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Interrelation of Physical and Mechanical Properties of Basalt

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ABSTRACT

Concrete is one of the most widely used construction materials throughout the world. Many desirable properties such as high compressive strength, excellent durability and fire resistance contributed toward its wide range of applicability.

The most advantageous and unique feature of concrete is that it can be produced using locally available ingredients as aggregates. Therefore in counties where steel is not readily available, concrete is the most used construction material. However the advantage of using local materials as concrete ingredients has its own demerits as well.Because of the variation in properties of locally available aggregates, the properties of concrete may vary widely. Concrete is an artificial stone, manufactured from a mixture of binding materials and inert materials with water.

Concrete = Binding materials + Inert materials + Water

Concrete is considered as a chemically combined mass where the inert material acts as a filler and the binding material acts as a binder. The most important binding material is cement and lime. The inert materials used in concrete are termed as aggregates. The aggregates are of two types namely, (1) Fine aggregate and (2) Coarse aggregate. Since at least three quarters of the volume of concrete is occupied by aggregates. It is not surprising that its quality is of considerable importance. Not only the aggregate limit the strength of the concrete, as weak aggregates cannot produce a strong concrete, but also the properties of aggregates greatly affect the durability and structural performance of the concrete. The coarse aggregate should be clean, strong, durable and well grades and free from impurities and deleterious materials, such as salts, coal residue, etc.

Physical properties (i.e. specific gravity, water absorption) affect the mechanical properties (i.e. Toughness, Hardness and Crushing) for basalt coarse aggregate a mathematical model for the interrelation of physical and mechanical properties of basalt has been derived and presented in this paper.

Keywords - *Physical properties, mechanical properties, concrete, basalt, durability*

I. INTRODUCTION

Aggregates are used in concrete as a filler material. They are bound by the cement paste to form a compositematerial. It is assumed that the type of aggregate does not affect the properties of concrete. If aggregates aredense and strong, the properties of concrete are governed by the quality of the paste, shape, surface texture,maximum size and grading of the aggregates.However, in case of average and low-quality aggregates, usuallycharacterized as porous and weak, the properties of concrete are found to be significantly affected by the typesof aggregates.

Two main aggregate qualities must be evaluated from aggregate tests: the susceptibility to wear and impact and the susceptibility to weathering or durability. All of these properties can be evaluated from tests viz. Specific gravity, water absorption, Abrasion value, Impact value, Crushing value and soundness. To evaluate these qualities aggregate tests must be able to: provide correlations with field performance; be suitable for aggregates from different sources; results in reasonable variability of aggregate from a single source; and give results representing the whole sample.

II. METHODOLOGY AND EXPERIMENTAL PROGRAM

Fourteen number samples of coarse aggregate are prepared with Basalt rock collected from different rock quarries to be used in mass concrete. Physical and Mechanical properties of these samples have been determined in laboratory as per IS: 2386-1963 (reaffirmed in 2016) and ASTM C-1260. Interrelation of Physical and mechanical properties has been studied in this research program.

Physical Properties

A. Specific gravity

In Portland Cement Concrete, the specific gravity of the aggregate is used in calculating the percentage of voids and solid volume of aggregates in computations of yield.The specific gravity of aggregate is also critical to the construction of water filtration systems, slope stabilization, railway bedding and many other applications.

Specific gravity of a coarse aggregate is defined by the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water and tested as per IS: 2386-1963 (reaffirmed in 2016) Part III.

B. Water absorption

Coarse aggregates must absorb less water. More water absorption makes it weak for its intended purpose. Assessment of water absorption capacity of coarse aggregates was performed in accordance to IS 2386–1963 (reaffirmed in 2016)Part III.

Mechanical Properties

A. Toughness

It is defined as the resistance of aggregate to failure by impact. Impact value of an aggregate is the percentage loss of weight particles passing 2.36 mm sieve by the application of load by means of 15 blows of standard hammer drop, under specified test condition in accordance to IS: 2386 - 1963 (reaffirmed in 2016)Part IV. The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregate differ from their resistance to a slowly applied compressive load.

This value should not be more 30% for aggregate to be used in concrete for wearing surfaces and 45% for non-wearing surfaces as per IS:383-2016.

