International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 6, ISSN No. 2455-2143, Pages 80-83
Published Online October 2021 in IJEAST (http://www.ijeast.com)

STUDY OF SHRINKAGE OF CONCRETE USING NORMAL WEIGHT AND LIGHTWEIGHT AGGREGATE

Taufiqur Rahaman
Department of Civil Engineering
Rajshahi University of Engineering & Technology
Rajshahi, Bangladesh

Dr. Md. Shafiqul Islam
Department of Civil Engineering
Rajshahi University of Engineering & Technology
Rajshahi, Bangladesh

Abstract— **Drying shrinkage can be a major cause of deterioration of concrete structures. Aggregate sizes, curing period and water-cement ratio imparts a great impact on shrinkage of concrete. This paper represents the observed effects of water-cement ratio, curing period and aggregate sizes on shrinkage of concrete using normal weight and lightweight aggregate. Structural lightweight aggregate concrete offers several benefits as compared to the normal weight concrete. This paper checks the suitability of using lightweight concrete instead of normal concrete in case of susceptibility to shrinkage. Though the cost of the production of the lightweight aggregate is high due to energy and raw material consumption, economy can be achieved by using locally available waste materials to produce lightweight aggregates. The experiments were carried out according to ASTM C157 and ASTM C490. The variations of aggregate sizes, curing period and the water-cement ratio were applied and their effects were observed on shrinkage of concrete. This paper also recommends the proper type of concrete owing to minimal shrinkage.**

Keywords— Drying shrinkage, lightweight aggregate, curing period, aggregate sizes, water-cement ratio.

I. INTRODUCTION

The shrinkage of concrete is a major distress that affects structural integrity and sustainability. When concrete is restrained by itself or outside constraint, the strain generated by drying shrinkage can result in residual stress. These changes are in both cases connected with moisture leaving the fresh or hardened concrete. There are three main categories of shrinkage that can be recognized- plastic shrinkage, chemical shrinkage (autogenous shrinkage) and drying shrinkage. The determination of the real progress of volume changes of concrete has received increased attention from civil engineers and concrete producers in recent years (Kucharczyková, B., Daněk, P., Kocáb, D. and Misák, P., 2017). This is connected mainly with the development of new concrete as far as composition and production technology is concerned. Determining shrinkage, applying some methods and these methods are used for determining the individual components of concrete shrinkage. Contemporary approaches to concrete shrinkage measurement are based mainly on the determination of relative length change (Neto, A.A.M., Cincotto, M.A. and Repette, W., 2008). In most cases, measurement begins after specimens have been removed from their molds, which is no sooner than the age of 24 hours (Zhutovsky, S., Kovler, K. and Bentur, A., 2002). Importantly, shrinkage is measured by using a length comparator. The significance of each type shrinkage is strongly dependent on the composition of the composite, the curing method and duration, and size of the aggregates. Here also mention that due to the variation of mix proportion, temperature-shrinkage value differs (Carlson, R.W., 1938). In recent years there has been greatly increased interest in determining volume changes in concrete at an early age. In this paper, we studied experimentally shrinkage of concrete using materials of lightweight aggregates and normal aggregates (stone aggregate). Shrinkage due to drying occurs in all types of cement composites in an environment with relative humidity less than 90% (M. Collepardi, Betonov´e stavitelstv´, 2009).

II. EXPERIMENTAL PART:

A. *Tested materials –*

Ordinary Portland Cement (OPC), equivalent to ASTM Type I, was used in this study. Crushed burnt clay and shale were used as lightweight aggregate. Crushed stone was used as normal aggregate. The maximum size of aggregate, 20 mm was chosen as coarse aggregate. Sand having a fineness modulus of 2.84 and maximum size, 5 mm was used as fine aggregate. The tested aggregate size was among 16 mm, 12 mm and 10 mm. The pore content of the aggregate was evaluated by soaking in water and measuring the absorption as a function of time. Saturation was reached in about 48 hours, and the absorption values after 120 hours of absorption are provided in the table below.

Table -1 Absorption value of the lightweight aggregate and normal aggregate after 120 hours of soaking.

Aggregate	Absorption	
	% weight	% volume
Lightweight aggregate	8.60	11.44
Normal aggregate	3.74	4.90

B. *Concrete composition –*

The concrete composition has been adopted from IS 10262: 2009 to design grade ratio, 1:2:4 and 1:3:6 of concrete. The total mixing composition has been given below the table for various mix ratios. (Nataraja, M.C. and Das, L., 2010.)
The volume of specimen was 1.06×10^{-3} m^3. The below table shows the composition of concrete for the mix proportion of 1:2:4. Size of the aggregate of group A and group C is in the range of 10mm to 12mm. Size of the aggregate of group B and group D is in the range of 16mm to 20mm.

