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Experimental Study of Conplast SP430 in Concrete Using Selected Brands of Portland cement

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ABSTRACT :*Different types of cement and super plasticizer are available in the market, even though the cements and super plasticizers complied with the respective code of practice, their performance are not the same in concrete, even if quality and source of other ingredients are kept constant. This has created a lot of problem among the users about what type of super plasticizers to be used with what type of cement and what optimum dosage of super –plasticizer should be added. Consequently, this study involves the application of Conplast SP 430 Superplasticizer on three different cement brands in northern part of Nigeria. The same Grade 42.5N of the three cements were selected and coded as NB, ND, and NS respectively. American concrete Institute (ACI) method of mix design was used to obtain the required proportion of the constituent materials for 30N/mm^{2}produced for the study. The study was limited to fresh properties (unit weight and slump test) and hardened properties (density, water absorption and compressive strength test). All the three cements indicated an improvement for the performances studied.*

KEYWORDS *Superplasticizer, SP 430, Concrete, Workability, Compressive Strength.*

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I. INTRODUCTION

Portland cement concrete is a composite material made by combining cement, supplementary cementing materials, aggregates, water, and chemical admixtures in suitable proportions and allowing the resulting mixture to set and harden over time [1]. Therefore, concrete hardening and forming of concrete properties depend greatly on the mixing water, aggregates and admixtures used. Concrete has to be solid mass that realizes the full potential hardened properties, as that makes the anticipated strength to be achieved. For the quality control in achieving that, the concrete should be handled, transported, placed, compacted and finished to form a homogenous mass that is void-free [2]. The concrete performance plays a vital role in the development of infrastructures including commercial, industrial, residential, military structures and other special reinforced concrete structures. As initially stated that the mixing water contribute on the concrete properties at the fresh state, which is responsible for workability of concrete. The water-cement ratio and degree of compaction are two factors by which the strength of concrete are assumed to be primarily depend on, when other constituents of it have been properly achieved. This is the rule established by Duff Abrams in 1919. To produce concrete with a desirable workability without using excess water content, Superplasticizer is being used to giving the cement particles highly negative charge so that they repel each other due to the same electrostatic charge. By deflocculating the cement particles, more water is provided for concrete mixing [3]. Workability is one of the major issues of a freshly prepared concretes; which can be enhanced by super plasticizers. The super plasticizers on one hand, lower the water cement ratio and other hand, they improved the workability of the concrete.

However, the suitability of a particular superplasticizer with different brand of cement is always point of concerned in concrete industry, as addition of some particular admixtures may develop undesirable interaction between varying ingredients of concrete. This therefore prevent the incompatibility between the admixture and cement, which might result into abnormal performances of finished concrete product [4]. Moreover, saturation dosage varies with the type of the superplasticizer and cement, the compatibility problems before application most always be checked [5]. The term compatibility refers to the desired effect on performance when a specific combination of cement and chemical admixtures is used.

It's also established that at constant water cement ratio, increase of superplasticizer dose in Self-Compacting Concrete leads to gain of good self-compaction ability in addition to marginal reduction in unit weight. Moreover, there is also slightly increase in compressive strength than that of normal concrete mix [5]. Report by James and Mathew [6] has demonstrated that the Fineness of cement also plays a role in the variation of admixture dosage, because as fineness increases, the surface area increases as well and resulting in more adsorption of admixture.

II. LITERATURE REVIEW

Researches investigating the relationship between cement and superplasticizer (SP) in different performance capacities have been carried out. Malagavelli and Paturu [7] modified concrete with four different types of superplasticizers in which the results on the workability and compressive strength of concrete were improved. Work by Mohammed et al., [8] revealed that over dosage of SP were found to deteriorate the properties of concrete with indication of lower compressive strength and higher porosity. Optimum dose of chemical admixture varies with the type of the chemical admixtures as well as type of cement and w/c ratio [4].

An investigation by Osuji and Ikogho [9] on the current effects of Naphthalene Based SP addition process on water reduction and grade C20/25 concrete's compressive strength. The study revealed the SP addition by the two different processes resulted in varying compressive strength development and water reduction recording maximum water reduction and compressive strength gains of 22.9% and 80.2% respectively compared to the control.

Conplast SP 432 MS conforming to BSEN 934-2 [10], chloride free and sulphonated naphthalene polymers was used by Ede and Adegbite [11] to study the properties of self-compacting concrete (SCC) at different replacement levels of cement with limestone powder. The influence of Nigerian limestone powder in the SCC is tested and the compressive strength of the SCC compared to that of normal concrete. However, in a situation where incompatibility case is mixed with cement containing high C_3A or alkali content such as pozzolanic cement. Limestone powder is found to be the best mineral admixture when it replaces a part of cement, where more fluidity is exhibited by the dilution effect [12]. According to Davoudi [13], SPs have a key role in the concrete compressive strength increase, but time is needed to have a concrete with a high compressive strength.

