COMPARATIVE STUDY THE EFFECT OF DIFFERENT TYPES CHEMICAL ADMIXTURES IN ECOFRIENDLY SAND CEMENT BLOCK

Md Wahab Ali[*1], Md Jahid Shahshuja[2], Tabassum Binte Reza[3], Ahsan Habib[4], Md Nafizur Rahman[5], Md Ashraful Alam[6]

[1]Research Officer, Housing and Building Research Institute, Bangladesh, e-mail: chemistmdwahabali@gmail.com
[2] Research Officer, Housing and Building Research Institute, Bangladesh, e-mail: jahid.shahshuja@hbri.gov.bd
[3]Research Fellow, Housing and Building Research Institute, Bangladesh, e-mail: tabassumreza497@gmail.com
[4]Senior Research Office, Housing and Building Research Institute, Bangladesh, e-mail: ahsan.habib@hbri.gov.bd
[5]Principal Research Officer, Housing and Building Research Institute, Bangladesh, e-mail: nafizhbri@gmail.com
[6]Director General, Housing and Building Research Institute, Bangladesh, e-mail: dg@hbri.gov.bd

***Corresponding Author**

ABSTRACT

Contaminated and unused dredged sediment may turn into national wealth if it is properly utilized. The main purpose of this research is to investigate the minimum cement content required with an appropriate water-to-cement ratio (w/c) to meet given workability, strength, and durability requirements in a concrete pavement; and to reduce carbon dioxide emissions, energy consumption, and costs. Along with a small ratio of Composite Portland cement (25%), a negligible percentage (0.5 to 1.5%) of admixture has been used during the research at Housing and Building Research Institute. Stabilization or solidification method was conducted to remove toxic and organic contaminants. Having been made the raw blocks manually and automatically, blocks were cured for 28 days to check the ultimate compressive strength, water absorption. From the perspective of cost and benefit, we have calculated that it outright cost-effective and environment gets enormous benefit. This new, effective idea and solution can certainly lessen the problem of dredging sediment disposal and produce eco-friendly construction materials.

Keywords: *Dredged Sand, Chemical Admixture, Composite Portland cement, Compressive Strength, Water Absorption*

1. INTRODUCTION

Concrete comprises 90–95 percent of all building materials used globally for structural and non-structural uses, compared to other materials used for corresponding purposes (Zaid et al., 2020). In general, cement, water, and aggregates make up concrete. An additional component known as an admixture is added to the mix to change certain properties of the concrete. Due to the numerous versatile possibilities, concrete blocks are among the most versatile building materials on the market.
In recent years, utilizing chemical and mineral admixtures in concrete buildings has seen tremendous success. Concrete blocks can benefit from various additive effects when admixtures are appropriately used. Admixtures are substances added to the mixture before or while it is being mixed to make concrete, in addition to Portland cement, water, and aggregates. According to test results, the ideal admixture dose varies depending on the kind and brand of cement and admixture, ranging from 0.9% to 1.1% of the weight of cement (Shrivastava & Kumar, 2016).

To increase high workability, greater strength, high modulus of elasticity, higher density, higher dimensional stability, low permeability, and resistance to chemical attack in concrete, superplasticizers are typically employed in high-strength concrete, precast concrete, and concrete for these purposes (Shah et al., 2013). The most popular method for enhancing workability is strengthening the concrete by adding more cement and gradation. Usually, more water is utilized, which could harm concrete's strength and longevity. Using a superplasticizer will reduce the amount of water needed to make the concrete more workable, according to (Muhit, 2013).

