A STUDY OF MULTI COMPONENT ON BLENDED CONCRETE

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Abstract

This work presents a study on the behavior of concrete produced from multicomponent blended cements. These blends were prepared by blending 20–60% ASTM Type I cement with the combination of Class C fly ash and clean coal ash. Two percent to four percent sodium sulfate anhydrite was added to the blends as a chemical activator. Tests were conducted on the prepared concrete for strength development, freezing and thawing resistance, resistance to chloride ion penetration, sulfate resistance, and alkali silica reaction. Test results show that concrete produced from blended cements had equivalent or higher strength than the control mixture at all test ages. Blended cements were effective in controlling expansions due to sulfate attack or alkali silica reaction. They also reduced the deterioration of concrete due to freezing and thawing action and greatly increased the resistance to chloride ion penetration into the concrete. - Need of the hour is to obtain a concrete that gives high strength and better performance characteristics. Research is being carried out on a large scale to achieve the same. Concrete as we all know is widely used in the construction industry, not only for its strength but also due to its demands of high strength, high performance and high durability at desirable cost. And also at the same time, the demand for reducing the usage of cement quantity is also essential. This, to a certain extent is being carried out using pozzolanic materials which are used as a partial replacement of cement.

Keywords: *Blended Concrete, Multicomponent, Development.*

1. INTRODUCTION

Concrete is the most essential ingredient in infrastructure development worldwide and lasting building materials may be a well-designed concrete. However, the environmental component of Portland cement is increasing, since the cement production sector accounts for about two and a half per cent of total global emissions from industrial sources. Particularly because of the greenhouse effect, carbon dioxide emission has been a major issue throughout the globe. Following the 1992 Rio-de-Janeiro Earth Summit, and the 1997 Kyoto Protocol, several nations committed to decrease carbon dioxide emissions. These environmental issues need to reduce clinker output in the cement industry solely by using cement ingredients referred to as mineral admixtures or pozzolans (also known as supplementary cementing materials). According to ASTM C 595, a pozzolana is defined as ‘a siliceous or siliceous and aluminous material, which in itself posses little or no cementation value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide to form compounds possessing cementitious properties’. A pozzolanic substance thus needs calcium hydroxide to make solids. As a result of hydration, Portland cement includes calcium hydroxide.

Hydrated cement paste comprises around 70% C-S-H, 20% calcium hydroxide, 7% sulfo-aluminum and 3% secondary phases. The calcium hydroxide that develops as a consequence of the hydration has a detrimental impact on concrete quality via the formation of cavities due to its water solubility and poor strength. The use of mineral admixtures has a beneficial impact on concrete quality by binding calcium hydroxide. The hydration of cement and pozzolanic processes are discussed here:

Cement Hydration Reaction:

$$\text{Cement } (C_3S, C_2S) + H_2O \rightarrow \text{C-S-H gel} + Ca(OH)_2 \quad \ldots(1)$$

Pozzolanic Reaction:

$$Ca(OH)_2 + SiO2 \rightarrow \text{C-S-H gel} \quad \ldots(2)$$

Therefore, when injected into the Portland cement paste, pozzolanic material reacts to calcium-silicate hydroxide gel as a partial cement substitute. Examples of pozzolan or mineral admixtures include grain granulated slag (GGBS), fly ash (FA), silica fume (SF), etc. A short comparison with portland cement in table 1 and the usual particle size distribution of various mineral admixtures is presented in Figure 1

Table 1 Brief comparison of cementitious materials

S. No.	Property	Portland Cement	Fly ash	GGBS	Silica fume
1.	Surface area (m^2/kg)	350-500	300-600	300-500	15000-20000
2.	Bulk density (kg/m^3)	1300-1400	1000	1000-1200	200-300
3.	Specific gravity	3.12	2.30	2.90	2.20
4.	Chemical composition				
	SiO_2	20	50	38	92
	Fe_2O_3	3.5	10.4	0.3	1.2
	Al_2O_3	5	28	11	0.7
	CaO	65	3	40	0.2
	MgO	0.1	2	7.5	0.2
	$Na_2O + K_2O$	0.8	3.2	1.2	2.0

As seen in the table, each of these mineral admixtures has distinct characteristics. They alter the composition of cement paste when used with cement, have an impact on the humidity and microstructure of the pastes and morters, and the strength and permeability of the concrete.

