25% and 30% replacement is raised 1.67N/mm2 and 2.72N/mm2. That the flexural strength is gradually increased for 28days of 30% replacement is increased strength by 8.07%. Detectable reductions in compressive strengths are observed with increasing the percentage of Bentonite Partially Substitute in Concrete beyond 35% due to W/C ratio is enhanced 23.2% than the conventional and 6.8% other mix proportions The percentage expansions of the specimens cast with partial replacement of Bentonite are within the permissible limits; hence the materials are safe for construction purpose. Use of Bentonite increases the strength and durability of concrete for construction.

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