Influence of Bentonite in Strength and Durability of High Performance Concrete

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Abstract - *Today's environmental problems are more and more important. The industrial area produces lots of waste materials. One of the most useful ways to solve these problems is the consumption of these waste materials in concrete. The quarry dust is an economic and waste material of rock and alternative to the river sand. Conventional concrete is the most extensively used construction material world wide, both in moderately and strongly aggressive environments. High performance concrete (HPC) appears to be a better choice for stronger and durable structures. Bentonite is a type of clay with a very high proportion of clay mineral montmorillonite, resulting from the decomposition of volcanic ash. The main uses of Bentonite are for drilling mud, binder (e.g. foundry-sand bond, iron ore pelletizer), purifier, absorbent (e.g. pelletizer), increase the strength of concrete and as a groundwater barrier. With high plasticity, Bentonite is highly water absorbent and has high shrinkage and swelling characteristics. In this research work strength and durability of the concrete is addressed. High Range Water Reducing Admixtures (HRWRA) are used. The durability was measured in terms of resistance offered to the penetration of sulphate ions into the concrete. Ultrasonic Pulse Velocity testing was performed for this purpose and the quality of concrete will be checked.*

Key Words: HPC, Quarry dust, Compressive Strength, Tensile Strength, Sulphate Attack, Chloride Attack, UPV Testing(NDT).

1.INTRODUCTION

The Normal Cement Concrete structures require costly repairs during their service life as they deteriorate before their service life is achieved. Four main environmental phenomenon's affect concrete. They are alkali-aggregates reaction, freezing and thawing of concrete, corrosive action of reinforcement, sulfate attack. In each case, concrete is penetrated by chemical solutions causing damages. [1]. High performance concrete (HPC) enhances the durability and/or high strength which results in economical and long-lasting structures. [2].The less permeable HPC resists the permeability of aggressive solutions and, therefore making concrete more durable. Pozollanic materials which are used as cementitious materials result in high compressive strengths, above 40 MPa. The sulfate attack can be well-defined as a sequence of chemical reactions, in the existence of sulfate ions, which arises in hardened concrete. The product obtained from these reactions holds larger volume than the reactants thus causing internal stresses in the concrete. These stresses lead to cracks in the concrete and reduce the life span of the concrete structure. [8]. The degradation caused by sulfate attack depends on several factors including the exposure conditions. The exposure conditions may be continuous immersion in sulfate environment, exposure to cyclic wetting and drying and partial immersion with evaporation. The characteristics and suitable use of clays and nutrients as alternative of cement in concrete is under study since decades. Blended cements containing higher amount of natural pozzolana shows excellent ability to reduce the alkali-silica expansion and yields almost equal strength to Portland cement at the age of 91 days. [3].The mechanical and durability properties of metakaolin clay and silica fume concretes have been also studied. It is found that metakaolinite-clay concrete has superior strength development and similar chloride resistance to silica-fume concrete. [4].The effect of metakaolin clay replacement of cement on the durability of concrete to sulfate attack has also been investigated. The study showed that metakaoline replacement of cement increased the sulfate resistance of the concrete. The sulfate resistance of metakaoline concrete increased with increasing the metakaolin replacement level. The sulfate resistance of metakaolin concrete at w/c ratio of 0.5 is more than, at w/c ratio of 0.6. [5]. Research has also been carried out on the use of Bentonite clay as replacement of cement. Hassan et al. (2003) 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). [6]. Bad shah (2003) 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. [7].

2. MATERIALS AND METHODS

Cement used in the project was Ordinary Portland Cement meeting the requirements of ASTM C150 Type I cement. Fineness of cement was determined using ASTM C184.The aggregate was purchased locally, naturally available. Tests were performed to obtain required data. The properties of cement, coarse and fine aggregates are tabulated in Table I. Bentonite was purchased from a local company from Coimbatore and Necessary tests were performed and are tabulated in Table II and Table III.

Table -1: Physical Properties

Description	Cement	FA	CA
Fineness modulus	1.78	-	3.66
Specific gravity	2.45	2.61	2.45
Water absorption	1%	0.76%	2%

Table -2: Physical Properties of Quarry Dust

Tests conducted	Value obtained
Specific gravity	2.5
Bulk density	1810 kg/m^3
Water absorption	1 %
Fineness modulus	3.07

Table -3: Chemical Properties of Cement

Compound	Amount
SiO_2	49.634
Al_2O_3	21.118
Fe_2O_3	3.235
CaO	12.563
MgO	3.591
SO_3	0.163
K_2O	2.091
Na_2O	0.449
TiO_2	0.498
MnO	0.07
P_2O_5	0.119
Cr_2O_3	0.007