The addition of superplasticizer (Conplast SP430) in the production of laterised concrete made with 12.5mm and 19mm coarse aggregate sizes reduced the shrinkage strain by 10.3 and 5.7% respectively [14]. Moreover, the laterised concrete made with SP also has a higher compressive strength than conventional laterised concrete irrespective of the size of coarse aggregates used. Despite that SP admixture increase workability and compressive strength, it also reduced slump loss [15], [16].

Gaud et al., [17] conducted a compatibility study on different types of cement and plasticizer, the research outcome by marsh cone test revealed that compatibility is achieved by adding 1.5 % PermaPlast by volume of cement with ultra tech OPC 53 grade cement & 1.3 % PermaPlast by volume of cement is compatible with Coromandal King PPC cement. Compressive strength of concrete with addition of SP keeping W/C ratio constant, increases with all dosages of SP when cured in water for 28 days [18].

Dosage is one of the dramatic effects of SP that requires great attention during application in concrete, because excessive usage can cause bleeding and segregation phenomenon. Therefore, Muhit [16] recommended the effective minimum dosage is 600 ml/100 kg of cement and maximum effective dosage is 1000 ml/100kg of cement.

Other common problems that arise as a result of incompatibility between cement and water reducers are: rapid loss of workability, excessive quickening / retardation of setting, and low rates of strength gain. These common problem have direct influence from temperature. Thus, Santhanam [19] evaluated the influence of ambient Conditions (temperature) on Superplasticizer and the results showed that with SP demand for a given slump as well as the 1 day compressive strength increased with a rise in the temperature, while the slump retention and initial setting time decreased.

This study involves the application of Conplast SP 430 Superplasticizers on three different cement brands in northern part of Nigeria. Upon completion the outcome will enable the construction industries to have better understanding the effectiveness of certain percentage of Conplast SP430 that will be compatible with different types of cement that are available in the market during construction.

III. MATERIALS AND METHODS

A. Materials

i. Cement

Ordinary Portland cement, Grade 42.5N which complied with BS EN 197-1[20] was used for casting all the samples. Commercial names of three cements used in this study, have not been reported in this paper, only coded as NB, ND & NS. All the three cements have a specific gravity of 3.15.

ii. Fine Aggregate

Natural river sand from a stream at Bayara town about eight (8) Kilometer along Bauchi - Dass Road Bauchi State Nigeria that complying with BS EN 12620[21] was used for the study with physical properties as depicted in Table 1.0 conforming to zone II of BS882 [22].

iii. Coarse Aggregate

The coarse aggregate used for the study was normal weight aggregate from an igneous rock source with a maximum size of 20mm, the coarse aggregates was procured from TRIACTA quarry site in Bauchi metropolis complying with BS EN 12620[21]. The Physical properties of the aggregates are given in Table 1.0

Table 1.0 Physical property of aggregates

Property	Fine Aggregate	Coarse Aggregate
Bulk specific gravity (SSD)	2.67	2.58
Bulk specific gravity (OD)	2.65	2.53
Apparent specific gravity	2.70	2.67
Water absorption (%)	0.65	2.0
Bulk density (kg/m^3)	1540	1600
Aggregate crusting value (%)	13.40	-
Aggregate impact value (%)	18.80	-

iv. Water

Water fit for drinking is suitable for mixing concrete, therefore water available in the college campus conforming to the requirements of water for concreting and curing.

v. Chemical Admixture

High performance super plasticizing admixture Conplast SP 430 which is sulphonatednapthalene polymers from Fosroc, Fars Iran limited which conforms with BS EN 934[10] and with ASTM C494[23] was used for this investigation.

B. **Methods**

i. Mix design

The grade concrete adopted for this study was M-30 that is 28 days compressive strength of 30N/mm^2. American concrete Institute (ACI) method of mix design was used to obtain the required proportion of the constituent materials. Table 2.0 below shows the constituent of each material with superplasticizer SP430 used. The level added dosage of superplasticizer SP430 was in accordance with manufacturer's specification, in which 0.5-0.8 L range was only adopted.

Table 2.0 Mix proportions used

Mix ID	Cement (kg/m^3)	Fine Aggregates (kg/m^3)	Coarse aggregates (kg/m^3)	Water (kg/m^3)	SP 430 (g)
Control	380	813	952	210	0
0.5L – 100kg of Cement	380	813	952	210	24.6
0.6L – 100kg of Cement	380	813	952	210	29.5
0.7L – 100kg of Cement	380	813	952	210	34.5
0.8L – 100kg of Cement	380	813	952	210	39.4

ii. Casting of Cubes

The mould of 100mm×100mm×100mm size was used to produce the test samples in accordance with BS EN 12390 [24].

iii. Curing of Cubes

The sample were completely immersed in water for curing age of 7days, 14days and 28days in accordance with BS EN 12390 [24].

iv. Workability

Slump test was carried out in accordance with BS EN 12350 [25].

v. Unit weight

It was carried out in accordance with ASTM C138 [26].

vi. Compressive Strength

The test specimens (cubes) were removed from water after specified curing time and excess water was wiped out from the surface. The dimension of the specimen was taken to the nearest 0.2m.The bearing surface of the testing machine was cleaned. The loading was carried out in accordance with BS EN 12390 [27].

vii. Water Absorption

The test was conducted in accordance with BS 1881[28].The cubes were removed from the curing tank; they were then weighed under saturated surface dry condition and after air dried for 24 hours. Finally the percentage difference in weight between the air dried and weight (SSD) is the water absorbed.

