ENGINEERING PROPERTIES OF CONCRETE MADE FROM GRAVELS OBTAINED IN SOUTH-WESTERN NIGERIA

Nurain Sulymon, Olatokunbo Ofuyatan, Olowofoyeku Adeoye, Simon Olawale, Ayobami Busari , Gideon Bamigboye, Joshua Jolayemi

Accepted Manuscript Version

Publisher: Cogent OA
Journal: *Cogent Engineering*
DOI: http://dx.doi.org/10.1080/23311916.2017.1295793

ENGINEERING PROPERTIES OF CONCRETE MADE FROM GRAVELS OBTAINED IN SOUTH-WESTERN NIGERIA

Nurain Sulymon[1a], Olatokunbo Ofuyatan[2b], Olowofoyeku Adeoye[3c], Simon Olawale[4d], Ayobami Busari [5e], Gideon Bamigboye[5e], Joshua Jolayemi[6f]
[a]Nigerian Building and Road Research Institute, Km 10 Idiroko Road, P/M/ B. 1055 Ota, Nigeria
[b,e,f]Department of Civil Engineering, **Covenant University,** P/M/B 1023 Ota, Nigeria
[c]Department of Civil Engineering, Yaba College of Technology, Lagos, Nigeria.
[d]Department of Civil Engineering, Osun State University, Osogbo, Osun State.

*email (corresponding author): olatokunbo.ofuyatan@covenantuniversity.edu.ng

ABSTRACT

This study investigates the engineering properties of concrete produced from gravels and also verify the suitability of local gravel aggregates obtained from South-western Nigeria in place of crushed granite. Preliminary investigations were carried out in five selected states (Ogun, Oyo, Osun, Ondo and Ekiti) in southwestern Nigeria to determine the registered gravel mining pits. Fifteen gravel mining pits based on age and scale of mining operations were selected for this study. Appropriate gravel constituents in concrete mix were determined using Gs factor. Concrete cubes 150 mm, 150 × 300 mm cylinder modes and 150 x 150 x 750 mm beams were cast with collected gravel. 1:2:4 mix ratio was employed. Sieves analysis, density, water absorption were carried out on aggregates, while compressive, flexural and split-tensile strengths of the concrete were determined for 28 days using ASTM and BS methods. High concrete strengths resulted from high FM, low AAV and average Gs of gravels. Gravel location with highest compressive, flexural and split-tensile strengths of concretes had 24.8N/mm^2, 3.5N/mm^2 and 2.8N/mm^2 satisfying the minimum requirement of BS 811: 1997 while that with lowest strengths had 9.6N/mm^2, 2.2N/mm^2 and 1.7N/mm^2 respectively. Sources of gravel highly influence compressive, flexural and split-tensile strengths of the cubes and beams.

Keywords: Coarse aggregates, Gravel aggregate, Concrete, aggregates properties.