B. Hardness

It is defined as the resistance to wear by abrasion and the aggregate abrasion value is defined as the percentage loss in weight on abrasion.

Los-Angeles abrasion Test

This test has been covered by IS: 2386 1963(Reaffirmed in 2016)Part-IV.The principle of Los Angeles abrasion test is to produce abrasive action by use of standard steel balls which when mixed with aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates. The percentage wear of the aggregates due to rubbing with steel balls is determined and is known as Los Angeles Abrasion Value.

This value should not be more 30% for aggregate to be used in concrete for wearing surfaces and 50% for non-wearing surfaces as per IS: 383-2016.

C. Crushing value

Aggregate crushing value test on coarse aggregates gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load in accordance to IS: 2386 – 1963 (reaffirmed in 2016) part IV. Coarse aggregate crushing value is the percentage by weight of the crushed material obtained when test aggregates are subjected to a specified load under standardized conditions. Aggregate crushing value is a numerical index of the strength of the aggregate and it is used in construction of hydro-projects, roads and pavements. Crushing value of aggregates indicates its strength.

This value should not be more 30% for aggregate to be used in concrete for wearing surfaces and 45% for non-wearing surfaces as per IS: 383-2016.

D. Soundness test

The soundness test determines an aggregate's resistance to disintegration by weathering and in particular, freeze-thaw cycles. Aggregates that are durable (resistant to weathering) are less likely to degrade in the field and potentially failure.

The soundness test repeatedly submerges an aggregate sample in a sodium sulfate or magnesium sulfate solution in accordance to IS: 2386 – 1963 (reaffirmed in 2016) Part V. This process causes salt crystals to form in the aggregate's water permeable pores. The formation of these crystals.

Creates internal forces that apply pressure on aggregate pores and tend to break the aggregate. After a specified number of submerging and drying repetitions, the aggregate is sieved to determine the percent loss of material.

This value should not be more 12% as per IS: 383-2016.

III. RESULTS AND DISCUSSIONS

Variation in Physical properties i.e. specific gravity, water absorption effect the mechanical properties i.e. toughness, hardness, crushing and soundness to great extent. All the test results of these tests are tabulated below:

S. No.	Sample prepared from Rock Types	Specific gravity	Water Absorption (%)	Abrasion Value (%)	Impact Value (%)	Crushing value (%)	Soundness loss (%)
1	Basalt	2.898	1.5	11.69	14.63	15.89	3.67
2	Basalt	2.906	1.3	10.72	12.25	14.9	3.56
3	Basalt	2.845	2.1	13.56	16.02	17.65	4.33
4	Basalt	2.895	1.2	9.97	10.1	13.23	3.8
5	Basalt	2.864	1.8	13.4	13.3	16.92	4.23
6	Basalt	2.892	1.6	11.56	13.4	15.29	3.88
7	Basalt	2.914	1.3	9.52	9.1	10.25	3.26
8	Basalt	2.894	1.4	9.56	12.23	10.92	4
9	Basalt	2.863	1.8	15.16	16.9	19.1	4.39
10	Basalt	2.900	1	10.26	9.8	12.64	3.52
11	Basalt	2.904	1.28	9.45	12.12	14.2	3.62
12	Basalt	2.975	0.5	7.8	8.42	10.5	2.85
13	Basalt	2.944	0.65	8.62	9.25	9.82	3.54
14	Basalt	2.776	2.3	14.68	16.25	17.83	4.67

Variation in mechanical properties due to change in physical properties on fourteen basalt aggregate samples has been developed and represented below:

1. A mathematical model showing effect of Specific gravity and Abrasion value has been developed for 14 nos. samples tested in the laboratory.

