IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 15, Issue 1 Ver. III (Jan. - Feb. 2018), PP 40-44
www.iosrjournals.org

Empirical Study of No – Fines Concrete Properties Produced From Natural and Artificial Aggregates for Construction

Ajigbon A.A, & Anifowose O.S.
Department of Building Technology, Federal Polytechnic Ado Ekiti
Corresponding Author: Ajigbon A.A

Abstract: *An empirical study on the physical and mechanical properties of no-fines concrete produced from natural and artificial aggregates through laboratory work is presented in this paper. Aggregates to aggregates bond was achieved through water-cement paste resulting in significant lightweight concrete. Laboratory tests were conducted on test cubes to study the basic physical and mechanical properties; that is, density, water absorption and compressive strength. The effect of water/ cement ratio and aggregates/cement ratio was also investigated for essential optimization. It was found that the strength of no-fines concrete produced from both natural and artificial aggregates was lower than that of normal weight concrete, but appears to be sufficient for specialized construction works where compressive strength demand is not very high. Its application in the construction industry may include core work in concrete like sandwich panels, drainage layer under reservoir and basement floors, paving and lightweight screed for leveling and roofs as a damp-proof material.*

Keywords: *No-fines concrete, lightweight concrete, density, compressive strength, water-cement paste.*

Date of Submission: 26-01-2018 Date of acceptance: 09-02-2018

I. Introduction

No-fines concrete consists of an agglomeration of coarse single sized aggregates covered with a thin layer of cement paste approximately 1.3mm thick (Neville, 1997). It has a high volume of voids, which is the factor responsible for the lower strength and its light weight nature. There are different names attached to thin concrete such as zero-fines concrete, pervious concrete or porous concrete. The use of fine aggregates is avoided in the production of no-fines concrete for construction. In this type of concrete, the covering of thin layer of cement paste surrounding the coarse aggregates gives it a point-to-point contact with each other that binds them (aggregates) together. No-fines concrete is widely used in construction after the pioneering work of Wimpey in the UK in 1924 (Ghafoori and Dutta, 1995a; Newman and Owens, 2003); however, its first use was noticed in the construction of two houses in the UK as far back as 1852. The advantages of no-fines concrete are lower density, lower cost, due to absence of fine aggregates, good thermal conductivity, relatively low drying shrinkage (one half of dense concrete), no segregation even in case of material discharge from high level, no capillary movement of water due to low hydrostatic pressure when wet (one third of dense concrete), better insulating characteristics than conventional concrete because of the presence of large voids. (Abadjieva and Sephrir, 2000; C&CI 2009; Nerille, 1981; Ghaffori and Dutta, 1995b; Malhotro, 1976, Sommerville et al, 2011). No-fines aggregate concrete has been used for walls in housing (later plastered) and as a drainage medium; especially to drain play areas and tennis courts. Many architects, engineers and contractors have recognized the inherent economies and advantages offered by lightweight concrete structures found today throughout the world (ACI213R-87, 1987). Lightweight concrete precast elements offer reduced transportation and placement costs (C&CI, 2009). The Objective of this study is to examine the physical and mechanical properties of no-fines concrete produced from natural and artificial coarse aggregates and to establish adequate mix proportion for its application in construction.

II. Materials And Methods

The materials used for this work were sourced locally. Ordinary Portland cement was procured from Dangote cement dealers in Ado Ekiti, Nigeria while coarse aggregates (artificial and natural) were collected from quarry and dredged pit respectively also in Ado Ekiti in Ekiti State. The crushed granite were graded size of 20mm downward using mechanical sieve analysis. The apparatus used are wheel barrow which is capable of resisting chemical attack from cement and of sufficient size to allow hand mixing, a shovel capable of resisting chemical attacks and abrasion during the mixing process and electronic balance capable of weighing the required mass with an accuracy of 0.1g and complying with AS 1141.2.

Mix Design

The mix design was the determination of the ratio of aggregates, cement and water that possessed the most favourable properties. Four trial mixes were designed. The mixes were determined from previous literature and particular mixes used by some companies. There are only three constituents of no-fines concrete that were considered and varied: aggregates, cement and water. Four different mixes were tried. The aggregate-cement-water ratio mixes were (8:1:0.4); (6:1:0.4); (4.8:1:0.36) and (4.5:1:0.4).

