IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 14, Issue 5 Ver. I (Sep. - Oct. 2017), PP 29-33
www.iosrjournals.org

Influence of Aggregate Sizes on the Performance indices of Self Compacting Concrete (SCC)

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Abstract*: The development of Self-Compacting Concrete (SCC) has recently been one of the most important developments in the building industry. The paper investigates the influence of aggregate sizes of 10mm, 12.5mm and 20mm on the performance indices of Self-Compacting Concrete (SCC). Concrete mixes of 1:2:4 were produced with addition of variable plasticizer admixture of COMPLASTSP430 at 3% constant value. Specified tests for Self-compacting concrete (SCC), related to workability such as flowability, filling-ability, and passing-ability tests were carried out on fresh samples. Compressive strength of hardened cured (150 x 150 x 150), results showed a maximum compressive strength of 19.86N /mm2, at 28 days, while the flowability, filling ability, passing ability, and segregation potential were 725mm, 4.45 seconds, 6 seconds and 270mm mm respectively. On analysis and comparison of the results with known SCC standard, aggregate 12.5mm size gave a better results than the remaining sizes for self-compacting concrete.*

Keywords: *Self Compacting concrete, Compressive strength, workability, segregation and plasticizer.*

Date of Submission: 24-08-2017 Date of acceptance: 08-09-2017

I. Introduction

Concrete is a mixture of water, cement or binder and aggregates and is a commonly used material for construction, [1]. The dimension of a concrete member influences the choice of maximum size of aggregate. [2] advised that the maximum aggregate size should be no more than 23 available clear space between reinforcing bars or between the bars and the formwork. Maximum aggregate size should also not exceed 13 of the minimum member thickness. Such rules-of-thumb can sometimes limit the size of aggregates to be used in structural applications, but for generally in pavements, larger sized aggregates may be readily accommodated. For this study, the type of fine aggregates considered is sand and the coarse aggregates used were 10mm, 12.5mm and 20mm. The effect of size of aggregate on concrete properties was investigated through the use of different combinations of fine and coarse aggregates of different sizes, in a 1:2:4 concrete mix ratio. These mix ratios and type of aggregates are considered because they are commonly applied in building constructions. Their strength will be compared to determine the aggregate combination and the corresponding concrete strength. In addition such data are useful for incorporation into concrete practice and also into software for computer aided mixture proportioning and quality control of structural concrete. [3]

In a separate investigation carried out by [4] to determine the effects of corn cob ash (CCA) on Self-Compacting Concrete (SCC), they concluded that, higher percentage of CCA up to 30% can be used to replace OPC in concrete mix of 1:2:4 to yield compressive strength of 18.44N/mm2. [5], conducted a research on developing a SCC with cement replacement up to 30% in all the mixes and examining its fresh properties. Result show that the fly ash acts as a lubricant material; it does not react with Super plasticizer and produce a repulsive force and the Super plasticizer may only act on the cement. As a result, the larger the amount of fly ash contained, lesser the Super plasticizer needed. [6], presented an experimental study on SCC with two cement contents; the work involved three types of mixes, the first considered different percentages of fly ash, the seconds used different percentages of silica fumes and the third used mixtures of fly ash and silica fume. It was concluded that higher the percentages of fly ash the higher the values of concrete compressive strength up till 30% of fine aggregate (*fa)*, however the higher values of concrete compressive strength is obtained from mix containing 15% (*fa)*. [7], reported the effect of Super Plasticizers [SP] on the flowability and viscosity of Self Compacting Concrete quantitatively. The results obtained from the experimental investigations, they have proposed an index for the effect of Super Plasticizer on the flowability and the viscosity for obtaining self compatibility. This index is very useful for evaluating the quantity of the Super Plasticizer for proper viscosity and flowability of SCC by usingone set of results. An interesting study performed by *[8]*, in which they introduced a non-toxic calcite depositing bacteria. The bacteria is implemented in the fresh concrete in order that the self-heal cracks in hardened concrete micro level could start. Results showed an increase in the mechanical properties such as compressive and tensile strength.

II. Experimental Procedures

A. Materials

The materials used for this research were crushed coarse aggregates (granite) locally sourced, Portland cement conforming to ASTM type 1, Sand (Fine aggregate), Granite (Coarse aggregate) super plasticizer (SP430) Conforming to [9] and clean and deleterious-free water.

B. Methods

The coarse aggregates were obtained from *a* quarry along *Ise* road, Ikere-Ekiti in *Ikere* Local Government in Ekiti State, the granite later underwent the sieve analysis to obtain the three (3) different aggregate sizes (10mm, 12.5mm and 20mm). The fine aggregate used for this research work was river bed sand obtained from a local supplier in Ado **local** government area of Ekiti State. The plasticizer (Complast SP430) used was obtained locally. The preparation of test samples were in accordance with EFNARC 2013 standards. Self-Compacting Evaluation tests to determine the workability, fillingability, passingability and segregation potential of the mix were performed in accordance to relevant standards. Determination of compressive strength was in accordance with British Standards for a mix of 1:2:4 at different curing ages of 7, 14, 21 and 28 days.

