# Inter Relationship among Physical and Mechanical Properties of Quartzite Coarse Aggregates

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*Abstract*— Aggregate is relatively inexpensive and does not have complex chemical reactions with water in concrete. It is inert filler in mortar and concrete. Aggregate is a granular material, such as sand, gravel or crushed stone used with cement to produce mortar or concrete. Due to increasing awareness of role being played by aggregates in determining properties of mortar and concrete, the view of aggregate as filler materials is required to be reviewed. The normal concrete strength is usually not dependent on the aggregate strength except light weight aggregates. Aggregate characteristics other than strength, such as shape, size, surface texture, particle size etc. and its mineralogy will affect the strength of concrete. The physical properties of aggregates are inter-related and have definite relationship. The relationship among the physical properties of coarse aggregate with mathematical model for quartzite aggregates has been derived and presented in this paper.

***Keywords:*** Coarse Aggregate, Physical Properties, Concrete, Mathematical Model, Quartzite Rock

## I. Introduction

Generally, aggregate properties affect not only the concrete mixture proportions but also the behavior of fresh and hardened concrete. Due to considerable overlap between the two, it can be categories into three groups based on micro-structural and processing factors:

- Characteristics dependent on porosity, density, water absorption, strengths, hardness, elastic modulus and soundness,
- Characteristics dependent on particle size, shape and texture, and
- Characteristics dependent on chemical and mineralogical composition, strength, hardness, elastic modulus and deleterious substances

A mineralogical composition of aggregate affects its crushing strength, hardness, elastic modulus and soundness which in turn influence various properties of hardened concrete.

## II. Physical and Mechanical Properties

Shape of an aggregate is characterized by flakiness and elongation indexes. Flakiness index is defined if the thickness is 0.6 times of the mean dimension and contributes more surface area for a unit volume occupied in concrete, whereas elongation index is defined if the greatest dimension or length being 1.8 times the mean dimension and contributes more surface area for a unit volume occupied in concrete.

Water absorption capacity is defined as the total amount of water required to bring an aggregate from oven dry to saturated surface dry condition. The amount of water in excess of the water required for the saturated surface dry condition is referred as the surface moisture. Specific gravity is defined as the density of the aggregate including internal joints/pores, whereas, bulk density is defined as the mass of the aggregate that fills a unit volume of rock. An aggregate is unsound when the volume changes in aggregate induced by weather e.g. alternate cycles of wetting and drying or freezing & thawing, results in the deterioration of concrete.

Mechanical properties of aggregates such as crushing strength, impact value, abrasion resistance and elastic modulus are interrelated that are greatly influenced by porosity. The limit for these properties as per IS: 383-2016 is as follows:

Crushing and impact value – 30% for wearing surface and 45% for non-wearing surface
Abrasion resistance – 30% for wearing surface and 50% for non-wearing surface

### *A. Laboratory Investigations*

All the coarse aggregate samples collected from different parts in Eastern part of India have been tested as per IS: 2386 - 1963 (Reaffirmed in 2016).

## III. Results and Discussions

Test results of Specific gravity, Impact value, Abrasion value, Crushing value, Soundness loss and Water absorption for twenty samples are shown in table.

| Sl. No. | Sample prepared from Rock Types | Specific gravity | Impact Value (%) | Abrasion Value (%) | Crushing value (%) | Soundness loss (%) | Water Absorption (%) |
|---|---|---|---|---|---|---|---|
| 1 | Quartzite | 2.96 | 19.38 | 20.2 | 18.7 | 0.3 | 0.4 |
| 2 | Quartzite | 2.9 | 16.62 | 18.8 | 17.8 | 0.6 | 0.5 |
| 3 | Quartzite | 2.95 | 20.3 | 19.48 | 17.6 | 0.8 | 0.3 |
| 4 | Quartzite | 2.74 | 21.54 | 29.7 | 23.3 | 2.3 | 0.65 |
| 5 | Quartzite | 2.71 | 28.6 | 30.58 | 26.9 | 2.17 | 0.6 |
| 6 | Quartzite | 2.76 | 26.15 | 30.18 | 25.3 | 2.0 | 0.75 |
| 7 | Quartzite | 2.76 | 28.6 | 34.1 | 24.9 | 1.5 | 0.56 |
| 8 | Quartzite | 2.73 | 27.0 | 32.9 | 25.8 | 2.83 | 0.7 |
| 9 | Quartzite | 2.671 | 27.1 | 33.72 | 24.18 | 2.36 | 0.82 |
| 10 | Quartzite | 2.619 | 28.6 | 37.52 | 29.09 | 2.56 | 0.76 |
| 11 | Quartzite | 2.825 | 20.8 | 27.36 | 23.82 | 1.65 | 0.61 |

