

PROPERTIES OF NEEM GUM POWDER IN CONCRETE

Aliyu, Y.¹ and Aboshio, A.²

¹Department of Civil Engineering, Faculty of Engineering, Modibbo Adama University, Yola

²Department of Civil Engineering, Faculty of Engineering, Bayero University, Kano

Corresponding email: aliyuyazid01@mau.edu.ng

ABSTRACT

In this paper, effect of neem-gum-powder as an admixture to modify both physical and mechanical properties of grade 20 concrete was assessed. The research work is aimed at investigating the properties of neem gum powder concrete. The neem-gum used for the study were collected from neem tree which possess a treat to the environment, thereby causing pollution to the environment. In addition, the use of neem gum powder in concrete production will help reduce the cost. Neem gum extruded from the tree were air-dried at ambient temperature and ground to powder. It was then added to freshly mixed concrete at different percentages of 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2% by weight of cement in the concrete mix. Experimental tests comprising setting time of cement pastes, slump of the concrete mixes as well as compressive strength and splitting tensile strength tests were carried out. Results from the assessments show that the setting time and consistency of the cement paste increases with increase of the neem-gum-powder. The initial and final setting time of the cement paste increased by 41 and 14.9% respectively and consistency increased by about 48% at 1.2 % addition of the neem gum powder. Workability of the concrete mixes also increases with increase in the amount of neem gum powder. At optimum content 0.4% neem-gum-powder addition, the compressive strength and splitting tensile strength of the concrete increased by 13.20 and 39.6% respectively at 28 days of curing but decrease with increase in the neem gum powder percentage in excess of 0.4%. Base on the finding, neem gum powder can be used as a retarder and further research can be carried out to regulate the effect of potassium and chlorine in the neem gum powder.

Keywords: Neem Gum Powder; Admixture; Workability; Concrete Strength; Innovative Concrete

1 INTRODUCTION

Concrete is one of the major materials widely used in construction industries both in Nigeria and around the world. However due to increase in complexities of modern structures and the drive for high performance concrete with excellent durability properties, admixture from industrial by-products and agricultural wastes have been utilized to mitigate the deficiencies in normal concrete [1]. To this effect, Gum arabic liquid used as an admixture in concrete was found to be useful as a water reducing admixture which has significant effect on strength properties of hardened concrete [2, 3]. Other admixtures such as *Polio-stigma-Thonningii* (Cameel foot tree) Fruit powder used as admixture in concrete shows the fruit powder accelerates the setting of cement and increases the strength of concrete [4]. Rice Husk ash improves compressive strength of concrete, but the durability of the concrete are impaired when used as an additive [5]. Neem-seed-husk-ash which is obtained from burning both the Neem-seed and Seed-husk was found to have a synergic effect on the strength of cement-sand mortar when 0, 5, 10, 15, 20 and 25% of cement was replaced by it [6]. Also, [7] have concluded that Neem Seed Husk Ash (NSHA) is a suitable material for use as a pozzolan in concretes

as it satisfied the requirement for such material by having a combined composition of Silicon Oxide, Ferric Oxide and Aluminium Oxide (SiO_2 , Fe_2O_3 , and Al_2O_3) of more than 70%, [8]. Preliminary investigation carried out in the course of this study indicates that the neem gum is of chemical constituents similar to the neem seed ash, rice husk ash, groundnut shell ash, and gum arabic with combined silicon, Iron and Aluminum oxides of 45.77%. It is thus, against this background that the study seeks to fully understand its effect on both fresh and hardened properties of grade 20 concrete with attendant plausible gains of reducing the associated ecological and environmental pollution caused by the production of cement and concrete. In addition, the neem gum powder is known to have high percentage of silicon oxide, calcium oxide, and aluminum oxide. These oxides have great significance in strength development of concrete and durability of concrete. According to [9, 10], silica fumes improve the strength of cement paste that binds the aggregates together to get a good workable concrete. The presence of calcium oxide which is commonly known as lime supports cement to be sound and provide strength to the concrete produced while the Aluminum oxide (Al_2O_3) present in the neem gum can add quick setting time in cement. Several Research works have been carried out on the use of cheap alternate materials to replace the conventional material in concrete production to reduce the high cost incurred during construction. These alternatives to conventional materials are mostly agricultural or industrial waste that causes environmental pollution. By using them as a substitute in cement production, the issue of environmental pollution will be tackled thereby leading to the production of less expensive concrete. In many developing countries the demand for building construction materials such as Ordinary Portland cement and admixtures is high to meet the infrastructure needs of the citizens. However, the production of these products requires capital-intensive plants and expertise, with consequent high cost, in addition, to an increase in the prices of traditional building materials to the common man due to inflation [9]. Agricultural or industrial waste can be used as an additive or admixture in concrete where there is a need to enhance or alter the properties of either fresh or hardened concrete or both for a particular purpose. In order to reduce environmental pollution and the cost of material and construction to an affordable rate, several attempts have been made to use these agricultural and industrial wastes such as rice husk, plantain peel, groundnut shell, coconut peel, fly ash, blast furnace slag, sawdust, carbide, gum Arabic liquid, gum Arabic karoo, neem seed, neem seed husk and much more useful especially in the building industry. In this research, neem gum powder was used to investigate its effect on the fresh and hardened properties of concrete. By doing so, the effect of environmental pollution caused by this neem gum will be curtailed and cheap concrete can be attained.

