Analysis on Compressive Strength of Concrete Using Different Sources of Fine Aggregates

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ANALYSIS ON COMPRESSIVE STRENGTH OF CONCRETE USING DIFFERENT SOURCES OF FINE AGGREGATES

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ABSTRACT
Aggregates strongly affect the concrete’s freshly mixed and hardened properties, mixture proportions, and economy. The utilization of fine aggregates of four local sources such as Sylhet, Rangamati, Rangunia, and Kalurghat on concrete compressive strength is investigated in this paper. Four separate mix designs were conducted targeting 3000 psi concrete for these four sources of fine aggregates. Total 12 concrete cylinders of 4 inches diameter and 8 inches height were cast for compressive strength test by using ordinary Portland cement which was previously tested for specific gravity. For each source of fine aggregates, three cylindrical samples were cast for different curing periods of 7, 14 and 28 days. The cylinders were tested in Universal Testing Machine of 1000 kN capacity against the consecutive curing periods. Overall, the concrete cast with Sylhet sand showed improved compressive strength compared to others. The 28 days compressive strength was found as 2862 psi for concrete cast with Sylhet sand, which was 12.51%, 15.65% and 31.27% more than concrete cast with Rangamati, Rangunia, and Kalurghat sand respectively. The results were then linked against the fineness modulus of the fine aggregates. Concrete compressive strength decreased as the fineness modulus of fine aggregates decreased.

Keywords: Concrete; Fine aggregates; Sand; Fineness modulus; Compressive strength.

INTRODUCTION

The standing of using the true quality and types of aggregates on concrete casting cannot be exaggerated. Among the aggregates used in concrete, fine aggregates have a vital impact on concrete strength. Bu et al. (2017) showed the effect on the compressive, flexural and split tensile strength of cement mortars using 4 sand content. By changing the sand content and water/cement ratio, the pore structure of cement mortar was studied. The test results showed that the strength of cement mortar increases with increasing sand content up to an extent. The sand content was found to be an important parameter influencing the pore structure of cement mortar. The relationship between the pore structure and strength of cement mortar was found to be good.

Donza et al. (2002) investigated the effects of crushed sands on high strength concrete. Results showed that concrete with crushed sand requires an increase of superplasticizer to obtain the same slump. It also presented a higher strength than the corresponding natural sand concrete at all test ages, while its elastic modulus was lower at 28 days and was the same after that. The influence of the mineralogical source of the crushed sands was studied using three different types of crushed sands (granite, limestone and dolomite) with similar grading. Results showed the adverse effects of shape and texture on the workability of concrete. But the compressive strength of concrete was improved. Granite crushed sand appeared as the most advantageous sand for the purpose. Krishnan et al. (2018) used locally available manufactured sand (M sand) as fine aggregate and partial replacement of cement with admixtures in the production of high-performance concrete. The flexural property of concrete was enhanced by partial replacement of sand with 50% of M sand substantially compared to normal mix concrete. Rahman et al. (2019) investigated the compressive and split tensile strength of concrete with partial replacement of sand by red soil.

In this study, the emphasis was given on locally available sand samples in Bangladesh for using as fine aggregates in concrete. This paper intends to create a comparative model of concrete strength using these locally availed sands. The objectives of the study were to inspect the compressive strength of concrete for different sources of sand as fine aggregates and thus finding out the best source of sand available locally for improved strength of concrete.

METHODOLOGY

Materials

Cement, sand and coarse aggregates were tested for different properties to conduct mix design. Ordinary Portland cement was used and specific gravity was tested. Sand collected from four locations of Bangladesh such as Sylhet, Rangamati, Rangunia and Kalurghat (Fig-1) were used as fine aggregate (FA) and tested for specific gravity, absorption tests, and gradation. Crushed stones of 19 mm downgrade were used as coarse aggregates (CA) and tested for specific gravity, absorption, dry rodded unit weight, and gradation. All the test results on materials are specified in Table-1. Sylhet, Rangamati and Rangunia sand showed the same specific gravity whereas Kalurghat sand showed less specific gravity. Again, the fineness modulus (FM) of Sylhet sand was found highest among four sources as it was coarser compared to others. The FM value decreased for Rangamati, Rangunia and Kalurghat sand respectively as they were finer.