IV. RESULTS AND DISCUSSION

A. Workability

The results of the slump test carried out on concrete with Conplast SP430 contents are presented in Figure 1. It showed a relation between dosages of Conplast SP430 and slump. The value of slump at different specific dosages of Conplast SP430 were plotted, which can be clearly seen that with the increase of Conplast SP 430 content, the slump (mm) also increased. The slump results value of NS cement falls within the true slump, while for the NB and ND cement, the slump result value falls within the shear and collapse slump respectively. The results clearly show that concrete mixes produced with Conplast SP 430 content exhibit higher slump value than the concrete mixes produced without Conplast SP430 content which is in conformity with finding by Elinwa [29]. The highest value of slump is 197mm falls within the limits of class S4 (≥160mm) under the NB cement and the lowest value of slump is 19mm falls within the limits of class S1 (10mm - 40mm) under the NS cement as specified by BS EN 206 [30] and also approved for concrete works. Moreover, more workable concrete requires minimum amount of work which will enhance the density of the concrete as presence of voids will affect the compressive strength [31]. Increased workability of concrete, due to presence of superplasticizer makes it possible to utilize industrial waste materials [32]. This also complied with the manufacturer's recommendation that for high workability concrete the normal dosage range is from 0.70 to 2.00 litres/100 kg of cementitious material. In addition, at higher dosage recommended by the manufacturer, the conplast SP430 can use in production of flowing concrete permits easier construction with quicker placing and compaction and reduced labour costs without increasing water content.

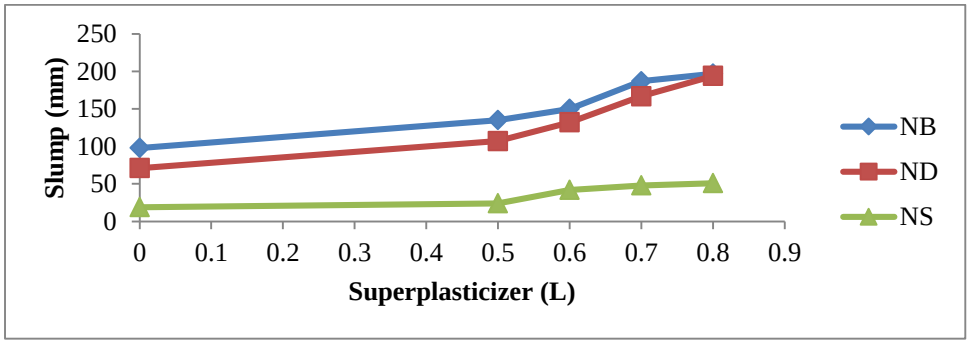

Figure 1: Variation of workability of concrete with superplasticizer content

B. Unit weight

From the Figure 2, one can conclude that increase in superplasticizer dosage percentage leads to increase in weight of fresh mix, resulting to better consolidation of the concrete after the addition Conplast SP430 super plasticizer. However, the unit weight test results value are falls within the specified range values which is maximum 2400kg/m^3 for normal concrete [33]. This indicate that less effort is required to manipulate a freshly mixed quantity of superplasticized concrete for homogeneity. Therefore, the concrete will have the less voids and this would reduce the effect of it for compressive strength [31]. The increase in weight can be attributed to the less voids.