Table 2**.** Composition of concrete.

Aggregate types	Specimen group	W/C	Cement (kg)	FA (kg)	CA (kg)	Water (kg)
LWA	Group A Group B	0.45 0.5	0.218 0.218	0.455 0.455	0.909 0.909	0.11 0.20
NA	Group C Group D	0.45 0.5	0.218 0.218	0.455 0.455	0.909 0.909	0.11 0.20

Note: LWA, Lightweight Aggregate
NA, Normal Aggregate
W/C, water-cement ratio; FA, fine aggregate; CA, coarse aggregate

The volume of specimen was 1.06×10^{-3} m^3. The below table shows the composition of concrete for the mix proportion of 1:3:6. Size of the aggregate of group A and group C is in the range of 10mm to 12mm. Size of the aggregate of group B and group D is in the range of 16mm to 20mm.

Table 3. Composition of concrete.

Aggregate types	Specimen group	W/C	Cement (kg)	FA (kg)	CA (kg)	Water (kg)
LWA	Group A Group B	0.45 0.5	0.153 0.153	0.477 0.477	0.954 0.954	0.08 0.09
NA	Group C Group D	0.45 0.5	0.153 0.153	0.477 0.477	0.954 0.954	0.08 0.09

Note: LWA, Lightweight Aggregate
NA, Normal Aggregate
W/C, water-cement ratio; FA, fine aggregate; CA, coarse aggregate.

C. *Test Apparatus –*

From ASTM C157 and ASTM C490, Length Comparator was used for determining shrinkage of concrete. It was very time dependent and the specimen was set up to the Length Comparator maintaining a time interval and the data was recorded accurately. Length comparator, for determining length change of concrete, specimens produced is shown in the figure. A dial micrometer graduated to read in 0.01 mm units or less, accurate within 0.01 mm in any 0.1 mm range. (Neto, A.A.M., Cincotto, M.A. and Repette, W., 2008.)

Fig. 1. Length comparator with tested material.

III. Results and Discussions

There are some effects on shrinkage of concrete due to variations of material's properties traits.

D. *Effect of size of aggregate –*

The variation of aggregate size has a good effect on the shrinkage of concrete. The size of aggregate (coarse) of 16 mm has less shrinkage value than 12 mm of coarse aggregate with respect to time. The shrinkage value of normal concrete is greater than lightweight concrete. The maximum shrinkage value for the normal concrete and the lightweight concrete using an aggregate size of 12 mm are 705µm/m and 693µm/m respectively. Also, the maximum shrinkage value for the normal concrete and the lightweight concrete using an aggregate size of 16 mm are 701µm/m and 689µm/m respectively. Water-cement ratio was kept at 0.45.

