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EFFECTS OF DIFFERENT SIZES OF AGGREGATES ON COMPRESSIVE STRENGTH OF CONCRETE

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Abstract- *Concrete is unique and extensively conducive construction material by virtue of its excellent compressive strength, which is one of the most important and useful properties of concrete. It is a composite material, consisting of aggregates enclosed in a matrix of cement paste. Concrete is the binder of cement, inert materials and water. In most structural applications, concrete is employed primarily to resist compressive stresses, which depends on plenty of factors like properties of ingredients, method of preparation, curing conditions etc. Concrete mixtures can be designed to provide a wide range of mechanical and durability properties to meet the design requirements of a structure. This paper describe the influence of aggregate size locally available to investigate the variation of compressive strength of concrete as well as to find out the proper mix ratio at which higher strength is to be found. Effects of size distribution of both fine and coarse aggregate on compressive strength are analyzed in this study. Six different sizes of coarse aggregates are used while developing a mix design. The sizes of coarse aggregate are 19 mm, 12.5 mm, 9.5 mm, 6.35 mm 4.75 mm, 2.36 mm and 1.18 mm. Mixtures of local sand and Sylhet sand (1:1) and with fineness modulus of 2.10 is used as fine aggregate. Ordinary Portland cement is used as binding material. Different trials of mixing of coarse aggregate are made {(12.5 mm and 9.5 m, 6.35 mm); (9.5 mm, 6.35 mm and 4.75 mm); (19 mm, 12.5 mm, 6.35 mm, 9.5 mm and 4.75 mm); (12.5 mm, 4.75 mm, 2.36 mm and 1.18 mm)} to investigate the influence of size of aggregate on compressive strength of concrete The concrete mixing is prepared by taking the four proportions of cement, sand and aggregate are {(1:1.5:3); (1:1.25:2.5); (1:1:2 & 1:0.75:1.5)}. The water-cement ratio (w/c) is fixed as 0.55. The gradation of both coarse and fine aggregate, unit weight of coarse aggregate, water absorption of coarse aggregate and slump test for concrete are conducted in the laboratory. Standard cylinder sizes are prepared for testing in universal testing machine. From the investigation it is observed that the compressive strength varies from 24.34 to 26.14 MPa for trial mix C (19 mm, 12.5 mm, 6.35 mm, 9.5 mm, 4.75 mm) at mix ratios 1 (1:1.5:3), 2 (1:1.25:2.5), 3 (1:1:2) after 7 days curing period but only in mix ratio 4 (1:0.75:1.5) the maximum strength obtained 32.38 MPa for trial mix A (12.5 mm 6.35mm & 9.5 mm). For 14 days curing period, the compressive strength varies from 27.17 to 28.19 MPa for trial mix C at mix ratios 1, 2, 3 but only in mix ratio 4 the maximum strength obtained 33.96 MPa for trial mix A. Similarly, the compressive strength varies from 36 to 36.34 MPa for aggregate trial mix C at mix ratios 1, 2, 3 after 28 days curing period but only in mix ratio 4 the maximum strength obtained 45.17 MPa for trial mix A.*

Keywords: *Aggregate, Concrete, Compressive strength and Mix ratio*

1. INTRODUCTION

Concrete is a composite material, consisting of aggregates enclosed in a matrix of cement paste. Concrete is the binder of cement, inert materials and water. It is generally designed for a particular strength using locally available ingredients specially brick aggregates. The strength of concrete depends upon the strength of these components, their deformation properties, and the adhesion between the paste and aggregate surface. Concrete mixtures can be designed to provide a wide range of mechanical and durability properties to meet the design requirements of a structure. The recycled aggregates can be used as sub base course materials. The crushing value, the impact value except the Loss Angeles abrasion value of recycled aggregate was within the standard specification. The test results concern road applications are very good and verified the adequacy of materials (B. Ahmed et al., 2013). Effects of size distribution of both fine and coarse aggregate size (37.5 mm) on concrete compressive strength were analyzed. Result states that compressive strength of concrete is strongly influenced by aggregate size distribution as well as fineness modulus (M. B. Haque et al., 2012). An investigation was conducted to achieve concrete of higher strength using crushed brick as ¾ in. (19 mm) down-graded coarse aggregate. Crushed bricks may be used satisfactorily as coarse aggregate for making concrete, the strength of which is much higher than that of bricks considered (M.A. Rashid et al., 2008). The concrete mixtures incorporate either basalt or crushed limestone, aggregate sizes of 12 mm ($\frac{1}{2}$ in.) or 19 mm ($\frac{3}{4}$ in.) and coarse aggregate contents with aggregate volume factors (ACE 211.1-91) of 0.75 and 0.67. Water-to-cementations material ratios range from 0.24 to 0.50. Compressive strengths range from 25 MPa to 97 MPa. The compressive strength of both normal and high-strength concrete is little affected by aggregate size (Rozalija Kozul and David Darwin, 1997).

