



# Quality Assessment Tests Of Coarse Aggregate Used In Jorhat District Of Assam

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**Abstract:** The functionality of a Reinforced Cement Concrete (RCC), Plain Cement Concrete (PCC) structure and Pavements depends on many factors like the selection of its ingredients i.e. binding materials, coarse aggregates, fine aggregates, reinforcement, water, admixture etc., and the interface between aggregate and mortar. The quality of concrete is also dependent on size of aggregates, method of mixing, placing of concrete in formwork, curing, temperature and exposure conditions. In case of high-performance concrete, the type coarse aggregate used has a great influence on the strength and elasticity modulus of concrete. The concrete may not be able to serve its intended purpose if aggregates do not meet the specified standards. In this research work, various quality assessment tests like- Shape Test (Flakiness and Elongation Index), Specific Gravity and Water Absorption Test, Aggregate Impact Value Test, Abrasion Value Test and Aggregate Crushing Value Test, were performed for coarse aggregates used in various construction projects of Jorhat district. The samples of mostly used 20 mm nominal size of coarse aggregates were from two different quarries namely -Bihubor and Uriumghat situated at Sibsagar and Golaghat District respectively, adjacent to Jorhat District of Assam. The tests were performed in the Material Testing Laboratory of Civil Engineering Department, H.R.H. The Prince of Wales Institute of Engineering & Technology, Jorhat, Assam. Results of both the samples considered for testing exhibit the quality standards as per Indian standards (IS), IRC and MORTH specifications.

**Key words:** Quarry, Coarse Aggregates, IS (Indian Standard), IRC (Indian Roads Congress), MORTH (Ministry of Road Transport and Highways), WBM (Water Bound Macadam), BC (Bituminous Macadam), WMM (Wet Mix Macadam), Flakiness, Elongation, Impact Value, Abrasion Value and Crushing Value.

**1. Introduction:** Coarse Aggregate used in manufacturing concrete plays important role as per strength and durability is concerned, as it forms the bulk of cement concrete. The workability, degree of compactness and overall strength of concrete depend on various test values, grading and types of parent rocks of coarse aggregates. The major quarries from which the aggregates are obtained for the locality are situated in Golaghat and Sibsagar Districts of Assam. Since many governments Mega Projects and National Highway Construction Project are going in the districts, there is always a great demand of crushed stone during the recent years. There are numbers of stone quarries running in this region and meeting the demands of the construction projects for many decades. They also contribute a lot to the state economy by depositing revenue and creating employment opportunities to the local communities at various levels.

In this attempt, the various test for coarse aggregate namely- Shape Test (Flakiness and Elongation Index), Specific Gravity and Water Absorption Test, Impact Value Test, Abrasion Value Test and Aggregate Crushing Value Test for 20mm nominal size have been conducted to assess the quality as per as per IS: 2386-1963.

**2. Objectives:** The objectives of this study are to achieve the following goals:

- To assess the quality of engineering properties of selected coarse aggregates as per relevant IS codes.
- To compare the quality of Coarse aggregates as per Indian Standards (IS), IRC and MORTH guidelines.
- To determine any deviations of test result from quality standards.

**3. Significance of the study:** Quality assessment of coarse aggregates used in the construction in this locality has manifold importance and advantages. Strength and structural integrity, safety, durability of structure and infrastructural development projects are primarily based on the quality of engineering materials used. The quality of coarse aggregate has a significant effect on the compressive strength of high strength concrete in particular. Use of substandard materials may fail a structure before design life and some structure during construction phase. This study determines the quality of coarse aggregates for selected quarries as per provisions of IS codes, used in the construction for the locality. Besides, the findings of this study can help the individual client, government agencies, builders, engineers about the current quality standards of the aggregates in the locality. It also becomes necessary to determine the quality of coarse aggregate obtained from approved quarry at certain interval of time to ensure the quality of construction.

