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Research Paper

Impacts of a Superplasticizer and Periwinkle Shells in Concrete Comprehensive Strength for Structural Integrity

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ABSTRACT: *The effort of producing high quality and durable concretes at low water cement ratio include experiencing fresh concrete with low workability and compaction difficulty in place. This study investigated a normal and periwinkle shells concretes of 3:1 aggregates cement and 0.45 water cement ratios. Additional investigation was also on superplasticized and superplasticized periwinkle concretes using 3:1 aggregates cement and 0.3 water cement ratios. Concretes produced by replacing granite with periwinkle shells was by equal volume of same in lieu of 0%, 5%, 10% and 15% of weight. Also, superplasticized concretes were produced with 0.5% of superplasticizer by replacement of water. Eight different batches of fresh concretes were produced and individual workability tests were carried out. A total of 480 specimens were produced whilst distributed equally among R-pavers, I-pavers, Z-pavers and cubes per batch. Compressive strengths of the concrete specimens were determined individually after curing in order of 7, 14, 28, 56 and 91 days. The superplasticized concrete specimens produced with 0.5% superplasticizer gave the highest comprehensive strength. The higher comprehensive strength was obtained by superplasticized periwinkle concrete specimens with 0.5% superplasticizer and 5% periwinkle shells. Whereas the normal concrete samples only gave the high comprehensive strength.*

KEYWORDS: *Periwinkle Shells, Superplasticized Concrete, Specimens, KONKRETO PC 896*

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I. INTRODUCTION

Normal concrete produced are not always providing the required workability at low water cement ratio for highest strength development Falade et al. [1]; Akiije and Adebiyi [2]. Periwinkle shells are found majorly at riverine areas and uncontrolled dumping do contribute to environmental messy conditions Agbede et al. [3]; Aimikhe and Lekia [4]. Using superplasticizer could be advantageous in concrete production to experience workability with easy compaction and high quality strength when hardened Akiije [5]. Also, periwinkle shells were used wholly and partially in the replacement of gravel in concrete production for purposes of waste reduction and decrease in the use of coarse aggregate Ettu et al. [6].

Water could be sourced from the ground, public tap, rain, river, lake, stream, reservoir and spring Akiije and Ajenifuja [7]. However, wherever it is sourced, same should not be polluted and must be drinkable in order to be useful for the production of concrete.

According to GCR [8] limestone, shells, chalk, marl, shale, clay, sale, blast furnace slag, silica sand, and iron ore are the common raw materials for cement production. Raw materials are usually crushed, grinded, blended according to the specified proportioning and burnt in the kiln and the clinker formed grinded with 5% of gypsum. The cement chemical and compounds materials are calcium, silicon, aluminum, iron and sulphate GCR [8]. Cement chemical composition are Silicon Dioxide (SiO_2), Aluminum Oxide (Al_2O_3), Iron oxide (Fe_2O_3), Calcium Oxide (CaO), Magnesium Oxide MgO, Sodium Oxide Na_2O, Silicon Dioxide SO_3. Tricalcium Silicate ($(CaO)_3 .SiO_3$), Dicalcium Silicate ($(CaO)_3 .SiO_3$), Tricalcium Aluminate ($(CaO)_3.Al_2O_3$), Tetracalcium Aluminoferrite ($(CaO)_4.Al_2O_3\ Fe_2O)_3$ are cement compounds.

Khaskheli et al. [9] submitted that superplasticizers are high range water reducers which are capable of producing high-strength concrete with low permeability. They further stated that recently a cement factory in Sindh has launched SPC (Superplasticized Cement) which contains the required amount of superplasticizers. Whilst results have indicated that structural concrete made with superplasticized cement could give higher compressive strength than that of OPC at all the curing ages, and 10% saving in cement content could be achieved by using superplasticized cement. They further claimed that structural concrete made with superplasticized cement could attain higher strength in a shorter period of time, and workability of structural concrete could be increased by using SPC.

Sathyan et al. [10] claimed that chemical admixtures are added to concrete at the time of mixing of its constituents to impart workability requirement which is the essence of good concrete. They further stated that the use of optimum use of admixtures is very important since low dosage may result in loss of fluidity. Also, over dosage of admixtures could lead to segregation, bleeding, excessive air entrainment etc. in concrete.

Coppola [11] dealt with the effectiveness of an innovative phosphonate-based superplasticizer (PNH) for ready mixed concrete. It was indicated that PNH-based admixture showed a better performance in terms of water reduction and workability retention with respect to napthalenesulphonate based admixtures (NSF). It was also pointed out that a higher dosage of PNH with respect to polycarboxylate ethers (PCEs) was needed to get the same initial fluidity. Yulia [12] confirmed the influence of some types of superplasticizers on the hydration and structure of cement stone. The influence as named included total open and conditionally-closed porosity, total contraction, autogenous shrinkage, contraction porosity and heat of hydration.

Ahuja [13] considered fine aggregate as is the granular material used to produce concrete or mortar and when the particles are so fine that they pass through a 4.75mm sieve. It is also considered as being widely used in the construction industry for increasing the volume of concrete, thus served a cost saving material. The quality of fine aggregate depends upon the grading zones being defined as the percent passing through the 600 microns sieve size. They are Zone I: 15% to 34%, Zone II: 34% to 59%, Zone III: 60% to 79%, and Zone IV: 80% to 100%. Generally density of fine aggregate is around 1450 - 2082kg/mm³ and the relative density is 2.65. Specifically, density of sand varies thus 2082 kg/m³ – density of wet packed sand, 1922 kg/m³ – density of wet sand, 1682 kg/m³ – density of packed sand, 1602 kg/m³ – density of dry sand, 1442 kg/m³ – density of loose sand.

According to Paluti et al. [14] the size, shape, texture, and hardness of coarse aggregates are used in their classification. Particle size analysis is mostly used for grading through sieve test being performed to determine the particle sizes of coarse aggregate sample in the laboratory. The coarse aggregate will have most of its particles remaining in the No. 4 fine sieve with a 4.75 mm opening or in a larger sieve. Specifically, density of coarse and fine aggregate varies thus 1750 kg/m³ – density of aggregate 10mm; 1600 kg/m³ – density of aggregate 12mm; 1450 kg/m³ – density of aggregate 20mm; 1200 kg/m³ – density of aggregate 40mm.; 1200 – 1450 kg/m³ – density of coarse aggregate; 1600 – 1750 kg/m³ – density of fine aggregate.

According to Dahiru et al. [15] periwinkle shells (PS) are waste products obtained from periwinkles that are small greenish-blue marine snails with spiral conical shell and round aperture. They reported that in Niger Delta of Nigeria periwinkle shells are waste and posed as environmental nuisance in terms of unpleasant odour and unsightly appearance in open-dump site. They also stated that these periwinkle shells are now being considered as coarse aggregate in the production of lightweight concrete be it partially or wholly for building structures.