However, a narrow range of 0.38 and 0.52 water/cement ratio must be chosen with care for satisfactory consistency. If too low water/cement ratio is applied, the paste will be so dry that aggregates do not get properly smeared with paste which results in insufficient adhesion between particles. On the other hand, if the water/cement ratio is too high, the paste flows to the bottom of the concrete particularly when compacted and the voids between the aggregates at the bottom makes portion dense. The condition also reduces the adhesion between aggregates and aggregate owing to the paste becoming very thin.

Material Mixing Process

The aggregate, cement and water for the mix were weighed. The working surface of the wheelbarrow was moistened to prevent the materials from sticking to the sides. The aggregates were placed in the wheelbarrow and approximately half of the water was added to mix the aggregates until they were wet. Cement and water was spread uniformly over the surface of the aggregate and continue mixing the concrete until the aggregate is evenly covered with cement paste.

Test on Workability of the No-fines Concrete Samples

The workability test that is examined is the compacting factor test which is suitable to determine the consistency of no-fines concrete as it is considered to be self compacting and can be dropped from height without affecting its properties. The equation for calculating the compacting factor is as follows:

$$\text{Compacting factor} = \frac{m_1}{m_2}$$

where:

m_1 = mass of the partially compacted concrete

m_2 = mass of fully compacted concrete

The result from the compacting factor test conducted on the concrete sample are as shown in Table 1

Table 1: **Compacting Factor of Concrete Samples.**

	Partially Compacted Concrete (m_1) kilograms	Fully Compacted Concrete (m_2) kilograms	Compacting factor
No-fines Concrete	10.925 10.245	11,435 11.435	0.96 0.90
Conventional concrete	13.095	13.565	0.97

The low cohesion between the aggregate particles helps the self compacting process of no-fines concrete. This particular fresh concrete test is the most useful for determining the properties of no-fines concrete. The result obtained from this test provides a method for assessing the amount of compaction required when placing a particular no-fines concrete mix. It will be observed that the compacting factor test for both conventional concrete and no-fines concrete is almost the same.

Preparation of Cubes Specimen for Laboratory Testing

Using a specified mix of 4.5:1:0.4 mix proportion of aggregate:cement:water ratio, standard 150x150mm x150mm cubes were cast with a total number of 18 cubes (six samples for each mix-design ratio). The cubes cast with natural coarse aggregates were marked 'NA' (Natural Aggregate no-fines concrete and 'AA' Artificial Aggregates no-fines concrete). Cubes cast with artificial coarse aggregate were demoulded after 24 hours of curing in water at room temperature of 37^0c for 7, 14 and 28 days respectively and tested using universal testing machine under monotonic loading condition. Laboratory tests were conducted on the representative concrete cubes according to ACI 211.2-98 and BS1881-113. During the concrete samples preparation, paste was first prepared using measured amount of cement mixed with water (Cement-Paste) for the specified cement ratio. Aggregates of known weight were then thoroughly mixed with the paste until aggregates were fully coated with cement paste. The mixture was then poured into previously oiled cube mould in three layers and each layer was rodded 35 times using 25mm diameter rod until subsidence took place. (ASTM C.09, 2006). Thereafter, specimens were weighed. The water absorbed was expressed as a percentage based on weight at the 65+2% relative humidity and 30^0C after conditioning, that is:

$$WA\% = \frac{W_2 - W_1}{W1} \times 100$$

Where:

WA = Water Absorption (%)

W_2 = Final Weight after treatment (g)

W_1 = Initial Weight (g)

The compressive strength was carried out by placing the block sample in between the piston of a compression machine. Loading was done continuously and at uniform speed of the testing machine until failure occurred (Plates 1 and 2).

$$\text{Compressive Strength} = \frac{\text{Maximum load to failure (N)}}{\text{Cross Sectional Area (mm}^2\text{)}}$$

Plate1: *The compression machine is set up for Cube test*

Plate 2: *The failure of the no-fines concrete sample on completion of the Cube Test*

Statistical Analysis of Data

The data obtained from the experiment were analyzed using Microsoft Excel Spread Sheet and Statistical Package for Social Scientists (SPSS) on a desktop computer. The analyses carried out include:

- Descriptive statistical analysis; and,
- Graphical analysis.

