

Laboratory investigation on the strength gaining of brick aggregate concrete using Ordinary Portland cement and Portland Composite Cement

¹Hoque M H, ²Numen E H, ³Islam N and ⁴Mohammed

¹Associate Professor, Department of Civil Engineering, Dhaka University of Engineering & Technology,

^{2,3,4}Structural Engineer, Development, Design & Management

Corresponding Email: ¹mhoque@duet.ac.bd

Abstract : *This study focused on the laboratory investigation of strength variation of brick aggregate concrete made with ordinary Portland cement (OPC) and Portland composite cement (PCC). The investigation was conducted by testing concrete cylinder specimens at different ages of concrete with concrete mix ratios: 1:1.5:3 and 1:2:4 by volume and with water cement ratios=0.45 and 0.60. The test result reveals that at the early age, concrete composed with OPC attained larger compressive strength than the concrete made of PCC. However, in the later age concrete made with PCC achieved higher strength than OPC.*

Keywords: Compressive strength, Brick aggregate, Fly ash, Pozzolanic reaction.

I. Introduction

With the advent of modern technology strength of concrete is the most significant among different engineering properties of concrete for RC structures in structural engineering world. Compressive strength of concrete is affected by a several factors including type and composition of cementitious materials, type and shape of coarse aggregate, concrete mix proportions, water cement ratio, as well as curing conditions, temperature and period. Since about seventy five percent of total volume of concrete is made up with aggregate, hence the strength is more like dependent to type of aggregate, stated according to Neville, A. M.(1995) [1]. Due to the availability and economic expenditure in Bangladesh, crushed brick is commonly used as a coarse aggregate compared to crushed stone. Akhtaruzzaman et al., (1983) [2] pointed out that the crushed brick are extensively used in Bangladesh and India for making concrete and the performance of this concrete is quite satisfactory. According to Cachim(2009) [3], the properties of concrete having crushed brick aggregate is partial substitute. Experimental investigation has also been done to achieve higher strength concrete using crushed brick aggregate. It has been found that even recycled brick can also be used as coarse aggregate in concrete. N.S. Apebo et al. (2013) [4] reported that for same workability of concrete, brick aggregate concrete requires greater water cement ratio than gravel aggregate concrete. Uddin et al. (2013) [5] investigated that the early age strength of PCC concrete is lower than that of OPC concrete. They found that the lack of proper pozzolanic reaction in the presence of fly ash in PCC concrete strength is lower at early age. The pozzolanic activity of fly ash also contributes to the strength gain at later stages of continuous curing. Strength at any given age and rate of strength gain of mortars and concretes containing fly ash will depend on the pozzolanic reactivity of the fly ash (Jansen et al., 2012[6]; Wongkeo et al., 2012[7]).

Shafiq (2011) [8]; Berry E. E et al., (1980) [9]; Naik, T.R. and Ramme, B.W. (1989) [10] stated that addition of fly ash in concrete increases the workability of concrete results lower water requirements in concrete. It also provides the conveniences of reduced bleeding, reduced segregation, lowered heat of hydration and reduce permeability. Sometimes drying ambient disorders significantly reduce the strength potential of concrete made with PCC for secondary (pozzolanic) reaction fails to contribute to gain of strength (Mahasneh and Shawabkeh, (2004) [11]; Razak and Sajedi, (2011) [12]; Sata et al., (2012) [13]). Ozlem Celik et al. (2008) [14] pointed out that the compressive strength of concrete is effectively depends on fineness of fly ash of Portland cement. Omotola Alawode et al. (2009) [15] indicated compressive strength of concrete is increase with age, but decreases as the water cement ratio increases. In view of Saul (1951) [16] and Kim et al. (1998) [17] investigation, the strength of concrete is relying on the combined effect of curing time and temperature during hardening process. They found that the concrete strength gain at early-age subjected to a high temperature. Now a days, there are two types of cement are available in the market named OPC and PCC. The PCC contains specified proportion of fly ash to minimize the raising production cost, whereas OPC do not use fly ash. The composition of ingredients of PCC and OPC are not same produced in the different industries. Since the properties as well as the contribution to strength of both PCC and OPC are differing. Hence it is necessary to investigate the variation of strength as well as the strength gaining rate of concrete consisting with PCC and OPC.

In this study the authors attempted to investigate the variation of strength of brick aggregate concrete made with PCC and OPC. For purposing the investigation a total of 96 concrete cylindrical specimens were made with concrete of two different mix proportions and two different water cement ratios. The specimens were tested at an ages of 7 days, 28 days, 60 days and 90 days. It was found from the experiment that at the early age OPC offers higher strength, but at later age PCC gains a higher compressive strength than OPC.