Several researchers have reported upon their experimental studies on periwinkle and the use of superplasticizer in the production of concretes separately. However, none has endeavour to combine them for the purpose of given comparison to strength worth of standard specification for rigid and flexible pavements. This study therefore aimed at the investigation of normal and superplasticized periwinkle shells concrete of low workability and high compressive strength.

This study determines possible suitable amounts of both periwinkle shells and superplasticizer to give highest value of the concrete compressive strength regarding certain mixtures. Each fresh concrete workability of the mixtures was determined by slump test and compaction factor test. We also the strength characteristics of rigid pavement and flexible pavements so developed from rectangular R-pavers, I-pavers and Z-pavers were defined. The justification for this research work is in the environmental mitigation of nuisance waste of periwinkle shells through the production of high-strength concrete with low permeability. Also, this study is of interest in the prevention of early road cracks and pot holes leading to highway distress and prodigy to the poor economy of a nation.

II. MATERIALS AND METHODOLOGY

The materials employed as well as the methods employed in this study are as expressed in this section as follows.

2.1. Concrete Material Constituents

The materials employed in this study were water, superplasticizer, cement, sand, granite and periwinkle shells to produce normal and superplasticized periwinkle shells concretes. The physical and chemical properties of constituents collected were tested appropriately in accordance to the relevant standard specification methods.

Water: The municipal water used for the individual concrete mixture was also suitable for human consumption. It was sourced in the laboratory of the Department of Civil and Environmental Engineering, Faculty of Engineering, University of Lagos where the experiment was carried out. The water was also suitable for cleaning the equipment used for concrete production and testing.

Cement: Eight bags of cement D by 50 kg each of 42.5N were purchased that are found being produced according to ASTM [16]. The bulk density, specific gravity, fineness, initial setting time, final setting time, chemical and compound composition properties of the cement were verified. The properties of cement D were determined in the laboratory according to ASTM [17] and ASTM [18] standard methods.

Aggregates: Sand and granite aggregates as well as periwinkle shells used were separately air dried in bits inside the laboratory before use. Both sand and granite were examined in accordance to AASHTO [19]. Both sand and 9.5 mm size granite used were subjected to tests regarding gradation, coefficient of uniformity and coefficient of curvature through laboratory tests. Sand used moisture content, relative density, dry density and absorption values were tested according to ASTM [20]. The bulk densities of fine and granite used were separately tested in accordance to AASHTO [21]. In accordance to ASTM [22], the moisture content, specific gravity, dry density and absorption of the granite were tested. Los Angeles abrasion test was employed in the laboratory to determine granite abrasion value in accordance to ASTM [23] standard specification methodology. The granite used was tested in accordance to ASTM [24] for the determination of its crushing and impact values.

2.2. *Concrete Constituents Proportioning by Weight and Absolute Volume Method*

The normal, periwinkle shells, superplasticizer and superplasticized periwinkle shells concretes produced in this study employed weight and absolute volume method of mix proportioning. Equation 1 Gambhir [25] was used for the development of the normal concrete mix proportioning. Equation 2 Akiije [26] was used for periwinkle shells concrete mixes. This study employed equation 3 for the development of superplasticized periwinkle shells concretes.

Weight and absolute volume method of normal concrete is defined.

$$\text{Volume} = V_{nc} = \frac{w}{S_w} + \frac{c}{S_c} + \frac{fa}{S_{fa}} + \frac{ca}{S_{ca}} = 1 \quad (1)$$

Weight and absolute volume method of periwinkle shells concrete is defined.

$$\text{Volume} = V_{psc} = \frac{w}{S_w} + \frac{c}{S_c} + \frac{fa}{S_{fa}} + \frac{ca}{S_{ca}} + \frac{ps}{S_{ps}} = 1 \quad (2)$$

Weight and absolute volume method of superplasticized periwinkle shells concretes is defined.

$$\text{Volume} = V_{psc} = \frac{w}{S_w} + \frac{aw}{S_{aw}} + \frac{c}{S_c} + \frac{fa}{S_{fa}} + \frac{ca}{S_{ca}} + \frac{ps}{S_{ps}} = 1 \quad (3)$$

Where;

V_{nc} = Absolute Normal Concrete Volume, m³; V_{psc} = Absolute Periwinkle Shells Concrete Volume, m³; w = Weight of Water, kg; aw = water admixture; S_{aw} = Specific Gravity of Gravity of water admixture; ca = Weight of Cement; fa = Weight of Fine Aggregate, kg; ca = Weight of Coarse Aggregate, kg; ps = Weight of Periwinkle Shells, kg; S_w = Specific Gravity of Water; S_c = Specific Gravity of Gravity of Cement;

S_{fa} = Specific Gravity of Fine Aggregate; and S_{ca} = Specific Gravity.

Concrete constituents proportioning by weight and absolute volume method are illustrated in Table 1.

Table 1: Concrete constituents proportioning by weight and absolute volume method

	Water (kg/m³)	SP (kg/m)³	Cement (kg/m)³	*fa* (kg/m³)	*ca* (kg/m³)	*ps* (kg/m³)	Total (kg/m³)
DNC1	240	0	534	534	1068	0	2377
DPSC2	240	0	534	534	1008	40	2348
DPSC3	240	0	534	534	949	80	2319
DPSC4	240	0	534	534	890	120	2327
DSC1	171	3	581	581	1161	0	2497
DSPSC2	171	3	581	581	1103	43	2482
DSPSC3	171	3	581	581	1045	87	2468
DSPSC4	171	3	581	581	987	130	2420

2.3. Fresh Concrete Production and Testing

Each mixture was proportioned with 50 kg of Portland cement D along with the variations of water, superplasticizer, sand, granite and periwinkle shells as presented in Table 2. In facets, eight concrete production were done with different mixes and each fresh concrete was produced using mixing machine. Slump and compacting factor tests were immediately carried for each concrete production. Hereafter, casting of cubes, R-pavers, I-pavers and Z-pavers followed. The dimensions of the specimens are cube (150 × 150 × 150) mm, R-paver of (200 × 100 × 80) mm. Also, the dimension of the I-paver is (220 × 110 × 80) mm and that of the Z-paver is (240 × 120 × 80). Of the eight batches of concrete produced 480 specimens were cast and placed inside the laboratory.

Table 2: Concrete constituents proportioning according to AASHTO T 23

S/No	Specimen label	W/C	Water (kg)	KONKRETO PC 896 (kg)	Cement (kg)	FA (kg)	CA (kg)	PS (kg)
1	DNC1	0.4	20	0	50	50	100	0
2	DPSC2	0.4	20	0	50	50	95	3.7 {5}
3	DPSC3	0.4	20	0	50	50	90	7.4 {10}
4	DPSC4	0.4	20	0	50	50	85	11.1 {15}
5	DSC1	0.3	14.75	0.25	50	50	100	0
6	DSPSC2	0.3	14.75	0.25	50	50	95	3.7 {5}
7	DSPSC3	0.3	14.75	0.25	50	50	90	7.4 {10}
8	DSPSC4	0.3	14.75	0.25	50	50	85	11.1 {15}

- Value in the bracket {} is the amount of granite in kg substituted.