2 MATERIALS AND METHODS

2.1 Materials

Cement: The cement used for this study is ordinary Portland cement, Dangote 3X cement of grade 42.5N manufactured by Dangote cement factory Plc. It was obtained from a local cement dealer at Gyadi-Gyadi roundabout in Kano.

Fine Aggregate: The fine aggregate used is composed of river sand obtained from Challawa river of Kano state.

Coarse Aggregate: The coarse aggregate obtained are crushed granite rock of maximum nominal size of 20 mm. It was obtained from a quarry in Bunkure Local Government Area, Kano state.

Neem Gum: Neem gum was obtained from the neem tree of *Azadirachta Indica species* within Yola metropolis.

Water: Clean portable water which meets the required specification of [11] was obtained within kano and used for casting and curing of concrete cubes produced from the study.

2.2 Methods

Neem Gum Powder: Neem gum exudes from neem trees were collected, air dried under room temperature for 3 days to reduce the moisture content from 30 to 10%. It was then ground to powder using mortar and pestle and then sieved through a $75\mu\text{m}$ sieve. X-ray Fluorescence (XRF) test was carried out on the powdered neem gum to obtain the oxide composition.

Specific Gravity: The specific gravity of both the fine aggregate and coarse aggregate were carried out in accordance with [12, 13].

Sieve Analysis: Sieve analysis was carried out on both fine and coarse aggregate. Fine aggregate of 1000g was used to pass through a sieve ranging from 13.2mm to 75um of British Standard to determine the particle size distribution and classify the fine aggregate to zone. Also, coarse aggregate of 2000g in weight was used in determining the sample size distribution. It was made to pass through several sieves ranging from 20.0 to 2.00 mm BS sieve in accordance with [14].

Determination of Consistency of Cement Pastes: The initial and final setting times of the cement paste was carried in according with [15].

2.2.1 Concrete mix design

The design of grade 20 concrete used as the control mix was based on the Department of Environment’s Design method (DOE method), [16]. Thereafter, the neem gum was added, and the mix was prepared at different proportions of 0, 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2% of the neem gum by weight of cement content. A summary of the mix proportion is presented in Table 1. Mixing was done manually and was assumed to be completed when a homogeneous mix is obtained. The fresh concrete was produced and then placed and compacted in three layers in cubes of size 150 x 150 x 150 mm and cylinders of size 200 x 100 mm and cured by complete immersion in a curing water tank in accordance with [17]. For each curing age, three numbers of the 150 x 150 x 150mm concrete cubes and 200 x 100mm cylindrical cubes were cast.

Table 1. Summary of Mix Proportion for 3, 7, 28, 56, and 90 days

% of NGP	Cement (kg)	Cement and neem gum powder (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Water (kg)
0	13.82	13.82	35.02	41.27	7.61
0.2	13.82	13.85	35.02	41.27	7.61
0.4	13.82	13.88	35.02	41.27	7.61
0.6	13.82	13.9	35.02	41.27	7.61
0.8	13.82	13.93	35.02	41.27	7.61
1	13.82	13.96	35.02	41.27	7.61
1.2	13.82	13.99	35.02	41.27	7.61

2.2.2 Slump Test

Slump test was carried out to determine the effect of neem gum powder on the workability of the concrete. Water cement ratio of 0.55 obtained from the mix design was used and the test was carried out in accordance with [18].