**4. Scope of the study:**

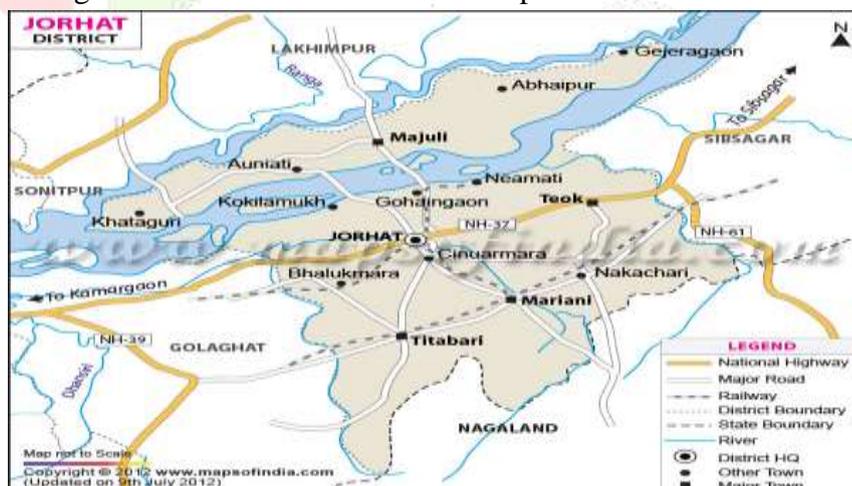
- The study emphasizes the quality assessment of coarse aggregates from the selected quarries of nearby Districts of Jorhat, Assam, India.
- This study covers various routine tests to assess the quality of coarse aggregates as per Indian standards.
- The study aims to provide a thorough understanding for the stakeholders about the coarse aggregates to be used in construction.

**5. Limitations of the study:** Following are the limitations of this study:

- The findings of this study are likely to be influenced as the samples were collected at different times from construction sites and other outlets which were exposed to different atmospheric conditions. They may not fully reflect the entire spectrum of coarse aggregate used in the region. Therefore, these findings may not be generalized for other regions without considering other specific local factors.
- Limitation in terms of use of modern equipment and expertise, time and budget may have the influences in the assessment.

**6. Research Methodology:** The methodology of the present study is as follows:

**6.1 Area of the Study:** The area of study, namely the Jorhat district, is a part of North-East India. The Jorhat district is bounded by Lakhimpur district on North, the state Nagaland on South, Sibsagar district on the East and Golaghat district on the West. The mighty river Brahmaputra flows from East to West on the northern side of the district which forms largest river Island of World. The map of the Jorhat district is shown in fig. -1.



**Fig.-1: Map of Jorhat District (Source: Google)**

**6.2 Sampling Strategy and collection:** The coarse aggregates were collected from few construction sites, and also from local builders and suppliers which they have originally collected from the selected quarries namely- Bihubor and Uriumghat. The aggregates were separated quarry wise and by mixing the collected aggregate thoroughly, the sample is prepared for testing. From the collected aggregates, one sample from each quarry is taken for quality assessment. As it sometimes becomes necessary to use aggregate from different sources in

the same project and hence this approach will be beneficial to the stake holders in selecting the aggregates for construction.

**6.3 Laboratory Testing:** The qualities of coarse aggregates were assessed by the routine tests performed in the Material Testing Laboratory of Civil Engineering Department of H. R. H. The Prince of Wales Institute of Engineering & Technology, Jorhat, Assam, India, using different testing equipment available in the laboratory.

**6.4 Compliance Assessment:** The test results were compared with the provisions of IS:383-1970 and other national standards to assess the compliance of the aggregate with specified quality requirements for construction. This comparison revealed conformities with standards, and suggesting for quality, safety and durability related issues if any.

**6.5 Data Analysis:** The results of obtained from different quality test of coarse aggregate from selected quarries are tabulated for the purpose of analysis and interpretation.