1.0 INTRODUCTION.

Unavailability or scarcity of construction materials with the resultant increase in cost had caused a great depression in the construction industry in Nigeria. As a result, the demand of the housing sector of the construction industry has not been met over the years regarding the construction materials like gravels (aggregate) as an important component of concrete (Dirisu & Olabiran, 1991; Idiake, 2006). Aggregates generally occupy 70 – 80% volume of concrete and can therefore be expected to have important influences on their properties (Fowler & Quiroga, 2003). They are granular materials derived from natural rocks, crushed stones, or natural gravels and sand, in addition to their use as economical filler, aggregates generally provide concrete with good dimensional stability and wear resistance [Dahunsi, 2003]. A good aggregate should produce the desired properties in both fresh and hardened concrete [Jackson, 1984]. Aggregate should be least porous, densest, and strongest and contains less deleterious materials such as clay, silt and dust [Chowdhury, 1982]. Brady, Clauser & Vaccnri, (2002) found that gravel are results of the natural disintegration of rock which are at least 2 mm diameter, larger sizes may be called pebbles, cobble or boulders and are usually rounded and as such required less amount of cement paste which saves about 4-5% cement paste. Shetty (2005) reported that in concrete, aggregates and paste are the major factors that affect the strength. Adebakin, Adu & Ofuyatan (2015) reported the use of recycled aggregate from old concrete cubes is suitable with up to 75% replacement of natural aggregate with recycled aggregate, the 28 days compressive strength of concrete is in close proximity with that of normal concrete. Aggregate properties significantly affect the workability of plastic concrete and the durability, strength, thermal properties, and density of hardened concrete (ACI, 1999). Lawal (2011) also worked on gravel mining in Nigeria and examined the effects and characteristics of aggregates in concrete. Bamigboye, Ede, Umana, Odewumi & Olowu (2016) discovered that gravel aggregates have not been adequately utilized as they should, partly because of the fear that gravel cannot withstand as much pressure as granite as granite due to its chemical composition. This paper however went further to establish gravel locations, cost and some other variables. In selection of gravels for construction work, there are certain factors that should be looked into, though the choice is in most cases further limited by the cost. Its cost depends upon the ease with which it could be quarried or mined, the proximity of the quarry to the place of use, and the availability of transport facilities. General structure, fineness of grain, compactness, porosity and absorption, hardness, resistance to weather, weight and strength are some of the characteristics of good gravels (Spencer & Cook, 1983). Kosmatka, Kerhhoff & Panarese (2002) concluded that close to half of the coarse aggregates used in Portland Cement Concrete in North America are gravels while most of the remainder are crushed stones. Therefore any advocacy for completely new or blended materials should be tested both structurally and mechanically to ascertain the short – time and long-time behavior of the materials. This will certainly help to establish a well – define boundary or clearly spelt out limitation especially when local code of practice for design, construction and workmanship is yet to be published for engineers and builders. Investigation of concrete properties produced from gravels obtained from southwestern Nigeria would enable the provision of data not only for the formulation of indigenous standards, but would also help to avoid use of sub-standard gravels that might contribute to failures of infrastructures. Engineering properties of concretes produced from gravels from selected locations in Southwestern Nigeria is the main focus of this paper.

1.1 Study Area

South-western Nigeria lies between latitudes 6 ^{0}N and 9 ^{0}N of Greenwich Meridian and longitudes 2.5 ^{0}E and 6 ^{0}E of the Equator. It is one of the six geo-political zones of Nigeria and comprises of six states. The states in this zone include Lagos that lies on latitude 6.27 ^{0}N and longitude 3.28 ^{0}E with land area of 3,345 km.; Oyo state on latitude 7.4 ^{0}N and longitude 4.0 ^{0}E with land area of 35,742.84

sq km; Ogun state with land area of 16,409.26 sq km is located between Lat. 6.2^0N and 7.8^0N and Long. 3^0E and 5^0E; Ekiti state is between latitudes 7^0 15^1 and 8^0 5^1 north of the equator and longitudes 4^0 5^1 and 5^0 45^1 East of Greenwich Meridian, with land area of 6,353 sq km; Osun state has land area of 10,456 km and located on Lat. 7^0 45^1N and Long. 4^0E; and Ondo state which is bonded in the east by Edo and Delta states, in the north by Ekiti and Kogi states, in the west by Osun and Ogun states and in the south by Atlantic ocean. Ondo is located on Lat. 7^0 10^1N and Long. 5.05^0 E.

In this study area shown in Fig. 1 there are many infrastructures such as high rise office buildings, residential, commercial and industrial buildings, as well as wide and expansive networks of highways and rural roads. These diverse infrastructures are made from different materials, mostly concrete, the constituents of which include gravels.

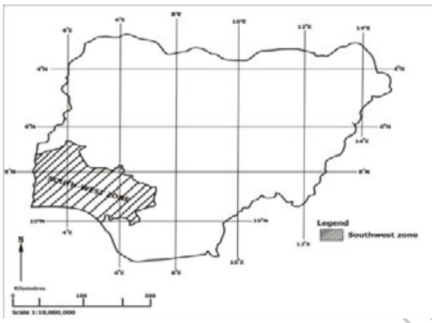

Figure 1.1. Map of Nigeria Showing the Study Area – Southwestern Zone Source: Digitally drawn

1.2 Availability of Gravels

The factors which affect the local availability and supply of construction gravel include demand and supply of the resource. The following factors have influences on future demand of gravel in Nigeria; population growth, personal income, statewide economic growth, state infrastructural needs and personal interest (MII, 2006).Gravel like other natural resources occurs where nature placed it, not where people need it. Even where nature has placed it, mining and supply of aggregate (gravel) near populated areas can be further limited due to land use conflicts. Some of these conflicts are: sterilization; building over a deposit as cities grow or extend into rural areas, encroachment; new residential development near existing quarries and gravel pits, depletion; extracting the resources in existing mines at a higher rate, difficulty of permitting new mines and competing land uses such as perpetual conservation easements (Langer & Glanzmann, 1993)