Five different sizes of coarse aggregates i.e. 37.5 mm, 25 mm, 20 mm, 10 mm, and 5 mm were used while developing a mix design. The compressive strength of concrete depends upon a number of factors such as mix ratio, size, texture of coarse & fine aggregate, method of compaction, curing period (M. Yaqub and Imran Bukhari, 2006).Use of quality materials, smaller water-binder ratio, larger ratio of coarse aggregate (C.A) to fine aggregate (F.A), smaller size of coarse aggregate, and suitable admixtures with their optimum dosages are found necessary to produce high strength concrete (HSC) (M.A. Rashid and M.A. Mansur, 2009).The effects of various fineness modulus (FM) of fine aggregate on the engineering properties of high-performance concrete (HPC) were studied. For the specific size gradation and maximum aggregate size of coarse aggregates used in this study (T. Chang et al., 2001).The present research describes the effect of aggregate and curing condition on the compressive strength of concrete with age. The compressive strength increases with an increase in curing period (Aminur et al., 2010).The existing experimental data of compressive strength of normal and recycled aggregate concrete and equation for compressive strength calculating given in Technical regulation are compared (Ksenija J. et al., 2011).The potential use of both agricultural and industrial wastes namely Rice Husk Ash (RHA) and Expanded Polystyrene (EPS) respectively as raw material for the production of 'Green' light weight concrete bricks. The thermal conductivity decreases as the density of the samples reduced (Ling I.H and Teo D.C.L, 2012).The physical and mechanical properties of different sizes of palm kernel shells (PKS) used as lightweight aggregates (LWA) and their influence on mechanical properties of palm kernel shell concrete (PKSC).The size and proportions of (PKS) have slight influence on the fresh and hardened densities of PKSC(U. Johnson Alengaram et al., 2010).The compressive strength of concrete was determined by testing cubes or cylinders made in laboratory or field. It depended primarily on the level of strength of concrete and was higher when the strength of concrete was higher (Mohd. Sarfaraz Banda et al., 2013).Concrete has a far greater strength than mortar and sand concrete of the same cement aggregate ratio. This exceeding strength is, most times, found to be triple (or more) that of mortar. Coarse aggregates, which are the interest of this study, make the difference (Aginam et al., 2013).The effect of maximum size of aggregate in higher grade concrete using high volume fly ash was analyzed. The workability of concrete increased as the size of the aggregate increased from 10 mm to 20 mm for all percentages of replacements of the fly ash (V. Bhikshma and G. Annie Florence, 2013).Common river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. Grit is more preferable than artificial sand as it is more economical (SachinBalkrishnaKande et al., 2012).