2.4. Harden Concrete Specimens Curing and Compression Tests

Each batch of the hardened specimens were demoulded for curing according to AASHTO [27] after 24 hours of casting. Demoulded specimens were kept inside clean and clear water tank at the laboratory pending the various compression testing days. A 2000 kN compression machine was used in the laboratory to determine the comprehensive strength of each cube based upon the scheduled testing day. Compression test was carried out on each of the specimen at a batch of three based upon schedule of water curing by 7, 14, 28, 56 and 91 days. The average value of each batch of the three specimens in times of compression tests is the compressive strength.

III. RESULTS AND DISCUSSIONS

A hybrid approach of mixing a superplasticizer with water and periwinkle shells with granite in the production of concrete has been carried out in this study. The findings through the process are hereby discussed. Hence, normal, periwinkle shells and superplasticized periwinkle shells concrete specimens produced are hereby described, analyzed, interpreted and the significance thereof disseminated.

3.1. Superplasticizer Properties

Table 3 is showing the results of physical and chemical composition of the KONKRETO PC 896 superplasticizer used in this study. The table also shows its comparison to the BS EN 934 [28] specification requirements on admixtures for concrete, mortar and grout. The superplasticizer is found to be satisfactory and therefore suitable for the production of the superplasticized periwinkle shells concrete.

Table 3: Physical and chemical composition of the KONKRETO PC 896 superplasticizer

Property	Value	BS EN 934 (2018) specification
Specific gravity	1.15	1.15
Chloride content (kg/m_3)	0.000	Free

3.2. Cement Properties

Table 4 is showing the results of the chemical analysis of cement D used in this study. They are compared to standard specifications of ASTM C114 [29] on chemical analysis of hydraulic cement. It has been revealed in Table 4 that chemical compositions of the cement D used conformed to the standard specification. Table 5 also shows the results of the compound composition of the cement as carried out in the laboratory according to ASTM C1356 [30] specification standard. In Table 5, Tricalcium Silicate $(CaO)_3\ SiO_2$ and Dicalcium Silicate $(CaO)_2\ SiO_2$ Tricalcium Aluminate $((CaO)_3\ .Al_2\ O_3\ )$ and Tetracalcium Aluminoferrite $((CaO)_4\ .Al_2\ O_3\ \ Fe_2\ O)_3$ are in conformity to the standard specification. The values of the physical properties of the cement used as obtained in the laboratory are shown in Table 6. In Table 6, the values of physical properties of the cement used are weighted with the standard specification and they respectively in conformity.

Table 4: Chemical composition of the cement

Chemical Compound	Value (%)	ASTM C114 [29] Specification (%)
Silicon dioxide (SiO_2)	21.0	18.7 – 22.0
Aluminum oxide ($Al_2\ O_3$)	5.23	4.7 – 6.3
Iron oxide ($Fe_2\ O_3$)	3.25	1.6 – 4.4
Calcium oxide (CaO)	65.58	60.6 - 66.3
Magnesium oxide (MgO)	1.27	0.7 – 4.2
Sulphur trioxide (SO_3)	2.54	1.8 – 4.6
Sodium oxide ($Na_2\ O$)	0.55	0.11 -1.2
Potassium oxide ($K_2\ O$)	0.87	0.11 -1.2

TABLE 5: COMPOUND COMPOSITION OF THE CEMENT

Chemical compound	Cement chemist notation (CCN)	Value (%)	ASTM C1356 [30] Specification (%)
Tricalcium Silicate ($(CaO)_3\ .SiO_2$)	C3S	73.45	45 - 75
Dicalcium Silicate ($(CaO)_2\ .SiO_2$)	C2S	7.78	7 - 32
Tricalcium Aluminate ($(CaO)_3\ .Al_2\ O_3$)	C3A	9.91	0 - 13
Tetracalcium Aluminoferrite ($(CaO)_4\ .Al_2\ O_3\ Fe_2\ O)_3$	C_4 AF	8.2	0 - 18

Table 6: Physical properties of the cement

Chemical compound	Cement chemist notation (CCN)	Value	ASTM C1356 [30] Specification (%)
Fineness, % retained on 45 μm	7	≤ 10	ASTM C786 (2017)
Specific gravity, ƔG	3.15	3.13-3.15	ASTM C188 (2017)
Bulk density, Ɣb (kg/m^3)	1440	1440	IS 875 (2013)
Standard Consistency, (%)	29	25-35	ASTM C187 (2011)
Initial setting time, (min)	114	≥ 30	ASTM C191 (2019)
Final setting time, (min)	244	≤ 60	ASTM C191 (2019)
Loss on ignition, (%)	0.04	0.04-0.05	ASTM D7348 (2013)
Insoluble residue, (%)	0.03	0.02-0.04	ASTM C465 (2019)

3.2. Aggregates Properties

Figure 1 is showing samples of the sand, 9.5 mm granite and periwinkle shells. Properties of sand and 9.5 mm aggregates used were determined through laboratory tests and their results are presented in Table 7. In Table 7 are shown the properties of sand and 9.5 mm granite used as determined upon specifications based on AASHTO T 27 [19], AASHTO T 19 [21], ASTM C128 [20] and ASTM C127 [22]. The fineness modulus, specific gravity, coefficient of uniformity, coefficient of curvature and percentage voids of sand values are as shown in Table 7. While the maximum size of the granite is greater than that of sand the phenomenon is similarly while considering percentage voids of the two materials. On the other hand, sand fineness modulus, specific gravity, coefficient of uniformity, coefficient of curvature, corresponding moisture content and water absorption properties are greater than those of 9. 5 mm granite. Periwinkle shells used to partially replace granite are found to pass through 12.5 mm sieve size but majorly retained on 9.5 mm sieve size. Hence, the periwinkle shells used for the production of concretes are single-size-aggregates.

Figure 2 and Figure 3 show the aggregate gradation charts of sand and the granite respectively. The fine aggregate curve for sand is closer to the middle of the upper and lower limits as shown in Figure 2. Whereas the 9.5 mm gradation curve nearly coincides with the lower limit as shown in Figure 3.