Plate 1: Ago-Iwoye Gravel Depot Ogun state

Plate 2: Gravel Pit at Ikole-Ekiti, Ekiti State

Plate 3: Gravel Pit: Laje Road, Ondo, Ondo State

METHODOLOGY

In order to select gravel pits for the collection of samples for this study, the research instrument adopted for the work was structured in two parts- questionnaires which consisted of 18 and 16 questions that were targeted at gravel suppliers and bricklayers respectively. As a results of this fifteen major commercially operated pits or sites were selected for the collection, testing and analysis/discussion of samples. The gravel samples were collected at different levels both vertically and horizontally to have a better representation of samples in a particular location. They were kept in polythene bags which were sealed to prevent moisture so as not to affect the natural conditions of the samples. The gravel aggregates used for this study were sourced locally from five states in Southwestern Nigeria; Ogun, Oyo, Osun, Ondo and Ekiti states as shown in plates 1, 2 & 3. The samples were coded according to state and town of collection as OG.01.AB for Ogun state, OY.02.IG for Oyo state, OS.01.OS for Osun state, OD.01.MD for Ondo state and EK.01.AD for Ekiti state. Ogun River at Majidun in Ikorodu, Lagos state were used as fine aggregates. Washed gravel was used as coarse aggregates. The ratio of fine to coarse aggregate adopted was 45:55 (ACI, 1992; Krell & Wischers, 1988). The Lafarge Elephant Portland Cement grade (42.5R) was used as binders for this study while portable water was used for the mixing. Also, 1:2:4 mix ratio with 0.60 water/cement ratio was adopted. All the aforementioned were used as constant parameters for all the samples. The physical test adopted for this study were particle size distribution to determine the grading of aggregates, water absorption and aggregates crushing value tests were determined in accordance with BS 882:1992, Specific Gravity was determined using BS 1881-122:1983. Absorption, and voids in Hardened Concrete were determined using ASTM C642 – 13. The specimen was dried at 100 to 110 ^{0}C and immersed in water at 21 ^{0}C. Also carried out were density to determine the solidity of hardened concrete, slump test to determine the degree of consistency of fresh concrete. Compressive, split tensile strength and flexural test were carried out on hardened concrete. The compressive strength f_c was determined in accordance with BS 1881-108: 1983 using 150 mm cubes as shown in plate 4 & 5. The flexural strength test, beams were cast, cured for 28 days and tested for flexure (modulus of rupture) using the three point loading method. After curing, the beams were tested using Universal Testing Machine (UTM) at a rate of increase in stress of 0.02 N/mm^2/s in line with BS 1881-118: 1983. Split tensile test was carried out as prescribed by BS 1881-117: 1983. The results obtained from the laboratory were compared with permissible limits given in different standard codes and specifications using ANOVA.

3.0 RESULTS AND DISCUSSION

Having completed the laboratory tests, the results were analysed using ANOVA and discussed in relation to relevant standards. Some of the engineering properties of fresh and hardened concrete measured were density, slump, water absorption, compression, flexural and split tensile strength. All the concrete specimens were made with gravel as coarse aggregate. Some of these characteristics of the concrete measured in the laboratory are shown in Table 3.1.

Plate 4 Casting of concrete cubes

Plate 5 measurement of slump

Table 3.1. Some Engineering Characteristics of Gravelly Concrete

State	Gravel Sample	No of Cubes	Ave.Slump	Ave. Wt. (kg)	Ave. Density (kg/m^3)	Ave. Load (kN)	Ave. Compr. Str. (N/mm^2)
OGUN	OG. 01 AB (Abeokuta)	3	30	7.93	2350.6	326.7	14.52
	OG. 02 AG (Ago-Iwoye)	3	25	7.98	2365.5	325.0	14.45
	OG. 03 OB (Obafemi Owode)	3	3	7.6	2251.8	365.0	16.22
OYO	OY. 01 IG (Igboora)	3	26	8.05	2385.2	418.3	18.59
	OY. 02 IB (Erunmi Ibadan)	3	17	7.97	2360.5	255.0	11.33
	OY. 03 IS (Iseyin)	3	Col.	7.98	2365.5	445.0	19.78
OSUN	OS. 01 OS (Oshogbo)	3	0	7.78	2306.2	206.7	9.63
	OS. 02 IK (Ikire)	3	5	7.17	2123.5	276.7	12.3
	OS. 03 MD (Modakeke)	3	70	7.83	2321.0	451.7	20.07
ON	OD. 01 OD (Ondo)	3	65	7.97	2360.4	426.7	18.96

