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Characteristics of Conplast SP430 Mixcombine Supplementary Cementitious Materials Produced Concretes

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ABSTRACT
Concrete admixtures perform specific properties on fresh and hardened concrete; admixtures are natural minerals and chemical additives to enhancethe consistency and performance of hardened concrete.The paper investigated the performance of super-plasticisersmixed with combine supplementary cementitious materials (SCM) partly replaced cement in concrete production. The research works used the chemical admixture conplast SP430 and mineral admixtures of ground granulated blast furnace slag (GGBFS), metakaolin (MK) and partly cement to produce concretes at 0, 30, 40, 50, 60% and addition of 1.5% conplast SP430 respectively by weight of cement. Concrete mix ratio of 1: 1: 2, water/ cement ratio 0.4 added to the mix. The study produced 48 numbers of 150 x 150 x 150 mm cubes and 36 numbers of beam size 100 x 100 x 450 mm tested at 7, 14, 28 and 60 days curing period to determine the workability, density, compressive and flexural strength of the concrete.The slump test carried out on the freshly mixed concrete due to the addition of conplast SP430showed plastic consistency ofM_B, M_C, M_D,and $M_E$resultedin slump ranges between 50- 85 mm of medium workability while the control M_A was a stiff concrete and low in workability of 30 mm slump. The compressive strength performed on the hardened concrete mixed with 1.5% conplast SP430 at 28 days, M_B 22.9%, M_C and M_D proportioned with supplementary cementitious materials resulted in 45.9 and 33.3% increase over M_A the control without conplast SP430. The flexural strength tested on the beam samples M_B, M_C and M_D resulted in 5.5, 17.1 and 10.5% increase over the control M_A without conplast SP430 at 28 days. The study revealed that conplast SP430 enhanced the fluidity, improved the consistency and workability of the concrete and enhance the proportioned combine supplementary cemetitious materials in attainment of high strength of the concrete products.

Key words: conplast-SP430, combine supplementary cemetitious materials, consistency, workability, compressive and flexural strength