Figure 1: Sand, 9.5 mm granite and periwinkle shells samples

Table 7: Properties of fine and coarse aggregates

Properties	Fine aggregate	Coarse aggregate	Coarse aggregate
Aggregates	Sand	Fine Granite	Periwinkle shells
Maximum size of the aggregate (mm)	4.75	9.5	9.5
Fineness modulus (%)	2.77	1.99	-
Specific gravity	2.67	2.7	2.1
Bulk density	1670	1700	1353
Coefficient of uniformity (Cu)	2.00	1.5	-
Coefficient of curvature (Cc)	1.28	0.96	-
Percentage voids (%)	60.11	83.01	-
Maximum percentage of bulking (%)	19.3	-	-
Corresponding moisture content (%)	2.19	-	-
Water absorption (%)	2.22	0.05	-

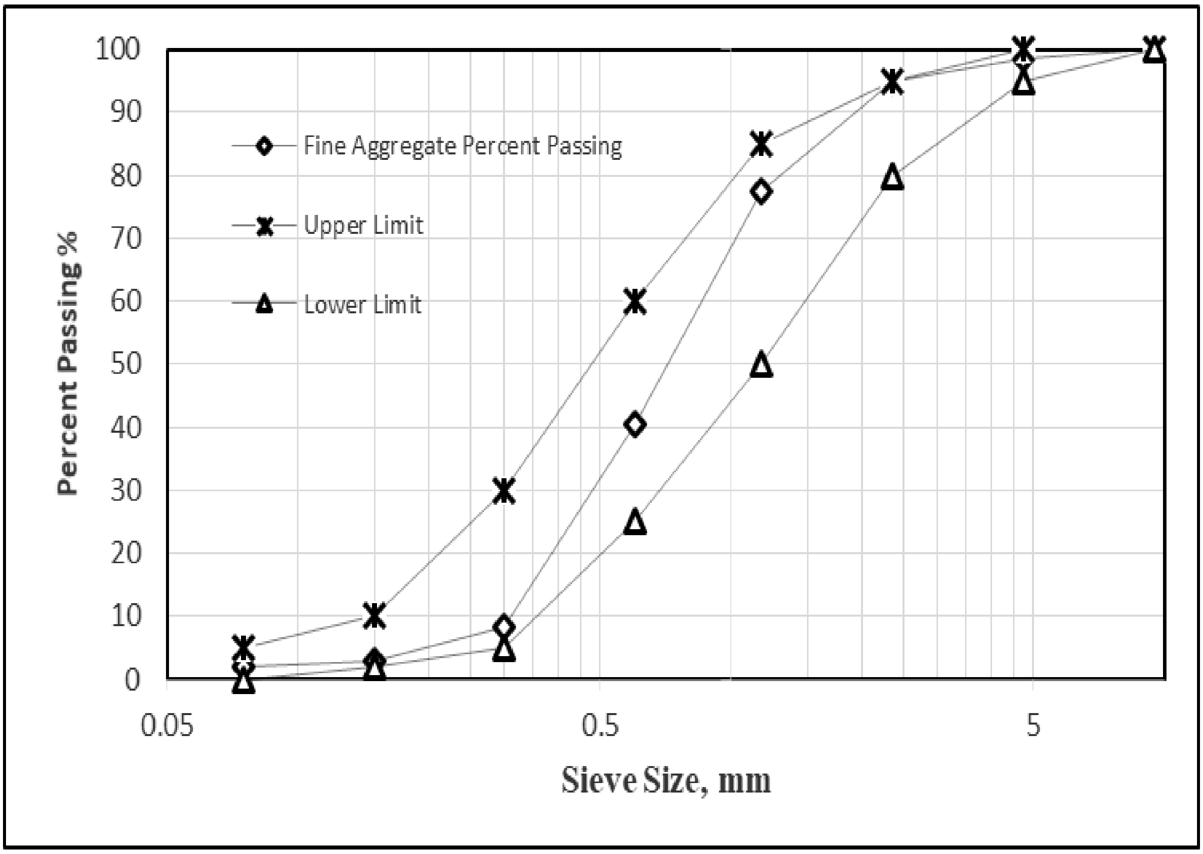

Figure 2: Sand gradation chat

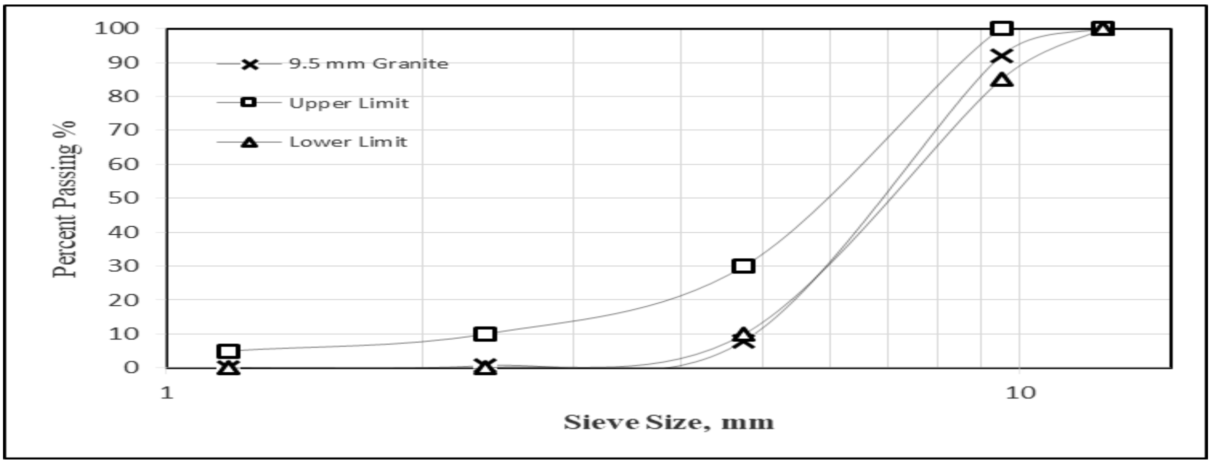

Figure 3: 9.5 mm gradation chat

Fresh Concrete Properties

Table 8 is showing the values of slump and compaction factor per each of the eight types of concrete produced in this study using cement D. Each of the eight fresh concretes produced has either zero or true slump. Normal and periwinkle shells concrete produced with water cement ratio of 0.4 and at 5% PS replacement of granite are of very low degree of workability. Whereas, periwinkle shells concrete produced with water cement ratio of 0.4 and at 10% and 15% PS replacement of granite are of low degree of workability.

Also in Table 8, it is pertinent to note that both periwinkle shells and superplasticized periwinkle shells fresh concretes with water cementitious ratio of 0.3 are of very low degree of workability. It should be noted that the kind of concretes produced here are to be compacted by power or hand operated machine at the construction site. And these kind of concretes are useful for the construction of rigid pavements as well as for producing pavers for flexible pavements.

Table 8: Properties of fresh normal, periwinkle shells and superplasticized periwinkle shells concretes

S/No	Specimen label	W/C	KONKRETO PC 896 %	PS %	Slump (mm)	Degree of Workability	Compaction Factor, CF	Degree of Workability
1	DNC1	0.4	0	0	0	Very low	0.784	Very low
2	DPSC2	0.4	0	5	15	Very low	0.829	Very low
3	DPSC3	0.4	0	10	35	Low	0.866	Low
4	DPSC4	0.4	0	15	26	Low	0.855	Low
5	DSC1	0.3	0.5	0	0	Very low	0.705	Very low
6	DSPSC2	0.3	0.5	5	5	Very low	0.740	Very low
7	DSPSC3	0.3	0.5	10	10	Very low	0.789	Very low
8	DSPSC4	0.3	0.5	15	0	Very low	0.706	Very low

3.3 Hardened Concrete Properties

Concrete specimens results trend of compressive strengths for normal, superplasticized, periwinkle shells and superplasticized periwinkle shells using cement D are as presented in Figures 4 to 7. Figure 4 is showing the obtained values of concrete comprehensive strengths of both normal DNC1 series and superplasticized concretes at 0.5% superplasticizer DSC1 series. The result shows that similar specimens of superplasticized concrete gave higher value of compressive strength than the normal mixes samples.