The descriptive statistics gave summaries of the raw data which are presented in tabular form, while the graphs plotted show the variation on the variables over different levels of the factors.

III. Results And Analysis

Table 2: Mean values of compressive strength of no-fines concrete at the age of 7 days

Test No	Specimen Type	Density (kg/m3)	Average Density (Kg/m^3)	Compressive Strength (N/mm2)	Average Compressive Strength (N/mm^2)
1	No-fines Concrete ('NA')	620		3.6	
2	-Ditto-	625		3.4	
3	-Ditto-	630	625	3.9	3.8
4	No-fines Concrete ('AA')	635		5.1	
5	-Ditto-	637		5.3	
6	-Ditto-	639	637	5.2	5.1

Fig 1: Mean values of compressive strength of no-fines concrete at the age of 7 days

Table 3: *Mean values of compressive strength of No-fines concrete at the age of 14 days.*

Test No	Specimen Type	Density (kg/m3)	Average Density (kg/m3)	Compressive Strength (N/mm2)	Average Compressive Strength (N/mm2)
1	No-fines Concrete ('NA')	640		4.2	
2	,,	645		4.4	
3	,,	647	644	4.6	4
4	No-fines Concrete ('AA')	660		6.4	
5	,,	650		5.7	
6	,,	655	655	6	6

Fig 2: Mean values of compressive strength of No-fines concrete at the age of 14 days.

Table 4: Mean values of compressive strength of No-fines concrete at the age of 28 days.

Test No	Specimen Type	Density (kg/m3)	Average Density (Kg/m3)	Compressive Strength (N/mm2)	Average Compressive Strength (N/mm2)
1	No-fines Concrete ('NA')	656		6	
2	,,	650		5.3	
3	,,	653	653	5.5	5.6
4	No-fines Concrete ('AA')	689		7.4	
5	,,	680		7.3	
6	,,	687	685	7.4	7.4

Fig 3: Mean values of compressive strength of No-fines concrete at the age of 28 days.

IV. Results And Discussion

Density

The no-fines concrete exhibited large inter connected voids distributed throughout the body of concrete. This is responsible for the lower density of no-fines as compared to ordinary concrete. The density of the investigated no-fines concrete produced from both natural and artificial aggregates varies between 620kg/m^3 and 689kg/m^3 (Tables 2-4) which are about 70 to 60 percent lower than the density of normal weight concrete. The decreased density indicates lower dead load of the structure. Density usually decreases with the increase of aggregate/ cement ratio.

Compressive Strength

The mean compressive strength of the no-fines concrete cubes was determined after 7, 14 and 28days of water curing respectively. This is shown in Tables 2-4 which varies from 3.8N/mm^2 for natural aggregate and 5.1N/mm^2 for artificial aggregate at the age of 7 days. This shows that aggregate/cement ratio using artificial aggregate produce higher strength than natural aggregate. The 14days old result of the compressive strength of the concrete produced from artificial and natural coarse aggregate varies from 4.0N/mm^2 to 6.0N/mm^2, this result shows slight increase in strength development it may be as a result of improper mixing resulting in deficient bonding of the aggregates by cement. After 28 days of curing treatment, the strength development increases more than the 14 days old as a result of increase in density for artificial no-fines concrete than in natural aggregates no-fines concrete. The mean compressive strength ranges from 5.6N/mm^2 to 7.4N/mm^2. From the results, it is clear that the compressive strength of no-fines concrete is lower than the compressive strength of conventional concrete which ranges averagely from 10N/mm^2 to 30N/mm^2 (NIS) due to increased porosity. However the strength of 4.0:1 trial mix appears to be sufficient for the application of no-fines concrete for floors and roofs, also for other works where comprehensive stress demand is not very high. The test results show that the compressive strength of no-fines concrete has larger pores. The strength and stiffness which depend on pore size, distribution, shape and total volume of pores in the individual particles as well as in no-fines mass, large irregularly shaped cavities may weaken the aggregate particles and concrete generally. (Bashir et al, 2012).

Capillary Movement, Water Permeability, Cohesion and Segregation.