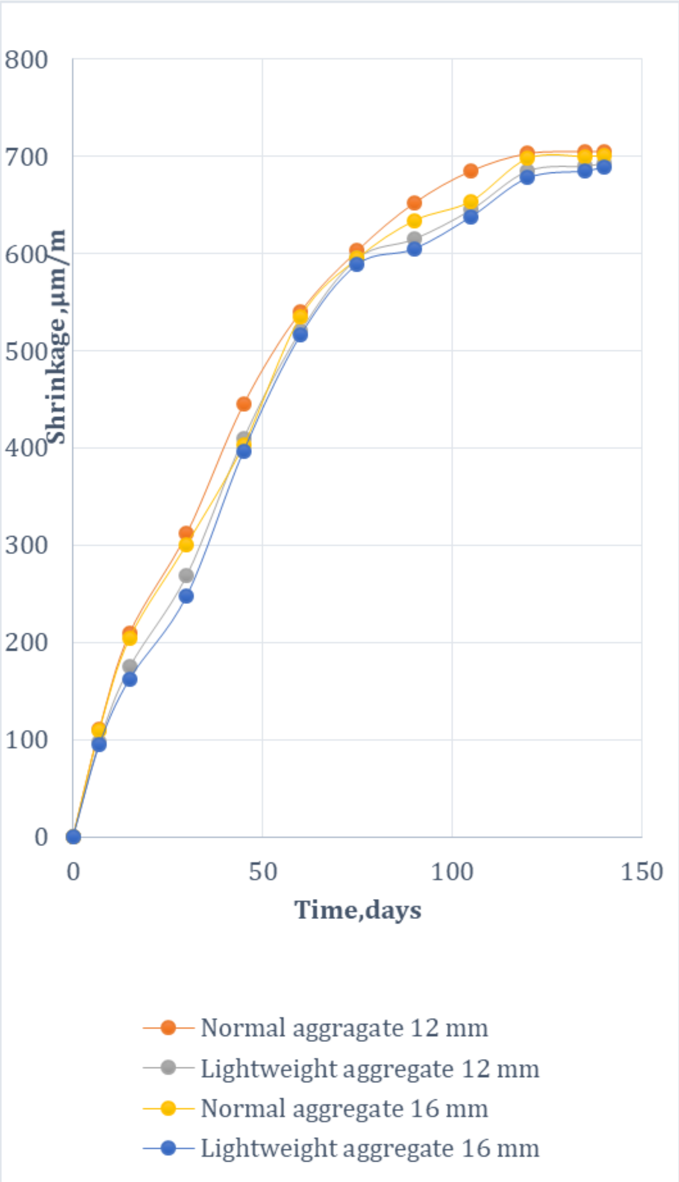

Fig. 2. Progress of shrinkage for the effect of sizes of aggregate.

E. *Effect of curing period –*

The variation of curing periods shows a good effect on the shrinkage of concrete. The result with variations of curing periods is shown in figure 03. For 7 days of curing period, the value of shrinkage of normal concrete was less than the lightweight concrete. From this, it is clear that lightweight concrete needs more curing for lesser shrinkage. On the other hand, for 15 days of curing period, the value of shrinkage of lightweight concrete was more than normal concrete at an early time. But after 45 days, the shrinkage value of lightweight concrete gradually decreases than normal concrete. The curing period of 28 days is very much effective for lightweight concrete. After 28 days of curing, the value of shrinkage of lightweight concrete was less than normal concrete.

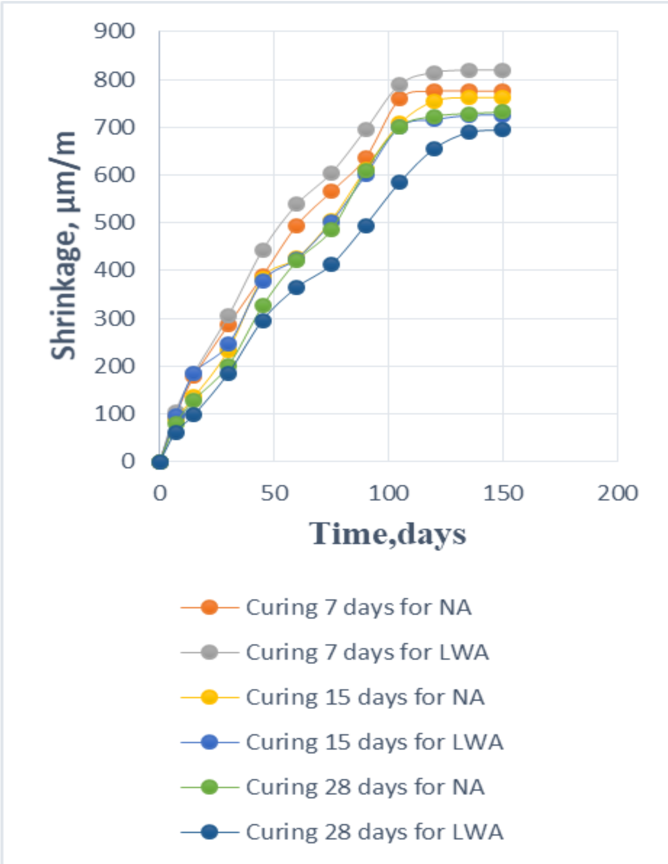

Fig. 3. Progress of shrinkage of concrete due to the curing period.

F. *Effect of w/c ratio on shrinkage –*

The effect of water-cement ratio on shrinkage of concrete was studied for normal concrete as well as lightweight concrete. The water-cement ratio was chosen in the range of 0.45 to 0.60. The water-cement ratio corresponding to the maximum shrinkage value for normal concrete was 0.60. From the experimental studies, it was also clear that the water-cement ratio below 0.47 showed a much better result. The result in figure 04 shows that the shrinkage of concrete for water-cement ratio 0.45 was less than shrinkage of concrete for water-cement ratio 0.60. By observing the shrinkage values of normal concrete and lightweight concrete, it was also clear that lightweight concrete shows less shrinkage at water-cement ratio 0.45 than that of 0.47. The shrinkage value of concrete increases if the water-cement ratio is higher than 0.47.