2.2.3 Compressive strength of concrete

The compressive strength of neem gum powder concrete was carried out in accordance with [19]. The mixed ratio of 1:2:3 and water-cement ratio of 0.55 was obtained from the mix design. A total of one hundred and five (105 Nos) of 150 mm cube specimens were cast and cured in water for 3, 7, 28, 56, and 90 days. At the end of every curing time, compressive strength was determined. For each of the curing ages, three cubes were weighed and crushed using the style made, model -1000/2000 compression testing machine to determine the strength. The crushing load from the machine was read and the density was calculated. Then, the strength of each cube was determined.

2.2.4 Splitting Tensile Test

The cylindrical concrete of size 200 x 100 mm was cast and cured at 3, 7, 28, 56 and 90 days. Universal compressive testing machine of Style-1000/2000 model was used to crush the cured cylindrical concrete at the end of the respective curing days. The specimen was placed horizontally with drawn diametrical lines perfectly centered with the platens of the testing machine. This test was carried out in accordance with [20].

3 RESULTS AND DISCUSSION

3.1 Oxide composition of neem gum powder

Result of oxides composition of the powdered neem gum are shown in Table 2. The result indicates a combined SiO_2 , Al_2O_3 and Fe_2O_3 content of 45.77% which is much less than that specified by [8] for pozzolana. However, the neem gum powder has high silica (38.91%) content which has been established to have a positive effect on concrete strength development [21], and high CaO content (23.939%) which confirms its self-cementing properties [9]. The oxide composition of NGP also indicated a high content of K_2O (15.058%) which may be a source of disruption when dosed in high quantity in cement and concrete matrix [9].

Table 2. Oxide Composition of Neem Gum Powder.

Oxides	Percentage (%)
MgO	4.50
Al_2O_3	5.81
SiO_2	38.91
P_2O_3	1.36
SO_3	2.63
Cl	1.03
K_2O	15.058
CaO	23.939
TiO_2	0.16
Cr_2O_3	0.05
Mn_2O_3	5.34
Fe_2O_3	1.064
SrO	0.16

3.2 Specific Gravity

The Specific Gravity of all the constituent of the concrete was carried out and the result is presented in the Table 3. The specific gravity of the neem gum powder is less than that of the cement by 31.4%. However, when neem gum powder is used as an additive in the mixture, the surface area of the cement is likely to increase, leading to usage of large amount of water in the mix which will produce cement gel that bind the concrete constituents.

Table 3. Specific Gravity for Neem Gum Powder, Cement, Fine and Coarse Aggregate

Constituent	Specific Gravity
Neem Gum Powder	2.16
Cement	3.15
fine aggregate	2.57
Coarse aggregate	2.72

3.3 Particle Size Distribution of Aggregates

The result of the grading of fine aggregate is shown in Figure 1. The grain size curve indicates that the sand used is of zone 1 as classified based on British Standard grading limits for fine aggregates. Zone 1 indicates that the fine aggregate is largely composed of coarse sand and is well graded. This helps in filling up all the void spaces which makes concrete more workable and well dense [22].