Sylhet sand　Rangamati sand　Rangunia sand　Kalurghat sand

[Fig-1: Different sources of fine aggregates.]

Table-1: Test results of different materials.

Materials	Name of material tests	Results			
Cement	Specific gravity (ASTM C188-16)	2.5			
Coarse aggregates	Specific gravity (ASTM C127-15)	2.18			
	Absorption capacity (ASTM C127-15)	1.02%			
	Dry rodded unit weight (ASTM C29-C29M-17)	91.77 lb/ft^3			
	Gradation (ASTM C33-C33M-16e1)	FM = 6.66			
Fine aggregates	**Sources⟶**	Sylhet	Rangamati	Rangunia	Kalurghat
	Specific gravity (ASTM C128-15)	2.45	2.45	2.45	2.42
	Absorption capacity (ASTM C128-15)	2.41%	2.43%	2.44%	2.77%
	Gradation (ASTM C778-13)	FM = 2.61	FM = 1.91	FM = 1.9	FM = 1.57

Mix Design

From the results of materials tests, four separate ACI mix designs were conducted for four sources of fine aggregates targeting 3000 psi compressive strength of concrete to find out the right proportions of cement, sand and coarse aggregates used for concrete casting. From the ACI mix design the ratio among cement (C), FA and CA and water-cement ratio (W/C) were originated as specified in Table-2. The detailed mix amount according to different sources of FA is revealed in Table-3. For each mix design slump test was carried out and found acceptable.

Table-2: Mix design results.

Sources of FA	Sylhet	Rangamati	Rangunia	Kalurghat
C: FA: CA	1: 2.11: 3.44	1: 2.44: 3.61	1: 2.52: 3.79	1:2.59:3.84
W/C	0.49	0.54	0.57	0.61

Table-3: Detailed mix amount according to different sizes of CA.

Sources of FA→	Sylhet	Rangamati	Rangunia	Kalurghat
Water (lb)	201.23	210.21	212.45	214.23
Cement (lb)	395.51	397.82	398.55	399.21
CA (lb)	1360.55	1436.13	1510.5	1532.97
FA (lb)	834.526	970.68	1004.35	1033.95
Total	2791.82 lb/yd^3 or, 103.3 lb/ft^3	3014.84 lb/yd^3 or, 111.55 lb/ft^3	3125.85 lb/yd^3 or, 115.66 lb/ft^3	3180.36 lb/yd^3 or, 117.67 lb/ft^3

Casting and Curing

A total 12 cylinders were cast (Fig-2) for the compressive strength test. The appropriate mix proportion was maintained during the construction. After 24 hours of casting, the cylinders were de-molded and submerged under the water for curing.

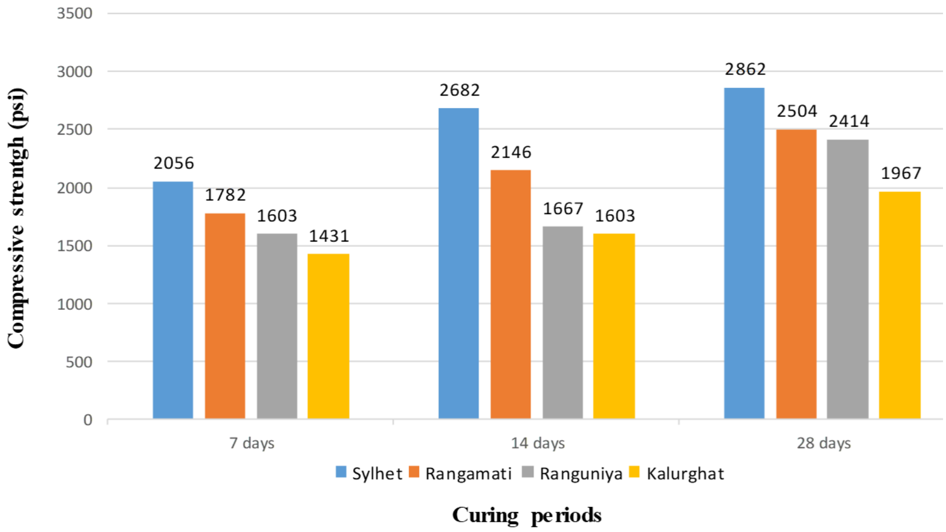
Compressive Strength Test

The cylinders were tested for compressive strength with respective ages of curing as 7, 14 and 28 days. A compressive strength test helps to determine concrete grading (ASTM C39-C39M-17). Universal Testing Machine (UTM) of capacity of 1000 KN was used for compressive strength test as shown in Fig-3.