I. INTRODUCTION

Concrete admixtures are natural and manufactured chemicals or additives added during concrete mix to enhance and attain specific properties of the fresh or hardened concrete.Such specific properties are workability, durability, early and final strength. Mineral admixtures are natural cement and supplementary cementitious materials or the combined while chemical admixtures are super-plasticisers.Concrete depends solely on cement orcementitious materials, water and aggregates to form a solid mass structure Kosmatka (2008).According to Fosroc (2016), Conplast SP430 is a form of super plasticizer a chloride free and sulphonated naphthalene polymers which conforms to BS EN 934 (2001) increases workability and enhances concrete strength. Super-plasticisers quicken the initial and final setting, reduce or lower the water/cement ratio and in the other hands improved the workability of the concrete (Mamlouk and Zaniewski (2006)). Addition of chemical admixtures such as super-plasticisers improves the properties of plastic concrete as well as workability, segregation (Rathan-Raj., et al (2013)). Nasir et al., (2019) stated that to produce concrete with good workability without excess water content,super plasticizer is used to give the cement the needed charge to reduce the water/cement ratio and enhance workability. Chemical admixture plays an important role in the fluidity and workability of concrete. Hence fluidity is one of the major factors of fresh concrete as it makes the concrete easy to transport, place and reduce segregation.Mohammed et al., (2016) revealed that over dosage of conplast in concrete deteriorate the concrete properties with reduce compressive strength and higher porosity. Mineral admixtures on the other hand are cements, supplementary cemetitiousor combined supplementary cemetitious materials that can partially replace cement as binder in concrete.Rathan-Raj, (2013) reported that supplementary cemetitious materialsadded partly to replace cement in concrete mix acts as pozzolanic materials as well as fillers, whereby the hardened concrete becomes denser improves the strength and durability properties of concrete. Minerals admixtures are natural, waste agricultural product and by-product of industrial materials processed or calcined to produce supplementary cementitious materials (SCM).Demirboga et al., (2001) reported that SCMs can be used in the concrete industry for sustainable development. According to Chen and Liu (2008) mineral admixtures enhance the workability of light weight aggregates concrete mixture and its strength,some of these minerals areground granulated blast furnace slag (GGBFS), metakaolin (MK) silica fumes, calcined clay, fly ash, corncob, rice ash and snail shell ash which contained silica, alumina and ferric oxides characteristics through which they influence the properties of concrete in different manner, improve the strength and durability of concrete. The utilization of ternary cements orcombined supplementary cementitious materials had attained much attraction in recent decades, andmetakaolin as an anhydrous calcined form of the clay mineral kaolinite has also received enormous attention when used as a supplementary cementitious material (Dual et al.,(2013)).Duan et al., 2013corroborated the efforts to include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice husk ash and metakaolin as alternative binders to Portland cement. Ground granulated blast furnace slag GGBFS is an excellent supplementary cementitious material that possessed high amount of silica and alumina,the GGBFS produces better concrete than ordinary concrete in aspects of mechanical, durabilityand on micro-structural properties (Ramezanlanpour and Jovein, (2013)). Effort was made by Ozbay et al., (2016) to study the strength parameters of concrete by replacement of cement in concrete with GGBFS and metakaolin,reported that they have no any cementing properties of their own,just only react with calcium oxide or calcium hydroxide in cement. The cementitious action of metakaolin lowers calcium hydroxide content which produces better workability of concrete (Mithun&Narasimhan, (2015)). The cementitious action of metakaolin consumes portladite content which improves porosity of concrete (Nicolas et al., (2014)).Similarly the metakaolin concrete has better micro structure than ordinary cement concrete (Shi and Quian(2015)). The durable properties such as porosity of concrete and sorptivity are improved by filling capacity and cementitious activity of metakaolin (Barbhuiya et al., (2015)). The effect of combined supplementary cementitiuos materials for the production of concrete according to Siddique and Klaus, (2009) of copper slag, GGFS and metakaolin on the properties of concrete shows that the workability of the concrete improved with increase in replacement of fine aggregate by copper slag, the addition of metakaolin reduces it. They further reported that compressive strength increased for all mix in which copper slag is used as fine aggregates containing metakaolin and GGFS, metakaolin also improve compressive strength when added due to cementitious reaction with calcium hydrate. The split tensile was also improved due to the substitution of fine aggregate by copper slag and cement by metakaolin and GGFS, also flexural strength.Sahahab and Attaullah, (2020) conducted a study on the effect of using pulverized fly ash (PFA) and GGBFS in replacement for cement in concrete. Results shows that the flexural strength of the concrete containing GGBFS up to 50% and PFA up to 30% have higher values of strength than the ordinary portland cement concrete when cured under the summer curing environment, concrete containing 20% PFA has higher flexural strength than the other PFA concretes. Naraindas et al., (2020) carried out compressive strength on ternary blended cements or combined supplementary cementitious using GGBS and Metakaoilin, results shows that 10% cement replacements enhance concrete strength by 12.28%, 9.93% and 9.93% at 7days to 28 days curing. The increment in strength may be attributed to the effect of pore filling and the pozzolanic reaction of the supplementary cementitious materials (SCM).

The research work used the chemical admixture conplast SP430 and mineral admixtures of GGBFS, metakaolin (MK) and partly cements to produce concretes at 0, 30, 40, 50, 60% and addition of 1.5% conplast SP430 respectively by weight of cement.Mix ratio of 1: 1: 2 water/ cement ratio of 0.4 added to the mix. The study produced 48 numbers of 150 x 150 x 150 mm cubes and 36 numbers of beam size 100 x 100 x 450 mm tested at 7, 14, 28 and 60 days curing period to determine

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the workability, density, compressive and flexural strength of the concrete.

II. MATERIALS AND METHODOLOGY

Metakaolin (MK)

The clay was obtained from a site at Lakiri Village km 11 Abeokuta Ajeboroads. It wascalcined or heated between 600 and 800^0in an electric furnace. The materials are grinded with the aid of a mechanical grinding machine, and then thoroughly sieved with 0.063 mm to remove dirt and organic matter present.

Plate 1:Samples of Metakaolin ash

Ground granulated blast furnace slag (GGBFS)

Ground granulated blast furnace slag is obtained as a waste product from molten iron ore as a waste product from a blast furnace;when it is cooled,ground and sieved with 0.063 mminto fine powder.