Superplasticizer based on polycarboxylate ether was utilized by Sadrmomtazi & Fasihi (2010) to control the fluidity of mortars. The recent generation of poly(carboxylate ether)-based superplasticizers, or PCEs, have side chains made of poly(ethylene oxide) that extend from the cement surface into the pore solution to provide steric hindrance effect in addition to having acrylate groups in the backbone (Fan et al., 2012; Liao et al., 2006). Mardani-Aghabaglou et al.,'s (2013) study of various polycarboxylic ether-based admixtures revealed good flowability was imparted to concrete by polycarboxylic ether-based admixtures with low side chain density. In a study of the compressive strengths of concretes made with various admixtures. Papayianni et al., (2005) found that, after 28 days, the admixture based on modified polycarboxylic ether polymer gave the concrete a higher compressive strength than the admixtures based on sulfonated polymer and synthetic polymer. The slump flow results of concretes manufactured with lignosulfonate-based admixture and naphthalenesulfonate-based admixture were examined by (Topçu & Ateşin, (2016). Their findings show that naphthalenesulfonate-based admixture improves the flowability of concrete when compared to lignosulfonate-based admixture.

Concrete can have its fluidity increased without adding more water by using superplasticizers. As shown in Chapter 11 by Gelardi & Flatt (2016), these molecules physically separate the cement particles by resisting their attractive forces with steric and/or electrostatic forces. Without changing the water-to-binder (w/b) ratio, which determines the strength and durability of concrete, they can be used to improve workability. The concrete is, therefore, easier to place. Long-term maintenance of the concrete's workability—at least one and a half hours—is advantageous for various procedures, such as transport, pouring, pumping, compaction, and casting (Nkinamubanzi et al., 2016). Superplasticizers frequently lessen the tendency of cement to bleed in both fresh and hardened conditions because they diminish the water/cement ratio or the water content of the concrete. Utilizing a superplasticizer in the case of hardened concrete increases compressive strength by improving compaction effectiveness, resulting in denser concrete (Alsadey, 2015).

With ever growing concern of environment pollution caused by construction materials/activities, scarcity of natural resources like water adoption of smart technical options to address the concerns is the key for survival of the concrete industry. With availability of variety of cements, apart from ordinary Portland cement, producing concrete of appropriate design strength at low water cement ratio necessitates the use of admixtures (Gandage, 2023). In order to produce ecofriendly sand cement concrete block, this research intends to assess the performance of polycarboxylate ether and lignosulfonate-based admixtures.

2. MATERIALS AND METHODOLOGY

2.1 Materials

This experiment used cement, fine aggregates, and admixtures (based on polycarboxylate ether and lignosulfonate). Sand cement solid blocks are mixed with two different admixtures to examine their effect on concrete blocks.

2.1.1 Cement

Portland Composite Cement (PCC), also known as CEM-II, was acquired commercially on the local market and used in this investigation. Table 1 shows the chemical composition of CEM-II cement. Table 2 shows the physical properties of cement.

Table 1 Chemical composition of cement

Chemical composition	**Content, %**
CaO	60-67
SiO_2	17-25
Al_2O_3	3-8
Fe_2O_3	0.5-6
MgO	0.1-4
Alkalies (K_2O, N_2O)	0.4-1.3
SO_3	1.3-3

Table 2 Physical properties of cement

Normal consistency	28%
Initial setting time	70 min
Final setting time	245 min

2.1.2 Sand

Sand that was dredged from rivers was employed as the fine aggregate in this experiment. The fine aggregate's features are shown in Table 3.

Table 3 Properties of fine aggregate (dredged sand)

Properties	**Sand**
Specific gravity	2.60
Fineness modulus	1.13
Unit weighty, kg/m^3	1620

2.1.3 Admixtures

Polycarboxylate ether (PCE) is a light brown liquid with a long lateral chain containing no chloride, adhering to ASTM C494 Type F. At 25 degrees Celsius, this superplasticizer's specific gravity is 1.05. The previous study found that it increases concrete's strength, density, and workability. An effective mix may be made using this high-range water-reducing admixture employed in research. PCE reduces water demand by 30–40%.

Lignosulfonate-based admixture is a dark brown liquid; its specific gravity is 1.17 at 25 degrees Celsius. The recommended dosage of this admixture is 0.23–0.47% (weight of cement), which reduces water demand by 10-15%. Figure 1 and Figure 2 show polycarboxylate-based superplasticizer and lignosulfonate-based admixture respectively.