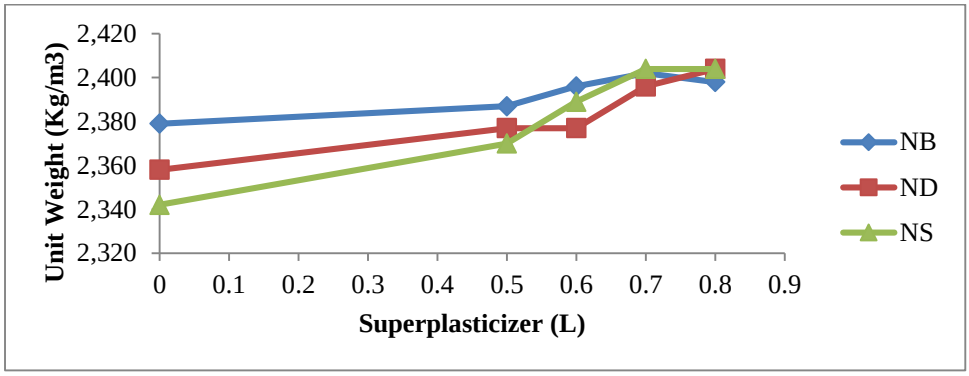

Figure 2: Variation of unit weight of concrete with superplasticizer content

C. **Density**

The variation of density with Conplast SP430 content for 7, 14 & 28 days curing period are presented in figure 6a, 6b & 6c. The bulk density increased with increases in Conplast SP430 content and increased with increases in curing periodwhich is in conformity with finding by Elinwa [29]. This is mainly due to better consolidation of the concrete after the addition Conplast SP430 superplasticizer. The density of the control concrete specimens ranged from 2437 - 2457kg/m^3 and that of the concrete samples containing Conplast SP 430 ranged from 2453 to 2560kg/m^3. These lie within the range of 2200 to 2600kg/m^3 specified as the density of normal weight concrete [34]. This shows that for the constant water cement ratio, increase of superplasticizer dose in concrete leads to gain of good self-compaction ability, which reduces the occupied voids and result in consumption of more concrete for full compaction.

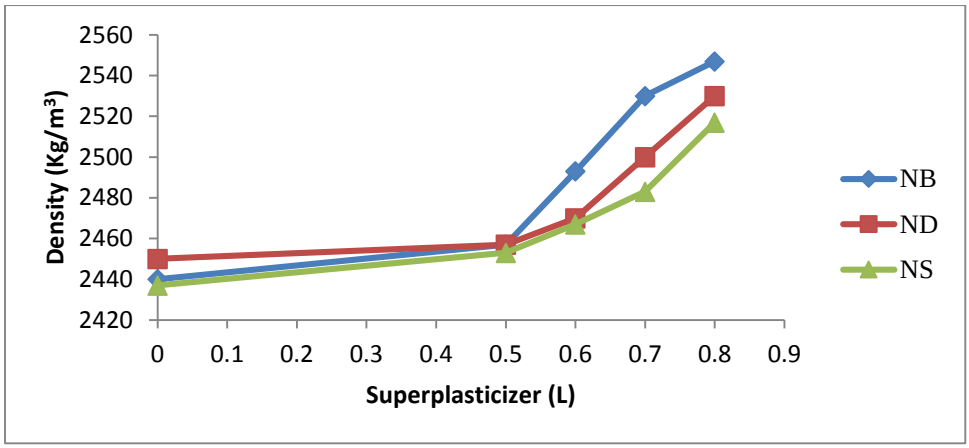

Figure 3(a): Variation of density of concrete with superplasticizer content in 7 days

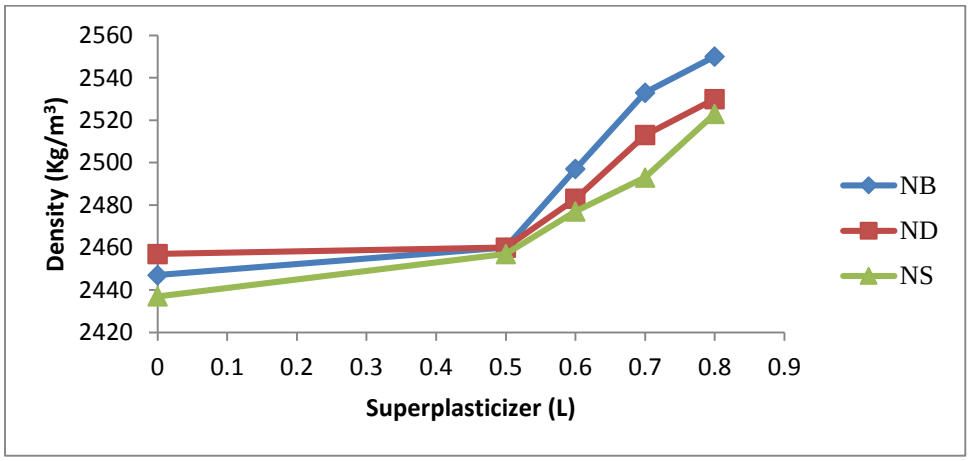

Figure 3(b): Variation of density of concrete with superplasticizer content in 14 days