 

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|---|---|---|---|---|---|---|---|
| 12 | Quartzite | 2.739 | 19.8 | 33.45 | 18.36 | 1.59 | 0.61 |
| 13 | Quartzite | 2.788 | 27.5 | 24.11 | 20.73 | 1.44 | 0.78 |
| 14 | Quartzite | 2.691 | 26.1 | 30.32 | 23.64 | 1.46 | 0.75 |
| 15 | Quartzite | 2.747 | 21.4 | 22.28 | 24.18 | 2.12 | 0.58 |
| 16 | Quartzite | 2.737 | 23.7 | 30.88 | 26.73 | 1.53 | 0.81 |
| 17 | Quartzite | 2.676 | 28.6 | 26.91 | 27.27 | 2.86 | 0.68 |
| 18 | Quartzite | 2.665 | 28.4 | 37.06 | 26.18 | 2.63 | 0.9 |
| 19 | Quartzite | 2.786 | 30.3 | 31.65 | 25.45 | 1.86 | 0.76 |
| 20 | Quartzite | 2.639 | 28.7 | 34.56 | 21.09 | 2.03 | 0.8 |

Inter relationship among physical and mechanical properties of quartzite coarse aggregate samples have been developed and presented below:

1) Correlation between Specific gravity and Impact value has been developed for 20 samples tested in laboratory

$Y = -30.101X + 107.88$

$R^2 = 0.4823$

Where Y= Impact Value (%)

X= Specific gravity

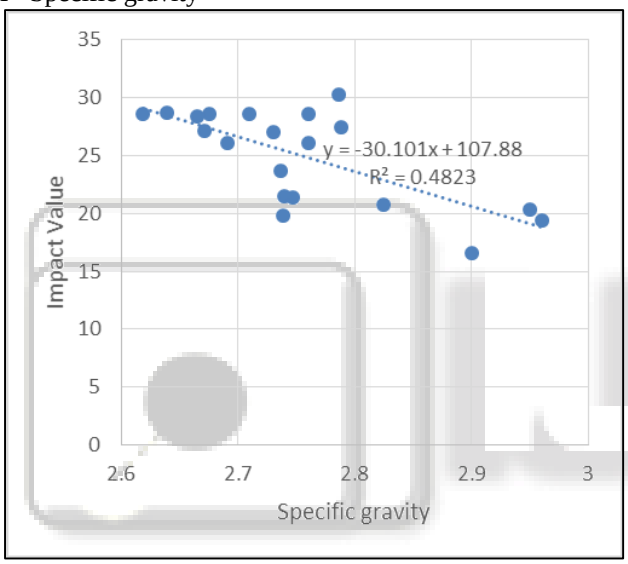


Fig. 1: Correlation between Specific gravity Vs Impact Value (%)

2) Correlation between specific gravity and abrasion value has been developed for 20 samples tested in laboratory

$Y = -49.547X + 165.77$

$R^2 = 0.6747$

Where Y= Abrasion Value (%)