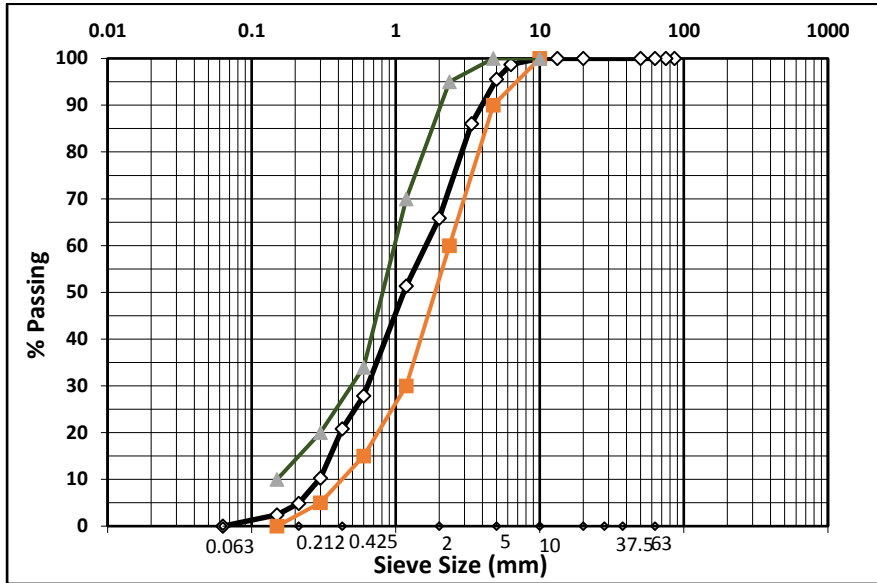


Figure 1. Particles Size Distribution for Fine aggregate

Similarly, grading of coarse aggregate was done and the result is presented in Figure 2. The curve indicates that the coarse aggregate is more of 20 mm which is the designed nominal size considered. Its content less particles and well graded. Coarse aggregate occupies 70 to 80% of the volume of concrete and it is a chemically inert material. Its size, shape and specific gravity affect the strength of concrete. The 20 mm size of the coarse aggregate used lead to a well compacted concrete which eventually helps in the strength development in the concrete. The aggregate consists of rounded shape and mostly angular shape. Due to the rough texture of the angular aggregates, the bond between the surface of the aggregate and the cement paste is likely to be stronger. [22] have observed that the increase in strength for a given increase in cement content depends on the type of aggregate used and the cement content itself. However, [23] have carried of a research on the effect of coarse aggregate size on the compressive strength of concrete and the results show that the compressive strength increases with increasing aggregate size up to 12.5 mm, while the concrete produced using 20 mm had greater compressive strength than those produced using 25 mm aggregate. This established the importance of ensuring that the right aggregate size is used in the production of concrete. Therefore, it is recommended that careful attention must be paid to the sizes of aggregates used in the production of concrete for structural purposes.

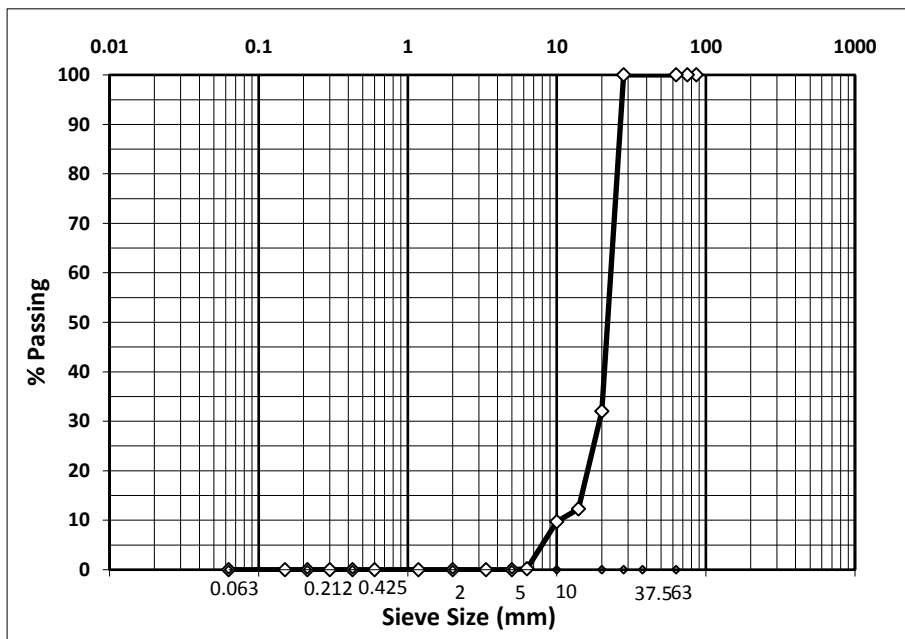


Figure 2. Sieve analysis of Coarse aggregate

3.5 Consistency Test Result

Consistency of the concrete mix increases with the addition of Neem Gum Powder as shown in Figure 3. At the optimum percentage addition of 0.4% of the neem gum powder, the consistency increase by 6.25%, and as it increases to 1.2% addition of neem gum powder, the consistency result increase by 28.91%. This is due to the increase in the surface area of the cement as the NGP is added. This result is consistency with that of [21], on size effect study of sawdust ash-concrete under compressive load.