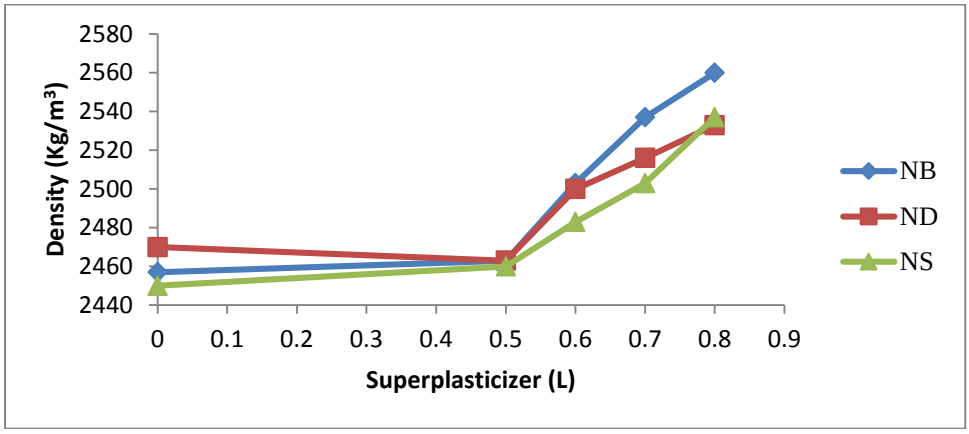

Figure 3(c): Variation of density of concrete with superplasticizer content in 28 days

D. **Compressive Strength**

Compressive strength of concrete with different dosages of Conplast SP 430 super plasticizer were tested on 7, 14 and 28 days. The values and fluctuation of compressive strength at different specific dosages of Conplast SP 430 super plasticizer are then shown in a figure 4a, 4b&4c. From the graph, it is clear that the strength gains continuously for addition of Conplast SP 430 super plasticizer and the compressive strength is increasing with the increment of Conplast SP 430 dosages. The results showed that all the concrete mixes with presences Conplast SP 430 super plasticizer exhibited improvement in compressive strength and noticeable reduction in water absorption compared to their control mixes. Since addition of Conplast SP 430 will provide more water for concrete mixing and also increase the entrapped water and promote hydration of cement [35]. From the observation of the efficiency of compressive strength it is seen that, compressive strength of concrete specimens is increased with different dosages of Conplast SP 430 super plasticizers for particular grade of concrete. The compressive strength results of the concrete with Conplast SP430 content is in conformity with finding of Elinwa [29], which indicated an increase in strength. Although, there was no appreciable strength gain at early age when compared with control for all the three type of cement. This is because setting time of concrete increased as the dosage increased, and thus Conplast SP 430 can be classified as a retarder [29]. It is therefore adequate for hot weather concreting. Moreover, the limited dosage which is within the manufactures specification also is satisfied, while NS demonstrated appreciable strength gain with superplasticizer in comparison with NB and ND.

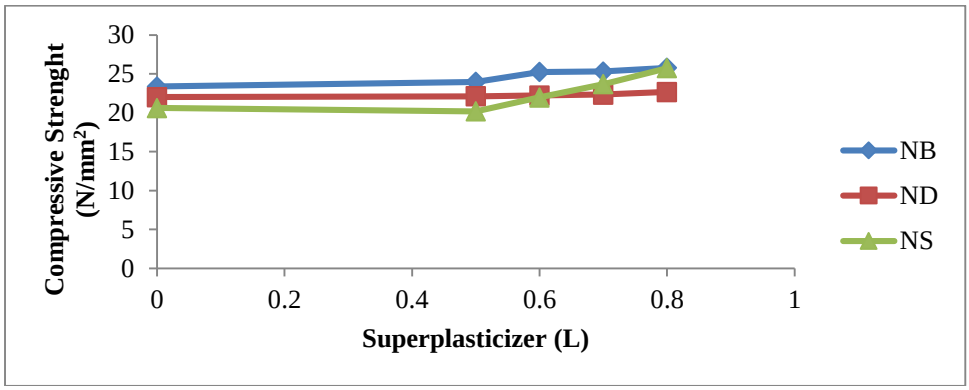

Figure 4(a): Variation of compressive strength of concrete with superplasticizer content in 7 days

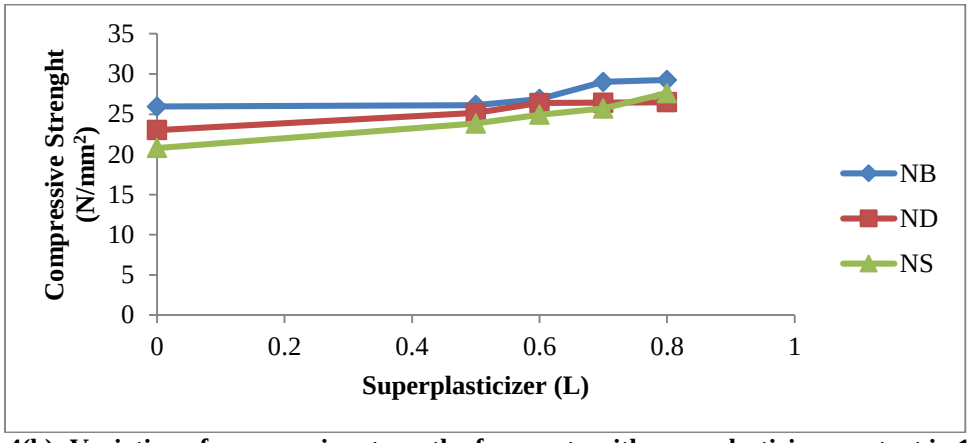

Figure 4(b): Variation of compressive strength of concrete with superplasticizer content in 14 days