Figure 5 is showing the obtained values of concrete comprehensive strengths of both periwinkle shells DPSC2 series and superplasticized periwinkle shells concretes DSPSC2 series. Both concretes are of 5% replacement of periwinkle shells but superplasticized periwinkle shells concretes was at 0.5% superplasticizer. The result shows that similar specimens of superplasticized periwinkle shells concretes gave higher value of compressive strength than the periwinkle shells mixes samples.

Figure 6 is showing the obtained values of concrete comprehensive strengths of both periwinkle shells DPSC3 series and superplasticized periwinkle shells concretes DSPSC3 series. Both concretes are of 10% replacement of periwinkle shells but superplasticized periwinkle shells concretes was at 0.5% superplasticizer. The result shows that similar specimens of superplasticized periwinkle shells concretes gave higher value of compressive strength than the periwinkle shells mixes samples.

Also, Figure 7 is showing the obtained values of concrete comprehensive strengths of both periwinkle shells DPSC4 series and superplasticized periwinkle shells concretes DSPSC4 series. Both concretes are of 15% replacement of periwinkle shells but superplasticized periwinkle shells concretes was at 0.5% superplasticizer. The result shows that similar specimens of superplasticized periwinkle shells concretes gave higher value of compressive strength than the periwinkle shells mixes samples.

Considering the line diagrams for Figures 4 through 7, each one in them is showing the trend of concrete compressive strength development at a higher rate from day 7 to day 14. It is as well followed by a high rate concrete development for day 14 to day 28. However, a low rate of development for day 28 to day 56 followed by a lower rated development of concrete compressive strength from day 56 to day 91.

Also for each line diagram, the trend of the compressive strength developed is that the higher the curing day the higher the concrete compressive strength. Also, comparing compressive strengths of rectangular R-paver, I-paver, Z-paver and also cube samples, cubes gave the highest values of them all. The compressive strength of Z-pavers is the highest of the three types of paver specimens. I-pavers are having the higher values compressive strength than those of R-pavers.

Among the eight categories of concretes considered as in Figure 8, specimens produced with label DSC1 gave the highest comprehensive strengths which is of superplasticized concrete with 0.5% superplasticizer. Followed by specimens with label DSPSC2 of superplasticized concrete with 0.5% superplasticizer and 5% periwinkle shells. Normal concrete DNC1 category is in the third position of compressive strength of the eight categories.

Of the four categories of shapes R-pavers, I-pavers, Z-pavers and cubes considered as in Figure 9, cube specimens produced the highest values of compressive strengths in respective the eight types of concrete production. Also, it is obvious that Z-pavers gave the highest value of compressive strengths of the three categories of pavers investigated. Correspondingly I-pavers are having higher values of comprehensive strengths than those of R-pavers.

Inference based upon the results of this study are defined in Tables 9 to 12 for cubes, Z-pavers, I-pavers and rectangular pavers.

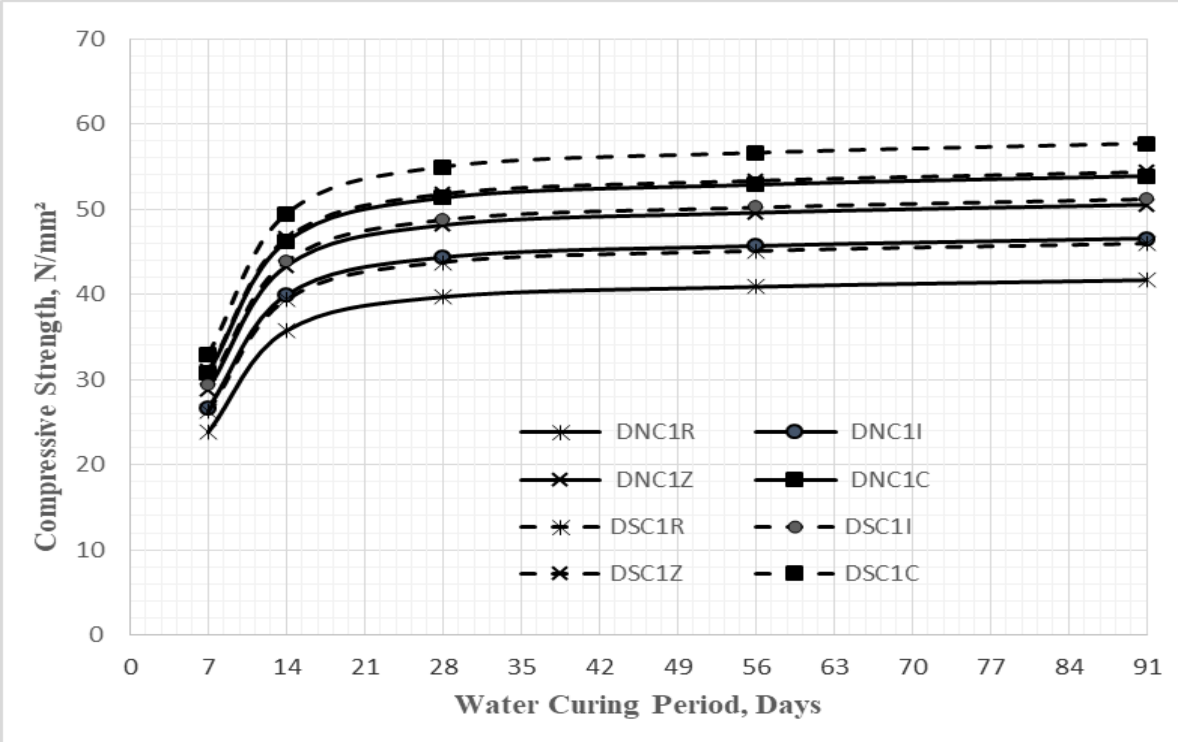

Figure 4: Specimens comprehensive strengths of normal and 0.5% superplasticized concretes