**7.0 Quality assessment of 20mm nominal size coarse aggregate:** The coarse aggregate used for construction purpose must fulfill the required quality standard as per Indian Standards. The coarse aggregate must undergo rigorous quality testing and exhibit the required standards for preparation of concrete and construction of pavements. In this study coarse aggregate of 20 mm nominal size from Bihubor and Uriumghat quarry are used for testing. Here are the few crucial tests to be performed on aggregate to evaluate the qualities:

**7.1 Shape Test (Flakiness and Elongation Index):** The shape of aggregate particle is determined by the percentage of flaky and elongated particles contained in it. In case of gravel, the shape may be expressed in terms of the angularity number. Presence of flaky and elongated particles in the coarse aggregates used for construction of base and surface courses of road pavements is considered undesirable, as these may cause inherent weakness with possibilities of breaking down during compaction as well as under heavy traffic. Rounded aggregates are preferred for cement concrete road construction as it increases the workability of concrete. Angular shapes of the aggregate are desirable for granular base course and also for use in bituminous mixes due to increased stability derived from better interlocking. When the shape of aggregates deviates more from the spherical shape, as in the case of angular, flaky and elongated aggregate, the void content in an aggregate of any specified size increases and hence the grain size distribution of graded aggregate has suitably altered in order to obtain minimum voids or highest density in the dry mix. Hence the shape of coarse aggregates is determined with respect to flakiness, elongation and angularity.

**Flakiness Index and Elongation Index:** The flakiness Index is determined for the coarse aggregate of size greater than 6.3mm. The flakiness index of aggregates is the percentage by weight of particles whose least dimension is less than three fifth or 0.6 times of their mean dimension. The Elongation Index of an aggregate is the percentage of particles whose greatest dimension is greater than one and fourth fifth times or 1.8 times of their mean dimension.

**Combined Flakiness Index and Elongation Index:** Combined Flakiness Index and Elongation Index of the aggregate is determined by adding the Flakiness Index and Elongation Index.

**Apparatus Required:** The apparatus shall consist of the following:

**1. Balance:** Balance should be able to weigh up to 1 g. Fig.2 shows balance required for the Test.

**2. Sieves:** Sieves required are 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10 and 6.3 mm (Based on requirement and Gradation of Aggregate). Fig.3 shows IS Sieves required for Shape Test.



Fig.2-Balance



Fig.3-IS Sieves

**3. Thickness Gauge for Flakiness Index:** Thickness Gauge have width equal to 0.6 times the mean dimension of the aggregate. Fig.4 shows the Thickness Gauge for Flakiness Index Test.

**4. Length Gauge for Elongation Index:** Length Gauge have length equal to 1.8 times the mean dimension of the aggregate. Fig. 5 shows the Length Gauge required for Elongation Index.



**Fig.4 -Thickness Gauge**



**Fig.5 -Elongation Gauge**

**Reference:** IS: 2386 (Part I)-1963: Methods of Test for Aggregates of Concrete-Particle Size and Shape: - Reaffirmed-2002

**Procedure:**

1. A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2. The sample shall be sieved with the sieves specified in Table-7.1

**Table:7.1-Dimensions (Length and Thickness) of Gauges**

| Size of Aggregate thickness(mm) |                      | Thickness gauge*<br>(mm) | Length Gauge**<br>(mm) |
|---------------------------------|----------------------|--------------------------|------------------------|
| Passing through IS Sieve        | Retained on IS Sieve |                          |                        |
| 63                              | 50                   | 33.90                    | -                      |
| 50                              | 40                   | 27.00                    | 81.0                   |
| 40                              | 31.5                 | 19.5                     | 58.5                   |
| 31.5                            | 25                   | 16.95                    | -                      |
| 25                              | 20                   | 13.5                     | 40.5                   |
| 20                              | 16                   | 10.8                     | 32.4                   |
| 16                              | 12.5                 | 8.55                     | 25.6                   |
| 12.5                            | 10                   | 6.75                     | 20.2                   |
| 10                              | 6.3                  | 4.89                     | 14.7                   |

\*This dimension is equal to 0.6 times the mean Sieve size

\*\*This dimension is equal to 1.8 times the mean Sieve size

3. Separation of Flaky material: Each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig.3, or in bulk on sieves having elongated slots. The width of the slot used in the gauge or sieve shall be of the dimensions specified in col. 3 of Table-7.1 for the appropriate size of material.