II. Material and Methodology

This part of the study demonstrates the materials and methods which are relevant to the experiments to have the strength variation of concrete made with OPC and PCC at earlier and later ages. Locally available materials were used like crushed bricks (Coarse aggregate), Sylhet sand (Fine aggregate), and cement (OPC and PCC). For performing experimental test a total of 96 cylinders were casted with

changing parameters. The specimens were measured 6 inch in diameter and 12 inch in height. The parameters used were concrete mix proportions (1:1.5:3 and 1:2:4), water cement ratio (0.45 and 0.60) and binding materials (PCC and OPC). The identification of the specimens is illustrated as in given table.1.

II.A Materials Properties

II.A.1 Properties of Aggregate

Locally available Sylhet sand was used as fine aggregate. While 20 mm downgraded crushed Brick was used as coarse aggregate. The physical properties of coarse and fine aggregate are enlisted in table 2. The particle size distribution (fineness modulus) of coarse and fine aggregate was performed by sieve analysis (Figure 1 & Figure 2) using ASTM standards C136. The fineness modulus of fine and coarse aggregate are obtained from sieve analysis is 2.65 and 4.86 respectively.

Table 1: Identification of specimens

Type of Cement	Concrete Mix Proportions	Water Cement Ratio	No. of Specimen
PCC	1:1.5:3	0.45	12
	1:1.5:3	0.60	12
	1:2:4	0.45	12
	1:2:4	0.60	12
OPC	1:1.5:3	0.45	12
	1:1.5:3	0.60	12
	1:2:4	0.45	12
	1:2:4	0.60	12

Table 2: Physical Properties of Coarse and Fine Aggregate

Properties	Local sand	Crushed Brick chips
Maximum Aggregate Size (mm)	2.73	20
Bulk Specific Gravity	-	6.79
Absorption Capacity (%)	1.20	9.26
Unit Weight (lb/ft ³)	99.01	68.30
Fineness modulus	2.65	4.86



Figure 1 Sieve Analysis of Coarse

Aggregate



Figure 2: Sieve Analysis of Fine Aggregate.

II.A.B Properties of Cement

Cement is used as an adhesive material in concrete mixture. In present investigation Portland composite cement (PCC) and Ordinary Portland cement (OPC) were used. The compressive and tensile strength of cement was given in table 3. The normal consistency and setting test of cement were accomplished according to the ASTM standard requirements of specification C 187 and C 191 for normal consistency and setting times respectively. The consistency value of cement was between 22 to 30 percent by weight of dry cement. The initial setting time was 34 minutes and final setting time 250 minutes.

Table 3: The average compressive and tensile strength of cement

Days	Compressive strength (MPa)	Tensile strength (MPa)
03	16.87	1.10
07	19.14	1.95

II.B Mixture Compositions

In this investigation concrete mixture proportioned of 1:1.5:3 and 1:2:4 by volume were used with a different water cement ratios 0.45 and 0.60. OPC and PCC were used for separated specimens but the coarse aggregate and the fine aggregate were constant in each specimen.

II.C Preparation of Specimen

In the study cement type, concrete mix proportions and water cement ratio were considered as parameters. The specimens were prepared by changing the parameters. For concrete mixing Batch mixture was used based on volumetric measurements. The mixing speed was 15 to 20 revolutions per minute and mixing time was 5 to 6 minutes. After mixing the concrete slump was measured. Slump was found 50 mm for the mixing proportions 1:1.5:3 and 1:2:4 and water cement ratio 0.45 and 0.60 for both PCC and OPC used concrete. Slump test was performed according to ASTM C-143-90a and BS 1881 part 120:1983. In placing and compaction of concrete ACI specifications was followed. Test specimens were then immersed in curing tank for 28 days.

II.D Testing Procedure

The cylinder specimens were placed on Universal testing machine with a load application capacity of 1000 KN for compressive strength test as shown in following figure. For tensile test of concrete splitting test was performed. The specimens were tested at an age of 7 days, 28 days, 60 days and 90 days.



Figure 3: A typical cylindrical specimen under loading

III. Results and Tables

The specimens were tested for both compressive strength and tensile strength. The obtained results are illustrated in Table.2-9. Concrete made of OPC and PCC exhibit the strength gaining characteristics at early and later ages. Figure 2 to Figure 5 represents the variation of strength gaining of OPC and PCC contained concrete. The line graph shows an increase in strength over 45 days. End of this period OPC concrete attains a higher strength than PCC concrete for both different mix proportions and water cement ratio. The line also represents that after 45 days PCC contained concrete achieves larger compressive strength than OPC. This trend was also observed for tensile strength equally.