X= Specific gravity

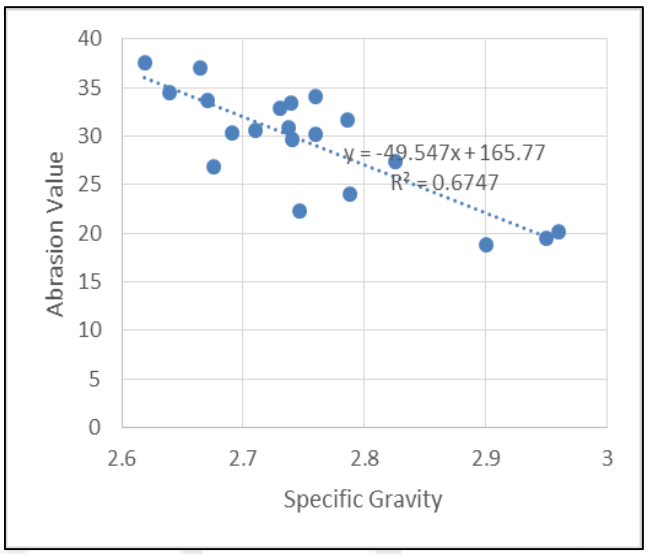


Fig. 2: Correlation between Specific gravity Vs Abrasion Value (%)

3) Correlation between Specific gravity and Crushing value has been developed for 20 samples tested in laboratory.

$Y = -25.011X + 92.449$

$R^2 = 0.4802$

Where Y= Crushing Value (%)

X= Specific gravity

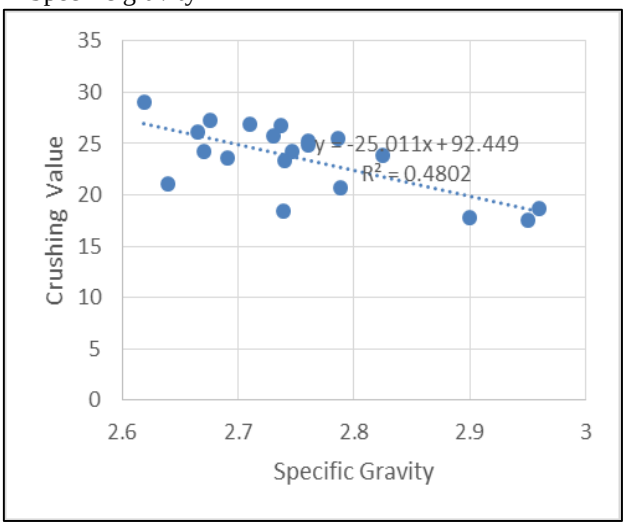


Fig. 3: Correlation between Specific gravity Vs Crushing Value (%)

4) Correlation between specific gravity and Soundness loss has been developed for 20 samples tested in laboratory.

$Y = -6.2431x + 19.027$

$R^2 = 0.6937$

Where X= Specific gravity

Y=Soundness loss (%)

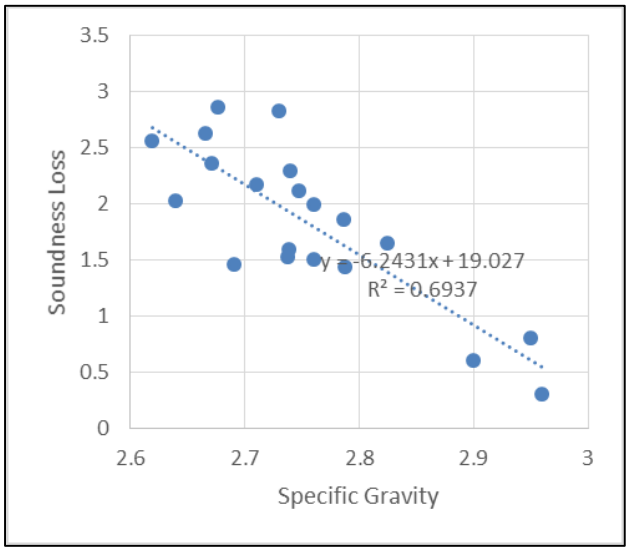


Fig. 4: Correlation between Specific gravity Vs Soundness Loss (%)

5) Correlation between specific gravity and Water absorption has been developed for 20 samples tested in laboratory.