Table -4: Chemical Properties of Bentonite

Tests conducted	Value obtained
Specific gravity	2.5
Bulk density	1810 kg/m^3
Water absorption	1 %
Fineness modulus	3.07

3. MIX PROPORTION

Following IS 10262:1982 mix design was aimed for Ordinary Portland Cement Concrete (PCC) having compressive 28 days strength of M40 for control samples. The data gathered from the experimental procedure on the concrete ingredients is tabulated Table V

Table -5: Mix proportion

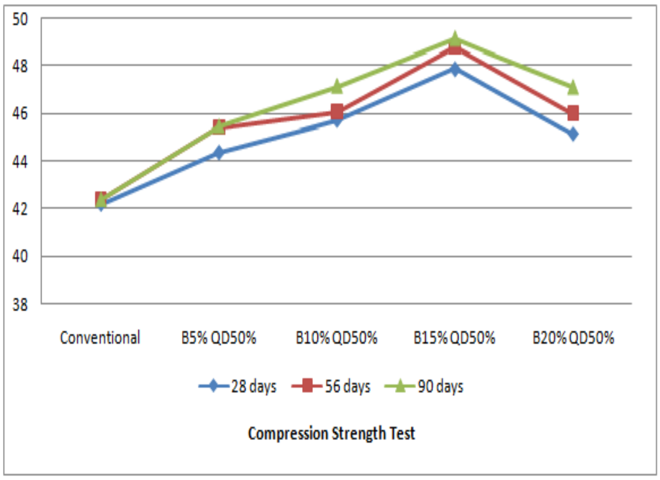
Material	Quantity(Kg/m³)
Cement	639
Fine Aggregate	469
Coarse Aggregate	1075
Water	192

Before introducing bentonite into the concrete suitable percentage of quarry dust replacement instead of fine aggregate is to be determined for the same mix proportion. After obtaining optimum percentage of Quarry dust then kept constant and the Bentonite can be replaced instead of cement like 5%,10%,15% & 20%.

4. TEST RESULTS

4.1 Compression Test

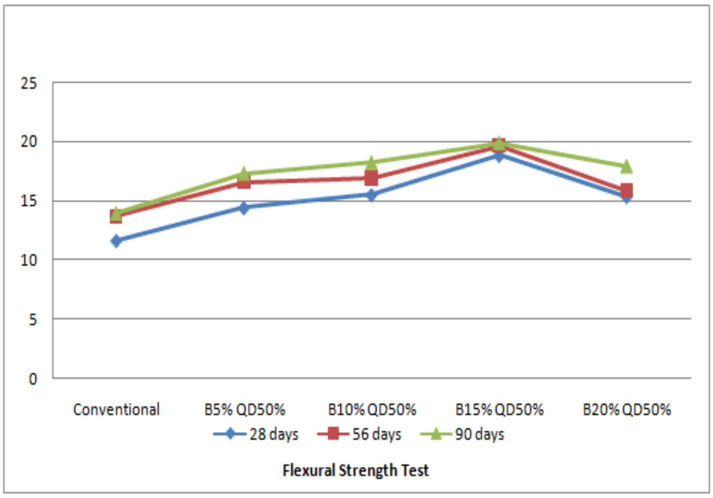
Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.



Graph -1: Compression Strength Test

4.2 FLEXURAL STRENGTH TEST

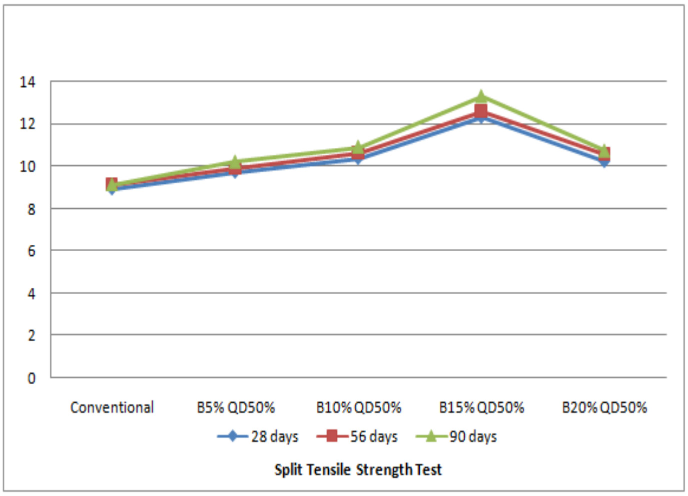
Concrete as we know is relatively strong in compression and weak in tension. In reinforced concrete members, little dependence is placed on the tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces.