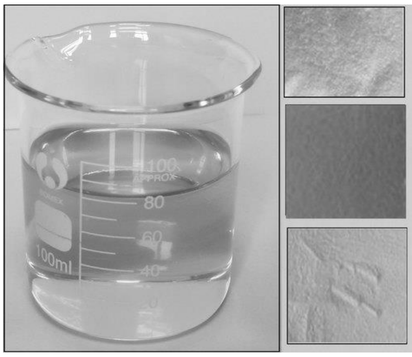

Figure 1: Polycarboxylate ether based superplasticizer

Figure 2: Lignosulfonate-based admixture

In a hydraulic press machine, the blocks are produced. The Hydraulic Hollow machine has blocks with a cast size of 400x200x100mm, consisting of dredged sand, cement, admixture, and water. The manufacturing process involves - mixing ingredients, placing them in molds, receiving hydraulic compaction pressure of 2000 psi, and drying the molded mixture. The blocks are then tested and cured in groundwater for 28 days.

2.2 Methodology

Cement and sand were mixed in a nominal ratio 1:4 in each case. This experiment employed three types of sample preparation. In case 1, just sand and cement were used in the construction, represented as Mix-1. In case 2, sand, cement, and a combination of polycarboxylic ether-based admixture (0.5%, 1%, and 1.5% of cement by weight) were employed, as represented by Mix-2, Mix-3, and Mix-4. In case 3, lignosulfonate ether-based admixture (0.5% of cement by weight) was used with sand and cement (Mix-5). In all cases, the water-cement ratio was kept at 0.4. Solid blocks containing sand and cement were prepared using a hydraulic press machine. The production method of blocks typically comprises three steps: 1) Combining the elements in the pan mixture, 2) Forming the blocks, and 3) After filling the molds with the combined components, the molds are compressed to around 2000 Psi using a hydraulic compaction pressure machine. Finally, the molded mixture material was transported to a drying area to give covered internal curing into polyethylene. Finally, the molded mixture material was moved to a drying area for covered internal water spray curing, followed by ASTM C31/C31M-21a. The blocks were placed on the field ground for 28 days to cure properly. After proper curing, Sand cement blocks of 9.5”X4.5”X2.75” were tested at 28 days. The average weight of the blocks was 3.5 kg.

2.2.1 Hardened Properties

The ratio of the load that causes a specimen to fail during uniaxial compression to the cross-sectional area is known as the compressive strength of concrete. A concrete block (9.5”X4.5”X2.75”) was used to test this quality. The procedure followed ASTM C39 (ASTM, 2020). The specimens were centered on the base plate to evenly distribute the load across the two sides. The load was gradually added at an 8–21 MPa/min rate until the sample failed.

The water absorption test was done in accordance with ASTM C642 (ASTM, 2013). After being oven-dried to a consistent mass, the samples were submerged underwater for at least 48 hours. It was then decided what the saturated and surface dry weight (SSD) were.

3. ILLUSTRATIONS

The inquiry focused on the characteristics of how concrete blocks treated with admixtures developed their strength. The identical W/C ratio was used throughout the examination, but each mixture's admixture dosage was different. At 7, 14, and 28 days, the effects of the polycarboxylic ether-based (PCE) admixture on the compressive strength of solid sand cement blocks were noted.

3.1 Figures and Graphs

Figure 3 shows the change of w/c ratio with varied admixture.