2. MATERIALS AND METHOD

The materials such as fine aggregates, coarse aggregates and cement are collected from Baliapukore, Talaimari, Rajshahi. To determine the physical properties of the materials for project work, the physical properties of materials for this work included unit weight, fineness modulus of both coarse and fine aggregate different laboratory tests are conducted as per standard testing methods. Sand of "Sylhet & Local sand" is used in 1:1 proportions in the experiment. The concrete trial mixer is prepared by taking the 4 proportions of cement, sand and aggregate i.e. 1:1.5:3; 1:1.25:2.5; 1:1:2 and 1:0.75:1.5 and taking water-cement ratio is 0.55. The specimen is prepared in cylindrical steel mould of size 6 inch diameter and 12 inch height by different sizes of aggregates. The different trial mixes of aggregates are: trial mix A (12.5 mm and 9.5 m, 6.35 mm); trial mix B (9.5 mm, 6.35 mm and 4.75 mm); trial mix C (19 mm, 12.5 mm, 6.35 mm, 9.5 mm and 4.75 mm); trial mix D (12.5 mm, 4.75 mm, 2.36 mm and 1.18 mm). The cement, fine aggregates are mixed thoroughly. The mixing reaches at uniform consistency after the additional of water to mixture. Then the mixture was cast in the cylinder mould. The moulds were oiled properly prior to the casting of specimen.

3. RESULT AND DISCUSSIONS

Unit weight and water absorption of coarse aggregates were determined according to the procedure specified AASHTO T 19 and AASHTO T 85 respectively. The abrasion value, impact value, crushing value for aggregates was determined by following test methods AASHTO T 104 and BS 812 (part-3) respectively. The soundness value of coarse aggregates was determined according to Sodium and Magnesium Sulfate Soundness (AASHTO T 104). Test results of intrinsic properties of coarse aggregates are given in Table 1.

Table 1: Basic properties of coarse aggregates

Properties	Obtained value
Unit weight, dense, (lb/ft^3)	101.50
Unit weight, loose, (lb/ft^3)	87.00
Absorption of water (%)	9.36
Fineness modulus (FM)	8.27
Aggregate Crushing value (%)	30.20
Aggregate Impact value (%)	13.70
Aggregate Abrasion value (%)	35.20
Soundness value (%)	5.00

The compressive strength of concrete determined after 7, 14 & 28 days curing period by conducting standard procedure are given in the table below for different trial mix.

Table 2: Compressive strength of concrete made by trial mix A with w/c = 0.55

Mix ratio	Compressive strength of concrete (MPa)		
	7 days curing periods	14 days curing periods	28 days curing periods
1:1.5:3	13.92	18.00	19.53
1:1.25:2.5	19.53	24.11	27.45
1:1:2	23.77	27.73	33.62
1:0.75:1.5	32.38	33.96	45.17

Table 3: Compressive strength of concrete made by trial mix B with w/c = 0.55

Mix ratio	Compressive strength of concrete (MPa)		
	7 days curing periods	14 days curing periods	28 days curing periods
1:1.5:3	15.28	20.38	23.21
1:1.25:2.5	19.13	26.38	28.07
1:1:2	17.27	21.96	25.47
1:0.75:1.5	23.88	28.53	33.62

Table 4: Compressive strength of concrete made by trial mix C with w/c = 0.55

Mix ratio	Compressive strength of concrete (MPa)		
	7 days curing periods	14 days curing periods	28 days curing periods
1:1.5:3	26.14	27.85	36.00
1:1.25:2.5	24.34	27.17	34.75
1:1:2	25.13	28.19	36.34
1:0.75:1.5	27.73	31.02	39.96

Table 5: Compressive strength of concrete made by trial mix D with w/c = 0.55

Mix ratio	Compressive strength of concrete (MPa)		
	7 days curing periods	14 days curing periods	28 days curing periods
1:1.5:3	20.37	23.21	28.30
1:1.25:2.5	23.43	27.04	34.75
1:1:2	24.45	28.13	34.87
1:0.75:1.5	25.13	29.43	36.00

Table 6: Compressive strength of concrete at different mix ratios after 7 days curing periods

Mix ratio	Compressive strength (Mpa)			
	A	B	C	D
1:1.5:3	13.92	15.28	26.14	20.37
1:1.25:2.5	19.53	19.13	24.34	23.43
1:1:2	23.77	17.27	25.13	24.45
1:0.75:1.5	32.38	23.88	27.73	25.13

Table 7: Compressive strength of concrete at different mix ratios after 14 days curing periods

Mix ratio	Compressive strength (Mpa)			
	A	B	C	D
1:1.5:3	18.00	20.38	27.85	23.21
1:1.25:2.5	24.11	26.38	27.17	27.04
1:1:2	27.73	21.96	28.19	28.13
1:0.75:1.5	33.96	28.53	31.02	29.43