Graph -2: Flexural Strength Test

4.3 Split Tensile Test

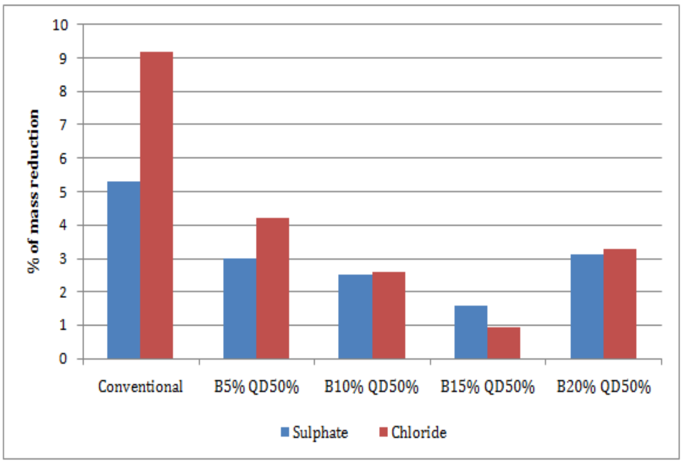
Cylinder splitting tension test: this is also sometimes reffered as, "Brazilian test". The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, alon the vertical diameter.



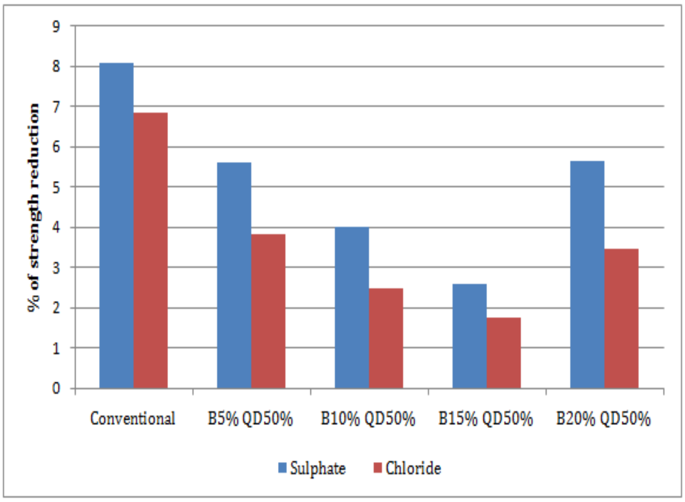
Graph -3: Split Tensile Strength Test

4.4 Durability Of High Performance Concrete

In this study durability concrete cubes are measured in terms of weight loss and reduction of compressive strength. Durability problems of ordinary concrete can be associated with the severity of the environment and the use of inappropriate high water/binder ratios. High-performance concrete that have a water/binder ratio between 0.30 and 0.40 are usually more durable than ordinary concrete not only because they are less porous, but also because their capillary and pore networks are somewhat disconnected due to the development of self-desiccation.



Graph -1: Percentage mass reduction



Graph -2: Percentage strength reduction

5.CONCLUSION

- The Usage of Bentonite in cement and Quarry Dust in Fine Aggregate as replacement in concrete shown good results in mechanical properties.
- The Compressive strength shows a achieved result for a percentage optimum of **B15% & QD50%**, it gives a difference from compressive strength to that of a conventional concrete is 11.88%,15.15% and 13.8% in 28,56 and 90 respectively. On further increase in the quantity of bentonite shows a reduction in the compressive strength.
- The Flexural strength also shows a increase in strength for **B15% & QD50%** of replacement of Bentonite in cement and Quarry Dust in Fine Aggregate and its levels are 27.44%,27.44% and 31.57% in 28,56 and 90 respectively.
- The Split tensile strength too shows the replacement of **B15% & QD50%**to a maximum an its levels are 38.26%,30.2% and 29.73% in 28,56 and 90 respectively.
- Cement & Fine Aggregate replaced by **B15% & QD50%** gives better durability result in both Sulphate and Chloride attack. Quality of concrete is also shows better result in this combination.
- Progressive increase in mechanical properties of High Performance Concrete is noted and Bentonite can be used in concretes where latter stages strength is required.
- From the results obtained it can be concluded that Bentonite can be used in structural concrete as a partial replacement, by weight of cement, to produce durable and reliable concrete.

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[9]IS CODES:

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- IS 456:2000; Plain and Reinforced concrete code of Practice.
- IS 383:1970; Specification for coarse and fine aggregates from natural sources for concrete
- IS 516: 1959; Methods of tests for Strength of concrete

BIOGRAPHIES

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