Experimental Study on the Use of Basalt Aggregate in Concrete Mixes

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ABSTRACT: *The purpose of this paper is to investigate the feasibility of using basalt aggregates in concrete mixes. Concrete is the most important engineering material and the addition or replacement of some of the materials may change the properties of the concrete. In recent years a lot of research work has been carried out in order to obtain more durable and long term performance of concrete structures in the dynamic environment. An experimental program is set up to test the effect of basalt aggregate content and its combinations with lime stone with variation of percentages in concrete mixes. Different aggregate percentage combinations were used in this study for basalt and limestone (0%,100%),(25%,75%),(50%,50%),(75%,25%),(100 %,0%) respectively. The laboratory investigation included measurement of compressive strength and workability. In addition the source aggregate properties were considered in this study: Los Angeles abrasion, specific gravity and absorption for coarse aggregates and fine aggregate. The result of this investigation indicate a general improvement in mix properties with the introduction of basalt aggregates in the mix.'*

Keywords*: basalt aggregate, concrete mixes, high strength, workability*

1. Introduction

Concrete technology has been changing rapidly and constantly since its discovery. The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. Though it is based on sound technical principles and heuristics, the entire process is not in the realm of science and precise mathematical calculations. This is because of impreciseness, vagueness, approximations and tolerances involved. The objective of any mix design method is to determine an appropriate and economical combination of concrete ingredients that can be used for a first trial batch to produce a certain concrete which is close to that can achieve a good balance between various desired properties of concrete at the minimum cost. A mixture proportioning only provides a starting mix design that will have to be more or less modified to meet the desired concrete characteristics. In spite of the fact that mix design is still something of an art, it is unquestionable that some essential scientific principles can be used as a basis for calculations.

Production of concrete and utilization of concrete has rapidly increased, which results in increased consumption of natural aggregate as the largest concrete component. It is well recognized that coarse aggregate plays an important role in concrete. Coarse aggregate typically occupies over one-third of the volume of concrete, and research indicates that changes in coarse aggregate can change the strength and fracture properties of concrete[1]. To predict the behavior of concrete under general loading requires an understanding of the effects of aggregate type, aggregate size, and aggregate content. This understanding can only be gained through extensive testing and observation.

It is customary to use limestone aggregates which are also available in great abundance. Basaltic rock aggregates are similar to limestone aggregates in many aspects. Basalt is a hard, dense volcanic igneous rock that can be found in most countries across the globe. For many years, basalt has been used in casting process to make tiles and slabs for architectural applications. Additionally, cast basalt liners for steel tubing exhibit very high abrasion resistance in industrial applications.in crushed form basalt also finds use as aggregate in concrete. Crushed basalt aggregate are dense fine grained rocks that are very dark color-green or black and are formed when molten lava from deep in earth's crust rises up and solidifies. Slightly coarser old sheets of basalt, now partially altered but still dark in color are extensively quarried, crushed and sold as "trap rock"[2]. Basalt is used in many countries, especially in highway and airfield pavement constructions[3].This tight grained structure provides high abrasion and excellent UV resistance. The crushed and graded aggregate is essentially free of moisture. The basalt aggregates are higher in specific gravity and lower in absorption and abrasion loss values. Based on this comparison, it is clearly obvious that basalt is likely to be suitable for use in concrete mixes.

Table 1: Key Properties of Limestone and Basalt Aggregates Used.

Properties	Lime stone	Basalt
Specific gravity	2.7	2.83
Absorption (%)	2.5	1.6
Abrasion (%)	29	18

Table 2: Chemical Composition of Basaltic aggregate

COMPOUND	PERCENT
Silicon dioxide	48.0
Aluminium oxide	14.4
Iron oxide	15.1
Calcium oxide	6.18
Magnesium oxide	5.95
Sodium oxide	4.05
Potassium oxide	2.29
Titanium oxide	2.29
Other oxides	1.74

2. Objectives

To evaluate the feasibility of using basalt aggregate in concrete mixes and to produce an economical concrete mix with relatively higher strength and good workability.

3.0 Design mixes

3.1.Materials Used

In the present study, Ordinary Portland cement of 53 grade conforming to IS:12269-1987[4]has been used throughout the experimentation which is having a specific gravity of 3.15.The locally available natural sand passing through 4.75mm IS sieve having specific gravity of 2.59 and conforming to grading zone-I of IS:383-1970[5] was used. The sand was dried in the sunlight before its use. Coarse aggregates lime stone and basalt of two fractions with specific gravities 2.7 and 2.83 respectively were used. Fraction-I was obtained by passing through 25mm and retained on 20 mm IS sieve and was taken at 60% of the total coarse aggregates content. Fraction II was obtained by passing through 12.5m IS sieve and retained on 10mm IS sieve and was taken at 40% of the total coarse aggregates content. Fly ash having specific gravity of 2.2 obtained from was used as a mineral admixture for developing HPC mixes. Most admixture manufacturers will have a range of super plasticizing admixtures tailored to specific user requirements and the effect of other mix constituents. The admixtures should bring about required water reduction and fluidity but should also maintain its dispersing effect during the time required for transport and application [6].Polycarboxylic ether (PCE) type super plasticizer having specific gravity of 1.10 was used.