Y = -1.2706X + 4.1661
R² = 0.642
Where X= Water absorption (%)
X=Specific gravity

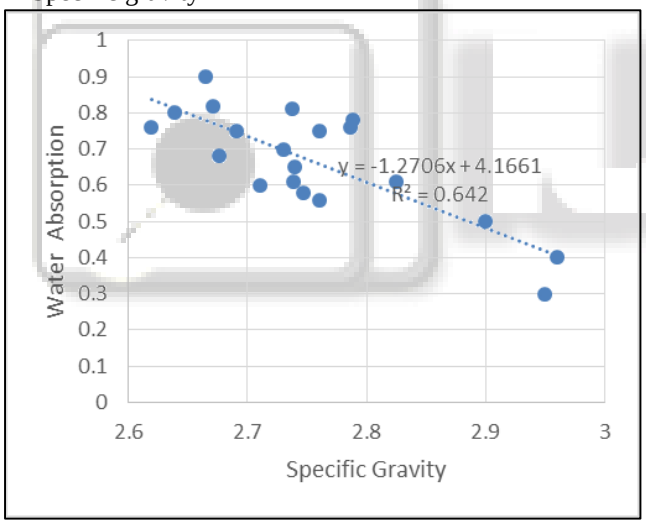


Fig. 5: Correlation between Specific Gravity Vs Water Absorption (%)

Correlations are also developed between water absorption and other mechanical properties of different quartzite coarse aggregate samples, which are presented below:

6) Correlation between Water absorption and Impact Value has been developed for 20 samples tested in laboratory.

Y = 18.196X + 12.841
R² = 0.4432
Where X=Water Absorption (%)
Y= Impact value (%)

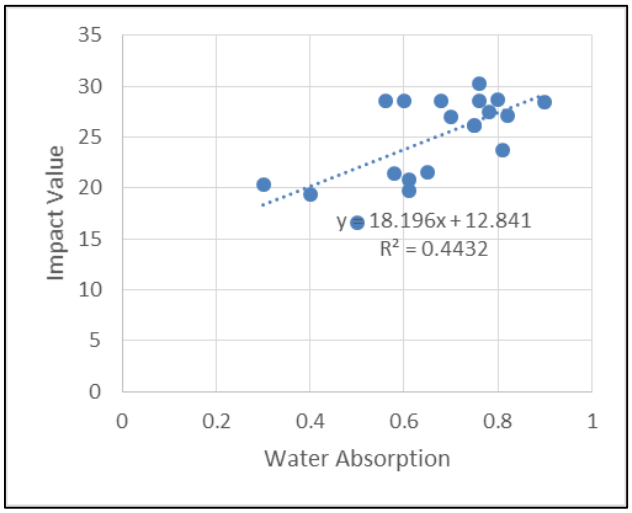


Fig. 6: Correlation between Water Absorption Vs Impact Value (%)

7) Correlation between Water absorption and Abrasion value has been developed for 20 samples tested in laboratory.

Y= 27.565X + 10.93
R² = 0.5252
Where X=Water absorption (%)
Y=Abrasion Value (%)

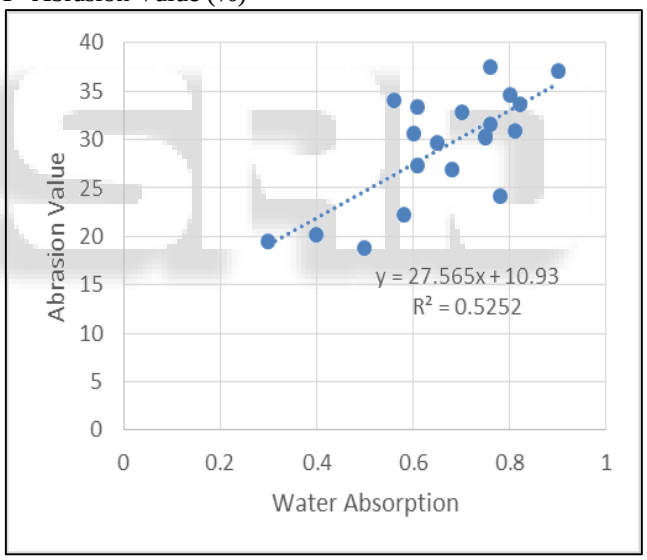


Fig. 7: Correlation between Water Absorption Vs Abrasion Value (%)