4. The total amount passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

5. The Flakiness Index is the total weight of the material passing the various thickness gauges or sieves, expressed as a percentage of the total weight of the sample gauged.

6. Separation of Elongated Material- Each fraction shall be gauged individually for length on a metal length gauge of the pattern shown in Fig.4.The gauge length used shall be that specified in col.4 of Table 7.1 for the appropriate size of material.

7. The total amount retained by the length gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

8.The elongation index is the total weight of the material retained on the various length gauges, expressed as a percentage of the total weight of the sample gauged.

**Observation And Recording:** The observations shall be recorded in the Table-7.2

**Table:7.2- Recordings for Flakiness Index**

| Passing through IS Sieves(mm) | Retained on IS Sieves (mm) | Flakiness Gauge (mm) | Weight Passing on Flakiness Gauge (g) | Percentage Weight Passing (%) |
|-------------------------------|----------------------------|----------------------|---------------------------------------|-------------------------------|
| 63                            | 50                         | 33.90                |                                       |                               |
| 50                            | 40                         | 27.00                |                                       |                               |
| 40                            | 25                         | 19.50                |                                       |                               |
| 31.5                          | 25                         | 16.95                |                                       |                               |
| 25                            | 20                         | 13.50                |                                       |                               |
| 20                            | 16                         | 10.80                |                                       |                               |
| 16                            | 12.5                       | 8.55                 |                                       |                               |
| 12.5                          | 10                         | 6.75                 |                                       |                               |
| 10                            | 6.3                        | 4.89                 |                                       |                               |
|                               |                            | Total                |                                       |                               |

**Table:7.3-Recordings for Elongation Index**

| Passing through IS Sieves(mm) | Retained on IS Sieves (mm) | Elongation Gauge (mm) | Weight Retained on Elongation Gauge (g) | Percentage Weight Retained (%) |
|-------------------------------|----------------------------|-----------------------|---|--------------------------------|
| 63                            | 50                         | --                    |   |                                |
| 50                            | 40                         | 81.00                 |   |                                |
| 40                            | 25                         | 58.5                  |   |                                |
| 31                            | 25                         | --                    |   |                                |
| 25                            | 20                         | 40.50                 |   |                                |
| 20                            | 16                         | 32.4                  |   |                                |
| 16                            | 12.5                       | 25.6                  |   |                                |
| 12.5                          | 10                         | 20.2                  |   |                                |
| 10                            | 6.3                        | 14.7                  |   |                                |
|                               |                            | Total                 |   |                                |

**Calculation:**

- The Flakiness Index on an aggregate is =  

$$\frac{\text{Total weight passing Flakiness Gauge} \times 100}{\text{Total weight of test sample}} = \dots \quad (\%)$$
- The Elongation Index on an aggregate is =  

$$\frac{\text{Total weight retained on Elongation Gauge} \times 100}{\text{Total weight of test sample}} = \dots \quad (\%)$$

**7.2 Specific Gravity Test and Water Absorption Test:** The specific gravity of an aggregate is considered to be a measure of strength and quality of a material. Stone having low specific gravity are generally weaker than those with higher specific gravity values. The specific gravity test helps in identification of stone. Water absorption of an aggregate is accepted as measure of porosity.

The specific gravity of coarse aggregates normally used in road construction ranges from about 2.5 to 3.2 with an average value of about 2.7. Water absorption value generally ranges from 0.1 to about 2.0 percent for coarse aggregates normally used in road surface course.

