Optimization of Super Plasticizers Dosage in Concrete with Different Brands of Cement with Complete Replacement of Natural Sand by PS Sand and also Partial Replacement of PS Sand and M-Sand

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Abstract— Concrete is a building material composed of a mixture of cement, water and aggregates with or without chemical admixtures. Now a day's sand is becoming a very scarce material, in this situation research began for inexpensive and easily available alternative material to natural sand. Although aggregates make up three fourths of the volume of concrete, the active constituent of concrete is cement paste [5]. The properties and performance of concrete are largely determined by the properties of the cement paste. In order to obtain workable concrete without strength loss, chemical admixtures such as super plasticizers are added in fresh mix of normal concrete. Super plasticizers in concrete confer some beneficial effects such as acceleration, retardation, air entrainment, water reduction, plasticity etc., and these effects are due to their action on cement [5]. It is important to find the optimum dose of Super plasticizer in order to minimize the trials and labor which leads to know the compatibility in different brands of cement. The experimental tests to determine the Physical properties of Concrete for M30 grade are studied and the results are compared among them. An attempt has been made in this paper to fully replace natural sand by Processed Slag (PS) sand and also partially replace with Processed Slag sand (50%) and Manufactured sand (50%). And also to decide the optimized dosage of Super plasticizers in fresh mix of normal concrete. For all the mixes, an addition of super plasticizer of about 0.5, 0.75 and 1.0% of cement content is used for a fixed water cement ratio. In this paper three different brands of cement namely Birla super, Ramco and Zuari and also two different brands of super plasticizers namely Glenium B233 and Conplast SP430 are selected for the test procedure. The investigations are to be carried out using several test which include workability test, compressive strength test and split tensile strength test.

Key words: Super Plasticizers, PS Sand, M-Sand, Workability, Compressive Strength, Split Tensile Strength

I. INTRODUCTION

The concrete performance plays a vital role in the development of infrastructures including commercial, industrial, residential, military structures etc. [6]. The most important part of concrete is the cement. Use of cement alone as a binder material produces large heat of hydration. On the other hand, the global consumption of natural sand is very high, due to the extensive use of concrete or mortar. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causing many problems, losing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc. are few examples. Hence some alternatives materials have already been used as a part of natural sand e.g. fly-ash, slag limestone and siliceous stone powder, foundry sand, M-sand and PS sand. An attempt has been made to replace natural sand by PS sand and M-sand to overcome the above problems.

The general objective of the present investigation is to evaluate the possibilities of using PS sand fully in one case and M-sand (50%) and PS sand (50%) in other case as a replacement to fine aggregate along with super plasticizers at a dosage of 0.5, 0.75 and 1% by weight of cementitious material for a fixed water cement ratio of 0.45. The specific objectives are 1) To know the effect of super plasticizers on workability and strength basis on different brands of cement of same grade. 2) To decide the optimized dosage of Super plasticizer in fresh mix of normal concrete. 3) To understand the mechanical properties of concrete such as compressive strength and Split tensile strength.

II. MATERIALS USED AND PROPERTIES

The process involves the selection of materials such as cement, fine aggregates, coarse aggregates and super plasticizers. Further, few tests of our interest are conducted as per codal provisions on concrete materials to determine their properties and suitability for the tests under consideration.

A. Cement

Portland cement is the most common type of cement in general usage. Out of the total production, ordinary Portland cement accounts for about 80-90%. Here we have used Ordinary Portland cement (OPC) of 53 grade of three brands namely BIRLA SUPER, RAMCO and ZUARI cements conforming to IS 8112-1989. Following are the test results of basic properties of cement.

Properties	Birla Super	Ramco	Zuari
Specific Gravity	3.1	3.16	3.12
Standard Consistency	31%	33%	31%
Initial Setting time	35min	45min	40min
Final Setting time	285min	300min	300min

Table 1: Properties of different brands of cement

B. Fine aggregates and coarse aggregates

1) Processed Slag Sand (PS Sand)

PS Sand is a non-metallic product, consisting of glass containing silicates and alumina silicates of lime. It is a by-product of metal smelting process sand does not contain material slag chlorides, organic matters, clay, silt and shells that may affect the strength and durability of concrete. PS sand of size below 4.75mm conforming to zone II of IS 383-1970 [3] is used as fine aggregate which is not locally

available and hence it was brought from Chetana power private limited (CCPL), Bellary for this project purpose.

