Authentication of Mathematical Models Developed for Properties of Basalt Coarse Aggregate

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Abstract — The coarse aggregate is treated as an inert material and only its physical properties like shape, size, water absorption and specific gravity are studied. Whereas, on increasing the quality of concrete mix, the strength of coarse aggregate also comes into picture. In this paper, effects of all physical properties namely Specific Gravity, Aggregate Impact value (%), Aggregate Abrasion Loss (%), Aggregate crushing Value (%), Soundness Loss (%) 5 cycles in Na2SO4 solution and Water Absorption (%) on concrete properties are discussed. Specific gravity and water absorption of coarse aggregate affect all other properties to an extent. Empirical mathematical models have already been developed between physical & mechanical properties using 14 nos. of basalt coarse aggregate samples. Using these mathematical models, mechanical properties can be determined with physical properties of Basalt coarse aggregates. In this paper, these developed mathematical models have been authenticated.

Keywords: Coarse Aggregate, Specific Gravity, Concrete, Physical Properties, Mechanical Properties, Mathematical Model, Authentication

I. INTRODUCTION

With the rapid growth in infrastructure in India, construction industry is booming and thus the demand for building materials has increased manifolds. The performance of the structural concrete is dependent on its strength and durability which in turn is dependent on the characteristics of the mortar, aggregate and mortar-aggregate bond. The type, texture and mineralogy of coarse aggregate affect the various parameters of concrete in its hardened and fresh state for same quality of mortar mix. In case of water/cement ratio of 0.4 and less, the strength of bond between mortar and aggregate is comparable to the strength of aggregate itself. Hence, the full potential of the coarse aggregate is required to be explored prior to its use as a raw material as it will not only affect the strength but also the modulus of elasticity of concrete. Thus, detailed investigation is to be conducted for coarse aggregate to enhance the mechanical properties of concrete. The coarse aggregate occupies around 70% of the volume of concrete, its role in affecting the strength and durability parameters of the concrete is paramount.

Mechanical properties of coarse aggregates like Abrasion Value, Impact Value, Crushing Value and Soundness loss are determined with standard procedures as per IS: 2386-1963 (reaffirmed in 2016) Part-IV & V. Physical properties like specific gravity and water absorption are also determined with standard procedures as per IS: 2386-1963 (reaffirmed in 2016) Part-III.

II. METHODOLOGY AND EXPERIMENTAL PROGRAM

Mathematical models have been developed between Physical and Mechanical properties using 14 nos. basalt aggregate samples tested in laboratory. To have the authenticity of these developed models, other basalt aggregate samples have been tested for its physical and mechanical properties and results have been compared with values obtained from formula derived from mathematical models of 14 nos. basalt aggregate samples.

III. DISCUSSIONS OF TEST RESULTS

Empirical mathematical models have already been developed between physical & mechanical properties using 14 nos. basalt coarse aggregate. In this mathematical models, the mechanical properties decreases with the increase of specific gravity and similarly these mechanical properties increases with the increase of water absorption.

In developed mathematical models value A is represented as Specific gravity and Mechanical properties i.e. B is represented as Abrasion value a, C is as Impact value, D is as Crushing value, E is as Soundness loss & F is as Water absorption respectively.

1) B= -42.621A + 134.34
2) C = -48.893A + 153.75
3) D = -51.258A + 162.4
4) E = -9.6132A + 31.597
5) F = -10.14A + 30.722
6) B = 4.0968F + 5.3657
7) C = 5.0076F + 5.3549
8) D = 5.1506F + 6.9656
9) E = 0.8626F + 2.593

To check authenticity of above developed models, 7 Nos, of other basalt aggregate samples have been tested for its physical and mechanical properties. Correlations between physical and mechanical properties for these 7 nos. of basalt aggregates have also been developed. These values of mechanical properties are compared with values obtained by putting Sp. Gravity in previously developed models (Sl. No I to V) and Water absorption in these developed models (Sl.No VI to IX). Test results and results from mathematical models and their percentage variations are shown in tables below. All the tested values and values obtained from mathematical models mostly have variations within 20%.