Previous works recorded that the most commonly occurring problems in construction works are because of the penetration of moisture and the most common source of entrance of water is by capillary action. The capillary movement of water is less likely to take place in no-fines concrete as there are sized continuous pores and rough open-textured structure. As a result of this feature such concrete has low hydrostatic pressure. Permanently, No-fines Concrete possesses less cohesion and shows signs of no segregation. Because of this, it can be dropped from greater heights during placing. (Bashir et al, 2012).

V. Conclusions And Recommendations

Based on the empirical study carried out to ascertain the properties of no-fines aggregate concrete for construction works, it was found that the:

- Strength of no-fines aggregates concrete is lower than that of conventional concrete.
- Trial mix aggregate/cement ratio 0.4:1 as one of the mix ratios for higher compressive strength of no-fines concrete.
- Water/cement ratio of between 0.38 and 0.5 is adequate for smooth surfaced aggregate.

- The water/cement ratio of 0.4 was adequate for aggregate having open poured texture when sprayed with water before mixing with water/cement paste.

The following are, thus, recommended:

- The mix ratio of 0.4:1 could be used for concrete sandwich panel construction, drain layers, paring and as a lightweight screed for leveling of floors and roofs after more extensive research.
- No-fines aggregates concrete could be sufficiently used for specialized construction works where compressive stress demand is not very high.

References

[1]. **Abadjeva. T and Sephir. P (2000):** Investigations on some properties of no-fines concrete, University of Botswana, Botswana.
[2]. **ACI 213R-87 (1987):** Guide for Structural Light Weight Aggregate American Concrete Institute (ACI). Detroit, MI. USA.
[3]. **ACI 211, 2-98 (1998):** Standard Practice for selecting proportions for Structural Light Weight Concrete. American Concrete Institute (ACI), Detroit, MI. USA.
[4]. **American Society for Testing and Materials (ASTM) Concrete Committee (C09), (2006):** Concrete Committee to consider pervious Activity, Tec news, viewed 15th April 2007, www.astm.org/.../concreteoct06.html retrieved on 25th March 2015 2:55p.m.
[5]. **Australian Standard. AS 1141.2 (1999):** Method 2: Basic Testing Equipment. Standards Australian Committee.
[6]. **Bashir Alam; Mohammed Javed, Qaisar A; Naveed A; Muhammad I (2012):** Mechanical Properties of No-fines Bloated Aggregate concrete for construction Application: Experimental study. International Journal of Civil and Structural Engineering. Vol. 3 Issue 2.
[7]. **BS 1881-113 (1983):** Testing Concrete: Method for making and curing no-fines test cubes. British Standards Institution (BSI). London. U.K.
[8]. **C&CI (2009):** Fulton’s Concrete Technology, Nineth Edition. Cement and Concrete Institute (C&CI), Midrand, Johannesburg, South Africa.
[9]. **Ghafoori, N. and Dutta,S., (1995a):** Building and Non Pavement Applications of no-fines Concrete Journal of materials in Civil Engineering. 7(4). Pp 285-289.
[10]. **Ghafoori, N. and Dutta., S., (1995b):** Laboratory Investigation of Compacted No-fines Concrete for paving materials. Journal of Materials in Civil Engineering. 7(3). Pp. 183-191.
[11]. **Malhotra. V.M. (1976):** No-fines Concrete- Its properties and applications. ACI Journal. 73(11). Pp. 628-644.
[12]. **Neville, A.M. (1996):** Properties of Concrete. John Willey & Sons. INC. New York. USA.
[13]. PP 711-713.
[14]. **Neville, A.M. (1981):** Properties of Concrete. Prentice Hall, Upper Saddle River. NJ. USA.
[15]. **Newman, N and Owens, P (2003):** Properties of Light Weight Concrete in Newman. J and Choo. B.S. (eds.) Advanced Concrete Technology, Butterworth-Heinemann Burlington. Vermont. USA.
[16]. **NIS (2000):** NIS 87:2000 Nigerian Industrial Standard: Standard for Sand Crete blocks. Standard Organisation of Nigeria, Lagos, Nigeria.
[17]. **Sommerville, J; Craig, N and Charles, A (2011):** No-fines Concrete in the UK Social Housing Stock: 50 years on Structural Survey. 29(4). Pp. 294-302.

Ajigbon A.A "Empirical Study of No – Fines Concrete Properties Produced From Natural and Artificial Aggregates for Construction”.” IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), vol. 15, no. 1, 2018, pp. 40-44.