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EFFECT OF HIGH RANGE WATER REDUCING (SUPERPLASTICIZER) ALONG WITH EARLY STRENGTH ADMIXTURE ON MECHANICAL PERFORMANCE OF SAND CEMENT BLOCK

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ABSTRACT

During July 2020 and June 2021, the experiments were conducted in a laboratory plant at the Housing and Building Research Institute,Dhaka,Bangladesh. In recent decades, the development of superplasti cizers has served as a source of inspiration for creating chemical admixtures. High range water reducing (Superplasticizer) (ASTM C494 type F) with a low water content of high functioning and accelerating additive (ASTM C494 type C) expresses concrete the fast adjusting and hardening impact of concrete. Every combination has a considerable effect on the concrete block. This study's goal is to determine the impact of a single application of High range water reducing superplasticizer (ASTM C494 type F) and a combined application of HRWR superplasticizer(ASTM C494 type F) and accelerating admixture (ASTM C494 type C) on the characteristics of Sand Cement block made from natural river sand and cement. This sand cement block is an alternative block to traditional brick. The cement and river sand was used in varying proportions, from 14% to 20% and 86 % to 80%, respectively. During this research, experiments were conducted on changes in the compressive strength of a concrete block with a single application of HRWR Superplasticizer (ASTM C494 type F) and mixing of two type admixtures with a varied water-cement ratio (0.28 and 0.3) between 7,14,28 days after casting. Admixture doses are taken in 200ml/50 kg of cement for the single superplasticizer application and 450ml/50 kg mixed cement usage of Admixture. Two tests were carried out: one for compressive strength and one for water absorption. When a 450 ml mix admixture dose is added to each cement bag, and the cement is allowed to cure for 28 days, compressive strength is increased by 3500 psi (24.14 Mpa)which is greater than that of a normal concrete block. When comparing the optimal water-cement ratio and chemical dosage to the normal block, the results showed that the compressive strength was higher with the best combination.

Keywords: *High range water reducing (Super plasticizer), Accelerating Admixture, Compressive Strength, Water Absorption, Sand cement block.*

1. INTRODUCTION

Compared to other materials used for similar functions, concrete represents 90-95 percent of all building materials utilized worldwide for structural and non-structural applications (Ahmad et al., 2020). In general, concrete is a material composed of cement, water, and aggregates, with an additional element known as an admixture to modify specific qualities of the concrete(Concrete, 2021). High range water reducers (HRWR) are generally used for high strength concrete, precast concrete, and concrete for increasing high workability, higher strength, high modulus of elasticity, higher density, higher dimensional stability, low permeability, and resistance to chemical attack (Shah et al., 2013).SP is classified into four basic categories: sulphonated naphthalene, Formaldehyde Condensed (SNF), Sulfonated Melamine Formaldehyde (SMF), and Modified Lignosulfonates (MLS), as well as other categories such as polyacrylates and polystyrene sulphonates, Polymers

(Ahmed et al., 2004). The most common approach to improving workability is to increase the gradation and cement content of the concrete. Typically, additional water is used, which can have a detrimental effect on the strength and durability of concrete. In this scenario, the final answer is to use a superplasticizer to minimize the amount of water required to make the concrete more workable (Muhit, 2013).

The HRWR affects a variety of characteristics of fresh and cured concrete. The slump increase caused by SP varies according to the kind of cement, the ambient temperature, the dose, and the type of HRWR ((Björnström and Chandra, 2003). Increasing the HRWR dose usually increases the initial setting time, which might benefit hot weather concrete (Gagn et al.,1996). On the other hand, Fresh concrete is exposed to cold weather in several countries or regions of countries. ACI defines cold weather as occurring when two conditions exist for three consecutive days: i) the average daily temperature does not exceed five °C; and ii) the air temperature surpasses ten °C for more than half a day during any 24 hours (306R-88 Cold Weather Concreting, 2002).

Cold weather retards the setting and hardening of concrete, freezes it at an early age, and thaws it, resulting in the formation of ice needles in the concrete. Cavities form due to the thawing of the ice needles, seriously hampering the structural integrity of the concrete and resulting in a significant loss of strength(Naqash et al., 2014). Accelerating Admixture is a substance added to concrete that speeds the hardening or development of early strength (Neville & Brooks, 1991).