2) Manufactured Sand (M-sand)

M-sand can be defined as residue or waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. The raw material for M sand production is the parent mass of rock. It is based on the parent rock that the chemical, mineral properties, texture, composition of sand would change.

3) Coarse aggregates

Natural crushed stone with 20mm down size are used as coarse aggregates. The aggregates are angular in shape and free from dust.

Following are the test results of basic properties of fine aggregates and coarse aggregates.

Properties	M-Sand	PS Sand	PS sand confirms under Zone-II as per IS:383-1970	Coarse aggregates
Specific Gravity	2.68	2.66		2.71
Finess modulus	3.34%	2.70%		4.40%

Table 2: Properties of Fine and Coarse aggregates

C. Super Plasticizers (SP)

Super plasticizers are also known as high range water reducers; this chemical admixture is used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands) and to improve the flow characteristics of suspensions. Their addition to concrete or mortar allows the reduction of the water-cement ratio without affecting the workability of the mixture and enables the production of self-consolidating concrete and high performance concrete. In this study based on the availability GLENIUM B233 from BASF company and CONPLAST SP430 from FOSROC chemicals are used as super plasticizers. They are chloride free, super plasticizing admixtures. They are used to enhance the workability of concrete. For a fixed water cement ratio of 0.45, super plasticizers at a dosage of 0.5, 0.75 and 1% by weight of cement content are added to required mix.

III. Concrete Mix Proportion and Samples Preparation

The concrete mix is designed as per IS 10262-2009 [2] and IS 456-2000 [1]. Target mean strength for M_{30} grade concrete is 38.25 N/mm2. For the performance analysis, three design mixes of M_{30} concrete grade with a fixed water cement ratio 0.45 in which complete replacement of natural sand by PS sand in addition to varying superplasticizer dose of 0.5,0.75 and 1.0% of cement content (abbreviated as A1, A2 & A3) and three design mixes using both PS sand (50%) and M-Sand (50%) in equal proportion in addition to varying superplasticizer dose of 0.5,0.75 and 1.0% of cement content (abbreviated as A4, A5 & A6) are prepared. The proportion and quantity are mentioned in the following table 3.

Trial mixes	Water		Cement		FA: PS sand		FA: M-Sand		Coarse aggregates		Super plasticizer	
	Proportion	Qty(lts)	Proportion	Qty(kg/m^3)	Proportion	Qty(kg/m^3)	Proportion	Qty(kg/m^3)	Proportion	Qty(kg/m^3)	Proportion	Qty(kg/m^3)
A1	0.45	140	1	320	2.33	746	--	--	4.04	1294	0.005	1.6
A2	0.45	140	1	320	2.33	746	--	--	4.04	1294	0.0075	2.4
A3	0.45	140	1	320	2.32	745	--	--	4.04	1293	0.01	3.2
A4	0.45	140	1	320	1.165	373	1.165	373	4.04	1294	0.005	1.6
A5	0.45	140	1	320	1.165	373	1.165	373	4.04	1294	0.0075	2.4
A6	0.45	140	1	320	1.164	372.5	1.165	372.5	4.04	1293	0.01	3.2

Table 3: Mix proportion for various trials mixes of M_{30} concrete grade

Standard cast iron moulds of size 150x150x150 mm and cylinder moulds of 150mm diameter and 300mm height are used in the preparation of cubes. The moulds have been cleaned to remove dust particles and applied with mineral oil on all sides before the concrete is poured into the mould. The super plasticizer is mixed with the constituents of concrete at the time of adding water. Full blending of the super plasticizer and the concrete is ensured by mixing for a period of at least two minutes. Thoroughly mixed concrete is filled into the mould and compacted in three equal layers. Excess concrete is removed with trowel after proper compaction and top surface is smoothened. After casting, the specimens are stored in the laboratory with room temperature for 24 hours. After this period, the specimens are removed from the moulds, immediately submerged in the clean and fresh water tank. The specimens are cured for 7 days and 28 days.

IV. Experimental Results and Discussions

The proposed study has undertaken the various tests on mix such as slump, compressive strength at 7th and 28th days and Split tensile strength at 28days. After the curing period the specimens were tested to determine the 7th and 28th days cube compressive strength is tested on cubes of size 150mmx150mmx150mm and for determining the tensile strength of concrete, tests are carried out on 150mmx300mm cylinders using a 3000kN Compression Testing Machine. The magnitudes of the tensile stress are given by $2P/\pi DL$, were P is the applied load and D, L, are the diameter, length of the cylinder respectively.