	OD. 02 IJ (Iju Itagbolu)	3	5	7.93	2350.6	453.3	20.15
	OD. 03 OK (Oke Igbo)	3	2	7.92	2345.7	350.0	15.55
EKITI	EK. 01 AD (Ado-Ekiti)	3	4	7.97	2360.5	558.3	24.81
	EK. 02 IK (Ikole-Ekiti)	3	26	8.2	2429.6	521.7	23.18
	EK 03 IG (Igbara-Odo)	3	55	7.97	2360.5	401.7	17.85

Test on Fresh Concrete

3.1 Slump

Table 3.1, third column shows the values of the slump. Relating these values after (Bartos, 1992), it can be analyzed that mixes of OS. 01 OS sample with zero slump and OG. 03 OB, OD. 03 OK as well as EK. 01 AD having slump values of 3mm, 2mm and 4mm respectively fall under 'no slump or stiff consistency'. Samples OS. 02 IK and OD. 02 IJ each has slump of 5mm. The two were grouped under 'very low consistency'. Similarly, OG. 01 AB, OG. 02 AG, OY. 01 IG, OY. 02 IB and EK. 02 IK with slumps of 30mm, 25mm, 26mm, 17mm and 26mm respectively were classified as 'low consistency'. Other samples such as OS. 03 MD, OD. 01 OD and EK. 03 IG measuring 70mm, 65mm, and 55mm slumps respectively showed 'medium consistency'. The only mix that exhibits collapsed slump which is an indication of too much water was OY. 03 IS.

3.2 Density

Table 3.1, column 7 reports the average density of concrete produced using the selected gravels as coarse aggregate. The values of the densities ranges from 2123.5 kg/m^3 for OS. 02 IK concrete specimen to 2429.6 kg/m^3 for EK. 02. IK concrete specimen. All the densities of concrete specimens therefore fall within the range of normal weight or dense concrete and by extension all the gravels can be used to produce normal weight concrete.

Test on Hardened Concrete.

3.3 Compressive Strength

Based on BS 8110-2:1985 it was found that specimens EK. 01 AD, EK. 02 IK, OS. 03 MD and OD. 02 IJ having concrete cube strength of 24.81, 23.18, 20.07, and 20.15 N/mm^2 respectively as shown in Table 3.1 are all grade 25 concrete. Other specimens expect OY. 02 IB, OS. 01 OS and OS. 02 IK are in the category of grade 20 concrete. The low values of some of these specimens might be due to one or more of the following factors;

- The variation in moisture content.
- The grading of the aggregates.
- The human or mechanical errors or inaccuracies in weighing and batching.
- The manner in which the cubes are made, etc.

3.4 Flexural Strength

The tensile strength of concrete otherwise known as modulus of rupture is much smaller than the compressive strength and is in most cases usually effectively eliminated by cracking, whether the crack is visible or not. Consequently, the tensile strength of concrete is not usually taken into account for design purposes, though it can be important inasmuch as it influences and contributes to the flexural strength of concrete paving (Shetty, 2005). A study of Table 3.2 shows a range of flexural strength from lowest value of 2.17 N/mm^2 for specimen OS. 01 OS to the highest value of 3.49 N/mm^2 for specimen EK. 01 AD. These values of flexural strength is well within the permissible values given by BS EN 1992 -1:2004.

3.5 Split Tensile Strength

Splitting tensile strength is one of the parameters that controls the rate of reinforcement corrosion and also indicates the potential for an increase in the usefulness of the service life of concrete. Abdullah (2012) confirmed that improvement in split tensile strength results in an increase in the useful service life of concrete by decreasing cracks due to reinforcement corrosion.