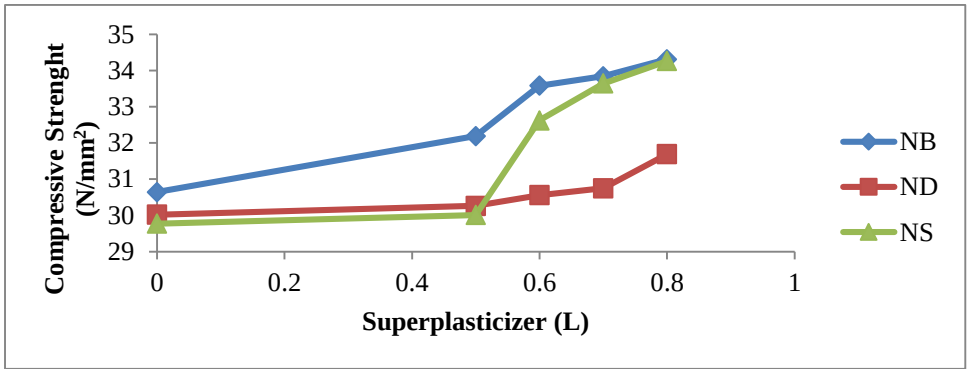

Figure 4(c): Variation of compressive strength of concrete with superplasticizer content in 28 days

E. **Water Absorption**

The variation of water absorption with Conplast SP 430 content in the concrete is presented in figure 5a, 5b & 5c. The water absorption decreased with increase in Conplast SP 430 content and increased with increase in curing period. The results showed that all the concrete mixes with presences Conplast SP 430 content, exhibit improvement in compressive strength and noticeable reduction in water absorption when compared to their control mixed. Hence increase of dosage of Conplast Sp 430 super plasticizer will increase the entrapped water and promote hydration of cement [35]. The low range of water absorption obtained was due to the limited for connectivity and reduced porosity of the concretes. The pores become discontinuous and thus the flow channel for the water movement are reduced. The rate at which a dry concrete surface absorbs a liquid can be taken as a predictor of its durability. The lower the water absorption of concrete the more durable is the concrete. A good durability can be achieved by decreasing the porosity and transport properties such as water absorption and water permeability of concrete [36]. Water absorption and porosity reduces when dosage of superplasticizer increases and this conforms to the manufacturer's recommendation.

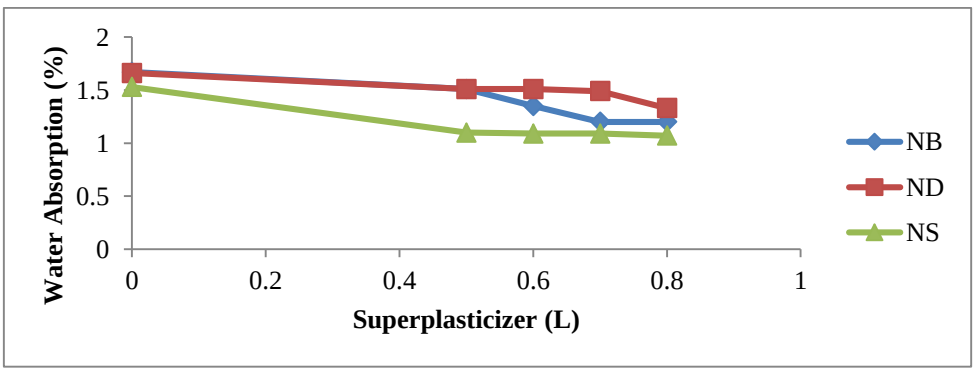

Figure 7(a): Variation of water absorption of concrete with superplasticizer content in 7 days

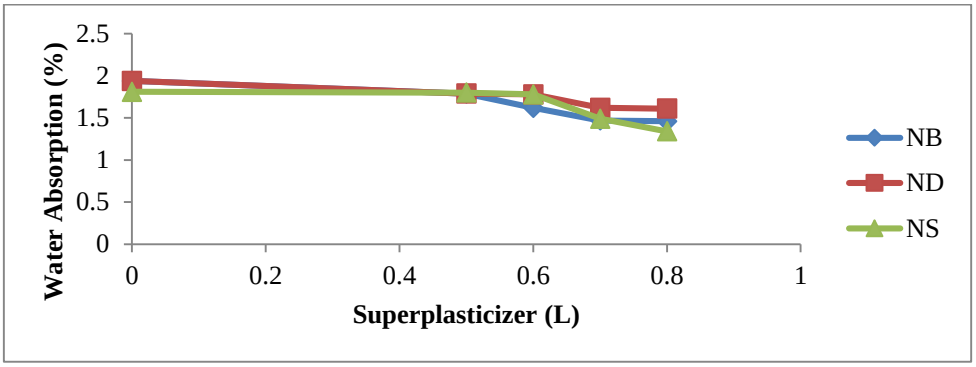

Figure 7(b): Variation of water absorption of concrete with superplasticizer content in 14 days