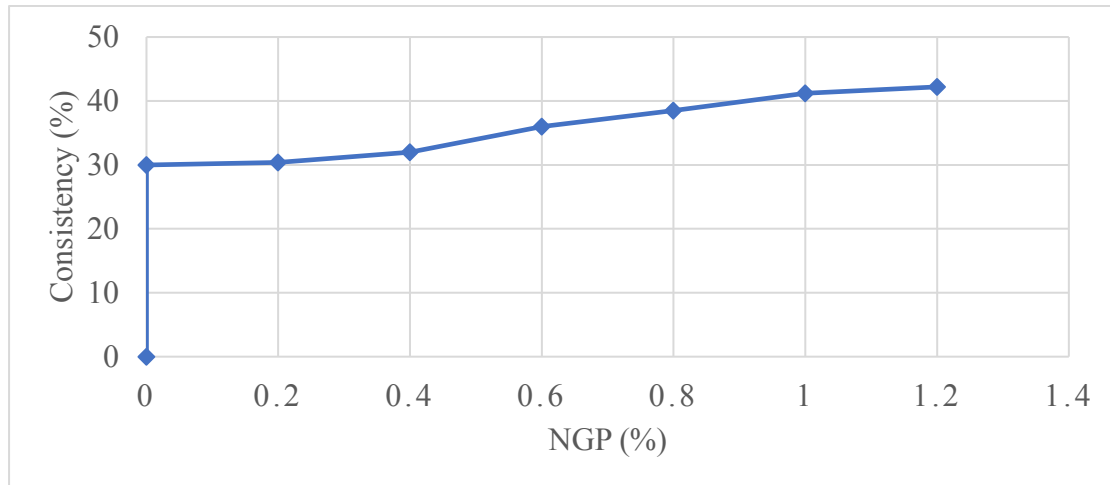


Figure 3. Consistency of cement admixed with neem gum powder

3.6 Setting Time of Cement with varying percentage of NGP

The results in Table 3 shows the effect of Neem Gum Powder (NGP) on setting time (Initial setting time and final setting time), where it increases with increasing NGP content. The increase in setting time could be due to the formation of potassium chloride in the paste which when adsorbed onto the cement surface will slow down the rate of hydration in the cement. This is in agreement with the work of [24], who discovered that the addition of alkalis had led to retardation of initial and final setting time. Also, [25] stated that the addition of KCl in OPC concrete have significant increase in the setting time of cement.

Table 3. Setting Time

% of NGP	Initial setting Time	Final setting Time
0	59	160
0.2	82	174
0.4	100	188
0.6	112	201
0.8	125	216
1	137	220
1.2	146	223

3.7 Slump Test Result for varying percentage addition of NGP

The result of slump test carried out on the control mix and other mixes containing varied percentage of Neem Gum Powder (NGP) is shown in the Figure 4. Results obtain shows that, the addition of Neem Gum Powder (NGP) improved the slump values of the mixes as compared to the slump of the normal mix. The slump value of the normal concrete was obtained to be 45 mm. As the percentage of the NGP increases, the slump value also increases. A significant increase in the slump value was observed when the NGP dosage was increased to 1 and 1.2%, in each case the slump was measured as 160 mm and 200 mm respectively. This could be due to the presence of alkali in the neem gum powder and it is in line with the findings of [26] on the effect of used engine oil as chemical admixture in concrete.

