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Effects of Using Washed Basalt Coarse Aggregates on Strength Characteristics of Concrete

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ABSTRACT *Concrete posses more compressive strength compared to mortar of the same cement: aggregate ratio. Here in this study two different coarse aggregates of basalt black stones of 20mm maximum size, were utilised. namely crushed washed basalt stone and unwashed basalt stones. The mix ratio and water/cement ratio adopted for the study was 1:2:4 and 0.6 respectively. Twelve concrete cubes (150mm x 150mm x 150mm) were cast for each coarse aggregate type of which four were crushed at each maturity age namely; 7, 14, 21, and 28 days. The 28 day strengths of the concretes made with crushed washed basalt stone unwashed basalt stones were. 24.0 N/mm2, and 19.9 N/mm2 respectively. Consequently, it was concluded that the strength of concrete depends greatly on the internal structure, surface nature and shape of aggregates.*

KEYWORDS : aggregates, concrete, compressive strength, granite, gravel, curing

I. INTRODUCTION

Concrete is a composite material produced by the homogenous mixing of selected proportions of water, cement, and aggregates (fine and coarse). Strength is the most desired quality of a good concrete. It should be strong enough, at hardened state, to resist the various stresses to which it would be subjected. Compressive strength of concrete, therefore, is the value of test strength below which not more than a prescribed percentage of the test results should fall Kong and Evans, 1987 [3]. The high variation in strength between concrete and mortar of the same cement/aggregate proportion, suggests the quintessence of coarse aggregates in the development of strength in concretes. The coarse aggregates are obtained naturally or artificially and occupies up to 60% by weight or volume of the concrete, depending on the mix proportion adopted which, in turn, depends on the expected compressive strength. Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Although aggregate is considered inert filler, it is a necessary component that defines the concrete's thermal and elastic properties and dimensional stability. Aggregate is classified into two different types, coarse and fine. Coarse aggregate is usually greater than 4.75 mm (retained on a No. 4 sieve), while fine aggregate is less than 4.75 mm (passing the No. 4 sieve). The compressive aggregate strength is an important factor in the selection of aggregate. When determining the strength of normal concrete, most concrete aggregates are several times stronger than the other components in concrete and therefore not a factor in the strength of normal strength concrete. Lightweight aggregate concrete may be more influenced by the compressive strength of the aggregates [7]. The strength of concrete is its major characteristic. Neville, 1981 [4] stated that aggregates are inert materials that are dispersed through-out the cement paste whose strength depends majorly on its shape, surface texture, and cleanliness. In his research findings, he published that entirely smooth coarse aggregates lowered the strength of concrete by 10% than when the aggregates were roughened. Young and Sam, 2008 [5] also stated that smooth rounded aggregates was more workable but yielded a lesser compressive strength in the matrix than irregular aggregates with rough surface texture. They were also of the opinion that a fine coating of impurities such as silt on the aggregate surface could hinder the development of a good bond and thus affects the strength of concrete produced with the aggregates.

II. MATERIALS AND METHODS

The fine aggregate used for this research work was river bed sand collected from shahpur area of Gulbarga District of Karnataka state India. Two types of coarse aggregate namely; two different coarse aggregates of basalt black stones of 20mm maximum size, were utilised. namely crushed washed basalt stone and unwashed basalt stones. These were obtained from the quarry existing near at the Hyderabad highway in Gulbarga district limts. The maximum size of the aggregates was 20mm.

The Pozalona Portland cement of Birla brand was used from Syed barey cement agency, Hazarath khwaja banda nawaz Darga area, Gulbarga. The cement was taken to the laboratory in 50kg bags and was carefully kept away from dampness to avoid lumps. Portable water supplied at the Concrete Technology laboratory of KCT Engineering College Gulbarga Karnataka state of India was used throughout the research work. The Particle Size Distribution of the coarse and fine aggregates was carried out after they were air dried as well as their Specific gravity tests.

The batching of the concrete was by weight and a mix ratio of 1:2:4 was adopted.. Water/cement ratio of 0.6 was employed. Four cubes were cast for each aggregate type for a particular age at curing, namely; 7 days, 14 days, 21 days, and 28 days. In other words, 12 concrete cubes (150mm x 150mm x 150mm) were cast for each aggregate type, making a total of 48 cubes. The fresh concrete was thoroughly tampered in the mould with steel rod and reference numbers were given to the moulds for easy identification of the concretes made with the same type of coarse aggregate. The moulds were removed after 24hours and the ponding method of curing in the tank of KCT Engineering college Civil Engineering Department, in which the cubes were totally immersed in water throughout the curing period, was adopted. The water in the curing pond was kept at an average laboratory temperature of 28^{0}C to prevent thermal stresses that could result in cracking, just as James etal, 2011 [2] suggested.