Sample No.	Sp. Gravity	Water absorption (%)	Abrasion Value (%)	Impact Value (%)	Crushing Value (%)	Soundness Loss (%)
1	2.898	1.5	11.69	14.63	15.89	3.67
2	2.906	1.3	10.72	12.25	14.9	3.56
3	2.845	2.1	13.56	16.02	17.65	4.33
4	2.895	1.2	9.97	10.1	13.23	3.8
5	2.864	1.8	13.4	13.3	16.92	4.23

6	2.892	1.6	11.56	13.4	15.29	3.88
7	2.914	1.3	9.52	9.1	10.25	3.26
8	2.894	1.4	9.56	12.23	10.92	4.00
9	2.863	1.8	15.16	16.9	19.10	4.39
10	2.900	1.0	10.26	9.8	12.64	3.52
11	2.904	1.28	9.45	12.12	14.2	3.62
12	2.975	0.5	7.8	8.42	10.5	2.85
13	2.944	0.65	8.62	9.25	9.82	3.54
14	2.776	2.3	14.68	16.25	17.83	4.67

Table 1: Actual Values as Per Test Conducted On 14 Nos. Aggregate Samples (Shows as Series 1 in Graphs)

Sample No.	Sp. gravity	Water Absorption (%)	Abrasion Value (%)	Impact Value (%)	Crushing value (%)	Soundness loss (%)
1	2.84	1.7	13.95	14.75	19.45	4.93
2	2.84	1.9	14	14.79	19.44	4.85
3	2.87	1.6	15	15.68	17	4.84
4	2.83	2.4	14.8	15.63	22.22	4.92
5	2.77	2.54	16	20.96	22.22	4.93
6	2.81	2.3	17.8	20.32	23.22	4.7
7	2.88	1.27	14.6	15.35	16.67	4.6

Table 2: Actual Values as Per Test Conducted On 07 Nos. Aggregate Samples (Shows as Series 2 in Graphs)

Sample No.	Abrasion Value (%)	% Difference with tested value	Impact Value (%)	% Difference with tested value	Crushing Value (%)	% Difference with tested value	Soundness Loss (%)	% Difference with tested value	Water Absorption (%)	% Difference with tested value
1	13.30	4.69	14.89	-0.98	16.83	13.48	4.30	12.87	1.924	-13.20
2	13.30	5.03	14.89	-0.70	16.83	13.44	4.30	11.43	1.924	-1.28
3	12.02	19.88	13.43	14.37	15.29	10.06	4.01	17.21	1.620	-1.26
4	13.72	7.28	15.38	1.58	17.34	21.96	4.39	10.74	2.025	15.59
5	16.28	-1.75	18.32	12.61	20.42	8.12	4.97	-0.78	2.634	-3.71
6	14.57	18.15	16.36	19.48	18.37	20.91	4.58	2.47	2.228	3.10
7	11.59	20.62	12.94	15.71	14.78	11.36	3.91	14.98	1.518	-19.59

Table 3: Values Obtained By Putting the Sp. Gravity Value in Mathematical Models (Sl.No. I To V) Derived With 14 Nos. Samples (Shown As Series 3 in Graphs)

Sample No.	Abrasion Value (%)	% Difference with tested value	Impact Value (%)	% Difference with tested value	Crushing Value (%)	% Difference with tested value	Soundness Loss (%)	% Difference with tested value
1	12.33	-11.61	13.87	-5.98	15.72	-19.17	4.06	-17.66
2	13.15	-6.07	14.87	0.54	16.75	-13.83	4.23	-12.74
3	11.92	-20.53	13.37	-14.75	15.21	-10.55	3.97	-17.91
4	15.20	2.69	17.37	11.15	19.33	-13.02	4.66	-5.22
5	15.77	-1.43	18.07	-13.77	20.05	-9.77	4.78	-2.96
6	14.79	-16.92	16.87	-16.97	18.81	-18.98	4.58	-2.62
7	10.57	-27.61	11.71	-23.68	13.51	-18.98	3.69	-19.82

Table 4: Values Obtained By Putting the Water Absorption Value in Mathematical Models (Sl.No.Vi to Ix) Derived With 14 Nos. Samples (Shown As Series 3 in Graphs)

Graphs have been plotted for test results of 14 Nos. of basalt aggregates(Series 1)for test results of 7 Nos. basalt aggregate samples (Series 2) and for values obtained for 7 Nos. of basalt aggregate samples from mathematical model developed for 14 Nos. of samples (Series 3).

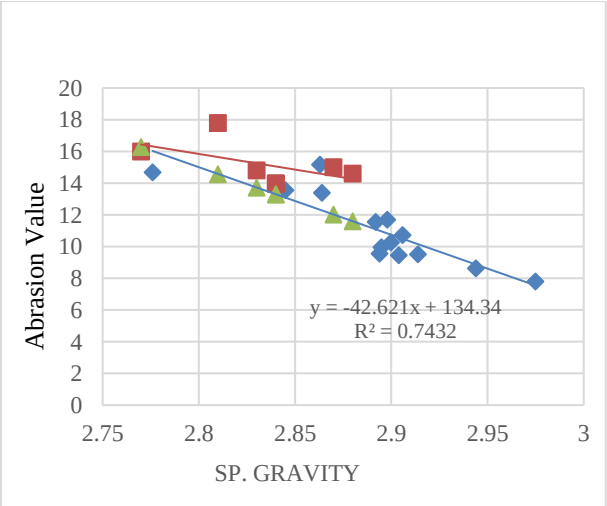

Fig. 1: Specific gravity Vs Abrasion value (%)