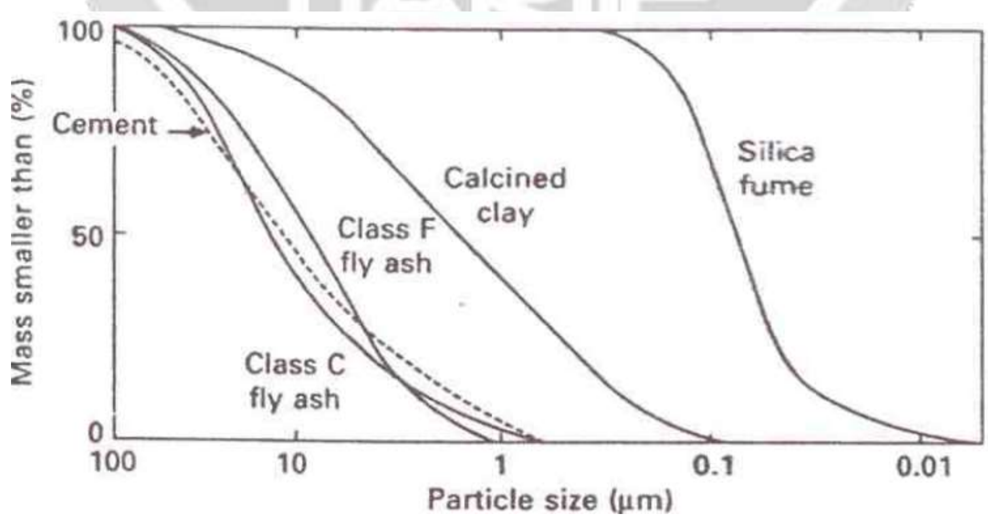

Figure 1 Particle size distribution of some supplementary cementing materials

The use of mineral admixtures has a twofold environmental advantage. The first is that reduced cement needs lead to a decrease in carbon dioxide produced by cement manufacturing. The concrete produced with additional cement ingredients is thus more sustainable. Secondly, the usage of mineral admixtures uses a product which is usually utilised for a landfill. The use of mineral admixtures is regarded to be the most effective method of addressing environment and carbon dioxide emissions and for the judicial use of industrial goods. In common concrete fly ash is mostly utilised for economic reasons, because it is cheaper than Portland cement to be substituted for, although silica fime is not used, since it is more expensive. However, the usage of silica fume is necessary for extremely high strength concrete and low permeability.

Concrete is the most frequently used building material and is almost three quarters of a century old in buildings. The latter two decades of the 20th century witnessed the growth of concrete technology as a material as a significant boom. It is the world's most used artificial building material and the second most used substance on the earth after water. The concretes are made by mixing them with different admixtures to meet sophisticated criteria. The substitution of cement mixes in concrete and the production of the mixed cement have provided the basis for making the best use of the mixtures available, mixing and other variables for producing the concrete that satisfies the higher performance criteria.

Concrete is a composite material consisting primarily of a connecting medium, consisting of embedded particles or aggregate pieces (ASTM C125). The binding ingredient is cement and cured concrete is also impermeable to water if the concrete is less porous. The frequently utilised embedded particles are coarse and fine aggregates. Fine aggregates fill the gaps of ground aggregates. Cement is a finely powdered substance which alone does not have any binding power, but acquires strength in interaction with water (hydration). Portland cement is the hydraulic cement most commonly employed by spray clinkers consisting mainly of hydraulic calcium silicates and a minor quantity of one or more calcium sulphate forms, as an inter-ground supplement (ASTM C150).

In India, the building industry is using 400 million tonnes of concrete each year and in less than a decade it will soon surpass a billion tonne milestone. Concrete is vulnerable to chemical assaults and degradation despite its great strength and the capacity to withstand water movement. The capacity of concrete to resist chemical assaults, weathering, abrasion or other kind of degradation of its life under certain circumstances is termed durability. The strength and durability of concrete rely on the constituent characteristics, design mix, circumstances of exposure and curing type and duration of the concrete. Concrete durability is affected by both physical and chemical factors. Concrete degradation physical causes may be widely categorised as surface wear and cracking. Abrasion, erosion and cavitation cause surface wear whereas cracking causes changes in volume, structural stress and exposure conditions. The chemical reasons of concrete degradation usually include, but not always, the chemical interactions between the aggressive substances in the environment and the cement paste components. One of the reactions that primarily affect the longevity of concrete buildings is that of corrosion of concrete steel reinforcement, induced principally either by chloride attack or by concrete carbonation. The porosity and permeable interconnecting pores in concrete also have a significant effect on their mechanical strength and durability.