A. Slump Test

The workability test such as slump test is conducted as per code of practice in order to produce homogeneous and workable mix. From the following graphs, the Slump readings of different brands of cement namely Ramco, Birla super and Zuari using Conplast SP430 and Glenium B233 Super plasticizers with a varied dose of 0.5, 0.75 and 1.0% of cement content for both with complete use of PS sand and also PS sand with 50% of M-sand are obtained. On overall view, we are getting the slump value in a range of 75-100mm which is also a true slump in nature. But to be specific we can also observe that 1.0% of optimum Super plasticizer dose is showing better Slump results then other two doses.

In fig-1, the details GPR, GPMR, CPR and CPMR are abbreviated as Glenium Super plasticizer added to only PS sand in Ramco cement, Glenium Super plasticizer added when both PS sand and M-sand is used in Ramco cement, Conplast Super plasticizer added to only PS sand and lastly Conplast super plasticizer added when both PS sand and M-sand is used. The details in fig-2 and fig-3 are similar as mentioned above.

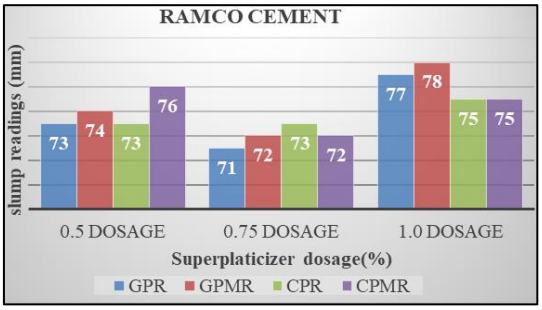

Fig. 1: Slump test results using Ramco cement

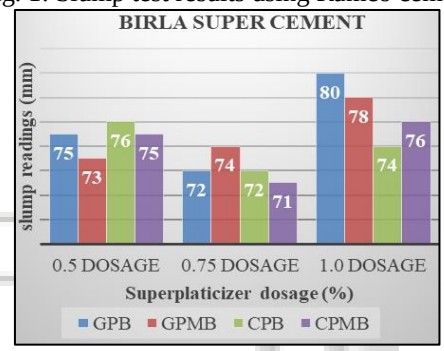

Fig. 2: Slump test results using Birla Super cement

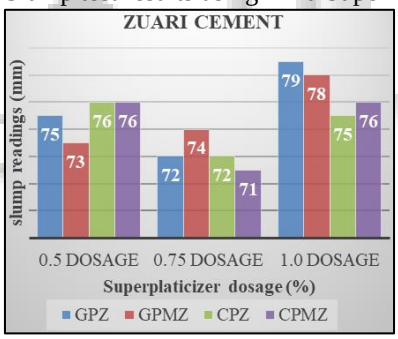

Fig. 3: Slump test results using Zuari cement

B. Compressive Strength test

The compressive strength results for 7 days testing can be seen in following graphs (fig-4, fig-5 & fig-6) using different brands of cement. From the resulting graphs, the compressive strength readings on using different brands of cement as well as with the use of Conplast SP430 and Glenium B233 Super plasticizers with a varied dose of 0.5, 0.75 and 1.0% for both with only use of PS sand as fine aggregate and other one PS sand with 50% of M-sand. We have obtained better compressive strength for either cases with only PS sand and PS sand with M-sand at an optimum dose of 0.75% for different brands of cement. From clear observation it is seen that Ramco cement is giving better strength which means the compatibility is good for both super plasticizers at 0.75% dose whereas other two brands of cement are giving good strength (compatibility) when only Glenium Super plasticizer at 0.75% dose.

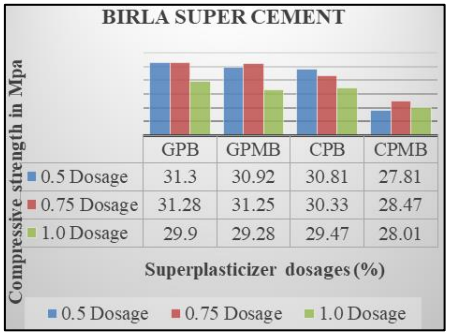

Fig. 4: Compressive strength results for 7 days using Birla super cement

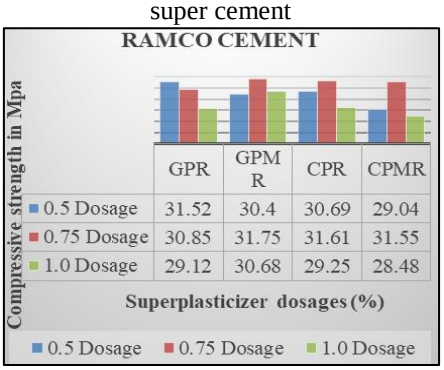

Fig. 5: Compressive strength results for 7 days using Ramco cement

From 7days compressive strength test results we know that 0.75% dose of super plasticizers are giving better results. To know the better cement brand and type of super plasticizer, we have considered the compressive strength results for 28days with only 0.75% super plasticizers dose. From the graph (Fig-7) it is clearly visible that compressive strength is maximum when Ramco cement and Glenium is added with partial replacement (50%) of M-sand in PS sand are used when compared to others.