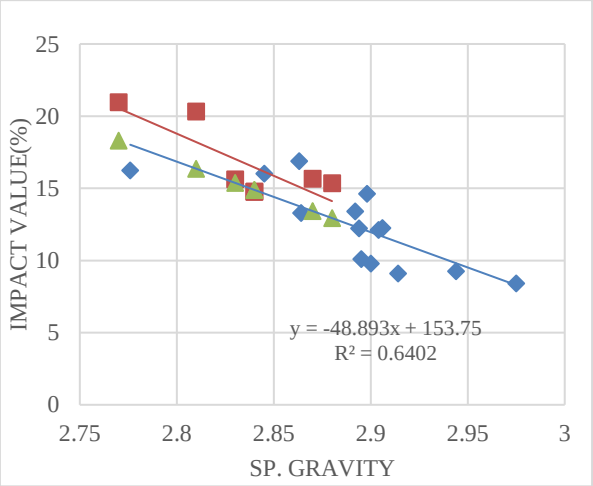

Fig. 2: Specific gravity Vs Impact value (%)

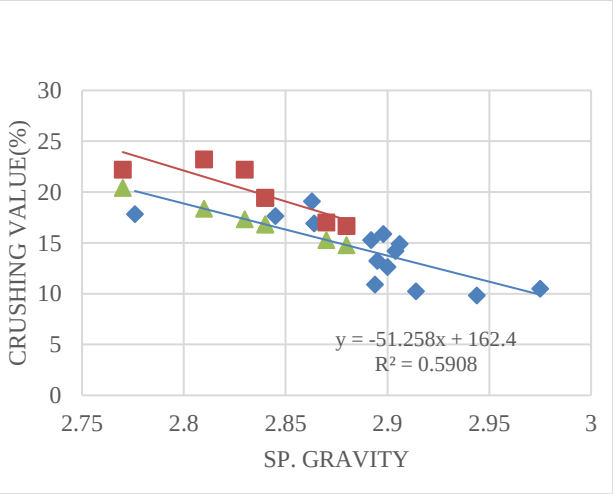

Fig. 3: Specific gravity Vs Crushing value (%)

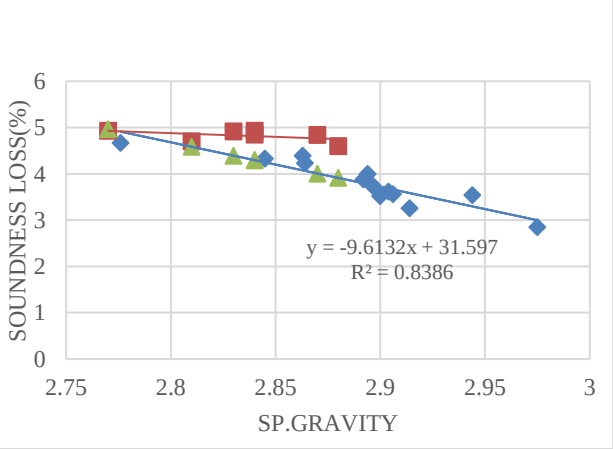

Fig. 4: Specific gravity Vs Soundness Loss (%)

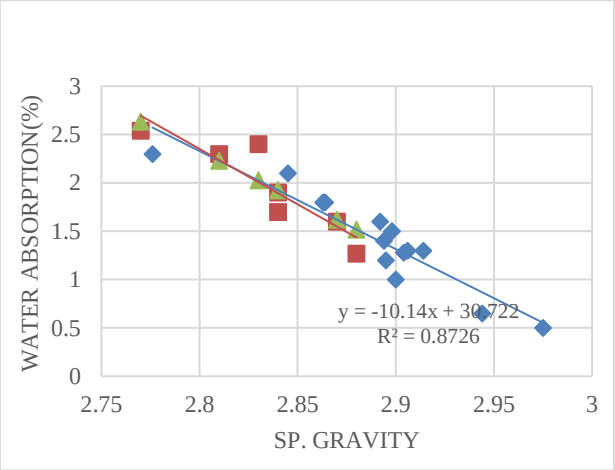

Fig. 5: Specific gravity Vs Water Absorption (%)