**Sample:** A sample of one kilogram of the aggregate should be used. Aggregates which have been artificially heated should not normally be used; if such material is used, the fact should be stated in report. (Two tests shall be made and it is recommended that sample should not be tested concurrently)

**Apparatus Required:** The following apparatus are used for the test-

**1. Balance:** Balance should be accurate up to 5gm

**2. Oven:** A well- ventilated oven, thermostatically controlled to maintain a temperature of 100<sup>0</sup> C to 110<sup>0</sup> C. Fig. 6 shows the Oven required for the Test.

**3. Glass Vessel:** A wide- mouthed glass vessel, such as jar of 1.5liter capacity, with a flat ground lip and a plane ground disc of glass plate, to cover it giving a virtually watertight fit. Fig. 7 shows the Glass jar required

for the test.



**Fig. 6- Thermostatically Controlled Oven**



**Fig. 7- Glass Vessel**

**4. Cloth:** Two dry soft absorbent cloths, each not less than 75x 45 cm.

**5. Tray:** A shallow tray of area not less than 325 cm<sup>2</sup>.

**6. Container:** An air tight container large enough to take the sample.

**Theory:** Specific gravity shall be calculated as =  $D/[C-(A-B)]$

Water absorption =  $100 \times (B-C)/C$

A- Weight in (g) of vessel containing sample and filled with water.

B- Weight in (g) of vessel filled with distilled water only

C- Weight in (g) of saturated surface dry sample

D- Weight in (g) of oven dry sample

**Reference:** IS: 2386 (Part III)-1963: Methods of Test for Aggregates for Concrete- for Specific Gravity, Density, Voids, Absorption and Bulking-Reaffirmed -2002

**Procedure: Method II for aggregates between 40 to 10 mm**

1. The sample shall be screened on 10 mm IS Sieve, thoroughly washed to remove fine particles of dust, and immersed in distilled water in glass vessel, air entrapped in or bubbles on the surface of the aggregate shall be removed by gentle agitation. This may be achieved by rapid clockwise and anti-clockwise rotation of the vessel between the operator's hands.

2. The vessel shall be overfilled by adding distilled water and the plane ground glass dishes over the mouth so as to ensure that no air is trapped in the vessel. The vessel shall be dried outside and weighed 'A'.

3. The vessel shall be emptied and aggregate allowed are to drain. Refill the vessel with distilled water. Side the glass disc in position as before. The vessel the vessel shall be dried and weighed 'B'.

4. The difference between temperature of the water in vessel during the first and second weighing shall not exceed 2<sup>0</sup> C.

5. The aggregates shall be placed on a dry cloth and gently surface dried with the cloth, transferring it in to a second dry cloth when the first will remove no further moisture. It shall then be spread out not more than one stone deep on second cloth, and left exposed to the atmosphere away from direct sun light or any other source of heat for not less than 10 minutes or until it appears to be completely surface dry (which with some aggregates may take an hour or more)

6. The aggregates shall be turned over at least once during this period and a gentle current of unheated air may be used after the first 10 minutes to accelerate the drying of difficult aggregates then the aggregates shall then be weighed 'C'

7. The aggregates shall be placed in the oven in the shallow tray, at a temperature of 100-to-110-degree centigrade for 24 and half hours. It shall then be cooled in air tight container and weighed 'D'

**Observation and Calculation:** The observed are values shall be put in the relations to determine the Specific Gravity and Water Absorption of the Coarse aggregate.

**7.3 Impact Value Test:** Aggregate Impact test has been designed to evaluate the toughness or the resistance of the stones aggregates to breaking down under repeated application of impact. Aggregate Impact value

indicates a relative measure of the resistance of aggregate to impact.

**Apparatus Required:** The apparatus shall consist of the following-

**1. Balance:** Balance shall be accurate up to 1g

**2. Sieves:** Sieves required are 12.5, 10, and 2.36 mm

**3. Impact Testing Machine:** Weight of hammer is 13.5 to 14 kg and height of fall is 380+5/380-5 mm. Fig.8 shows the

Impact Testing machine used for the test.