8) Correlation between Water absorption and Crushing value has been developed for 20 samples tested in laboratory

Y = 13.61X + 14.487
R² = 0.3576
Where X= Water absorption
Y= Crushing value (%)

 

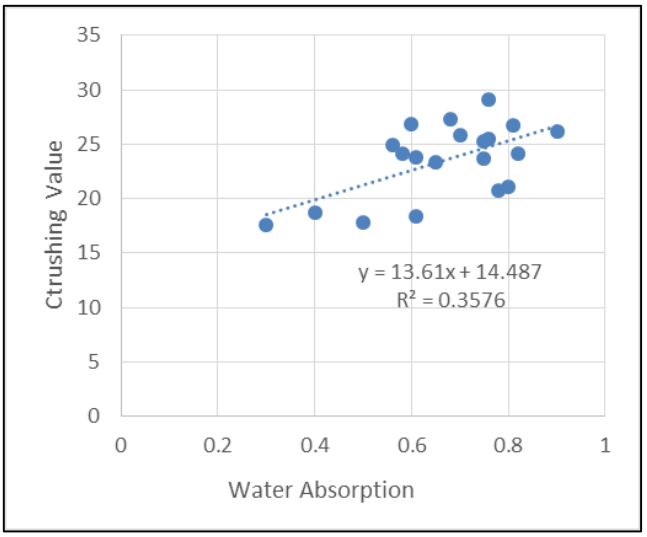


Fig. 8: Correlation between Water Absorption Vs Crushing Value

9) Correlation between Water absorption and Soundness loss has been developed for 20 samples tested in laboratory

$Y = 3.0647X - 0.2116$

$R^2 = 0.4204$

Where X=Water Absorption (%)

Y=Soundness Loss (%)

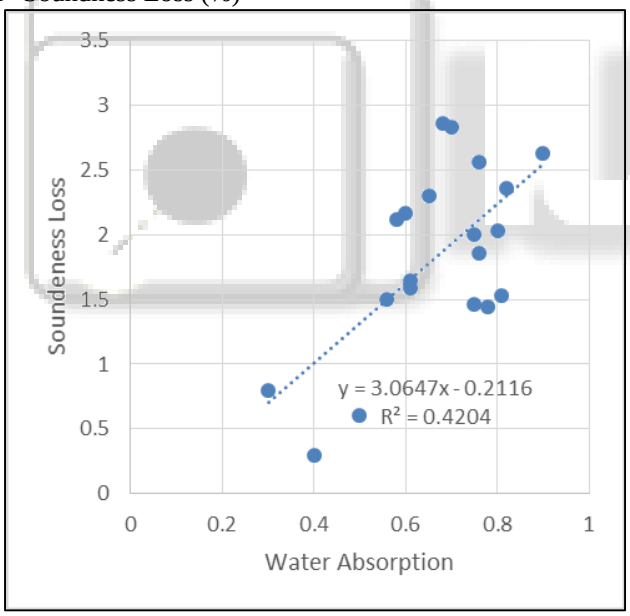


Fig. 9: Correlation between Water Absorption Vs Soundness Loss (%)

## IV. CONCLUSIONS

20 quartzite coarse aggregate samples collected and prepared from different quartzite rock quarries were tested and interpreted the relationship among physical and mechanical properties developed has been presented above. Approximate value of mechanical properties of coarse aggregate i.e. abrasion value, impact value, crushing value and soundness loss may be predicted with physical properties i.e. specific gravity and water absorption by using above correlations. However, exact values of these properties can be achieved by laboratory testing as laid down in IS: 2386-1963 (reaffirmed in 2016).

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