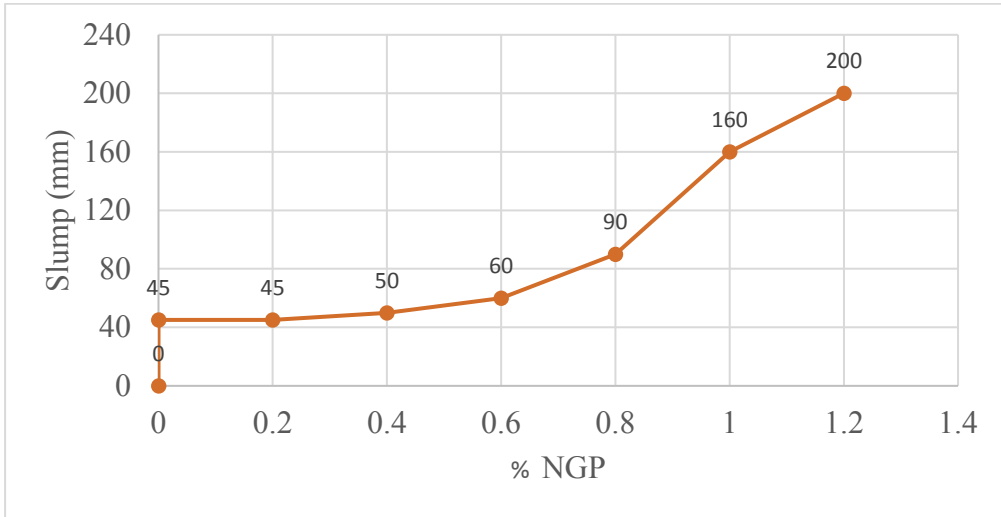


Figure 4. Slump of Concrete with varying addition of NGP

3.8 Compressive Strength Result of NGP Concrete

Concrete cubes cast and cured were tested for compressive strength and the results are shown in Figure 5. The compressive strength of the concrete increases with increase in the percentage addition of the Neem Gum Powder (NGP) up to 0.4% addition, and subsequently decreases with a higher percentage addition of the neem gum powder. The result obtained for the optimum percentage of 0.4% addition of NGP at different curing ages of 3, 7, 28, 56, and 90 days are 18.8 N/mm², 30.7 N/mm², 35.6 N/mm², 36.7 N/mm², and 38.0 N/mm² respectively. The increase is attributed due to the presence of silicon oxide and calcium oxide in NGP which collaborate with that of cement to form more calcium silica hydrate that increases [2]. At 1 and 1.2% addition of NGP, the concrete disintegrates when placed in the cured tank as shown in Plate 1, making the concrete unsound. This could be attributed to the presence of Potassium Oxide and chlorine at these percentages in the concrete which leads to the formation of alkaline that weaken the concrete constituent bond.

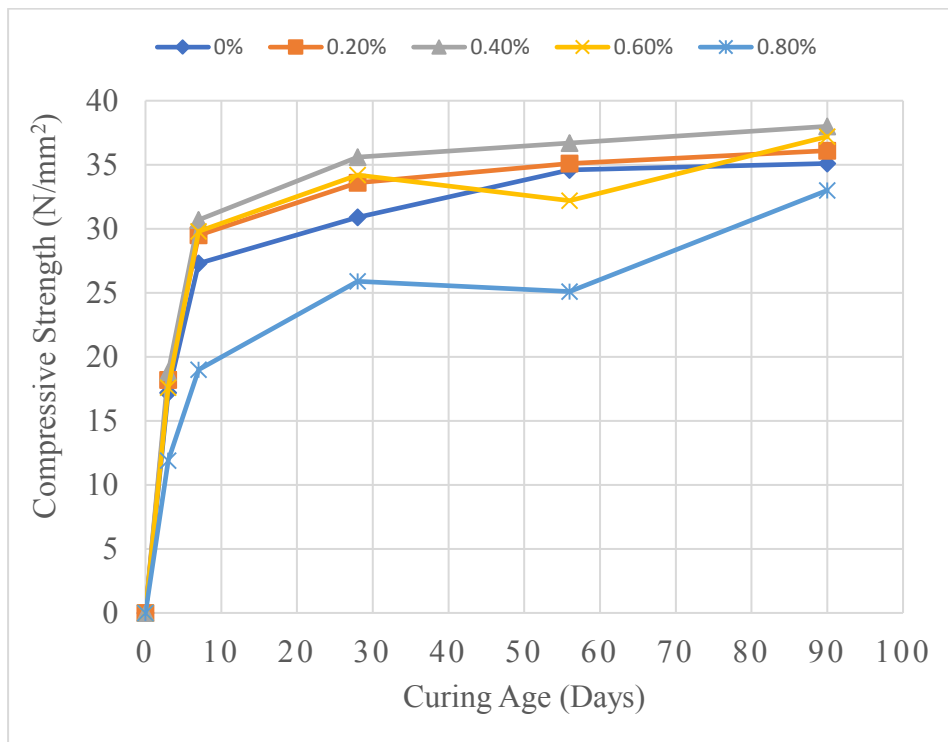


Figure 5. Compressive Strength Test Result



Plate 1. Disintegrated concrete cubes with NGP content of 1 and 1.2% during curing

3.9 Splitting Tensile Test

Results from the splitting tensile strength are presented in Figure 6. Splitting tensile strength increases with the addition of neem gum powder. From 0% addition to 0.4% addition of NGP, an increase of 39.6% at 28 days curing age was obtained. The strength further increases at 56 and 90 days curing age. The strength later reduces by 12.2 and 46.6% of the control value at 0.6 and 0.8% addition of NGP respectively for 28 days curing age. At 1 and 1.2% addition of NGP, the concrete again disintegrated when placed in the cured tank, making the concrete unsound based on reasons presented earlier [9].