Design mix concrete is the type of concrete used in construction, to produce the grade of concrete having the required workability and characteristic strength nominal mix, In this paper, the concrete mix is designed as per IS 10262 – 2009[7]. The grade of concrete which we adopted are M40 and M 50 with the water cement ratio of 0.4 and 0.37 respectively.

Table3: M40 Mix Proportions

Water (kg/m^3)	Cement (kg/m^3)	Limestone/Basalt (kg/m^3)		Sand (kg/m^3)
160	400	1188	1245	660

Therefore the proportions of the mix are approximately,

Water:cement:sand:coarse aggregate=0.4:1:1.65:2.97

Table4: M50 Mix Proportions

Water (kg/m^3)	171
Cement(kg/m^3)	427
Fly ash(kg/m^3)	33
Fine aggregate (kg/m^3)	634
Lime stone (kg/m^3)/	1197
Basalt (kg/m^3)	1231
Super plasticizer(kg/m^3)	2.3

Therefore, the proportions of the mix are approximately,

Water: binder content:sand:coarse aggregate= 0.37:1:1.378:2.8

4.0. Experimental work

Five design mixes were used including limestone controlmix,25%,50%,75% and 100% basalt for each set.

4.1. Laboratory tests

The key properties investigated in this research Paper included:

1. Key properties of an aggregate such as specific gravity, absorption and abrasion are determined for both lime stone and basalt aggregates.

2. Workability is determined by performing slump cone test for every mix.

3. Compressive strength is determined by breaking cube samples(15x15x15) cm. Three cubes for each mix were tested.

Five mixes were prepared; namely 0% basalt (as a reference mix), 25% basalt, 50% basalt, 75% basalt and
100% basalt. The composition of each mix was 60% coarse aggregate of 20 mm size and 40% coarse aggregate of 10mm size. Fine aggregate confines to zone-I.

4.2 Casting and Curing

Two different sets of specimens are prepared using design mixes M40 and M50 for each set respectively. In each set, the specimens are casted by varying the percentage of replacement of coarse aggregate (lime stone) with basalt aggregate starting from 0 to 100% with an increment of 25% by weight of coarse aggregate and they are represented as 0%,25%,50%,75%,100% respectively. In the second set, the former procedure is followed, in addition to that mineral admixture of 7.7% by weight of cement is replaced.
Cubes with size 150mm X150mm X150 mm, are prepared. The samples aredemoulded after 24 hrs.' from casting and kept in a water tank for 7 days and 28 days curing.

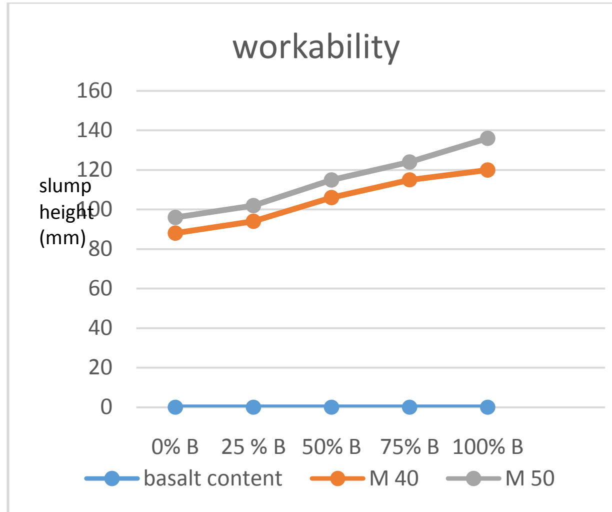
5. Results and Discussion

The laboratory testing of these mixes yielded the following results:

5.1 Slump Test Result and Analysis

The slump test indicates a decreasing trend of slump height when the percentage of basalt aggregate is increased.Fig.1 below shows a graphical representation of slump height. According to the result, the lowest slump obtained was 88 mm for 0% basalt content mix and the highest slump was 120mm for 100% basalt mix, for M 40 grade concrete mix. And for M50 concrete mix the lowest slump recorded was 96mm for control mix and lowest was 136mm for 100% basalt mix. Therefore, the workability was good and can be satisfactorily handled for all the mixes. There was no problem for the placement and compaction of fresh concrete. But the workability is higher foe basalt aggregate rather than limestone because of the high absorption capacity of lime stone aggregate. From the result obtained, it shows that the workability was getting higher when more basalt aggregate were used due to its low absorption capacity as shown in Table2.