Table 8: Compressive strength of concrete at different mix ratios after 28 days curing periods

Mix ratio	Compressive strength (Mpa)			
	A	B	C	D
1:1.5:3	19.53	23.21	36.00	28.30
1:1.25:2.5	27.45	28.07	34.75	34.74
1:1:2	33.62	25.47	36.34	34.87
1:0.75:1.5	45.17	33.62	39.96	36.00

The variation of compressive strength of different trial mix of aggregate at various mix ratios which is presented in Table: 6, 7 & 8 is shown in graphical representation.

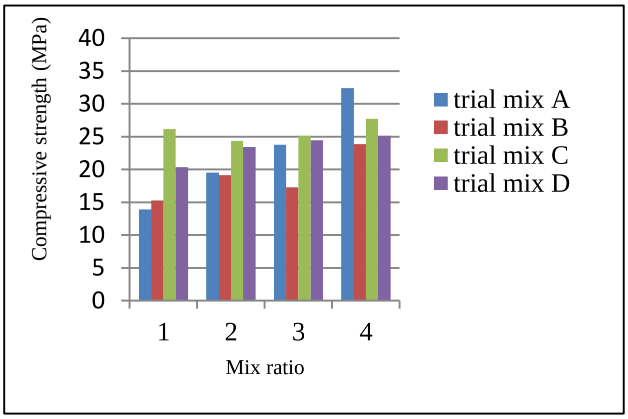

Fig.1: Compressive strength for trial mix A, B, C & D for different mix ratios after 7 days curing period

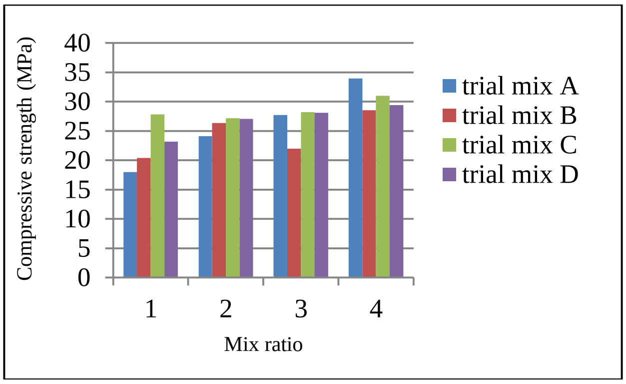

Fig.2: Compressive strength for trial mix A, B, C & D for different mix ratios after 14 days curing period

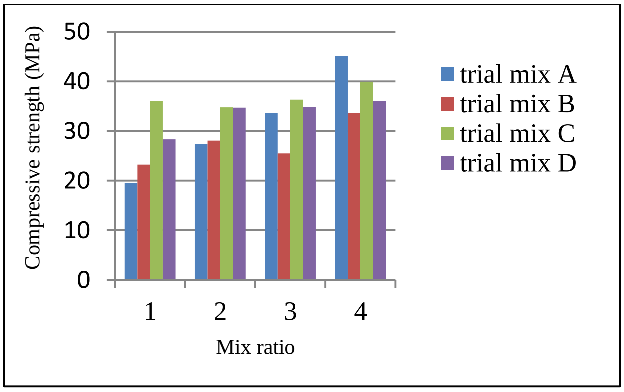

Fig.3: Compressive strength for trial mix A, B, C & D for different mix ratios after 28 days curing period

4. CONCLUSIONS

Based on the experimental results, it can be concluded that the mix ratio of concrete 1:0.75:1.5 gives higher strength than others with sufficient workability. Trial mix of aggregate sizes 19 mm, 12.5 mm, 9.5 mm and 4.75 mm confirm better strength result in mix ratios 1, 2 & 3 after 7, 14 & 28 days curing period but only in mix ratio 4 the maximum strength obtained for trial mix of aggregate sizes 12.5 mm & 9.5 mm. In practical, the maximum compressive strength of concrete mix can be found by mixing two specific sizes of aggregate at 1:0.75:1.5 ratios.

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