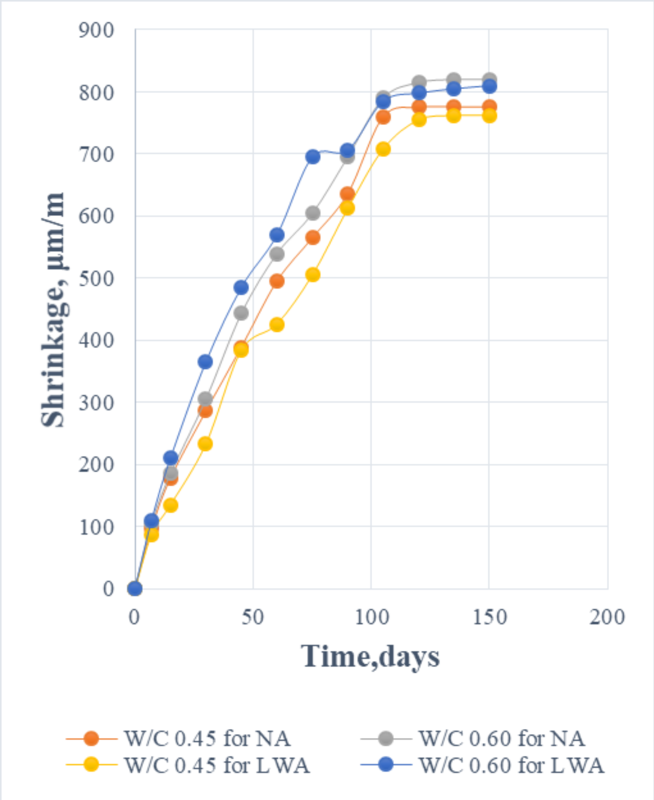

Fig. 4. Progress of shrinkage of concrete due to the water-cement ratio

IV. CONCLUSION

The experimental studies clearly show the benefits of using lightweight aggregates than normal aggregates in different conditions for drying shrinkage. From the study of aggregate sizes, it is found that the range of 16mm to 20mm is much more effective than that of 10mm to 12mm. Curing period of 28 days is much more effective for lightweight concrete than other periods such as 7 days or 15 days. It is also observed that higher water-cement ratios cause more shrinkage of concrete. The effective range of water-cement ratio is 0.45 to 0.47. From the total study of shrinkage of concrete, it is observed that lightweight concrete shows more suitability than normal concrete.

V. REFERENCE

[1] Junaid S.M., Saddam S., Yusuf K., Huzaifa S.A. and Junaid M.. (2015). "Self-Curing Concrete with Shrinkage Reducing Admixture",Journal of Civil Engineering and Environmental Technology, ISSN:2349-8404, Volume 2, Number 6,(pp. 506-509).

[2] Nataraja L., M.C. and Das.(2010). "Concrete mix proportioning as per IS 10262: 2009–Comparison with IS 10262: 1982 and ACI 211.1-91", *The Indian Concrete Journal*, (pp.64-70).

[3] Neto A.A.M., Cincotto M.A. and Repette W.. (2008). "*Cement and Concrete Research*", *38*(4), (pp.565-574).

[4] Zhutovsky S., Kovler K. and Bentur A.(2002). "*Materials and Structures*", *35*(2), (pp.97-101).

[5] Kucharczykova B., Kocab D., Danek P., Terziski I. (2019). "Cost-Effective High-Performance Concrete: Experimental Analysis on Shrinkage *Materials",* row. 12, č. 17:2730, s. 1-19. ISSN: 1996-1944.

[6] Kholia Nirav R., Prof. Binita,Vyas Prof. A.,T. G. Tank. (April-June,2013). "EFFECT ON CONCRETE BY DIFFERENT CURING METHOD AND EFFICIENCY OF CURING COMPOUNDS", international journal of advanced engineering technology/Vol. IV/ Issue Il.

[7] Ya Wei, Yaping Xiang and Qianqian Zhang.(MAY 2014)."Internal Curing Efficiency of Prewetted LWFAs on Concrete Humidity and Autogenous Shrinkage Development ", journal of materials in civil engineering © ASCE.

[8] Kucharczykova B., Topolar L., Danek P., Kocab D. and Misak P.(2017). "Comprehensive Testing Techniques for the Measurement of Shrinkage and Structural Changes of Fine-Grained Cement-Based Composites during Ageing", Advances in Materials Science and Engineering,Hindawi Publishing Corporation, ISBN-1687-8434, (pp 01-10).

[9] Aslam M., Shafigh P. and Jumaat M.Z.(2015) "*Applied Mechanics & Materials*", (pp-*749*).

[10] Collepardi M., Betonov´e stavitelstv.(2009). "*The New Concrete*", the ˇCKAIT Information Centre for the Czech Chamber of Certified Engineers and Technicians Active in Construction (ˇCKAIT), Praha, 1st edition, (pp.342).

[11] Kucharczykova B., Danek P., Kocab D. and Misak P.(2017) "*Advances in Materials Science and Engineering*".

[12] Kumar P.S., Babu M., Kumar K.S. and Kumar.(2008). "Experimental Study on Lightweight Aggregate Concrete." *The Indian Concrete Journal*, (pp.46-52).

[13] Carlson R.W.(1938) "Drying shrinkage of concrete as affected by many factors." *American Soc Testing & Materials Proc.*.