III. Results And Discussion

A. Workability of SCC

From table 1.0 and figure 1.0 below, it was observed that the flow value of the batch with 10mm aggregate size attain the maximum flow value with 735mm compare to other batching of 12.5 and 20mm aggregate sizes having flow value of 725 and 720mm respectively, however they all met the recommendation value according to [9], which range from 650mm-800mm

Table 1.0: Summary of Self Compacting evaluation tests results

S/N	Size of Aggregate	Flow value	T_{50} Time at 50cm flow value	V -Funnel	U-Box
1	10mm	735 mm	5.00 secs	7 sec	280mm
2	12.5mm	725 mm	4.45 secs	6 sec	270mm
3	20mm	720 mm	4.87 secs	-	-

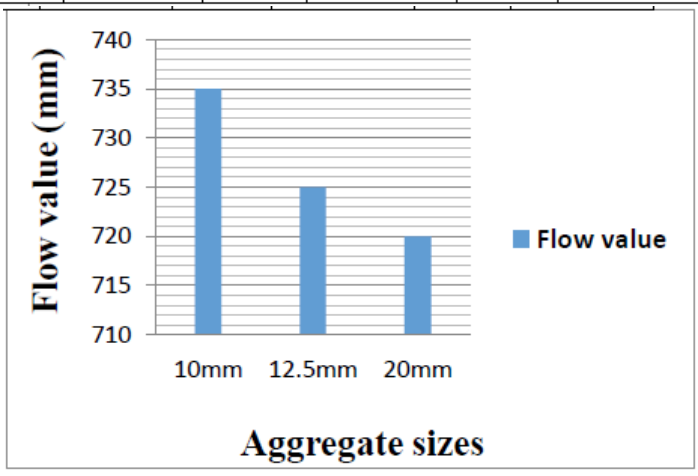

Fig. 1.0: Flow value against the aggregates

B. FLOW TIME RESULTS

From table 1.0 figure 4.2 above the aggregate size of 12.5mm concrete has the minimum time to reach the 50cm marked area with 4.45secs, however 10mm size aggregate has the maximum time of 5secs before it could reach the marked area, according to [9], and the recommended range is 2-5secs.

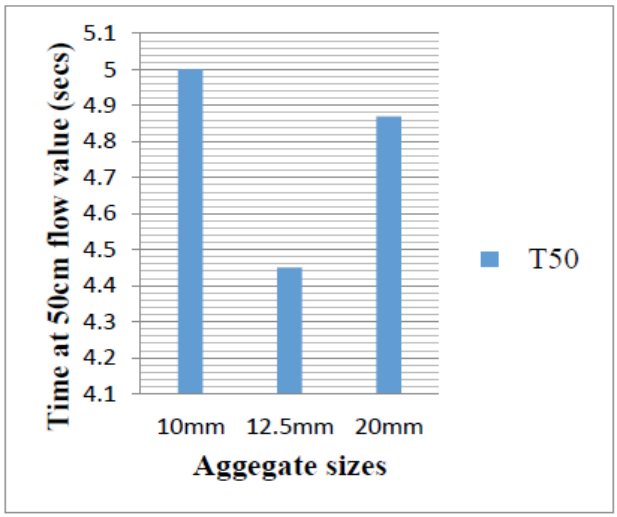

Fig. 2.0: Flow time against the aggregate

ANALYSIS ON FILLINGABILITY

From figure 3 above, batching with 10mm aggregate size has maximum passing time of 7secs compare too the concrete with 12.5mm aggregate size which takes 6secs to get emptied from the funnel, more so the batching with 20mm stucked in the funnel, the recommended range according to [9] is 6-12secs.

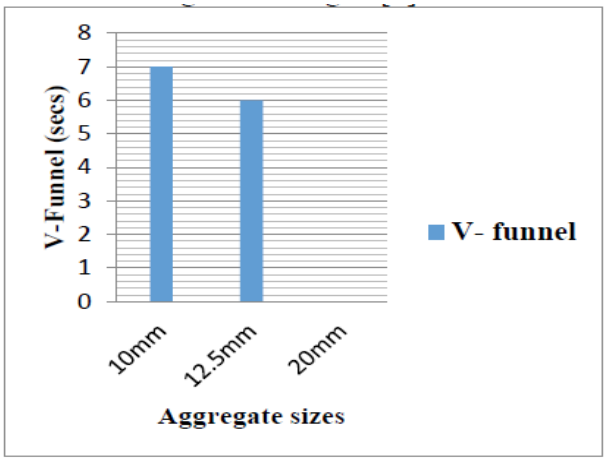

Fig. 3.0: V-Funnel Flow time against the aggregates

D. ANALYSIS ON FILLINGABILITY

From table 1.0 above and figure 4 below, batching with 10mm aggregate size has maximum passing time of 7secs compare to the concrete with 12.5mm aggregate size which takes 6secs to get emptied from the funnel, more so the batching with 20mm stucked in the funnel, the recommended range according to [9], is 6-12secs.