**Fig.8- Impact Testing Machine**

**Reference:** IS: 2386 (Part IV):1963 Methods of Test for Aggregates for Concrete Mechanical Properties, Reaffirmed –Dec 2016

**Procedure:**

1. The test sample shall consist of aggregate the whole of which passes 12.5mm IS Sieve and is retained on 10 mm Sieve. The aggregate comprising the test sample shall be dried in an oven for a period of four hours at a temperature of 100<sup>0</sup> C to 110<sup>0</sup> C and cooled.

2. The measure shall be filled about one-third full with the aggregate and tamped with 25 strokes of the rounded end of the tamping rod. Further similar quantity of aggregate shall be added and a further tamping of 25 strokes given. The measure shall finally be filled to overflowing, tamped 25 times and the surplus aggregate struck off, using the tamping rod as a straight edge. The net weight of the aggregate in the measure shall be determined to the nearest gram (Weight A).

3. The impact machine shall rest without wedging or pack in upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

4. The cup shall be fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by a single tamping of 25 strokes of the tamping rod.

5. The hammer shall be raised until its lower face is 380 mm above the upper surface of the aggregate in the cup, and allowed to fall freely on the aggregate. The test sample shall be subjected to a total of 15 such blows each being delivered at an interval of not less than one second.

6. The crushed aggregate shall then be removed from the cup and the whole of it sieved on the 2.36 mm IS Sieve until no significant amount passes in one minute. The fraction passing the sieve shall be weighed to an accuracy 0.1g (Weight B)

7. The fraction retained on the sieve shall also be weighed (Weight C) and, if the total weight (C+B) is less than the initial weight (Weight A) by more than one gram, the result shall be discarded and a fresh test made. Two tests shall be made.

**Observation and calculation:**

The ratio of the weight of fines formed to the total sample weight in each test shall be expressed as percentage, the result being recorded to the first decimal place:

Aggregate Impact value=  $(B/A) \times 100$

Where

B= weight of fraction passing 2.36mm IS Sieve, and

A= weight of oven-dried sample

#### 7.4 Abrasion Value Test:

Due to the movement of traffic, the road stones in the surfacing course of pavements are subjected to wearing action at the top of surface. Resistance to wear or hardness is hence an essential property for road aggregates, especially when used in wearing course. Thus, road stone should be hard enough to resist the abrasion due to the traffic.

Abrasion test on aggregates is generally carried out by any one of the following methods:

1. Los Angeles abrasion test
2. Deval abrasion Test
3. Dorry abrasion test

**Los Angeles Abrasion Test:** The Indian Road Congress (IRC) and the Ministry of Road Transport and Highways (MORTH) have specified only Los Angeles abrasion test with reference to the requirement for resistance to abrasion.

**Apparatus Required:** The apparatus shall consist of the following-

**1. Balance:** Balance shall be accurate up to 1g

**2. Sieves:** Sieves required are 80, 63, 50, 40, 25, 20, 12.5, 10, 6.3, 4.75 (as per gradation of aggregate) and 1.75 mm. Fig.9 depicts few of the IS Sieves used in the Test.

**3. Los Angeles Abrasion Testing Machine:** Inside length=500 mm and Inside diameter=700 mm. Fig.10 depicts the Los Angeles Abrasion Testing Machine used in the test.