[Fig-2: Concrete cylinders after demolding.]

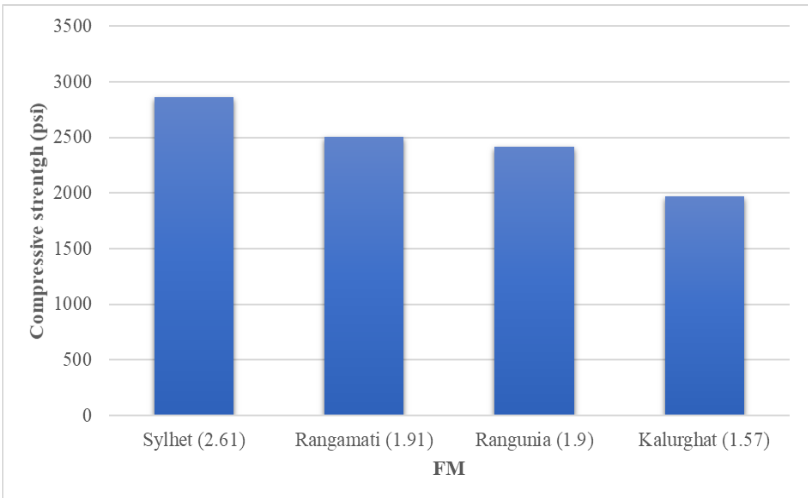
[Fig-3: Compressive strength test of concrete cylinder.]

RESULTS AND DISCUSSIONS



[Fig-4: Comparison between compressive strength of concrete with different sources of FA with respect to curing periods.]

Fig-4 shows the comparison between compressive strength of concrete different sources of FA with respect to curing periods. The compressive strengths were measured in 7, 14, and 28 days of curing respectively for all the specimens and compared. It was perceived that, compared to Sylhet sand the compressive strength decresed in all three curing period for Rangamati, Rangunia and Kalurghat sands. The decement was in between 13.33% to 30.04% in curing period of 7 days, 19.99% to 40.23% in 14 days and 12.51% to 31.27% in 28 days.



[Fig-5: Comparison between compressive strength of concrete with different sources of FA with respect to FM.]

Fig-5 shows the comparison between compressive strength of concrete different sources of FA with respect to FM. It can be seen that the compressive strength decreased as the FM value decreased. The compressive strength of concrete in 28 days curing period was found as 2862 psi for Sylhet sand having FM of 2.61. It was decreased to 12.51%, 15.65% and 31.27% respectively for Rangamati (FM 1.91), Rangunia (FM 1.9) and Kalurghat sand (FM 1.57).

CONCLUSIONS

The following conclusion can be drawn based on this study:

a. The different sources of fine aggregate strongly influenced the compressive strength of concrete because of the difference in aggregate size distribution.
b. The compressive strength of concrete was found close to the mix design target for Sylhet sand and decreased respectively for Rangamati, Rangunia, and Kalurghat sand as the FM value decreased.
c. Fineness Modulus is an indication of the grading of particle size. More the value of FM coarser the aggregate is.
d. As the Sylhet sand was coarser than others, it made the concrete volume stronger and thus increased the compressive strength.
e. But strength does not only depend on FM of aggregate. Shape, size, and grading played a key role in achieving the required compressive strength.

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ASTM C33-C33M-16e1 Standard Specification for Concrete Aggregates.

ASTM C39-C39M-17 Standard test method for compressive strength of cylindrical concrete specimens.

ASTM C127-15 Standard test method for density, relative density (specific gravity), and absorption of coarse aggregate.

ASTM C128-15 Standard test method for relative density (specific gravity) and absorption of fine aggregate.

ASTM C188-16 Standard test method for density of hydraulic cement.

ASTM C778-13 Standard specifications for standard sand.

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