The strength, durability and other qualities of concrete rely on the attributes of its components, the substitution of admixtures with cement, the quantities of mixture, the compaction technique and other controls in their pouring, vibrating and curing. There has been enormous infrastructure development in the nation (in all parts of the globe) and making concrete important for greater strengths to meet needs. Ordinary concrete has improved its compressive strength from 15 MPa in 1910 to 60 MPa in 2001. Furthermore, this progress has led to a number of novel materials being introduced in cement. Literature extensively discusses the positive benefits of the incorporation of these elements in concrete. The inclusion of a broad variety of construction materials of various chemical compositions has also created considerable variation in the cement system. The vast variety in the performance of building materials may be shown by the variance in physical, chemical and mineralogic composition resulting from industrial processes further connected with the raw materials utilised in the production of these materials. Furthermore, as a result of these ingredients' pozzolanic reaction, frequently sluggish, mixed cement concrete has a longer duration than plain concrete.

Beton carbonation means the calcium (Ca^{2+}) ion interaction of the cement and carbonate ions (CO_3^{2-}) to precipitate calcium carbonate from the dissolved carbon dioxide (CO_2); ($CaCO_3$). Betons have a certain porosity when the requirements of proportion mixing are not fulfilled. Even when the surface of concrete is long exposed to air fluids, its linked capillary pores degrade and occasionally disintegrate.

Concrete's durability is its capacity to return to its original quality and serviceability when exposed to its planned service environment. A substance is regarded to terminate its life when it deteriorates to an extent that it is made hazardous under a certain set of circumstances. When used in transport, concrete performance is usually considered acceptable when composition, slump and strength criteria are met and are afterwards proven to be "durable." There is a misunderstanding that concrete possesses a characteristic called "durability." This is not the case because concrete with certain characteristics can last for centuries or even millennia, without visible changes, in one environment, and will be degraded in a few years or even a few months to a fragment. Durability comprises a set of characteristics that are necessary for a specific environment to which concrete is exposed throughout its service life. Sustainable concrete is what resists the pressures in this environment that lead it to prematurely degrade without significant maintenance effort. Many believe that a specific strength, a minimum quantity of cemented elements, and a maximum water to cement ratio (w/cm) are needed to guarantee lasting concretes. This may be deceptive; sustainable concrete must have environmental characteristics.

2. COMPONENTS OF CONCRETE

Beton consists of two components, aggregates and paste. In general, aggregates are divided into two categories, fine and coarse and cover about 60 to 80% of the concrete volume. The paste consists of cement, water and air and usually accounts for 20-40% of total volume.

The aggregate should consist of particles that are appropriately constructed of concrete with sufficient strength and weather resistance and should not include elements with harmful effects. For ef! cient usage of paste a properly graded aggregate with a low void content is required. Each aggregate particle is fully covered with paste and is filled with paste in the area between the aggregate particles. The quality of the concrete depends heavily on the paste quality, which in turn depends on the water to cement content ratio and the degree of the treatment employed. Cement and water mix chemically in a process, termed hydration, which takes occur under favourable circumstances of moisture extremely quickly and more slowly for a long time. More water is utilised in concrete mixing than is needed for full cement hydration. This is necessary to make the cement material more workable; nevertheless, when the paste is diluted by water, its quality is reduced, its strength is decreased and its weather resistance is decreased. A correct amount of water to cement is necessary for excellent concrete.

Desirable Properties of Concrete

1. **Durability:** Capacity of hard concrete to withstand weathering, chemicals and abrasion degradation
2. **Workability:** Facility to place, handle and finish
3. **Weather Resistance:** Freezing and thawing, wetting and drying and heating and cooling resistance
4. **Erosion Resistance:** Resistance to water flow, traffic and wind degradation
5. **Chemical Resistance:** Resistance to de-icing salts, salt water, sulphate salts
6. **Water Tightness:** Resistance to penetration of water

3. INGREDIENTS IN CONCRETE

Hydraulic Cement

Portland cements and blended cements are hydraulic, since they create and harden a stone-like mass via water reactions. The phrase hydraulic cement is the newest term used for both Portland cement and Blended Cement.

Joseph Aspdin, an English mason, was credited with the development of Portland Cement in 1824. He called Portland Cement his invention, since it created a concrete similar to a natural calcareous stone found on Portland Isle.