Nominal ratios were determined based on-field practice. When mixing cement and water, it is possible to modify the specific clinker components to react with the water by adding chemical compounds. They are accelerating substances that impact these rates in an overall increase in the rate of hydration, i.e., an accelerating effect, which are termed accelerating admixtures. As a result, an accelerator is added to concrete to accelerate the curing process. They are establishing a schedule and enhancing early strength development (Naqash et al.,2014). There are several advantages to using a superplasticizer: Produce high workability concrete with constant cement content and strength to support placement and compaction; Produce concrete with normal workability but a lower water requirement; and design an average strength and workability concrete with less cement (Ramachandran et al., 1981). The usage of a Superplasticizer has a positive effect on the qualities of concrete in both the fresh and hardened states (Yamakawa et al.,1990). When it is used fresh, superplasticizers often reduce the tendency of cement to bleed due to a decrease in the water/cement ratio or the water content of the concrete. In the case of hardened concrete, using a superplasticizer increases compressive strength by increasing compaction efficiency, resulting in denser concrete (Alsadey,2015). Generally, various types of superplasticizers have varying impacts on the characteristics and performance of concrete(Borsai, 2000). This study will examine the effects of two kinds of SP on fresh and hardened concrete block properties.

2. METHODOLOGY

2.1 Materials

Cement, fine aggregates, and superplasticizers (SP-1 and SP-2) were performed in this experiment. Two categories of Superplasticizers are applied to sand cement solid blocks and investigate their characteristics for certain uses.

2.1.1 Cement

The cement utilized in this study is CEM-II,52.5 N Portland Composite Cement (PCC), acquired commercially on the local market.

2.1.2 Fine Aggregates

In this experiment, river dredged sand was used as the fine aggregate. F.M. value of this sand was 1.05, which is collected from the Meghna River at Chandpur region. It has a specific gravity of 2.60.

2.1.3 Characteristics of Super plasticizer

SP-1: This is liquid with a light brown color derived from the Polycarboxylate ether (CEE) group with a long lateral chain and contains no chloride. SP-1, adhering to ASTM C494 Type F. Specific gravity of this Super plasticizer is 1.27 at 30 degrees Celsius. According to the previous study, it improves the concrete strength, density, and workability. It is a high-range water-reducing admixture used in research to obtain a workable mix. This Super plasticizer was collected from the local market which commercial code is C 234.

SP-2:This is a chloride-free mixing liquid based on specified synthetic poly inorganic and organic compounds. It is delivered as a darkish brown solution with a specific gravity of 1.20 at 27 degrees Celsius. It meets ASTM C494 type C standards, collected from the local market whose commercial code is D 220. The raw materials are shown in figure-1.

a) Dredged Sand   b) Cement   c) HRWR Superplasticizer(SP-1)   d) Accelerating Admixture(SP-2)

Figure-1(a, b, c, d): The raw materials a) Dredged Sand, b) Cement, c) HRWR Super plasticizer (SP-1), and d) Accelerating Admixture (SP-2).

2.2 METHODS

Cement, fine aggregates were mixed in three nominal ratios of 1:4, 1:5, and 1:6 by weight. This experiment employed two types of sample preparation. In Case-1, just sand, cement, and SP-1 were used in the construction represented as Mix-A, Mix -B, and Mix-C.In Case-2, sand, cement, and a combination of SP-1 and SP-2 were employed as other materials, represented as Mix-D, Mix -E, and Mix-F, respectively. The nominal ratios were applied based on-field practice. In all mixtures, i.e., Mix A to Mix C, the SP-1 dosage was kept at 0.4 percent by weight of cement, and the water cementitious material ratios were 0.28. In case -02, i.e., Mix D to Mix F, mix uses of the SP-1 dose were held at 0.4 percent by weight of the cement as well as SP-2 was added 0.3 percent by weight of the cement in concrete block production where the water cementitious material ratios were 0.3. Solid blocks containing sand and cement were prepared using a hydraulic press machine at the HBRI campus. The production method of blocks typically comprises three steps: 1) Combining the elements in the pan mixture 2) Forming the blocks 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 is moved to a drying area for covered internal water spray curing, followed by ASTM C31/C31M-21a. The blocks were placed on field ground for 7, 14, and 28 days to cure properly. After proper curing, Sand cement blocks of size 240mm x115mm x 70 mm were tested at 7,14 and 28 days, respectively.