Table 3.2. Flexural Strength of Gravel Concretes

Beam Specimen	No. of Beam	Ave.Weight (kg)	Ave. Den. (kg/m^3)	Load (kN)	Point of fracture (mm)	Average Flexural Strength (f_b) (N/mm^2)
OG. 01 AB	2	39.93	2366	28	318	2.65
OG.02 AG	2	39.91	2362.8	30	300	2.65
OG. 03 OB	2	38.81	2362.8	30	315	2.73
OY. 01 IG	2	40.21	2391.3	32	320	3.04
OY. 02 IB	2	39.84	2365.35	26	305	2.35
OY. 03 IS	2	40.0	2367.9	33	318	3.11
OS. 01 OS	2	39.57	2288.7	27	270	2.18
OS. 02 IK	2	37.48	2145.5	26	319	2.49
OS. 03 MD	2	40.16	2390.1	33	320	3.12
OD. 01 OD	2	39.77	2367.75	35	295	3.08
OD. 02 IJ	2	39.83	2365.3	35	300	3.11
OD. 03 OK	2	40.03	2359.1	32	295	2.79

EK. 01 AD	2	40.0	2365.35	37	322	3.50
EK. 02 IK	2	40.5	2415.3	36	315	3.38
EK. 03 IG	2	39.66	2363.85	35	285	2.97

Table 3.3 shows the results of splitting tensile strength of concrete. The values range from minimum of 1.72N/mm^2 for sample OS. 01 OS to maximum value of 2.80N/mm^2 for specimen EK. 02 IK. These results conforms to (Hannant, 1972) values of tensile strength in relation to strength class. The values ranging from 1.7N/mm^2 to 2.8N/mm^2 for strength class C12/16 and C25/30 respectively. Critical examination of this standard also confirms an assertion that splitting tensile strength is generally greater than direct tensile strength and lower than flexural strength - modulus of rupture (Hannant, 1972). Shetty (2001) recommended minimum split tensile of 10N/mm^2 for 1:2:4 mix proportion at 28 days and 4N/mm^2 for 1:3:6 mix proportion at 28 days.

Table 3.3. Splitting Tensile Strength of Gravelly Concrete

Cube Specimen	**Trial No.**	**Ave. Wt. (Kg)**	**Ave Density (Kg/m^3)**	**Ave. Load (kN)**	**Ave. Split Strength f_{spt} (N/mm^2)**
OG. 01 AB	3	7.8	2350.6	76	2.13
OG. 02 AG	3	7.9	2370.4	75.2	2.13
OG. 03 OB	3	7.5	2288.9	79.7	2.23
OY. 01 IG	3	8.0	2380.3	85.0	2.43
OY. 02 IB	3	8.0	2390.1	67.0	1.88
OY. 03 IS	3	8.0	2370.4	88.0	2.48
OS. 01 OS	3	7.8	2301.2	60.0	1.71
OS. 02 IK	2	7.0	2074.1	70.0	1.97
OS. 03 MD	3	7.9	2321.0	90.0	2.53

OD. 01 OD	3	8.0	2370.4	87.0	2.45
OD. 02 IJ	3	8.0	2380.3	88.7	2.52
OD. 03 OK	3	8.0	2370.4	78.0	2.21
EK. 01 AD	3	8.0	2370.4	99.1	2.80
EK. 02 IK	3	8.5	2429.6	95.0	2.69
EK. 03 IG	3	8.0	2370.4	84.0	2.38

3.6 Water Absorption Capacity

Table 3.4 shows the results of the water absorption capacity of concrete. The absorption tests are not used frequently except for routine quality control of precast products. The results reveals that specimen OS. 02 IK has the highest value of absorption capacity of 6.80%, while specimen OS. 03 MD has the lowest water absorption capacity of 4.32%. From this finding, it can be inferred that specimen OS. 02 IK is the most porous of all the samples, while specimen OS. 03 MD is the least porous. However, going by the assertion that most good concretes have absorption well below 10 per cent, it can be inferred that all the selected gravel aggregate samples from Southwestern Nigeria produce good quality concrete in terms of water absorption characteristic of concrete products.

Table 3.4. Water Absorption Capacity of Gravelly Concretes.