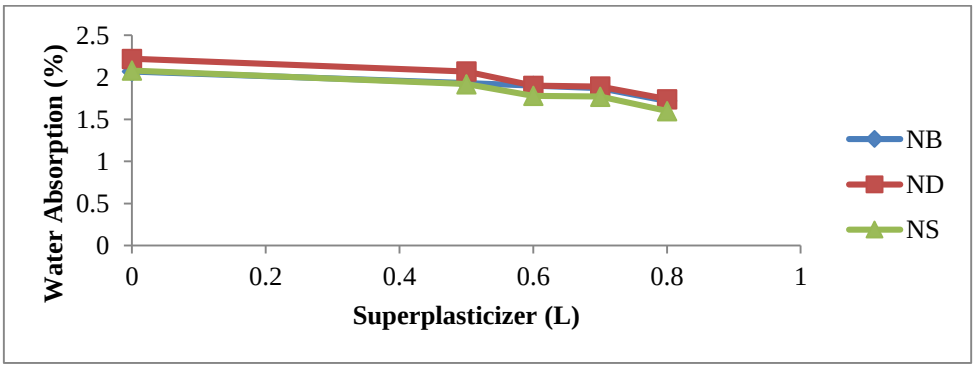

Figure 7(c): Variation of water absorption of concrete with superplasticizer content in 28 days

V. CONCLUSION

The effects of the dosage of Conplast SP 430 on concrete materials made with three selected Portland cement of the same grade have been carried out on its performance. The following conclusions were made:

1. The Conplast SP430 is suitable for use with all types of Portland cement as recommended by the manufacturer.
2. The workability of concrete was also improved and the density is a normal weight concrete, as indicate that the control mix has the lowest value when compared it with their corresponding mixes that containing of Conplast SP 430 super plasticizer admixture.
3. Increase workability due to presence of superplasticizer makes it possible for three type of cement studied to utilize industrial waste materials.
4. The result showed that all the concrete mixes with presences Conplast SP 430 admixture exhibited an improvement in compressive strength and noticeable reduction in water absorption compared to their control mixes.
5. The compressive strength increased as curing proceeded from 7 days to 28 days for all the mixes.

REFERENCES

[1]. Kosmatka, S.H.: Properties and Performance of Normal-Strength and High-Strength Concrete, in Concrete Construction Engineering Handbook, E.G. Nawy, CRC Press, Taylor & Francis Group, New York (2008).
[2]. Domone, P.L.: Fresh concrete, in Advanced Concrete Technology Concrete properties, Newman, J.& Choo, B.S., Butterworth-Heinemann, London(2003).
[3]. Neville, A. M..: Properties of concrete, Pearson. Prentice Hall, p 255- 262 (2005).
[4]. Jadhav, D.: Compatibility of Chemical Admixture with Cement: Marsh Cone Test. International Journal of Advances in Mechanical and Civil Engineering, Volume-3, Issue-3, (2016).
[5]. Dumne, S. M.: Effect of Superplasticizer on Fresh and Hardened Properties of Self-Compacting Concrete Containing Fly Ash. American Journal of Engineering Research, 3(3), pp. 205-211(2014).
[6]. James, T.K. & Mattew, L.A.: Compatibility Study of an Admixture with Different Cement Brands of Varying Chemical Composition for SCC. International Journal of Engineering Research & Technology, Vol. 5 Issue 09 (2016).
[7]. Malagavelli, V.& Paturu, N.R.: Strength and Workability Characteristics of Concrete by Using Different Super Plasticizers. International Journal of Materials Engineering, 2(1), pp.7-11(2012).
[8]. Mohammed, M.S. Mohamed, S.A. & Johari, M.A.M.: Influence of Superplasticizer Compatibility on the Setting Time, Strength and Stiffening Characteristics of Concrete. Advances in Applied Sciences, 1(2), pp.30-36 (2016).
[9]. Osuji, S.O. & Ikogho, D.: Current Effects of Naphthalene Based Superplasticizer's Addition Process on Water Reduction and Grade C20/25 Concrete's Compressive Strength. Journal of Civil Engineering Research, 8(1), pp. 9-14(2018). DOI: 10.5923/j.jce.20180801.02