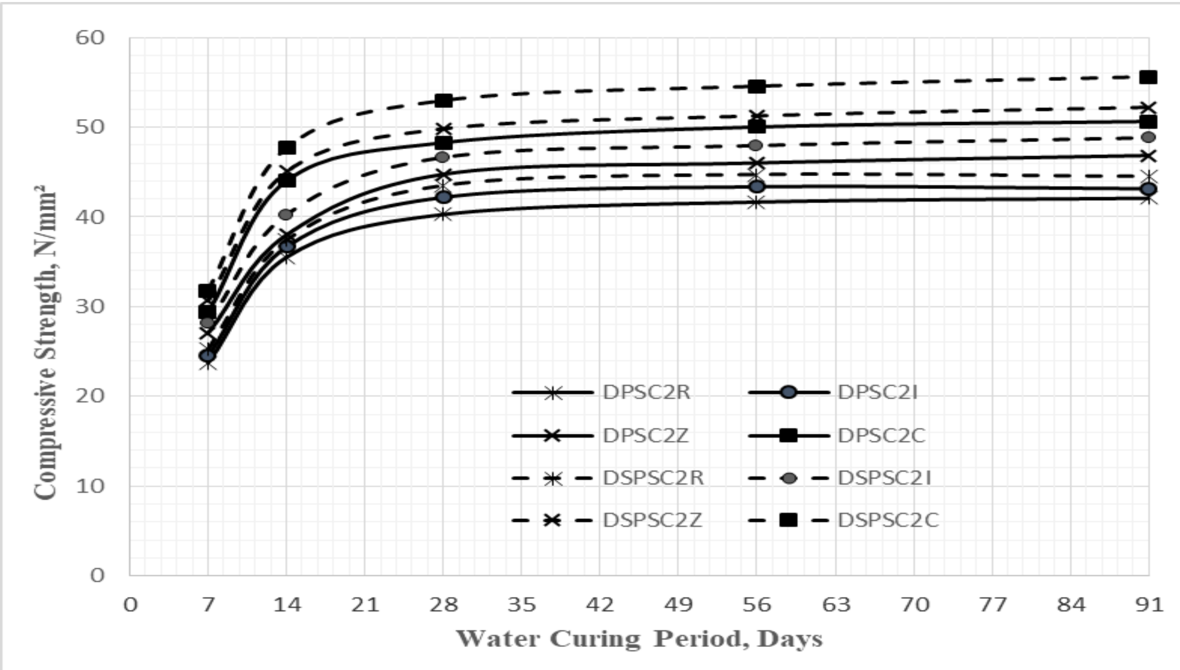

Figure 5: Specimens comprehensive strengths of 0.5% superplasticized concretes and 5% periwinkle shells replacement

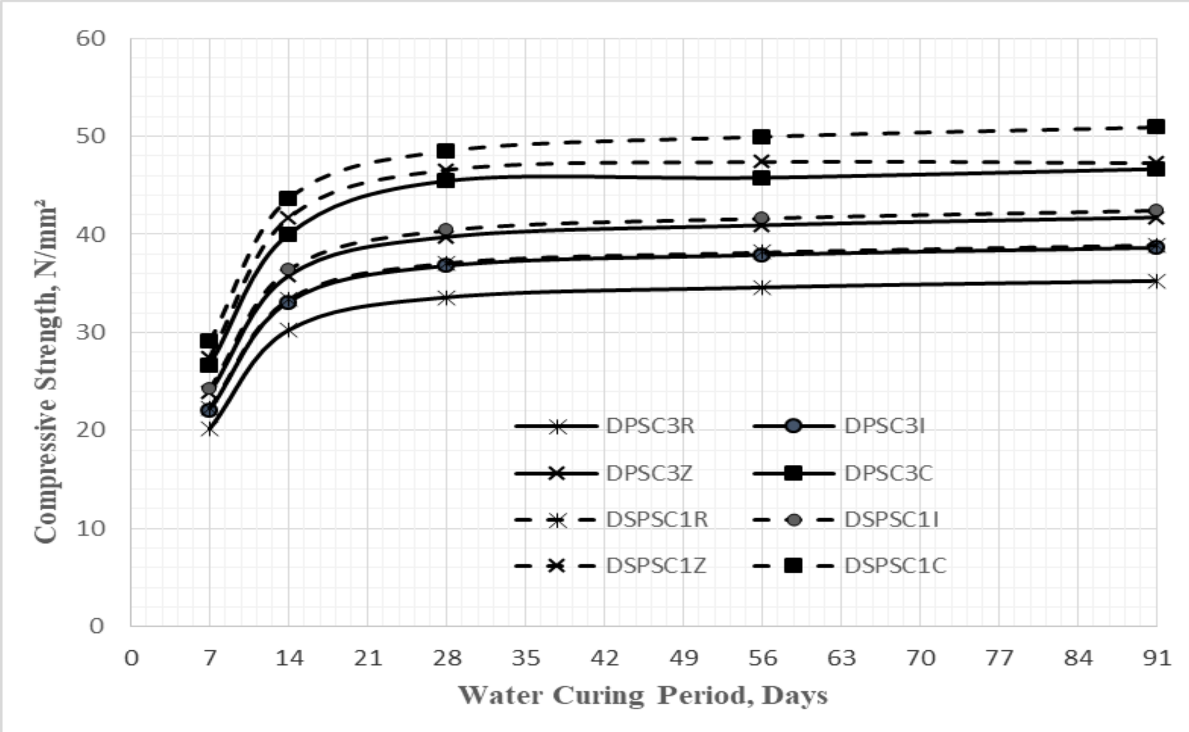

Figure 6: Specimens comprehensive strengths of 0.5% superplasticized concretes and 10% periwinkle shells replacement