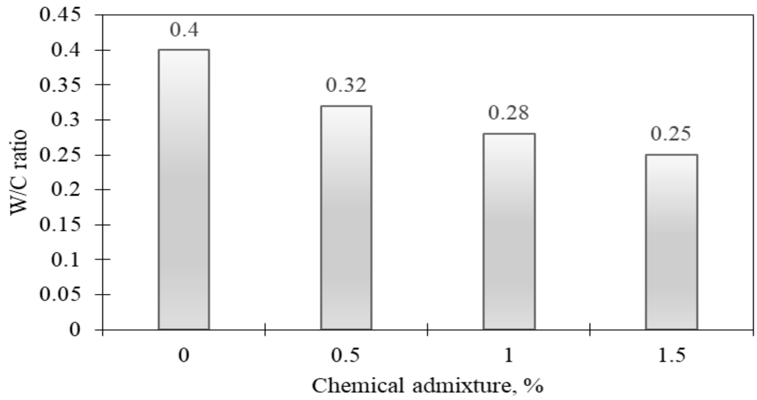

Figure 3: Variation of W/C ratio with chemical admixture

Figure 4 shows the effect of PCE on compressive strength, where 0.5% SP bar shows the highest compressive strength in each case. 0.0% SP bar shows the lowest compressive strength where no admixture was used. It is seen that the compressive strength is gradually decreasing in 1.0% and 1.5% bars.

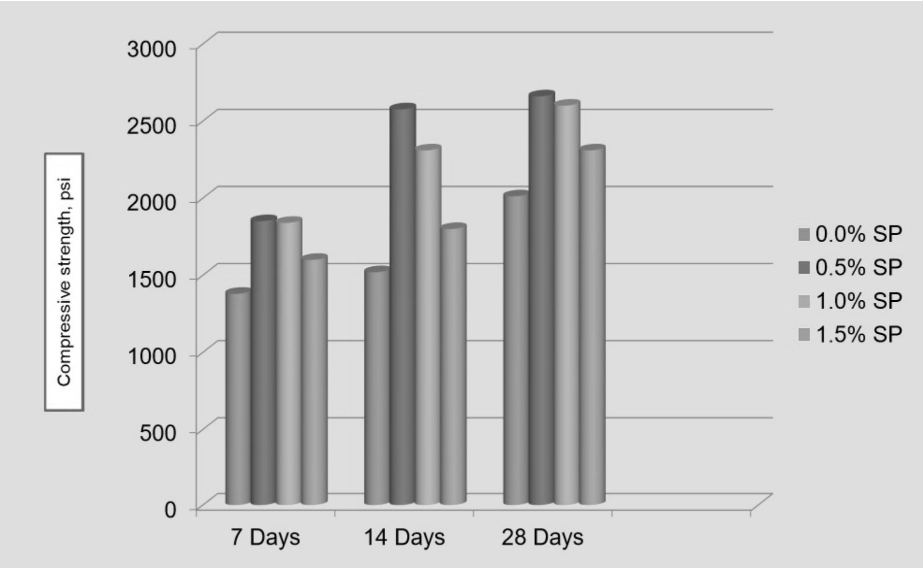

Figure 4: Effect of polycarboxylate ether based superplasticizer on compressive strength

Figure 5 shows the average compressive strength in all the cases. No plasticizer blocks have the least and superplasticizer blocks have the highest value of compressive strength.