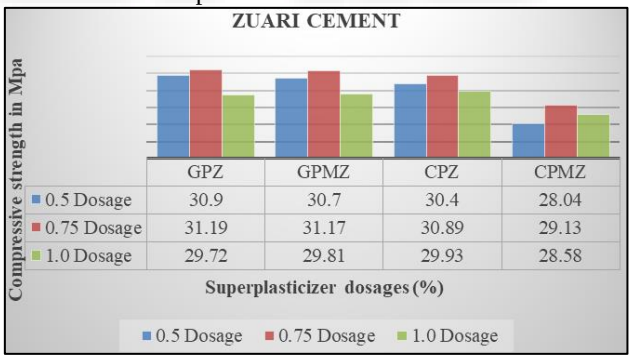

Fig. 6: Compressive strength results for 7 days using Zuari Cement.

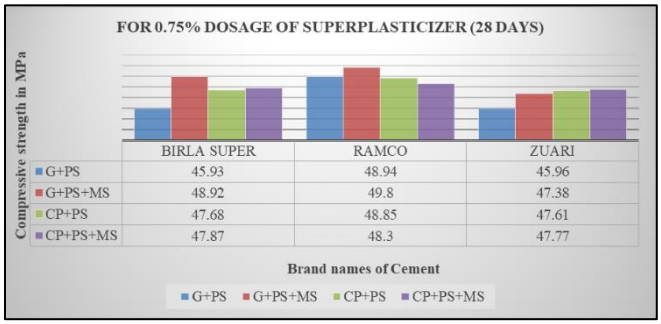

Fig. 7: Compressive strength results for 28 days at 0.75% dose of super plasticizer.

C. Split tensile Strength test

From compressive strength test results of 7 and 28days it is clear that 0.75% dose of superplasticizers are giving better results. The Split tensile strength test is carried out only for 28days using different brands of cement considering an optimum dose of 0.75% to know the specific results. From the resulting graph (fig-8) it is clearly visible that Tensile strength is also maximum when Ramco cement and Glenium is added with partial replacement of M-sand in PS sand are used when compared to others.

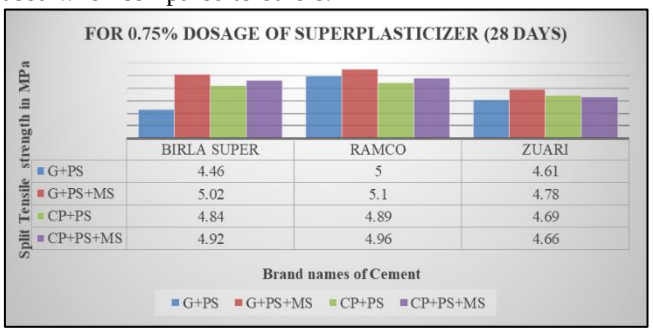

Fig. 8: Split tensile Strength results for 28days at 0.75% dose of super plasticizer

V. CONCLUSION

The general objective is to evaluate the workability, compressive strength and Split Tensile Strength for M30 grade of concrete mix in two conditions, that is one with complete use of PS sand as fine aggregate and the other with 50% replacement of PS sand by M-sand in addition to varying doses of two types of superplasticizers on three different brands of cement. From the test results, the following conclusions are

1) Usage of Glenium B233 superplasticizer by partial replacement of PS sand by M-sand is showing better results when compared to Conplast SP430 used.
2) Also partial replacement of M-sand (50%) in PS sand is giving better results when compared to fully replaced PS sand by natural sand.
3) Optimized dosage of 1.0% is showing better results for workability and optimized dose of 0.75% is showing better strength characteristics when compared to other dosages.
4) The use of Ramco brand cement is showing better strength results which means it more compatible or adjustable to both types of super plasticizer when compared to other brands of cement such as Birla super cement and Zuari cement which is compatible to only Glenium B233.

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