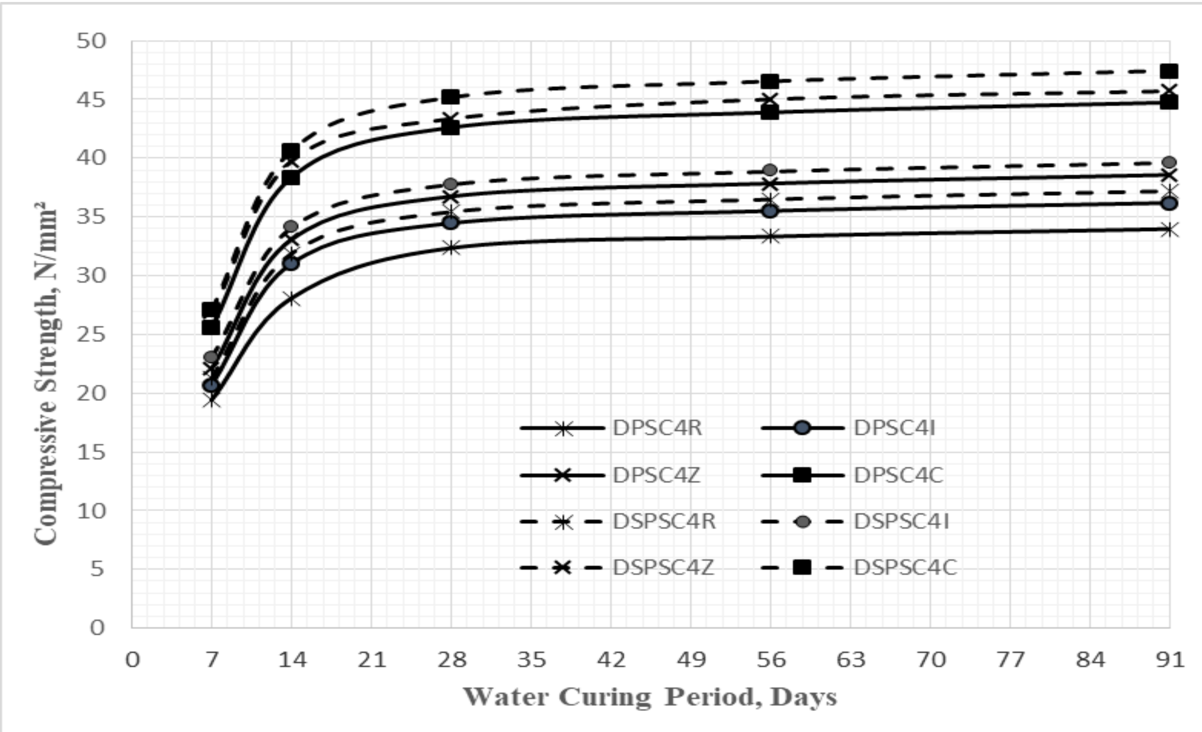

Figure 7: Specimens comprehensive strengths of 0.5% superplasticized concretes and 15% periwinkle shells replacement

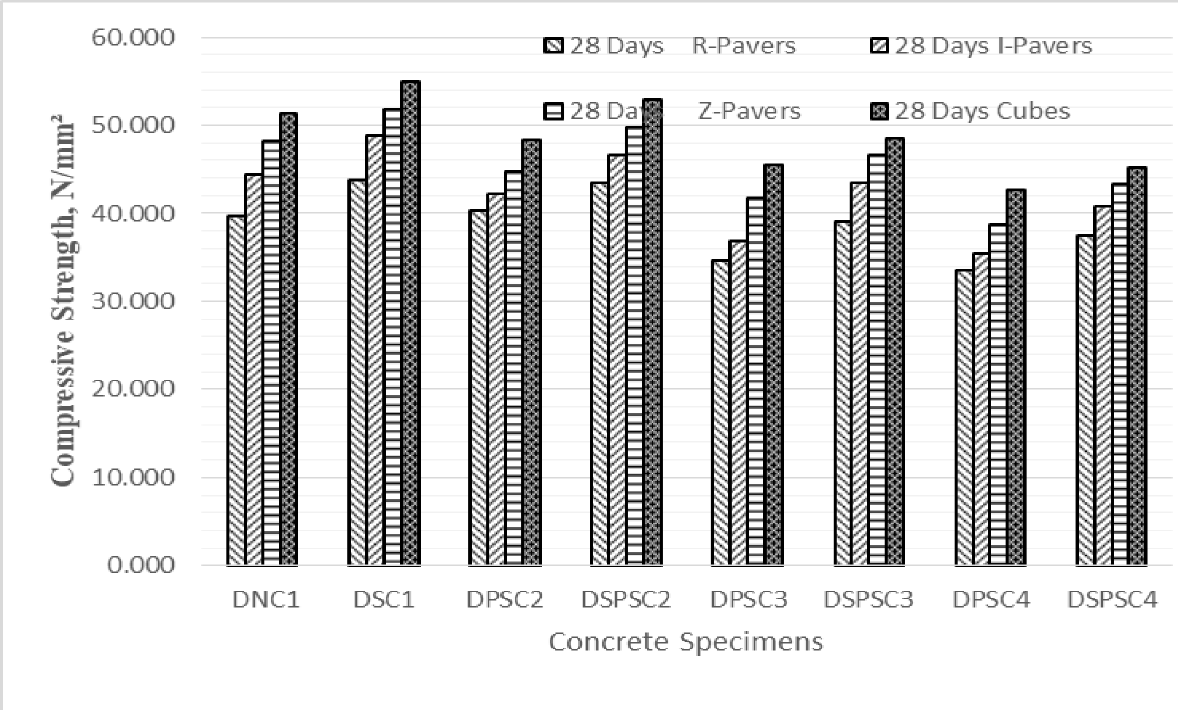

Figure 8: Compressive strength of specimens at 28 days water curing by individual concrete batch

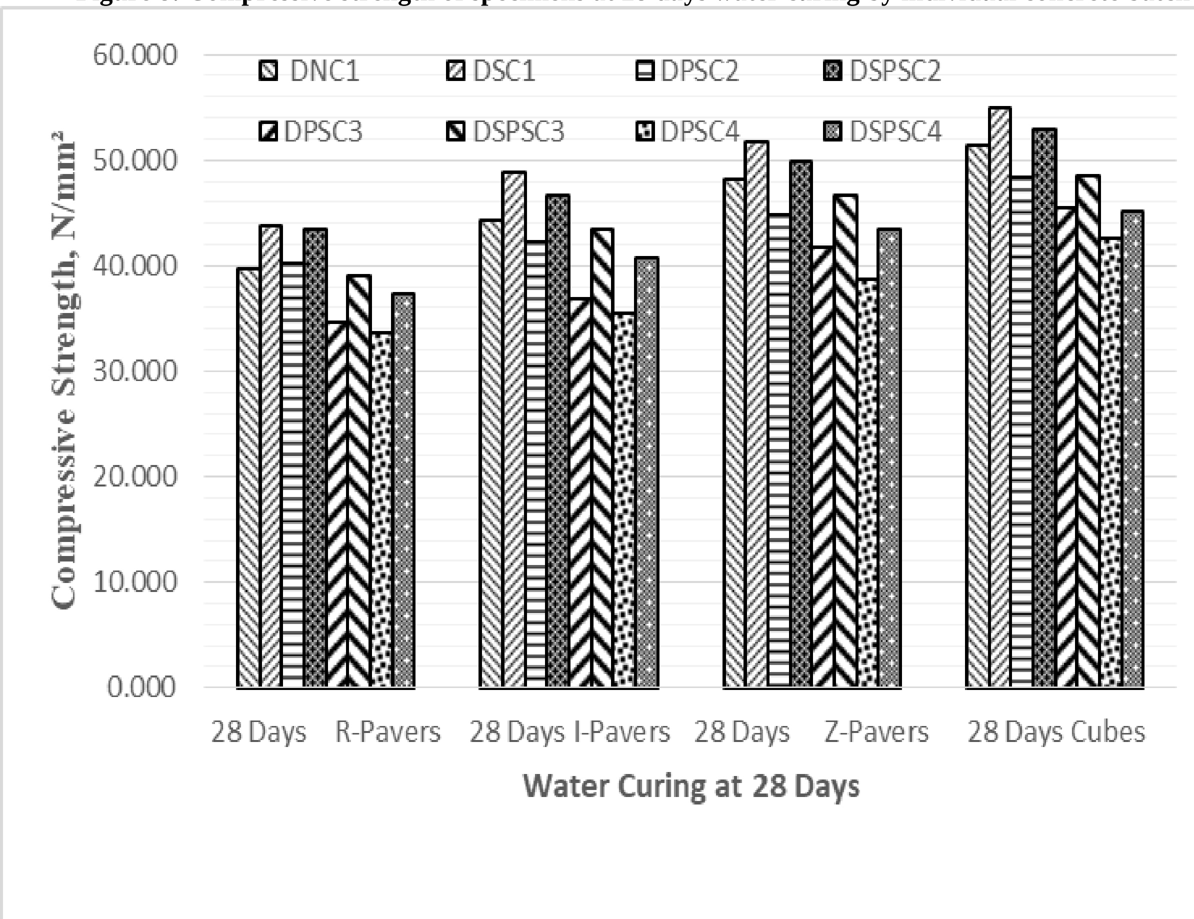

Figure 9: Compressive strength of specimens at 28 days water curing by concrete specimen shapes