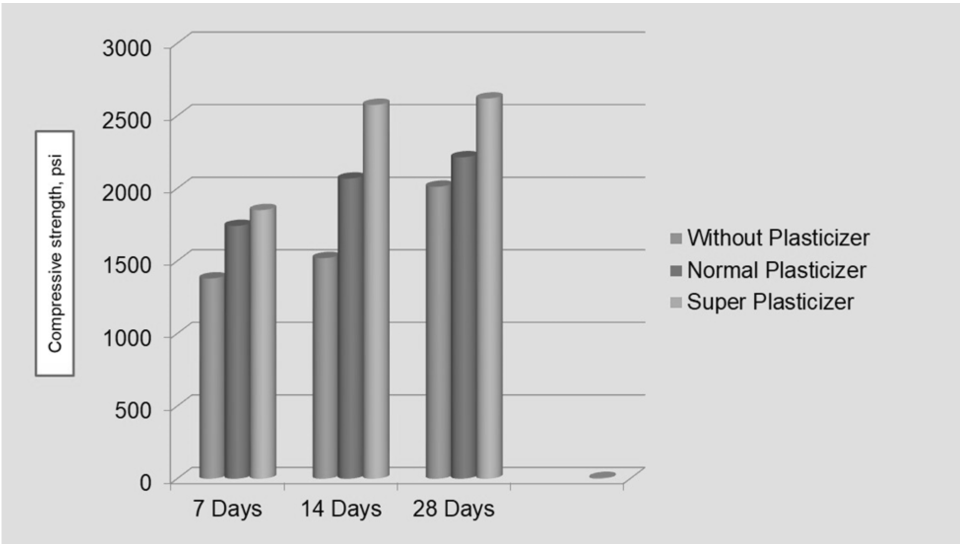

Figure 5: Effect of admixtures on compressive strength

3.2 Tables

A summary of the results is shown in Table 4. It should be highlighted that when 0.5% admixture is applied, the strength for 28 days rose by 41.5% compared to 7 days for Mix-2. Additionally, the 28-day strength for 1% admixture (Mix-3) has been increased to 41.3% from 7 days, though the strength is lower than Mix-2. At 28 days, Mix-4 shows the highest strength increase, 44.4%, compared to 7 days. But the strength is lower than Mix-2 and Mix-3.

Table 4: Compressive strength of concrete

Specimen	Mix ratio (cement:sand)	Chemical admixture % (polycarboxylic ether-based)	Water:cement	Average compressive strength (psi)		
				7 days	**14 days**	**28 days**
Mix-1	1:4	-	0.4	1380	1520	2012
Mix-2	1:4	0.5	0.32	1851	2576	2620
Mix-3	1:4	1.0	0.28	1840	2310	2600
Mix-4	1:4	1.5	0.25	1600	1800	2310

1. It is found that all the mixes with different percentage of PCE have higher compressive strength than Mix-1.
2. Mix-2 has the highest compressive strength 1851 psi, 2576 psi, and 2620 psi after 7, 14, and 28 days, respectively.
3. With the increase of admixture percentage in Mix-3, and Mix-4, the compressive strength decreases.
4. Mix-4 has the least compressive strength 1600 psi, 1800 psi, and 2310 psi after 7, 14, and 28 days, respectively.

As the maximum compressive strength is found when 0.5% PCE based admixture is used, another mix (Mix-5) is done using the same percentage of sulfonate-based admixture. The result is better than the control mix (Mix-1) but hasn't reached the strength of PCE. Table 5 summarizes the results.

Table 5 Summerize result

Specimen	Mix ratio (cement:sand)	Chemical admixture, %	Water:cement	Average compressive strength, psi		
				7 days	**14 days**	**28 days**
Mix-2	1:4	0.5 (PCE)	0.32	1851	2576	2620
Mix-5	1:4	0.5 (LS)	0.36	1354	1742	2022

1. The compressive strength of Mix-2 after 7, 14, and 28 days are 1851 psi, 2576 psi, and 2620 psi, respectively.
2. The compressive strength of Mix-5 after 7, 14, and 28 days are 1354 psi, 1742 psi, and 2022 psi, respectively.

4. CONCLUSIONS

From the experiment, the following conclusions may be drawn:

- The water cement ratio of mortar (1:4) decreases with increases of chemical admixture.
- The 0.5 to 1% of plasticizer is recommended for higher compressive strength.
- At higher dosages, there is a problem of excessive retardation and also decreases compressive strength.
- We got higher compressive strength sand cement block with using super plasticizer rather than normal plasticizer.
- The water absorption of the blocks was between 4-6% which satisfy the standard value.
- No efflorescence was found when the blocks were tested.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Physical and Chemical Testing & Research Laboratory team at HBRI's friendly cooperation. The authors appreciate the advice they received from the senior HBRI officials

REFERENCES

Alsadey, S. (2015). Effect of Superplasticizer on Fresh and Hardened Properties of Concrete. In *Journal of Agricultural Science and Engineering* (Vol. 1, Issue 2). http://www.publicscienceframework.org/journal/jasehttp://creativecommons.org/licenses/by-nc/4.0/

Fan, W., Stoffelbach, F., Rieger, J., Regnaud, L., Vichot, A., Bresson, B., & Lequeux, N. (2012). A new class of organosilane-modified polycarboxylate superplasticizers with low sulfate sensitivity. *Cement and Concrete Research*, *42*(1), 166–172. https://doi.org/10.1016/j.cemconres.2011.09.006

Gandage, A. S. (2023). *Admixtures in Concrete-A Review*.