Four cubes were removed from each set of cubes at each maturity age. The cubes were weighed and crushed. The ratio of the crushing loads to the surface area of the cubes gave the compressive strengths of the cubes.

III. RESULTS AND DISCUSSION

Particle Size Distribution

Sieve analysis carried out on both the fine aggregate and the coarse aggregates in accordance with the guidelines specified by BS 1377; Part 2,1990 [6]. The figure shows that the river sand used for the experiment was well graded with a maximum size of 3mm. The maximum and minimum sizes of the coarse aggregates were 20mm and 3mm respectively. This is proper for coarse aggregates to be used in construction works.

Specific Gravity and Water Absorption of Aggregates

Table 1 Shows the relative density or specific gravity of aggregates utilised in the study.

Aggregate type	Specific Gravity S_g			Water absorption
Shapur sand	2.63	2.64	2.64	-
Basalt CA	2.32	2.31	2.32	0.4

The sand, the crushed basalt displayed Specific Gravity values of 2.64, 2.32, respectively. The low specific gravity of the crushed basalt shows that it is an impervious light weight aggregate.

IV. Compressive Strength

Tables 2, 3, shows the result of cube crushing at 7, 14, 21, and 28 days respectively. From the result, the compressive strengths of the concrete cubes cast with two types of coarse aggregates were found to have exceeded the target mean strength after seven days of curing. The compressive strength of the washed and unwashed basalt was very close at the 7th day of curing. The compressive strength of crushed washed basalt at the 7th day exceeded those of the uncrushed basalt with a significant margin. Apart from the fact that the unwashed basalt was coated with dirt of clay, silt, and humus, it is the same material with the washed gravel. The closeness of their compressive strengths is, therefore, not a surprise. More strength was gained as the curing age increased. This increase in strength as the curing age increased.

In all cases, the compressive strength of the unwashed basalt remained the least, though it was from the same source with the washed basalt and is the same material with it. This variation in strength development could be due to the micro fine coatings of silt, clay and humus which are deterrents to the development of concrete strength. This further supports the opinion of Bloem and Gaynor, 1963 [1] that says that the cleaner the aggregates, the better the strength performance. Indeed cleanliness is an important factor in concrete strength development. The micro fines absorb the water that is made available for the initial hydration of cement and consequently, disrupts the aggregate-cement bond. The effect of this could be more pronounced at larger quantities of the fines.

Table 2; Compressive Strength of Concretes made with washed crushed Basalt

Curing age	Specimen reference	Crushing loads in KN	Compressive strength f_{ck} in KN/mm^2	$f_{ck\ mean}$
7 days	CS1	448	19.9	20.1
	CS2	459	20.4	
	CS3	445	19.8	
	CS4	452	20.1	
14 days	CS1	459	20.1	21.45
	CS2	486	21.6	
	CS3	495	22.0	
	CS4	479	21.3	
21 days	CS1	515	22.9	22.5
	CS2	513	22.8	
	CS3	515	22.9	
	CS4	482	21.4	
28 days	CS1	531	23.6	24
	CS2	529	23.5	
	CS3	551	24.5	
	CS4	549	24.4	

Table 3; Compressive Strength of Concretes made with unwashed crushed Basalt

Curing age	Specimen reference	Crushing loads in KN	Compressive strength f_{ck} in KN/mm^2	$f_{ck\ mean}$
7 days	CS1	410	18.2	17.9
	CS2	398	17.7	
	CS3	394	17.5	
	CS4	409	18.2	
14 days	CS1	425	18.9	19.1
	CS2	434	19.3	
	CS3	432	19.2	
	CS4	427	19.0	
21 days	CS1	437	19.4	19.3
	CS2	432	19.2	
	CS3	427	19.0	
	CS4	434	19.3	
28 days	CS1	441	19.6	19.9
	CS2	450	20.0	
	CS3	452	20.1	
	CS4	450	20.0	

V CONCLUSIONS AND RECCOMENDATIONS

Based on the results of this investigation which have been discussed above, the following conclusions can be drawn:

- Concretes made with washed crushed basalt performed best in compression than those made with unwashed crushed basalt of similar grading.
- Concretes made with unwashed basalt had the least compressive strength. This, therefore, reaffirms that variation in concrete strengths is due to factors like; surface nature, cleanliness and internal structure of the aggregate materials.

It is, therefore, recommended that;

1. The investigation should be extended to the effect of different sizes of coarse aggregates on the compressive strength of concrete. 2. Proper compaction of the concretes must be ensured, as compaction is observed to improve the strength of concrete. 3. Coarse aggregates if sourced with impurities must be washed before use. 4. Lightweight but strong aggregates like washed crushed basalt should be used (notwithstanding the cost) in high rise buildings and other massive structures in which high factors of safety for the strength of concrete is required. 5. For smaller structures, the natural unwashed basalt can be more economical.

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