Different preparation steps of Sand Cement Solid blocks are shown in figure-2 (e. f. g).

e) Mixing of water with SP-1 and SP-2.

f) Mixing of SP-1 and SP-2 with other raw materials.

g) Processing of block

3. RESULTS & DISCUSSIONS

3.1.1 The compressive strength of concrete block at various super plasticizer dosages is shown in Table 1 and Table 2, respectively. According to the study, Compressive strength ratings for different super plasticizer dosages are greater than conventional concrete (Alsadey,2015).In this research, compressive strength testing was carried out on a superplasticizer containing block samples that had been wet cured for 7, 14, and 28 days before testing. Following the experiment, the compressive strength graph was plotted using two distinct types of super plasticizer. Figure 4 and Figure 5 show the rise in compressive strength with dose indicates continuous strength gain if a chemical admixture is used. On the other side, increasing the dosage of the Superplasticizer increases the compressive strength. After 7, 14, and 28 days of spray curing, all the samples were kept wet dried until the testing was completed. By ASTM C-39, The compressive strength of the specimen is calculated by dividing the maximum load achieved during the test by the cross-sectional area of the specimen. Sand cement solid block was subjected to a compressive strength test using a UTM (Universal testing machine), as shown in figure- 3(h, i).

h) Sand Cement Solid Block

i)Sand Cement Solid Block tested by UTM Machine

Figure-3: Compressive strength test by UTM machine of Sand Cement Solid Block.

3.1.2 Water Absorption:

The water absorption capacity was measured to evaluate the pore spaces information due to ingredients settlement, compactness, and mixing ingredients. Water absorption of all the surrogate samples was determined at 3, 7, and 28 days of curing ages. Specimens were kept in fully immersion condition. Water absorption after immersion was calculated using the following equation recommended by ASTM C1585-13:

$$\% \text{ Water absorption } (W) = [(WS - WD) / WD] * 100$$

Where WS = weight of specimen at fully saturated condition (kg) and WD = weight of oven-dried specimen (kg). Water absorption is expressed in percentage and the water uptake relative to the dry mass.

3.1.3 Effect of SP-1 (High range water reducing Super plasticizer) on compressive strength of sand cement solid block.

The investigation focused on the strength development characteristics of concrete blocks treated with SP-1. A thorough examination was performed using the same W/C ratio. The effects of the Super plasticizer (SP-1) branded code C-234 on the compressive strength of sand cement solid blocks were observed during seven days beginning at 7 DAO (days after observation) and ending at 28 DAO. The results are summarized in Table -1. It is noted that the strength for 28 days has been increased compared to 7 days at 27 % for Mix-A when used 200 ml SP-1 per bag of cement. Also, the 28-days strength has been enhanced to 25% at the same amount of SP-1 for Mix-B compared to 7 days. At 28 DAO, Mix C shows the lowest strength increase, 20%, followed by specimen Mix C at 1800 Psi compared to 7 days. The study revealed that water absorption percentages are relatively low from Mix A to Mix C. Values ranged from 4% to 5%, showing the lowest water absorption compared to the traditional block.

Table-1. Effect of SP-1 (High Range Water Reducing Super plasticizer) on compressive strength of sand cement solid block.

Speci men	Mix Ratio Cement: Dredged Sand	Percentage (%) of super plasticizer used, SP-1 (ml)	Water/ Cement Ratio	Average compressive strength (psi)			% Of increased strength at 28 days compared to 7 days	Water absorption %
				7 days	14 days	28 days		
A	1:4	200ml	0.28	2200	2700	2800	27	4.5
B	1:5	200ml	0.28	2000	2300	2500	25	3.5
C	1:6	200ml	0.28	1500	1650	1800	20	4.7

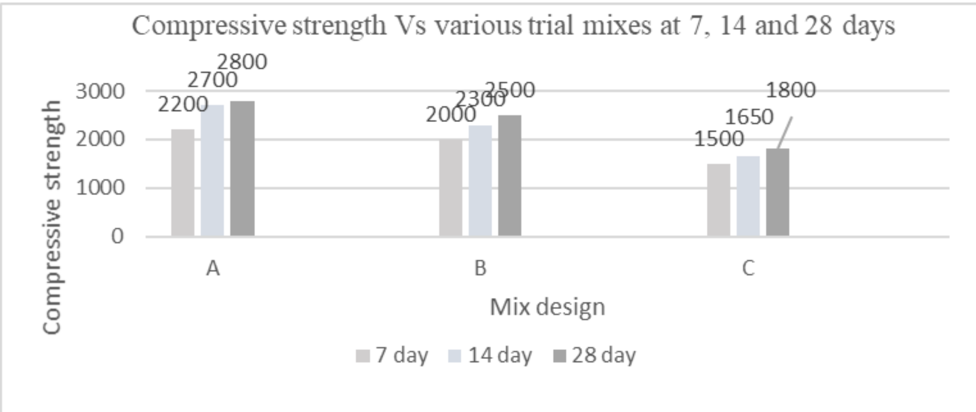

Figure 4: Compressive Strength of various sand cement block mixes with SP-1 at 7, 14, and 28 days.