The raw materials used for cement production include mixtures of calcareous, marl or oyster shells, shale, clay and iron ore. The raw ingredients must include enough quantities of lime, silica, alumina and iron. Selected raw materials are crushed and proportioned to the appropriate chemical composition of the resultant combination. This is done using molten and mixed dry ingredients in a dry way or by using a wet slurry in a wet procedure. In the production process, material analysis is done regularly to guarantee that Portland cement is of consistent high quality.

The prepared combustion is supplied to the top end of the oven while fuel is burned to produce 2600 °F to 3000 °F of temperature (1425 °C to 1650 °C) at the lower end of the oven. During the process there are numerous reactions that lead to Portland Cement clinker production. The clinker is refreshed and then sprayed. During this process, gypsum is applied to regulate the cement setting time. Portland Cement is the crushed final product. It is so well ground that most of it passes a sieve with 40,000 apertures per inch (1.6 apertures per mm2).

Portland Cement kinds include five (Types I, II, III, IV, V) and two blended cement types (Types I-P, I-S). Each kind is produced for particular applications to satisfy certain physical and chemical criteria.

Type I is a general-purpose cement. It is appropriate for all applications when specific characteristics of the other kinds are not necessary.

Type II Cement is utilised when ground water sulphate levels are greater than usual. Type II generates typically less heat at a slower pace than Type I or Normal cement. It may thus be utilised in big constructions, such as massive piers, strong pillars and hefty retaining walls. Its usage will reduce the increase in temperature which is particularly essential in warm weather conditions.

Type III It is a cement with a high early strength and greater strength at an earlier age. It is employed when the form is intended early deletion. For early strength, richer mixes (greater cement content) of Types I and II may be utilised.

Type IV In large constructions, such as dams, cement is utilised. This cement type is utilised when the heat produced during hardening is essential.

Type V Cement is used for concrete subjected to strong sulphate action and is primarily utilised in the western US.

Type I-P A mixture of Portland Cement and a pozzolan is a blended cement. A pozzolan, such as fly ash, has no cementing characteristics alone, but when coupled with humidity and calcium hydroxide, it creates the cementing effect.

Type I-S A mixture of Portland cement and blast-furnace slag is a blended cement. The weight of the mixed cement is between 25 and 65 percent.

Hydraulic cements may basically be regarded to consist of the following components:

Tricalcium Silicate 3

$CaO.S_1O_2$ $= C_3S$

Dicalcium Silicate 2

$CaO.S_1O_2$ $= C_2S$

Tricalcium Aluminate 3

$CaO.Al_2O_3$ $= C_3A$

Tetracalcium Aluminoferrite $4 CaO.Al_2O_3.Fe_2O_3 = C_4AF$

These chemical formulae must not be memorised; nevertheless, you know the contribution each component contributes to the concrete.

Tricalcium Silicate quickly hydrates and hardens and mainly causes initial setting and early strength.

Dicalcium Silicate hydrates and progressively hardens and helps to build strength over a period of one week.

Tricalcium Aluminate releases heat during the first few days of hardness and adds somewhat to early strength. Cement with low concentrations of this chemical is particularly sulphate resistant.

4. CONCLUSION

This paper discussed about the importance of the concrete prepared with the replacement of different admixtures. In this study, the objective of adding the admixture, types of admixtures etc are discussed. Finally, the first study, the introduction, is concluded with adetailed objective of the project. The second study, review of literature presents an overview on the use and purpose of the admixture in the concrete. It also gives the observations and the importance of various parameters affecting the properties of the concrete like the effects of the concrete subjected to the durability properties such as sulphate attack, chloride attack, corrosion studies etc and mechanical properties such as compressive strength, tensile strength, flexural strength, permeability, etc by the addition of the various admixtures. Based on various and repeated trials, it was determined that by the replacement of the admixtures in the following proportions of 15.0% fly ash, 10.0% silica fume, 10.0% rice husk ash and 3.0% calcium nitrate with the cement, durability properties and strength properties of the concrete were improved. It was observed that inspite of low water cement ratio for M30 grade of the concrete, a better workability was observed with the replacement of the various admixtures. A required compaction factor was obtained for both the grades of concrete. There is no segregation observed in the concrete prepared by using admixtures. The water absorption was reduced in the concrete specimen prepared with the addition of the admixtures.

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