Y = -42.621X + 134.34
$R^2 = 0.7432$
Where Y= Abrasion Value (%)
X= Specific gravity

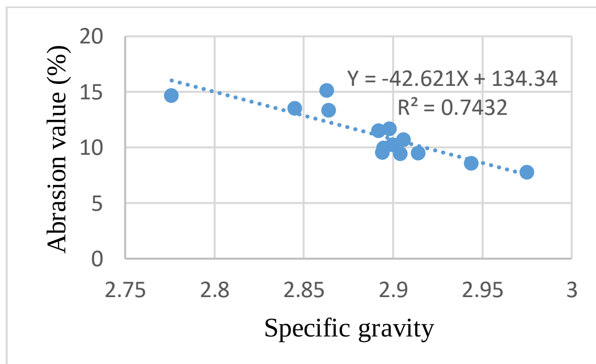

Figure 1: Correlation between Specific gravity Vs Abrasionvalues (%)

2. A mathematical model showing effect of Specific gravity on Impact value has been developed for 14 nos. samples tested in laboratory.

Y = -48.893X + 153.75
$R^2 = 0.6402$
Where Y=Impact value(%)
X=Specific gravity

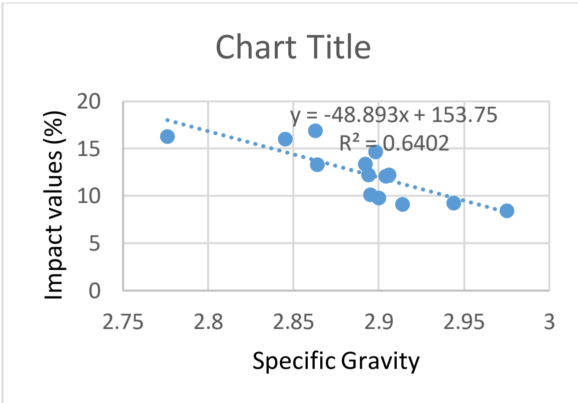

Figure 2: Correlation between Specific gravity Vs Impactvalues (%)

3. A mathematical model showing effect of Specific gravity on Crushing value has been developed for 14 nos. samples tested in laboratory.

Y = -51.258X + 162.4
$R^2 = 0.5908$
Where Y=Crushing value(%)
X=Specific gravity

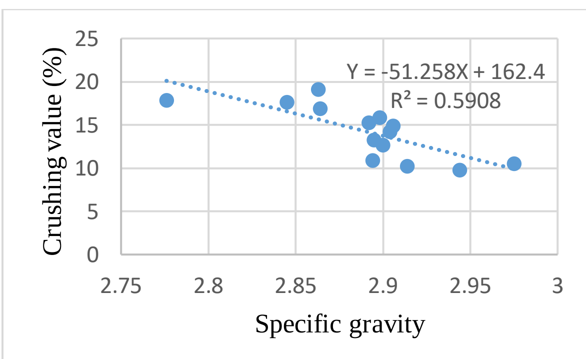

Figure 3: Correlation between Specific gravity Vs Crushingvalues (%)

4. A mathematical model showing effect of Specific gravity on soundness loss has been developed for 14 nos. samples tested in laboratory.

Y = -9.6132X + 31.597
$R^2 = 0.8386$
Where Y=Soundness loss(%)
X=Specific gravity

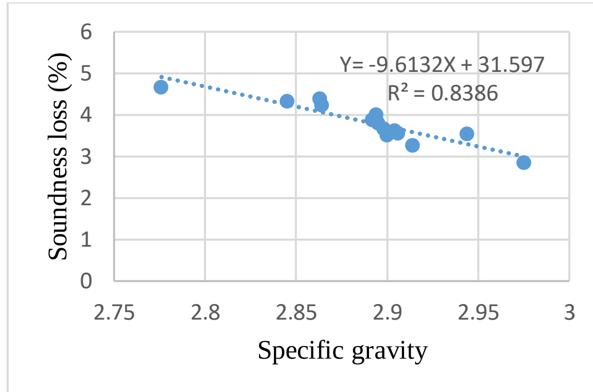

Figure 4: Correlation between Specific gravity Vs Soundnessloss (%)

5. A mathematical model showing effect of Water absorption on Abrasion value has been developed for 14 nos. samples tested in laboratory

Y = 4.0968X + 5.3657
$R^2 = 0.8093$
Where y=Abrasion Value(%)
X=Water Absorption(%)