3.1.4 Effect of mix use of SP-1 and SP-2 on compressive strength at 0.3 W/C ratios of Sand Cement Solid Block.

A comprehensive examination was conducted using the same water-cement ratio for various sand cement solid blocks utilizing the mixture of SP-1 and SP-2 and examined the strength development characteristics. The effects of mixed-use of super plasticizers (SP-1) C-234 and Accelerating admixture SP-2, D-220 on the compressive strength of sand cement solid blocks were observed during seven days beginning range at 7 DAO (days after observation) and ending at 28 DAO. The results are summarized in Table- 2. The strength for 28 days increased by 40 % compared to 7 days for Mix-D at 450ml/50 Kg of cement. Also, the 28-days strength has been enhanced to 33.33 % at 450 ml/50 Kg of cement for Mix-E at 28 DAO compared to 7 days. Specimen F had the lowest strength performance at 22.22%, followed by specimen F at 2200 Psi compared to 7 days. The study revealed that water absorption percentages are relatively low from D to F, and values range from 3% to 7%, showing the lowest water absorption compared to the traditional block.

Table-2. Effect of mix use of SP-1 and SP-2 on Compressive Strength of sand cement Solid block.

Specimen	Mix Ratio Cement: Dredged Sand	% Percentage super plasticizer (SP-1) ml + Accelerating Admixture (SP-2) ml	W/C Ratio	Average compressive strength(psi)			% Of increased strength at 28 compared to 7 days	Water Absorption %
				7days	14 days	28 days		
D	1:4	150+ 300=450	0.3	2500	2800	3500	40	3.5
E	1:5	150+ 300=450	0.3	2250	2500	3000	33.33	5.3
F	1:6	150+ 300=450	0.3	1800	2000	2200	22.22	6.2

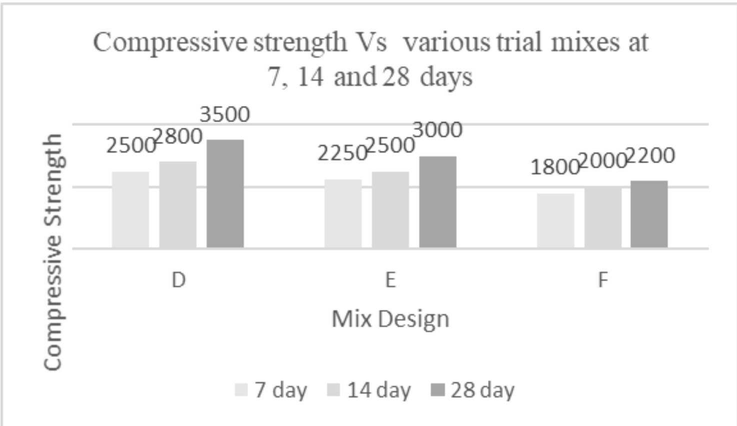

Figure -5: Compressive Strength of various sand cement block mixes at 7, 14, and 28 days.

4. CONCLUSION

Based on the results and discussions, the following conclusions are drawn.

1. Compressive strength increases much more in the presence of a mixture of two types of super plasticizer containing Polycarboxylate ether (SP-1) groups and inorganic and organic base super plasticizer (SP-2) with 0.3 w/c ratios.
2. With the usage of SP- 1 and SP- 2, significant reductions in water absorption have been observed.
3. After 28 days of curing, the Polycarboxylate ether group (SP-1) may achieve a strength of more than 27% (2800 psi) at mix A, making it an excellent choice for concrete block.
4. In addition, the 28-day compressive strength of Polycarboxylate ether group (SP-1) concrete block with synthetic poly organic and inorganic base (SP-2) offers relatively high Strength Concrete (HSC) more than 40% with 28-day compressive strength over 3500 psi (24.14 Mpa), which is much better than case- 01. More research is required on the use of HRWR Sand cement block.

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