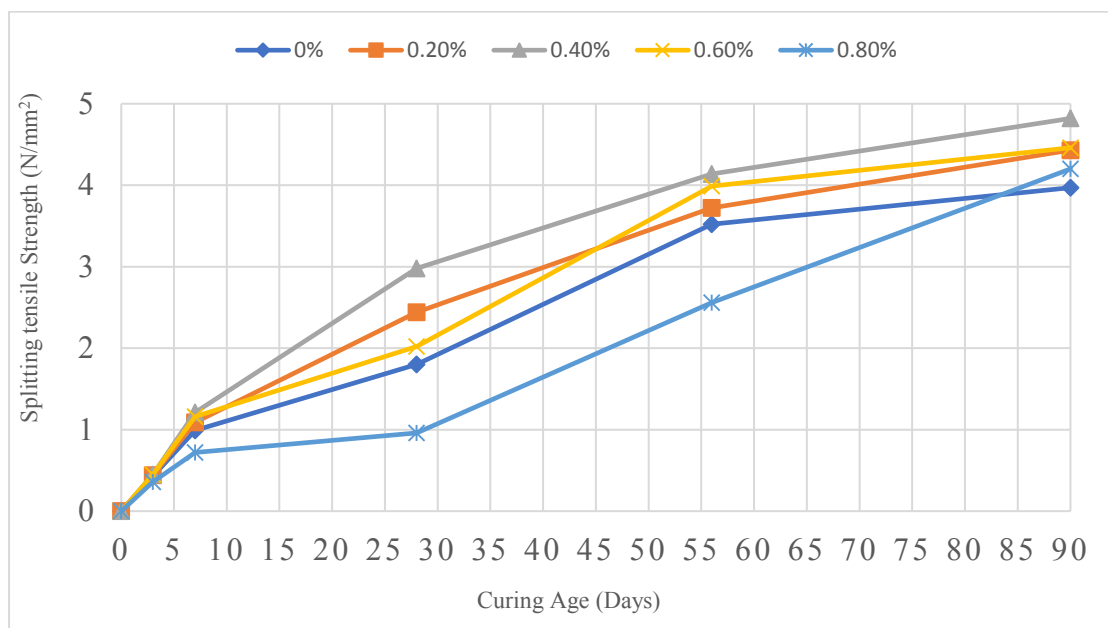


Figure 6. Splitting Tensile Test Result

4 CONCLUSIONS

The effect of neem gum powder as an admixture in concrete was investigated on grade 20 concrete and the following conclusions were made; Neem Gum Powder can be classified as a mineral admixture with a combined SiO_2 , Al_2O_3 and Fe_2O_3 percentage of 45.78%. The presence of SO_3 and K_2O in NGP could disrupt the bindings characteristics of the concrete when added in excess of 0.8% by weight of cement. Neem Gum Powder increases consistency and workability of concrete with

increase in the gum content. Neem gum powder up to 0.4% addition increased the compressive and tensile strength properties of concrete.