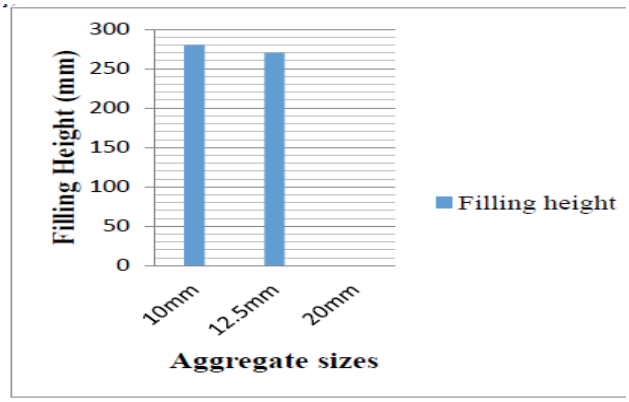

Fig. 4. Filling ability against Aggregates

From figure 4. above, 10mm size aggregate attain the highest filling height of 280mm, while 20mm size aggregate stucked and 12.5mm aggregate has afilling height of 270mm, the recommended range according to [9], is between 0 to 300mm.

E. COMPRESSIVE STRENGTH RESULTS

From the figure 5 and table 2 below, it was observed that the Crushing value increases with increase in days of curing and size of aggregates, also 28days of curing 10mm, 12.5mm and 20mm aggregate sizes attain 19.48N/mm2, 19.76 N/mm2 and 19.86 N/mm2 respectively. Compressive strength test was carried out to determine the strength of the concrete at various ages. the concrete was placed in a curing tank filled with water and left to cure for 7, 21 and 28 days and a total of 100 specimens, the compressive strength of each concrete cubes was found. Table 2 showed the summary of the compressive strengths at different curing days for each mix, while figure 5, illustrates the inter-relationship between each aggregate and the compressive strengths for different curing age. The results indicate that maximum compressive strength of 19.86N /mm2, at 28 days.

Table 2: Summary Of Compressive Strength (N/Mm2).

S/N	AGGREGATE SIZES (mm)	COMPRESSIVE STRENGTH (N/mm^2)			
		7days	14days	21days	28days
1.	10	11.15	12.59	18.88	19.48
2.	12.5	15.65	17.01	19.68	19.76
3.	20	16.50	18.42	19.75	19.86

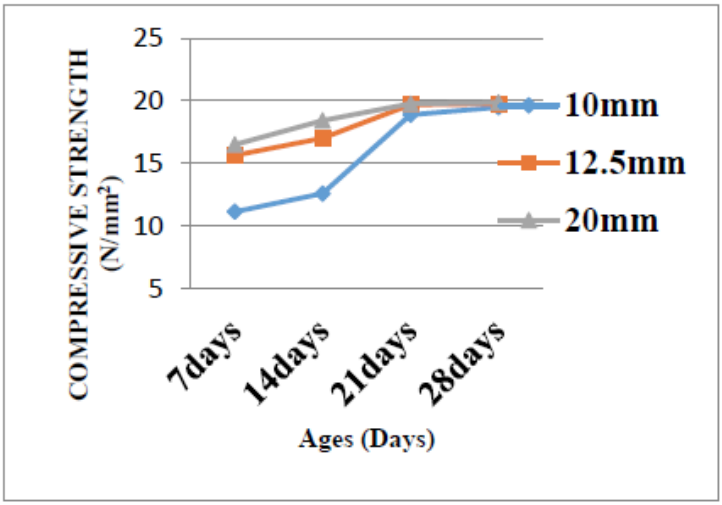

Fig 5: Average Value of Compressive strength for SCC.

IV. Conclusion

From the experimental results, it can be concluded that the fresh properties of all the aggregate sizes used are within the recommended range by [9], but the 20mm size of aggregate stucked at the V-funnel and U-box test. The results further showed that aggregate sizes has significant effects on the performance indices of SCC. Compressive strength obtained were within the range as specified by [10], which is in accordance with [11] that the batching of the concrete with a mixing ratio of 1:2:4 will give a target mean strength not lesser than 15N/mm2. The compressive strength for 10mm, 12.5mm and 20mm were 19.48 N/mm2, 19.76 N/mm2 and 19.86 N/mm2 respectively at 28days of curing. The concrete batch containing 20mm gave the optimum compressive strength.

V. Recommendation

It is therefore recommended that aggregate size of 12.5mm be used for self-compacting concrete, because it possess good engineering properties and still meet the target mean strength. Also other self-compacting evaluation tests such L- Box, Abram cone etc. be carried out to really establish the influence of these aggregates on self-compacting concrete.

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