[10]. BS EN 934: Admixtures for concrete, mortar and grout- Part 2: Concrete admixtures- Definitions, requirements, conformity, marking and labelling. British Standard Specification. London, United Kingdom (2001).
[11]. Ede, A. N. & Adegbite, A. A.: Effects of Nigerian Limestone and Superplasticizer on the Hardened Properties of Self Compacting Concrete. Journal of Chemical, Mechanical and Engineering Practice, Vol. 3, No. 1 - 3, pp. 17-24(2013).
[12]. Hallal, A., Kadri, E.H., Ezziane, K., Kadri, A. & Khelafi, H.: Combined effect of mineral admixtures with superplasticizers on the fluidity of the blended cement paste. Construction and Building Materials, 24, pp. 1418–1423(2010).
[13]. Davoudi, H. : Evaluation of the Superplasticizer Effect on the Concrete Compressive Strength using the Tree-Classification Decision Algorithm, Civil Engineering and Urban Planning: An International Journal , Vol.4, No.1, pp 25-32(2017). DOI:10.5121/civej.2017.4103
[14]. Falade, F., Ukponu, B. & Ugbaja, O. J.: Influence of Superplasticizer and Varying Aggregate Size on the Drying Shrinkage and Compressive Strength of Laterised Concrete. Nigerian Journal of Technology, Vol. 36, No. 3, pp. 734 – 739(2017).
[15]. Alsadey,S.: Effect of Superplasticizer on Fresh and Hardened Properties of Concrete. Journal of Agricultural Science and Engineering, Vol. 1, No. 2, pp. 70-74 (2015).
[16]. Muhit, I. B.: Dosage Limit Determination of Superplasticizing Admixture and Effect Evaluation on Properties of Concrete. International Journal of Scientific & Engineering Research, Volume 4, Issue3 (2013).
[17]. Gaud, D. S., Paghdar, D. K., Shah, J. A., Pathak, V. B.& Shah, R.A. : A Compatibility Study on Different Types of Cement and Plasticizer. International Journal for Scientific Research & Development, 1(9), pp. 1952-1954 (2013).
[18]. Shah, S. N. R. & Aslam, M.: Behaviour of Normal Concrete Using Superplasticizer under Different Curing Regimes. Pak. J. Engg. & Appl. Sci. Vol. 15, pp. 87-94 (2014).
[19]. Santhanam, M.: Evaluation of Superplasticizer Performance in Concrete, in the third International Conference on Sustainable Construction Materials and Technologies (2016). http://www.claisse.info/Proceedings.htm
[20]. BS EN 197: Cement- Part 1: Composition, Specifications and Conformity Criteria for Common Cements. British Standard Specification. London (2000).
[21]. BS EN 12620: Aggregate for Concrete. British Standard Specification. London, United Kingdom (2002).
[22]. BS 882: Specification for aggregates from natural sources for concrete. British Standard Specification. London (1992).
[23]. ASTM C 494: Standard Specification for Chemical Admixtures for Concrete. ASTM International West Conshohocken, PA: USA (1992).
[24]. BS EN 12390: Testing Hardened Concrete - Part 2: Making and Curing Specimens for Strength Tests. British Standard Specification. London, United Kingdom (2002).
[25]. BS EN 12350 part 2: Testing of Fresh Concrete: Method for determination of Slump. British Standard Specification. London (2000).
[26]. ASTM C138: Standard test method for density (Unit Weight), Yield and Air Content (Gravimetric) of Concrete. ASTM International West Conshohocken, PA: USA. Vol. 04(2) (2011).
[27]. BS EN 12390: Testing Hardened Concrete - Part 3: Compressive Strength of Test Specimens. British Standard Specification. London, United Kingdom (2000).
[28]. BS1881 part 122 (1983). Testing Concrete: Method for determination of water absorption. British Standard Specification. London.
[29]. Elinwa, A.U.: Mechanical Strength of Admixed Conplast SP 430 Cement Paste and Concrete (May 7, 2018). Available at SSRN: https://ssrn.com/abstract=3174640 or http://dx.doi.org/10.2139/ssrn.3174640
[30]. BS EN 206 part 1: Specification, performance, production and conformity. British Standard Specification. London, United Kingdom (2000).
[31]. Neville, A.M. & Brooks, J.J.: Concrete Technology, 2nd Ed. Pearson Education Limited, England. Pp 408-409(2010).
[32]. Verma, A., Shukla, M. & Sahu, A. K.: Use of Superplasticizers in Concrete and their Compatibility with Cements. International Journal of Civil Engineering and Technology, Volume 4, Issue 1, pp. 138-158(2013).
[33]. Shetty, M.S.: Concrete Technology Theory and Practice. S. Chand & Company Ltd, Ram Nagar, New Delhi (2005).
[34]. Neville, A.M.: Properties of Concrete, 5th Ed. Pearson Education Limited, England (2011).
[35]. Hanadi, A. L.: Studying of Effect the High-range Water-reducer/super Plasticizer, Retarding Admixture on Properties of Concrete. International Journal of Scientific and Engineering Research 7 (1) (2016).
[36]. Vanwalleghem, H., Blontrock, H., and Taerwe, L.: Spalling Test on Self-Compacting Concrete. In on. Walevik, and I. Nielsson (Ed.), Proceedings of the Third International Symposium on Self-Compacting Concrete. RILEM Publication, Bagnex, France. 855-862(2003).

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