**4. Abrasive charges:** Diameter=48mm and weight=390 to 445 g. Fig.11 shows the abrasive Charges used during the test.



Fig.9-IS Sieves



Fig.10- Los Angeles Abrasion Testing Machine



Fig.11- Abrasive Charges

#### Reference:

IS: 2386(Part 4):1963 Methods of Test for Aggregates for Concrete Mechanical Properties, Reaffirmed –Dec 2016

#### Procedure:

##### A. Gradation of aggregate:

1. Gradation of aggregate should be carried out so as to assess the Grade of the Aggregate (A to G)

Table:7.4 - Gradation of Aggregate

| Sieve Size   |                  | Weight in gm. of Test Sample for grade |      |   |   |      |      |      |
|--------------|------------------|--|------|---|---|------|------|------|
| Passing (mm) | Retained on (mm) | A                                      | B    | C | D | E    | F    | G    |
| 80           | 63               |  |      |   |   | 2500 |      |      |
| 63           | 50               |  |      |   |   | 2500 |      |      |
| 50           | 40               |  |      |   |   | 5000 | 5000 |      |
| 40           | 25               | 1250                                   |      |   |   |      | 5000 | 5000 |
| 25           | 20               | 1250                                   |      |   |   |      |      | 5000 |
| 20           | 12.5             | 1250                                   | 2500 |   |   |      |      |      |

|      |      |      |      |      |      |  |  |  |
|------|------|------|------|------|------|--|--|--|
| 12.5 | 10   | 1250 | 2500 |      |      |  |  |  |
| 10   | 6.3  |      |      | 2500 |      |  |  |  |
| 6.3  | 4.75 |      |      | 2500 |      |  |  |  |
| 4.75 | 2.36 |      |      |      | 5000 |  |  |  |

### B. Procedure for Los Angeles Test:

1. The test sample shall consist of clean aggregate which has been dried in an oven of 105 to 110<sup>0</sup> C to substantially constant weight and shall conform to one of the grading shown in the Table:7.4. The grading used shall be those most nearly representing the aggregate furnished for work.
2. The test sample and abrasive charge shall be placed in the Los Angeles Abrasion Testing machine and the machine rotated at a speed of 30 to 33 revolution/minute. For grading A, B, and C the machine shall be rotated for 500 revolutions; for grading E, F and G, it shall be rotated for 1000 revolutions.

**Table: 7.5- No of Charges as per Grading of Aggregate**

| Grading | Number of spheres | Weight of charge (gm) |
|---------|-------------------|-----------------------|
| A       | 12                | 5000±25               |
| B       | 11                | 4584±25               |
| C       | 8                 | 3330±20               |
| D       | 6                 | 2500±15               |
| E       | 12                | 5000±25               |
| F       | 12                | 5000±25               |
| G       | 12                | 5000±25               |

3. The machine shall be so driven and so counter balanced as to maintain a substantially uniform peripheral speed. If an angle is used as the shelf, the machine shall be rotated in such a direction that the charge is caught on outside surface of the angle
4. At the completion of the test, the material shall be discharged from the machine and a preliminary separation of the sample made on a sieve coarser than the 1.70 mm IS Sieve.
5. The material coarser than the 1.70mm IS Sieve shall be washed dried in an oven at 105 to 110<sup>0</sup> C to a substantially constant weight, and accurately weighed to nearest gram.

### Observation and calculations:

Weight of the sample (and Grade) =W1

Number of balls as per grade =

Weight of the sample retained on IS 1.7 mm Sieve after test = W2

The difference between original weight and the final weight of test sample is expressed as the percentage of the original weight of test sample. This value is reported as percentage wear.

**7.5 Aggregate Crushing Value Test:** The strength of coarse aggregate or resistance to crushing of the coarse aggregates under the applied load is generally assessed by conducting aggregate crushing test.

A low aggregate crushing value indicates higher resistance to getting crushed under the application of the specified load or higher crushing strength.

**Apparatus Required:** The apparatus shall consist of the following-

**1.Balance:** A Balance of capacity 3kg, readable and accurate up to 1g.

**2.Sieve:** Sieves required are 12.5,19and 2.36 mm

**3.Steel mould:** A steel cylinder with a 15cm diameter, equipped with a plunger and base plate

**4.Tamping rod:** A round straight steel rod used with concrete cylinder mould.

**5.Compression Testing Machine:** A compression testing machine capable of applying a load of 40 tones and which can be operated to give a uniform rate of loading so that maximum load is reached at 10 minutes. Fig. 12 depicts the Compression Testing Machine used for the test.