Table 9: Characteristics of 28 days cubes compressive strength for normal and PS concretes

	Strength N/mm^2	Interpretation, implication, importance and relevance of results based upon AASHTO T 23 [17] test that provides the comprehensive strength of concrete 28 Days Cubes
DNC1	51.333	DNC1, DSC1 and DSPSC2 cubes satisfied 50 N/mm^2 compressive strength which is of high-strength concrete grade quality. The concrete strength is satisfactory for placement in a harsh condition where aggressive chemicals or where high level of abrasion is present. DSPSC3, DPSC2, DPSC3 and DSPSC4 cubes satisfied 45 N/mm^2 compressive strength which is of standard concrete grade by quality. The concrete strength is satisfactory for placement in an exposed rural areas and of heavy-duty construct\ion. DPSC4 cubes satisfied N/mm^2 compressive strength which is of standard concrete grade by quality. They are useful for highway pavements, drives, paths and footings.
DPSC2	48.284	
DPSC3	45.444	
DPSC4	42.617	
DSC1	54.963	
DSPSC2	52.963	
DSPSC3	48.519	
DSPSC4	45.185	

Table 10: Characteristics of 28 days Z-paver compressive strength for normal and PS concretes

	Strength N/mm^2	Interpretation, implication, importance and relevance of results based upon AASHTO T 23 [17] test that provides the comprehensive strength of concrete28 Days Z-Pavers
DNC1	48.129	DSC1Z-Pavers satisfied 50 N/mm^2 compressive strength which is of high-strength concrete grade quality. They are useful for flexible pavement of very heavy traffic category. They are also satisfactory for placement in a harsh condition where aggressive chemicals or where high level of abrasion is present. DSPSC2, DNC1 and DSPSC3 Z-Pavers satisfied 45 N/mm^2 compressive strength which is of standard concrete grade by quality. They are useful for flexible pavement of heavy traffic category. Also, they are satisfactory for placement in an exposed rural areas and of heavy-duty construct\ion. DPSC2, DSPSC4 and DPSC3 satisfied 40 N/mm^2 compressive strength which is of standard concrete grade quality. They are useful for flexible pavement of medium traffic category. DPSC satisfied 35 N/mm^2 compressive strength which is of standard concrete grade quality. They are useful for flexible pavement of light traffic category
DPSC2	44.763	
DPSC3	41.738	
DPSC4	38.748	
DSC1	51.794	
DSPSC2	49.840	
DSPSC3	46.578	
DSPSC4	43.377	

Table 11: Characteristics of 28 days I-pavers compressive strength for normal and PS concretes

	28 Days I-Pavers Strength N/mm^2	Interpretation, implication, importance and relevance of results based upon AASHTO T 23 [17] test that provides the comprehensive strength of concrete
DNC1	44.353	DSC1 and DSPSC2 I-Pavers satisfied 45 N/mm^2 compressive strength which is of standard concrete grade by quality. They are useful for flexible pavement of heavy traffic category. Also, they are satisfactory for placement in an exposed rural areas and of heavy-duty construct\ion. DNC1, DSPSC3, DPSC2 and DSPSC4 satisfied 40 N/mm^2 compressive strength which is of standard concrete grade quality. They are useful for flexible pavement of medium traffic category. DPSC3, and DPSC4 satisfied 35 N/mm^2 compressive strength which is of standard concrete grade quality. They are useful for flexible pavement of medium traffic category.
DPSC2	42.187	
DPSC3	36.800	
DPSC4	35.481	
DSC1	48.783	
DSPSC2	46.618	
DSPSC3	43.404	
DSPSC4	40.800	

Table 12: Characteristics of 28 days R-pavers compressive strength for normal and PS concretes

	Strength N/mm ^{2}	Interpretation, implication, importance and relevance of results based upon AASHTO T 23 [17] test that provides the comprehensive strength of concrete 28 Days R-Pavers.
DNC1	39.694	DSC1, DSPSC2 and DPSC2 satisfied 40 N/mm ^{2} compressive strength which is of standard concrete grade quality. They are useful for flexible pavement of medium traffic category. DNC1, DSPSC3 and DSPSC4 satisfied N/mm ^{2} compressive strength which is of standard concrete grade quality. They are useful for flexible pavement of medium traffic category. DPSC3 and DPSC4 satisfied 30 N/mm ^{2} compressive strength which is of standard concrete grade quality. They are useful for flexible pavement of non-traffic category.
DPSC2	40.278	
DPSC3	34.583	
DPSC4	33.611	
DSC1	43.750	
DSPSC2	43.472	
DSPSC3	39.083	
DSPSC4	37.417	

IV CONCLUSION AND RECOMMENDATIONS

Substituting coarse aggregates with other materials in the production of concrete has been emphasized of which periwinkle shells have been considered along with the use of superplasticizer in this study. Normal, superplasticized, periwinkle shells and superplasticized periwinkle shells fresh concretes and hardened specimens were produced using D cement and KONKRETO PC 896 superplasticizer.

Fresh concrete produced with 5% periwinkle shells substitution as well as normal, superplasticized, and superplasticized periwinkle shells gave very low degree of workability. Correspondingly, fresh concrete produced with 10% and 15% periwinkle shells substitution respectively gave low degree of workability.

Comprehensive strength of hardened superplasticized concrete specimens DSC1 and water pond cured for 28 days were of the highest values. Correspondingly followed by 5% superplasticized periwinkle shells DSPSC2 and then normal concrete DNC1.

Also, comprehensive strength of hardened superplasticized concrete cube specimens respectively were of highest values comparing with the other Z-pavers, I-pavers and R-pavers. Of the three types of pavers, Z-pavers were having the highest compressive strength values correspondingly while comparing same with I-pavers that followed and lastly R-pavers.

We need to be constantly improving concrete production whilst making use of waste materials that could be used as aggregates such as periwinkle shells without diminishing required concrete standard strength. Such kind of research could bring economy into highway pavements and other structural development and by also preventing structural collapse with healthy environment.

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