REFERENCES

1. Ogork, E.N. and Araga, A.O. (2015). Potentials of cassava peel powder (CPA) as admixture in Concrete. *Journal of Engineering and Technology*, vol. 10, no. 1, pp. 7-15.
2. Abdeljaleel, N.S., Hassaballa, A.E., Rahman, A. and Mohamed, E. (2012). The Effect of Gum Arabic Powder and Liquid on the Properties of Fresh and Hardened Concrete. *International Journal of Engineering Inventions*, vol. 1, issue 12, pp: 57-65. Available at www.ijeijournal.com.
3. Mbugua, R., Ramadhan, S. and Julius, N. (2016). Effect of Gum Arabic karroo as a Water-Reducing Admixture in Cement Mortar. *Journal of Material*, vol. 5, issue 2, pp. 100-111. Available at <https://doi.org/10.1016/j.cscm.2016.09.002>.
4. Ogork, E.N. and Rimi, M.K. (2007). Kargo (*Poliostigma Thonningi*) fruits powder as admixture in concrete. *Journal of Engineering and Technology*, vol. 5, no. 1, pp. 81-89.
5. Aboshio, A., Ogork, E.N. and Balami, D.A. (2009). Rice husk ash as admixture in concrete. *Journal of Engineering and Technology*, vol. 4, no. 2, pp. 97-103.
6. Musa, N.M. and Ejeh, P.S. (2012). Synergic Effect of Neem Seed Husk Ash on Strength Properties of Cement-Sand Mortar. *International Journal of Engineering Research and Applications*, vol. 2, issue 5, pp. 27-30.
7. Ibiwoye, E. and Naalla, A. (2017). Effect of neem seed husk ash on the workability of concrete. *TETFUND Sponsored Kwara State Polytechnic Journal of Research and Development Studies*, vol. 11, no. 1, pp. 1-11.
8. ASTM C618 (2019). Standard Specification for coal Fly Ash and Raw or Calcined Natural Pozzolan for Used in Concrete. *American Society for Testing and Materials*, pp. 1-11. Available at www.bsigroup.com.
9. Ogork, E.N and Ibrahim, A.O. (2017). Properties of Cement Paste and Concrete Containing Calcium Carbide Waste as Additive. *Nigerian Journal of Technology*, vol. 36, no. 1, pp. 26-31.
10. Cong, X., Gong, S., Darwin, D. and McCabe, S.L. (1990). Role of silica fume in compressive strength of cement paste, mortar, and concrete. *University of Kansas Center for Research, Inc.*, vol. 89, pp. 375-387.
11. BS EN 1008 (2002). Mixing Water for Concrete. *British Standard Institute*, pp. 1-21. Available at www.bsigroup.com.
12. BS 812-2 (1995). Testing Aggregate Part 2: Methods of Determination of Density. *British Standard Institute*, pp. 1-10. Available at www.bsigroup.com.
13. BS 812-105.2 (1990). Testing Aggregate. Methods of Determination of Particle Shape. Elongation Index of Coarse Aggregate. *British Standard Institute*, pp. 1-10. Available at www.bsigroup.com.
14. BS EN 933-1 (2012). Tests for Geometrical Properties of Aggregates. *British Standard Institute*, pp. 1-12. Available at www.bsigroup.com.
15. BS EN 196-3 (2005). Methods of Testing Cement. *British Standard Institute*, pp. 1-18. Available at www.bsigroup.com.
16. Ali, S.F., Sharma, L., Rakshit, D. and Bhattacharjee, B. (2020). Influence of passive design parameters on thermal comfort of an office space in a building in Delhi. *Journal of Architectural Engineering*, vol. 26, no. 3, 04020017.

17. BS EN 12390-2 (2000). Testing Hardened Concrete. Making and Curing Specimens for Strength Tests. *British Standard Institute*, pp. 1-10. Available at www.bsigroup.com.
18. BS EN 12350-2 (2019). Testing Fresh Concrete. *British Standard Institute*, pp. 1-8. Available at www.bsigroup.com.
19. BS EN 12390-3 (2019). Compressive Strength Test. *British Standard Institute*, pp. 1-16. Available at www.bsigroup.com.
20. BS EN 12390-6 (2009). Tensile Splitting Strength Test Specimens. *British Standard Institute*, pp. 1-11. Available at www.bsigroup.com.
21. Marthong, C. (2012). Size effect study of sawdust ash-concrete under compressive load. *Journal of Mechanical and Civil Engineering*, vol. 1, issue 5, pp. 27-32.
22. Olumide, M.O., Akinkulore, O.O., Emeka, S.N. and Patrick, O.A. (2018). Effects of Coarse Aggregate Size on the Compressive Strength of Concrete. *Civil Engineering Journal*, vol. 4, no. 4, pp. 836-842.
23. Şahin, R., Ramazan, D., Habib, U. and Rüstem, G. (2003). The effects of different cement dosages, slumps, and pumice aggregate ratios on the compressive strength and densities of concrete. *Cement and Concrete Research Journal*, vol. 33, issue 8, pp. 1245-1249.
24. Selman, M.M. and Ali, A.M. (2012). The effect of alkalis on the properties of Portland cement. *Anbar J Eng Sci.*, pp. 25-38.
25. Reddy, V.V., Gnaneswar, K., Ramana, N. and Sashidhar, C. (2011). Effect of Potassium Chloride (KCl) on Ordinary Portland cement (OPC) Concrete. *Research Journal of Chemical Sciences*, vol. 1, no. 2, pp. 103-107.