Plate 2: GGBFS

Plate 2: Samples of GGBFS ash

Cement

The cement used for the production of concrete is an ordinary Portland cement [Elephant cement] produced by Lafarge Cement Company, Ewekoro in Ogun state. The cement was obtained from a store close to MoshoodAbiola Polytechnic in Abeokuta Ogun state.

Water

The water used to mix the concrete was clean and odourless, pure and free from oil. The water used for the mix was obtained from Civil Engineering Department Laboratory.

Conplast SP430

Conplast is a liquid chemical super-plasticisers used as a water reducing agent.This wasprocured from cement manufacturing company store. 1.5% conplast SP430 by weight of cement was used for the mix.

Fine aggregates

The fine aggregate (sand) of size less than 5mm was used, clean and free from impurities that could hinder the strength of concrete.

Coarse aggregates

Well graded granite size greater than 5mm up to 20mmwas adopted as the coarse aggregate for the work. The granite was procured froma quarry; it is irregular inshape and free from dirt that could affect the concrete.

Method of batching

The batching was carried out by weighing the various mix value Table 2, which comprises of cement, MK, GGFS, fine sand, coarse aggregate and 1.5% of conplast SP430. These were measured with the aid of weighing balance. The MK, GGBFS and 1.5% SP 430 was added in the required percentage by weight of cement. The mix ratio used was 1:1: 2 and water/cement ratio of 0.4,to

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cast the cubes size of 70 x 70 x 70 mm and 100 x 100 x 450 mm for beams.

Table 1: Total numbers of concrete sample cast.

Curing days	Cubes	Beams
7	12 samples	12 samples
14	12 samples	12 samples
28	12 samples	12 samples
60	12 samples	-
Total	48	36

Table 2: Mix proportion for cube and beam samples

Sample No.	Cement: SCM%	OPC (kg)	GGBFS (kg)	Metakaolin(MK) (kg)	Fine aggre. (kg)	Coarse aggre.(kg)	1.5% Conplast SP430(kg)
M_A	100 : 0	29.1	0	0	29.1	58.2	0
M_B	100 : 0	29.1	0	0	29.1	58.2	0.442
M_C	0.7:0.2:0.1	20.37	5.82	2.91	29.1	58.2	0.442
M_D	0.6:0.2:0.2	17.46	5.82	5.82	29.1	58.2	0.442
M_E	0.5:0.3:0.2	14.55	8.73	5.82	29.1	58.2	0.442
M_F	0.4:0.35:0.25	11.64	10.18	7.28	29.1	58.2	0.442

Table 2, showed the quantities of materials used in casting samples of 48 numbers of cubesand 36 numbers of beams for the study.Materials were mixed thoroughly and the workability of the concrete consistency was tested on a slump cone before being placed into the concrete mould that has been coated with oil for easy demoulding. Curing of samples was done after 24 hrs of casting in water for 7, 14, 28 and 60 days. Samples were tested for densities and finally on universal tensile machine for compressive and flexural strength Plate 3.

Plate 3: Universal Tensile Machine

III. RESULTS AND DISCUSSIONS

Test for slump

The fresh concretes were testedin a slump cone to measure the slump in millimeters (mm), the slump of control concrete M_A was 30 mm resulting instiff concreteand oflow workability than the mixed conplast SP430 M_B, M_C, M_D, M_E and M_F concretewhich gave value ranges between 50-85 mm, are plastic and of medium workability due to the consistency nature of concrete Table 3 and Fig. 1.

Table 3: Workability of concrete for different mixes

Sample No.	Slump Value (mm)	Degree of Workability
M_A	30	Low (stiff)
M_B	70	Medium (plastic)
M_C	85	Medium (plastic)

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M_D	80	Medium (plastic)
M_E	50	Medium (plastic)
M_F	40	Low (stiff)