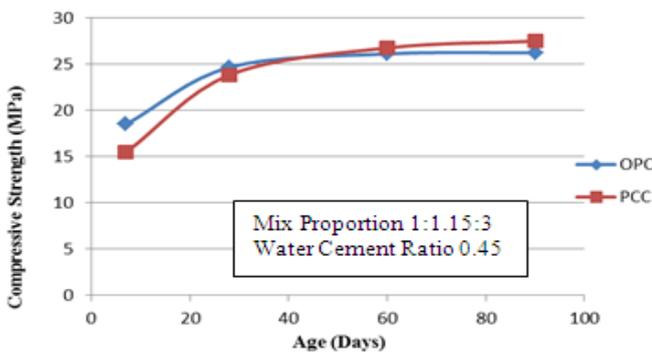


Figure 4: Effect on Compressive strength of OPC and PCC in brick aggregate concrete.

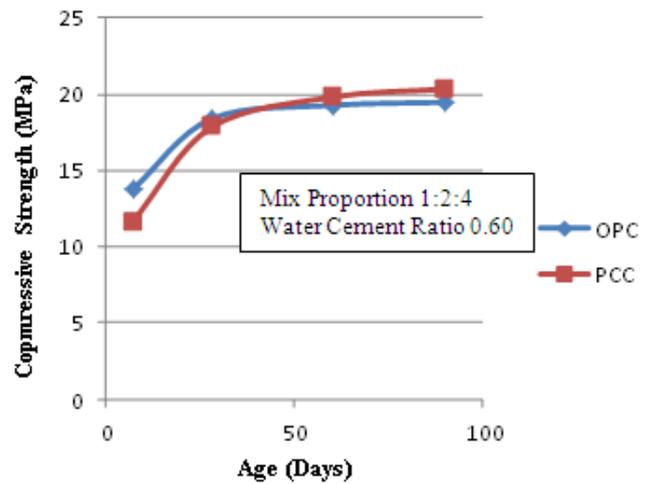


Figure 5: Effect on Compressive strength of OPC and PCC in brick aggregate concrete.

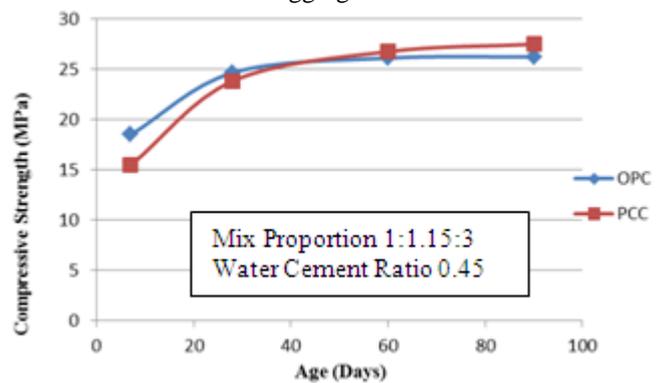


Figure 6: Effect on Tensile strength of OPC and PCC in brick aggregate concrete.

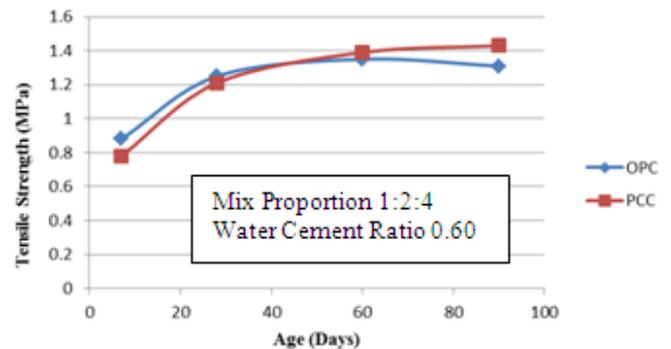


Figure 7: Effect on Tensile strength of OPC and PCC in brick aggregate concrete.