Concrete Sample	No of cubes	Ave. Weight of Saturated Specimen (kg)	Ave.Weight of Oven dried Specimen (kg)	Ave. Water Absorption Capacity (%)	Ave. Value of Water Absorption Capacity (%)
OG. 01 AB	3	7.70	7.30	5.48	5.44
OG. 02 AG	3	8.00	7.65	4.58	5.02
OG. 03 OB	3	7.65	7.30	5.38	5.05
OY. 01 IG	3	7.95	7.60	4.61	5.30
OY. 02 IB	3	7.90	7.50	5.33	5.09
OY. 03 IS	3	7.90	7.60	3.95	4.52
OS. 01 OS	3	7.50	7.18	4.46	5.08
OS. 02 IK	3	7.00	6.60	6.06	6.80

OS. 03 MD	3	7.80	7.50	4.00	4.32
OD. 01 OD	3	7.85	7.40	6.08	5.27
OD. 02 IJ	3	7.75	7.35	5.44	4.46
OD. 03 OK	3	7.80	7.35	6.12	4.97
EK. 01 AD	3	7.85	7.45	5.37	4.48
EK. 02 IK	3	8.10	7.70	5.20	5.01
EK. 03 IG	3	8.00	7.63	4.85	4.70

4.0 CONCLUSIONS

The study has established that:

1. OS.03 MD, OD. 01 OD and EK. 03 IG show medium consistency while others fall under very low and stiff consistency.
2. All the densities of concrete specimens fall within the range of normal weight or dense concrete
3. EK. O1 AD, EK. 02 IK, OS.03 MD and OD. 02 IJ produced grade 25 concrete while OY. 02 IB, OS. 01 OS, and OS. 02 IK are in the category of grade 20 concrete.
4. EK. O1 AD produced the highest value of 3.49 N/mm2 flexural strength while OS. O1 OS produced the lowest value of 2.17 N/mm2. The values of flexural strength fall within the permissible values given by EN 1992-1-1 (2004).

5. Engineering properties of concrete cubes and beams produced from gravel sourced from different locations in southwestern Nigeria varied. Gravelly concretes with high strength could be used in construction of low rise buildings and rural roads while those with low strength could be employed in applications (walkways) where high strength is not required.

6. The engineering properties of concrete (compressive, flexural and split-tensile strengths, consistency measured with slump, density, and absorption capacity of concrete) made with the gravel as coarse aggregate though varied from location to location are within specified standards. Therefore the results provide data bank for technical and economical infrastructural developments in Southwestern Nigeria.

ACKNOWLEDGMENTS

The research work was accomplished in the structural laboratory of Nigerian Building and Road Research Institute, Ota, Nigeria. Also, the authors wish to thank the management of NIBRI for the platform made available for this research.

Cover image

Source: Authors

REFERENCE

Abdullah, M. (2012). Effect of Aggregate Type on Compressive Strength of Concrete. *International Journal of Civil and Structural Engineering*. 2(3), 791-800.

ACI Committee 201. (1992). Guide to Durable Concrete. ACI 201.2R – 92, reapproved 1997, American Concrete Institute, Farmington Hills Michigan.

ACI Education Bulletin E1 – 99. (1999). Aggregate for Concrete. Developed by Committee E – 701.

ASTM C496/C496M – 11. Standard test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.

ASTM C642 – 13. Standard Test Method for Density, Absorption and Voids in Hardened Concrete.

Adebakin I.H., Adu, J. T., & Ofuyatan O.M., (2015) Implementing Innovative Ideas in Structural Engineering and Project Management 2015, ISEC Press ISBN: 978-0-9960437-1-7.

Assakkaf, I.A. (2012). Reliability design of double plates for sea tanker. *Proc. International Conference on Civil Engineering and Building Materials (CEBM).*

Bamigboye G.O., Ede A.N., Umana, U. Odewumi T.O., & Olowu O (2016). Assessment of Strength Characteristics of Concrete Made from Locally Sourced Gravel Aggregates from South-South Nigeria. British Journal of Applied Science & Technology 12(5): 1-10, 2016.

Bartos, P. 1992. Fresh Concrete: Properties and Tests. Amsterdam, New York; Elseview.

Blake, L. S. 1951. Civil Engineer's Reference Book. Fourth ed. 1989, Butterworths London, Boston, Toronto.

Brandy, S.C., Clauser H.R. & Vaccnri J.A. Material Handbook, 15th edition, Mc Graw-Hill Handbook 2002.

British Standard Institution; BS 1881 – 122: 1983. Testing Concrete. Method for Determination of Water Absorption. BSI London.