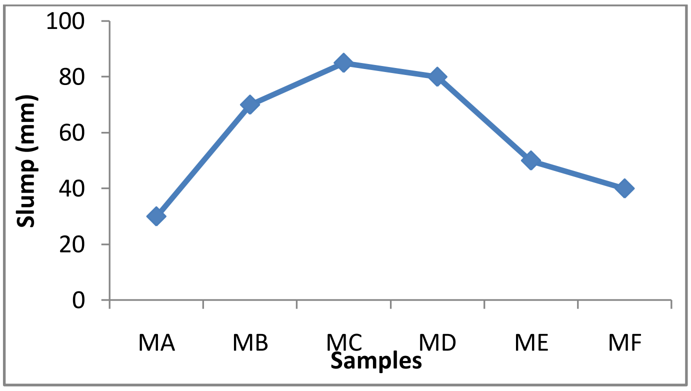

Fig. 1: Slump value of concrete

Density

The density of M_A (control) cured for 7, 14, 28 and 60 days ranges between 2,420 – 2580 kg/m^3, the addition of conplast SP430 to samplesM_B, M_C, M_D, M_E and M_F cured for same period Table 4 and fig. 1., increased the density as the curing days increases. This increase in concrete density is as a result of the continuous hydration of cementitious materials in the concrete.Considering M_E and $M_F$which are denser than M_A, M_B, M_C and M_D due to permeability and retention of waterin the body mass of samples delaying complete hydration.

Table 4: Density of cubes at 7, 14, 28 and 60 days.

Sample No.	Density kg/m^3 Days			
	7	14	28	60
M_A	2,420	2,420	2,463	2,580
M_B	2,420	2,426	2,463	2,639
M_C	2,478	2,522	2,537	2,653
M_D	2,478	2,566	2,570	2,682
M_E	2,507	2,571	2,586	2,721
M_F	2,536	2,658	2,669	2,740

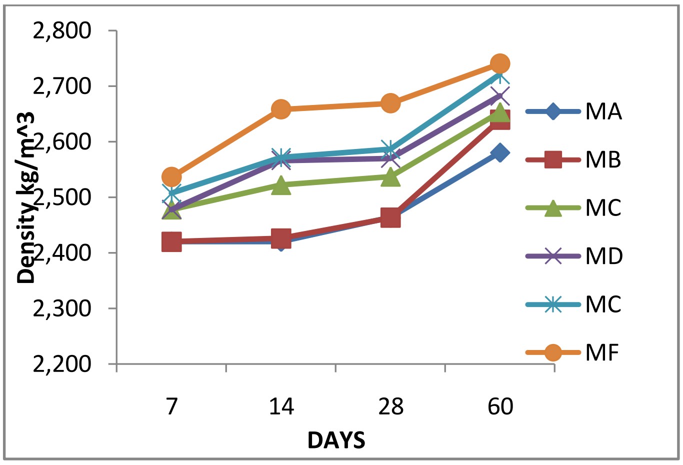

Fig. 2: Density of concrete cubes

Table 5: Compressive strength at 7, 14, 28 and 60 days

Sample No.	Compressive strength N/mm² Days			
	7	14	28	60
M_A	7.3	10.5	14.5	20.1
M_B	7.2	10.4	18.8	25.7
M_C	11.8	18.2	25.9	29.9
M_D	9.8	14.0	23.9	26.7
M_E	6.9	8.8	11.3	13.4
M_F	6.7	8.3	10.8	13.1