Figure.1:Graph showing results for slump test



5.2. Compressive Strength test results

This test was performed according to the BritishStandard (B.S. 1881, part 3).
Table5 to table 8 and Figure 2 show the results of the compressive strength tests that were conducted on the trial mixes containing 0%,25%, 50%,75% and 100% basalt, respectively. In general, the compressive strength increased as the percentage of basalt content in the mix is increased.

Table5:7 days compressive strength test results for M 40 grade concrete mix in N/mm^2

Specimen	0% basalt	25% basalt	50% basalt	75% basalt	100% basalt
1	32	34.66	38.66	41.33	42.66
2	33.33	35.55	39.55	40.88	43.11
3	30.22	33.77	39.11	40.44	41.77

Table6:28 days compressive strength test results for M40 grade concrete mix in N/mm^2.

sample	0% basalt	25% basalt	50% basalt	75% basalt	100% basalt
1	51.11	52.44	57.77	58.66	62.22
2	51.55	53.33	55.55	60.44	61.33
3	52.44	53.77	56.88	59.11	62.66

Table7:7 days compressive strength test results for M50 grade concrete mix in N/mm^2.

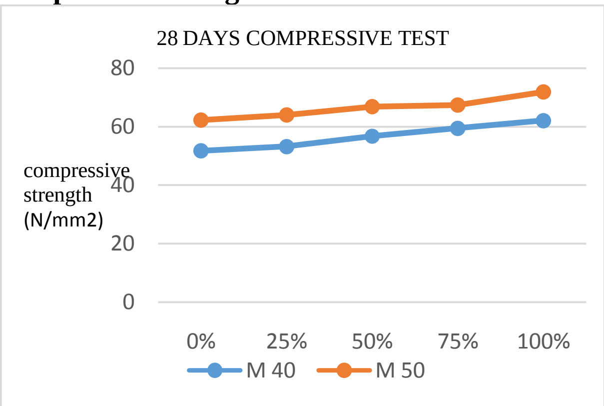
sample	0% basalt	25% basalt	50% basalt	75% basalt	100% basalt
1	39.11	40.88	41.77	45.33	46.22
2	41.33	39.55	43.55	44.88	45.77
3	40.44	41.33	42.66	44.44	44.88

Table8:28 days compressive strength test results for M50 grade concrete mix in N/mm^2.

sample	0% basalt	25% basalt	50% basalt	75% basalt	100% basalt
1	61.33	64	66.22	68.44	72

2	62.22	64.88	67.55	66.22	71.11
3	63.11	63.11	66.66	67.55	72.44

Figure2: Graph showing results for 28 days compressive strength



6. Conclusions

The laboratory test results in compressive strength, seems to indicate that the increase in basalt percentage enhances the mix strength over the conventional limestone mix. This is due to the fact that basalt is denser and more durable and less water absorbing than limestone. Also higher workability is obtained for more basalt aggregate content mix which reduces the cost of labour.As basalt aggregate isa natural aggregate also available in plenty at low cost, an economical and relatively high strength concrete is obtained by using basalt aggregate as coarse aggregate in concrete mixes.

References

[1]Rozalija kozul, DavidDarwin, Effects of aggregate type, size, and Content on concrete strength and fracture energy, university of Kansas center for research, INC.Lawrence, kansas,1997

[2]Hamadallah Mohammad Al-Baijat ,The Use of Basalt Aggregates in Concrete Mixes in Jordan, ,Jordan Journal of Civil Engineering, Volume 2, No. 1, 2008

[3]Hadeel Maiah, Ghazi Al-Khateeb,Effect of basalt and limestone aggregate combinations on Superpave aggregate properties

[4]IS 12269 (1987): Specification for 53 grade ordinary Portland cement (BI-LINGUAL) [CED 2: Cement and Concrete]

[5]IS: 383-1970 (Second Revision), Specifications for Coarse and Fine Aggregates from Natural Resources for Concrete.

[6] .P. D. Kumbhar and P. B. Murnal ,A New Mix Design Method For High Performance Concrete Under Tropical Concrete, ,Asian Journal of Civil Engineering (BHRC) Vol. 15, No. 3 (2014).

[7]IS: 10262-2009 (first revision), Concrete Mix Proportioning Guidelines

[8]de Larrard, F and Malier, Y, "Engineering Properties of Very High Performance Concretes" High-Performance Concrete - From Material to Structure,(Editor- Malier), E&FN Spon, 1994, London, pp 85 -114.

[9]Hamadallah M. Al-Baijat Comparison between Composite Beam of Limestone and Basalt Concrete Jordan Journal of Civil Engineering, Volume 3, No. 3, 2009

[10]IS: 456 – 2000 (Fourth Revision) Indian Standard Plain and Reinforced Concrete Code of Practice.

[11] Aitcin, P.C., "High-performance Concrete", E & FN Spon, UK, 1998

[12]Rosenbaum, M. and Skene, M. 1995. Airfield Pavement Construction Using Basalt Aggregate, Bulletin-International Association of Engineering Geology, 51:71–79.