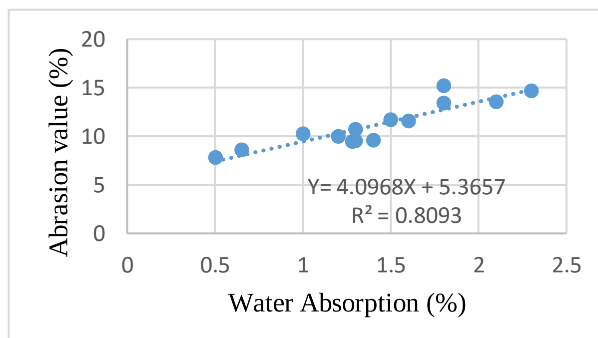

Figure 5: Correlation between Water AbsorptionVs Abrasion values (%)

6. A mathematical model showing effect of Water absorption onImpact value has been developed for 14 nos. samples tested in laboratory.

Y = 5.0076X + 5.3549
$R^2 = 0.7914$
Where Y=Impact value(%)
X=Water Absorption(%)

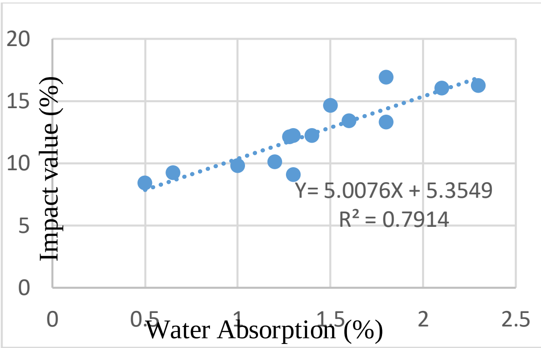

Figure 6: Correlation between Water Absorption VsImpactvalues (%)

7. A mathematical model showing effect of Water absorption onCrushing value(%) has been developed for 14 nos. samples tested in laboratory.

$Y = 5.1506X + 6.9656$
$R^2 = 0.7029$
Where Y=Crushing Value (%)
X=Water Absorption (%)

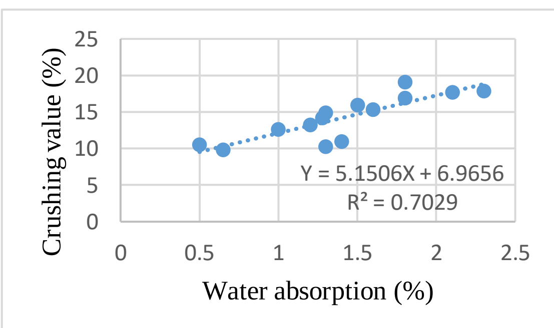

Figure 7: Correlation between Water Absorption Vs Crushing values (%)

8. A mathematical model showing effect of Water absorption on Soundness loss has been developed for 14 nos. samples tested in laboratory.

$Y = 0.8626X + 2.593$
$R^2 = 0.7956$
Where Y=Soundness Loss(%)
X=Water Absorption(%)

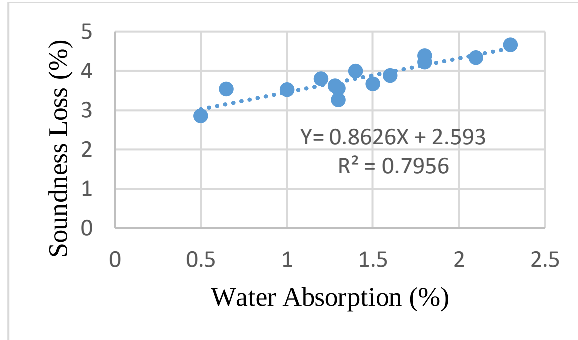

Figure 8: Correlation between Water Absorption (%) Vs Soundness Loss (%)

IV. CONCLUSIONS

Properties of concrete depend upon physical and mechanical properties to a great extent for any type of concrete construction works. Physical properties of aggregates can be determined in easy way, but for mechanical properties one needs laboratory equipments i.e. Loss angles abrasion machine, Crushing machine, Impact machine etc.

All mechanical properties can be predicted by knowing physical properties for basalt aggregates using above developed mathematical models. These predicted values give approximate idea mechanical properties to a great extent.However exact value can be determined with original procedure as per IS: 2386-1963 (reaffirmed in 2016).

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