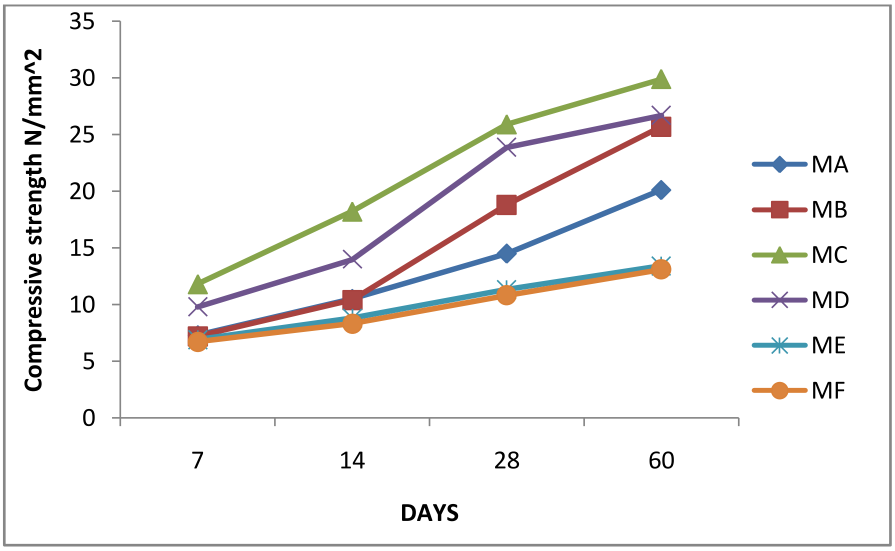

Fig. 3:Compressive strength of concrete cube

Compressive strength test

There was an initial hydration delay in the harden of the concrete $M_B$with conplast SP430 due to consistency of the concrete at the early ages resulting in compressive strength loss of 7.2 and 10.4 N/mm^2 as against the control M_A without conplastwhich gave compressive strength of 7.3 and 10.5 N/mm^2 at 7 and 14 days curing period but at 28 days compressive strength M_B with conplast SP430was 18.8 N/mm^{2}i.e 22.9% over the control M_A without conplast SP430 Table 5 and fig. 3. The proportioned SCMs and the super-plasticiers samples M_C and M_D gave boost to compressive strength at 28 days at 45.9 and 39.3% over the control M_A, this revealed thatconplast SP430increased fluidity of the concrete and improvedhydration of the cementitious materials and enhanced strength of the concrete.

Flexural strength of the beam

Similar trends were observed on the flexural test performed on the M_B and SCM specimens M_C and M_D with conplast SP430 which resulted in 5.5, 17.1 and 10.5% over M_A the controlwithout conplast SP430. This also typified the consistency of the specimens due to the plastic fluidity of the concrete which made the samples to be workable and further enhanced their strength due to delayed hydrationover M_A (control) without conplast SP430 Table 6 and fig. 4.

Tables 6: Flexural strength at 7, 14 and 28 Days

Sample No.	Flexural strength N/mm² Days		
	7	14	28
M_A	3.3	3.4	3.4
M_B	2.9	3.2	3.6
M_C	3.9	3.9	4.1
M_D	3.5	3.7	3.8
M_E	2.8	2.9	2.9

M_F	2.6	2.7	2.8

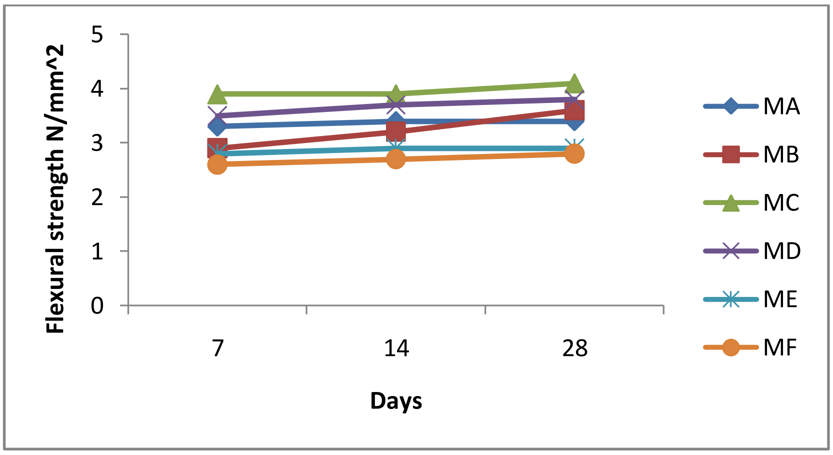

Fig. 4: Flexural strength of concrete beam

IV. CONCLUSIONS AND RECOMMENDATION

- The consistency of the OPC mixed with super-placisers M_B andSCMs mixed concreteM_C, M_D, M_E and $M_F$improved due to the addition of conplast SP430 this made the concrete plastic (fluid), easy to place and workable.
- The slump value ranges between 50-85 mm and it is of medium workability.The control mix (M_A) without conplast SP430 has the lowest slump value of 30 mm.
- The compressive strength of M_B, and SCMs concrete products of M_C, and $M_D$increased at over 22.9, 45.9 and 39.3% increase to M_A at 28 days strength.
- The flexural strength which determines structure in bending also showed increment of 5.5, 17.1 and 10.5% over M_A the control (without conplast SP430).
- The addition of conplast SP430 and the proportioned combine supplementary cemetitious materials of ground granulated blast furnace slag (GGBFS) and metakaolin (MK) enhanced concrete consistency, workability and improved concrete strength.

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