IV. Conclusion

This study illustrates the influence of using OPC and PCC in brick aggregate concrete on the strength discrimination. In the experimental investigation it has been found that concrete with OPC achieves higher strength than concrete made with PCC in the early age. However in the latter age concrete of PCC shows higher strength than that of OPC contained concrete. Particularly concrete with OPC achieves higher compressive strength up to an age of 40-45 days, whereas after 40-45 days concrete made with PCC starts to attain higher progressive compressive strength with age. Indeed, like compressive

strength same trend is also observed equally for tensile strength. Finally, it may conclude that the compressive strength is increased by 0.135% while the tensile strength is climbed by 0.175% up to 90 days for concrete containing PCC

References

- i. Neville, A. M. "Properties of Concrete" (Fourth and Final Edition), Pearson Educational Limited, Delhi, 1995.
- ii. Akhtaruzzaman, Ali A., and Abdul, H, "Properties of Concrete Using Crushed Brick as Aggregate", *Concrete International, Design and construction*, vol. 5, No. 2, PP. 58-63, Feb.1983.
- iii. Cachim, P.B. "Mechanical Properties of brick aggregate concrete" ,*Construction and Building Materials*, 23, 2009, pp. 1292-1297.
- iv. Apebo, N.S., Iorwu, M.B., and Agunwamba, J.C. (2013). "Comparative analysis of the compressive strength of concrete with gravel and crushed over burnt bricks as coarse aggregate" *Nigerian journal of technology (NIJOTECH)*, Vol. 32, No. 1, March, 2013, pp. 7.
- v. Uddin, M.A, Jameel, M., Rahman, H.S., Islam, M.S., and Hasan, N.M.S. (2013). "Experimental study on strength gaining characteristics of concrete using Portland cement." *KSCE journal of Civil Engineering* (2013) 17(4):789-796.
- vi. Jansen, D., Neubauer, J., Goetz-Neunhoeffler, F., Haerzschel, R., and Hergeth, W.-D. (2012). "Change in reaction kinetics of a Portland cement caused by a superplasticizer — Calculation of heat flow curves from XRD data." *Cem. Concr. Res.*, Vol. 42, No. 2, pp. 327–332.
- vii. Wongkeo, W., Thongsanitgarn, P., and Chaipanich, A. (2012). "Compressive strength and drying shrinkage of fly ash-bottom ash-silica fume multi-blended cement mortars." *Materials & Design*, Vol. 36, pp. 655-662.
- viii. Shafiq, N. (2011). "Degree of hydration and compressive strength of conditioned samples made of normal and blended cement system." *KSCE J. Civ. Eng.*, Vol. 15, No. 7, pp. 1253-1257.
- ix. Berry, E.E., and Malhotra, V.M., "Fly Ash for Use in Concrete - A Critical Review", *ACI Journal*, Vol. 77, No. 2, March/April, 1980, pp. 59-73.
- x. Naik, T.R., and Ramme, B.W., "High-Strength Concrete Containing Large Quantities of Fly Ash", *ACI Materials Journal*, Vol. 86, No. 2, March-April 1989, pp 111-116.
- xi. Mahasneh, B. Z. and Shawabkeh, R. A. (2004). "Compressive strength and permeability of sand-cement-clay composite and application for heavy metals stabilization" *American J. of Applied Sci.*, Vol. 1, No. 4, pp. 01-04.
- xii. Razak, H. A. and Sajedi, F. (2011). "The effect of heat treatment on the compressive strength of cement-slag mortars" *Materials & Design*, Vol. 32, Nos. 8-9, pp. 4618-4628.
- xiii. Sata, V., Tangpagasit, J., Jaturapitakkul, C. and Chindapasirt, P. (2012). "Effect of W/B ratios on pozzolanic reaction of biomass ashes in Portland cement matrix" *Cem. Concr. Comp.*, Vol. 34, No. 1, pp. 94-100.
- xiv. Celik, O, Damci E, Piskin S. (2008). "Characterization of fly ash and its effects on the compressive strength properties of Portland cement." *Indian journal of Engineering and Materials Sciences*, Vol. 15, October 2008, pp. 433-440.
- xv. Alawode, O. and Idowu, O.I. (2011) *The Pacific Journal of Science and Technology* Volume 12. Number 2. November 2011 "Effects of Water-Cement Ratios on the Compressive Strength and Workability of Concrete and Lateritic Concrete Mixes."
- xvi. Saul, A. G. A. (1951). "Principles underlying the steam curing of concrete at atmospheric pressure" *Magazine of Conc. Res.*, Vol. 2, No. 6, pp. 127-140.
- xvii. Kim, J. K., Moon, Y. H., and Eo, S. H. (1998). "Compressive strength development of concrete with different curing time and temperature" *Cem. Concr. Res.*, Vol. 28, No. 12, pp. 1761-1773.