British Standard Institution; BS 1881: Part 108: 1983. Method for Making Test Cubes from Fresh Concrete, BSI London.

British Standard Institution; BS 1881: Part 118: 1983. Method for Determination of Flexural Strength. BSI London.

British Standard Institution; BS 1881: Part 117: 1983. Method for Determination of Tensile Splitting Strength. BSI London.

British Standard Institution, BS 8110 – 2: 1985. Structural Use of Concrete. Code of Practice for Special Circumstance. BSI London

British Standard Institution, BS 8110: Part 1; 1985. Structural Use of Concrete. Part Code of practice for design and construction. BSI London.

British Standard Institution; BS 12: 1991. Specification for Portland Cements, BSI London.

Chowdhury, K. P. R. (1982). Engineering Materials. Seventh ed. Oxford and IBH Publishing Co. New Delhi.

Dahunsi, B.I.O. (2003). Properties of Periwinkle-Granite Concrete. *Journal of Civil Engineering, JKUAT,* 8, 27 – 35.

Dirisu, A. O. and Olabiran, E. O. (1991). Building Material and Technology for Rural Area. In-house Seminar Paper, Nigerian Building and Road Research Institute.

EN 1992 -1 – 1: 2004. Design of Concrete Structures. General Rules and Rules for Buildings

Fowler D.N. and Quiroga (2003). The Effect of Aggregates Characteristic on the Performance of Portland cement Concrete, *International Center for Aggregates Research ICAR 104-IF*, 382.

Hannant, D. J. (1972). The Tensile Strength of Concrete: A Review Paper. *The Structural Engineer* 50 (7), 253-257.

Idiake, J. E. (2006). The Effects of Macro-economic Variables on Private Residential Housing Development in Minna, Niger State. Journal of Environmental Sciences.10 (1), 146 – 152.

Jackson, N. (1984). Civil Engineering Materials. 2nd ed. Macmillan Press Ltd. London.

Kosmatka S.H, Kerhhoff B & Panarese W.C. (2002). Design and control of concrete mixtures fourteen ed. Portland Cement Association, Skokie, IIlinois, USA. EBOO1.

Krell, J. & Wischers, G. (1988). The influence of Fines in Concrete on Consistency, Strength and Durability. *Beton,* 38 (9), 356-9 and10, 401-4. *British Cement Association translation*.

Lawal, P. O. (2011). Effects of Sand/Gravel Mining in Minna Emirate Area of Nigeria on Stakeholders. *Journal of Sustainable Development*. 4 (1). Published by Canadian Center of Science and Education. Retrieved June 13 2012 from http://www.ccsenet.org/jsd.

Langer, W. H. & Glanzman, V. M. 1993. Natural Aggregate Building America's Future. US Geological Survey Circular 1110.

Lea, F. M. (1970). The Chemistry of Cement and Concrete. Arnold London. Mineral Information Institute. 2006. Retrieved Aug. 6 2010 from http://www.mii.org

Spencer, R. J. S. & Cook, D. J. (1983). Building Materials in Developing Countries. John Wiley and Sons, New York

Shetty, M.S**.** Concrete Technology; Theory and Practice, Multi-Color Illustratio.Ed New Dehil.S. Chand; 2005.

ABOUT THE AUTHORS

Sulymon Nurain (Dr) is the Head of Department of Civil Engineering, Nigerian Building and Road Research Institute, Ota, Nigeria. His research interest is in Building and construction materials.

Ofuyatan Olatokunbo (Dr) a lecturer in the Department of Civil Engineering, Covenant University, Ota, Ogun State, Nigeria. Her research interest is materials – SCC, normal concrete, effect of environmental degradation on their strength under various loads (wind and gravity), numerical analysis of composite structures, blast loading of concrete structures and seismic forces on foundation.

Sulymon Nurain (Dr)

PUBLIC INTEREST STATEMENT

The factors which affect the local availability and supply of construction gravel include demand and supply of the resource. The following factors have influences on future demand of gravel in Nigeria; population growth, personal income, statewide economic growth, state infrastructural needs and personal interest. Gravel, like other natural resources occurs where nature placed it, not where people need it. Economic recession and gravel availability in South western Nigeria call for urgent investigations of available borrow pits in southwestern Nigeria to ascertain their strength in line with the standard and to recommend for construction the borrow pits satisfied the BS standard to the community.