Gelardi, G., & Flatt, R. J. (2016). Working mechanisms of water reducers and superplasticizers. In *Science and Technology of Concrete Admixtures* (pp. 257–278). Elsevier Inc. https://doi.org/10.1016/B978-0-08-100693-1.00011-4

Liao, T. S., Hwang, C. L., Ye, Y. S., & Hsu, K. C. (2006). Effects of a carboxylic acid/sulfonic acid copolymer on the material properties of cementitious materials. *Cement and Concrete Research*, *36*(4), 650–655. https://doi.org/10.1016/j.cemconres.2005.10.005

Mardani-Aghabaglou, A., Tuyan, M., Yilmaz, G., Ariöz, Ö., & Ramyar, K. (2013). Effect of different types of superplasticizer on fresh, rheological and strength properties of self-consolidating concrete. *Construction and Building Materials*, *47*, 1020–1025. https://doi.org/10.1016/j.conbuildmat.2013.05.105

Muhit, I. B. (2013). Dosage Limit Determination of Superplasticizing Admixture and Effect Evaluation on Properties of Concrete. *International Journal of Scientific & Engineering Research*, *4*. http://www.ijser.org

Nkinamubanzi, P. C., Mantellato, S., & Flatt, R. J. (2016). Superplasticizers in practice. In *Science and Technology of Concrete Admixtures* (pp. 353–377). Elsevier Inc. https://doi.org/10.1016/B978-0-08-100693-1.00016-3

Papayianni, I., Tsohos, G., Oikonomou, N., & Mavria, P. (2005). Influence of superplasticizer type and mix design parameters on the performance of them in concrete mixtures. *Cement and Concrete Composites*, *27*(2), 217–222. https://doi.org/10.1016/j.cemconcomp.2004.02.010

Sadrmomtazi, * A, & Fasihi, A. (2010). INFLUENCE OF POLYPROPYLENE FIBERS ON THE PERFORMANCE OF NANO-SIO 2-INCORPORATED MORTAR. In *Iranian Journal of Science & Technology, Transaction B: Engineering* (Vol. 34, Issue B4). www.SID.ir

Shah, A., Khan, S., Khan, R., & Jan, I. U. (2013). "Research Note" EFFECT OF HIGH RANGE WATER REDUCERS (HRWR) ON THE PROPERTIES AND STRENGTH DEVELOPMENT CHARACTERISTICS OF FRESH AND HARDENED CONCRETE. In *Transactions of Civil Engineering* (Vol. 37).

Shrivastava, A. K., & Kumar, M. (2016). Compatibility issues of cement with water reducing admixture in concrete. *Perspectives in Science*, *8*, 290–292. https://doi.org/10.1016/j.pisc.2016.04.055

Topçu, İ. B., & Ateşin, Ö. (2016). Effect of high dosage lignosulphonate and naphthalene sulphonate based plasticizer usage on micro concrete properties. *Construction and Building Materials*, *120*, 189–197. https://doi.org/10.1016/j.conbuildmat.2016.05.112

Zaid, O., Manan, A., Beddu, S., Ahmad, J., Ur Rehman, S., & Ahmad, M. (2020). TO STUDY THE CHARACTERISTICS OF CONCRETE BY USING HIGH RANGE WATER REDUCING ADMIXTURE. In *www.tjprc.org SCOPUS Indexed Journal editor@tjprc.org*. https://www.researchgate.net/publication/352704892