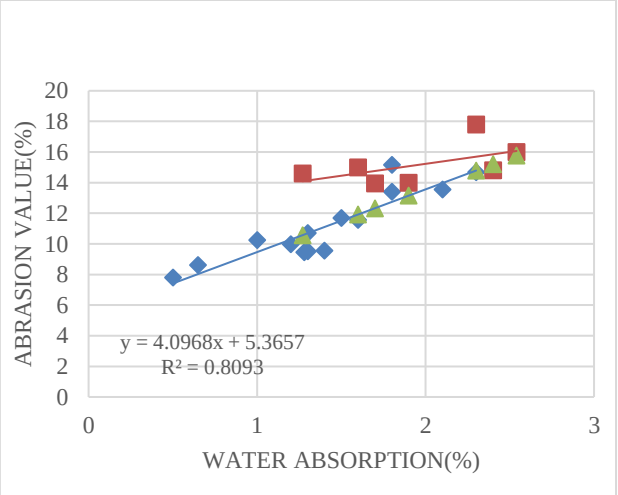

Fig. 6: Water Absorption (%) Vs Abrasion value (%)

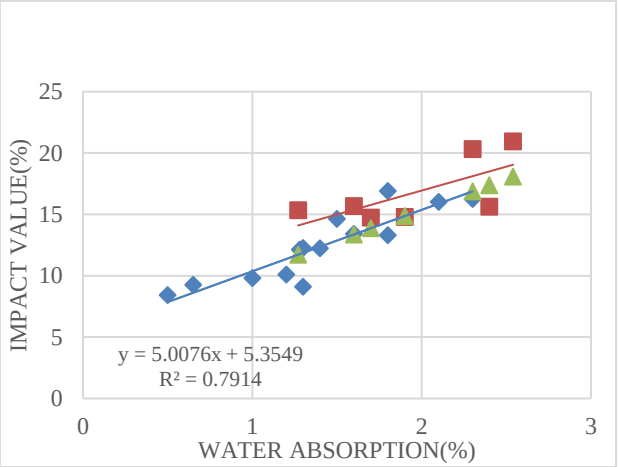

Fig. 7: Water Absorption (%) Vs Impact value (%)

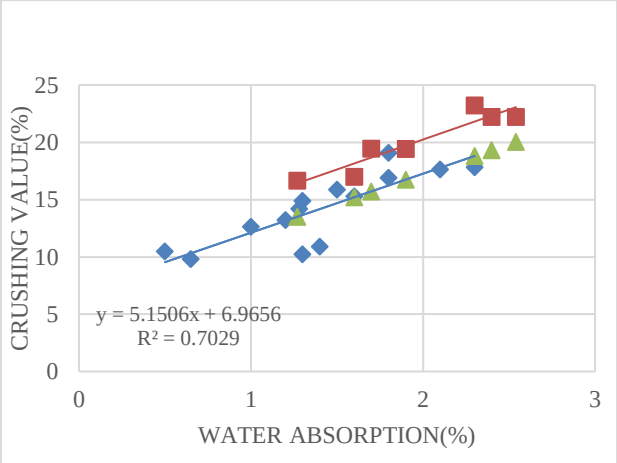

Fig. 8: Water Absorption (%) Vs Crushing value (%)

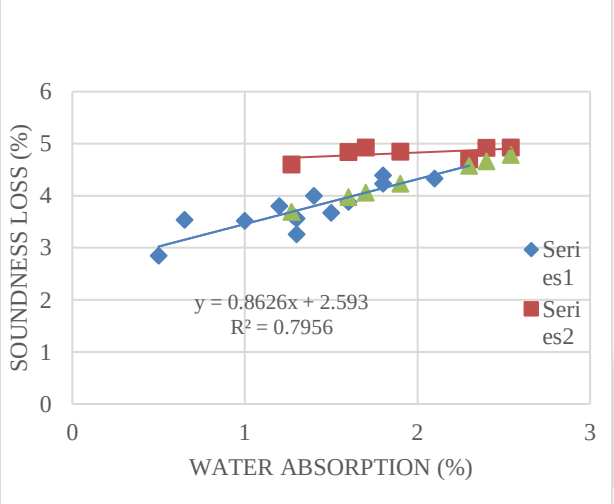

Fig. 9: Water Absorption (%) Vs Soundness loss (%)

IV. Conclusions

Empirical mathematical model developed for finding approximate values of mechanical properties using physical properties gives most of values with maximum variation (+/- 20%) with actual values it justifies the authenticity of developed mathematical models. Thus results may be used for construction purposes at site when time is limited for testing of basalt aggregates. However, exact values of these properties can be achieved by laboratory testing as per IS: 2386-1963 (reaffirmed in 2016). Petrography analysis of aggregates should also be carried out to find mineral composition and Alkali reactivity test to be done to find that aggregates are of innocuous behavior.

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