**Fig.12- Compression Testing Machine**

**6. Cylindrical measure:** A cylindrical metal measure of diameter 11.5 cm and height 18 cm.

**Preparation of sample:**

1. The material for the standard test shall consist of aggregate passing 12.5 mm IS Sieve and retained on a 10 mm IS Sieve and shall be thoroughly separated in these sieves before testing.
2. The aggregate shall be tested on surface dry condition. If dried by heating, the period of drying shall not exceed four hours, the temperature shall be 100 to 110<sup>0</sup> C and the aggregate shall be cooled to room temperature before testing.
3. The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping shall be 10 cm.
4. The appropriate quantity may be found conveniently by filling cylindrical measure in three layers of approximately equal depth, each layer being tamped 25 times with the round end of the tamping rod and finally levelled off, using the tamping rod as a straight edge.
5. The weight of material comprising the test sample shall be determined (weight A) and the same weight shall be taken for the repeat test.

**Procedure:**

1. The cylinder of the test apparatus shall be put in position on the base plate and the test sample added in thirds, each third being subjected to 25 strokes from the tamping rod. The surface of the aggregate shall be carefully levelled, and the plunger inserted so that it rests horizontally on this surface, care taken to ensure that the plunger does not jam in the cylinder.
2. The apparatus with test sample and plunger in position than be placed between the plates of the testing machine and loaded at a uniform rate as possible so that the total load is reached in 10 minutes. The total loads shall be 40 tones. The load shall be released and whole of the material removed from the cylinder and sieved on a 2,36 mm IS sieve for standard test. The fraction passing the appropriate sieve shall be weighed (weight B).

**Observation and Calculations:**

The ratio of the weight of fine forms to the total sample of weight in each test shall be expressed as percentage, the result shall be recorded to the first decimal place.

$$\text{Aggregate Crushing Value} = (B/A) \times 100\%$$

Where

- A- Weight of surface dry sample
- B- Weight of fraction passing appropriate sieve size

**8.0 Quality assessment Test:** In this study, five (5) principal quality assessment tests such as Shape Test (Flakiness and Elongation Index), Specific Gravity Test and water Absorption Test, Impact Value Test, Abrasion Value Test and Aggregate Crushing Value Test were carried out in order to determine the quality of coarse aggregate for the aforesaid two selected quarry.

**8.1 Shape Test (Flakiness Index and Elongation Index):**

**Aim:** The aim of this test is to determine the percentage of flaky and elongated particles contained in a given

sample of aggregate.

**Reference:** IS: 2386 (Part I)-1963: Methods of Test for Aggregates of Concrete-Particle Size and Shape: -Reaffirmed-2002.

**Theory and Scope:** Flakiness and Elongation tests are conducted on coarse aggregates to assess the shape of aggregates. Presence of flaky and elongated particles in the coarse aggregates used for construction of base and surface courses of road pavements is considered undesirable, as these may cause inherent weakness with possibilities of breaking down during compaction as well as under heavy traffic.

The Flakiness Index of aggregate is the percentage by weight of particles whose least dimension (thickness) is less than three-fifths of their mean dimension it is determined with the help of a standard metal thickness gauge. The Elongation Index of an aggregate is the percentage of particles whose greatest dimension is greater than one and fourth fifth times or 1.8 times of their mean dimension.

To determine the Combined Flakiness and Elongation Index, first flakiness index of the samples found out and then then elongation index of nonflaky aggregates of the sample is found out. The Combined Flakiness and Elongation Index is calculated by adding the flakiness and elongation index of the aggregates sample.

**Apparatus required:** Balance, IS Sieves, Thickness Gauge and Length Gauge

**Procedure:** From the mixed coarse aggregates from each quarry the test samples were prepared for Shape Test for size of aggregates greater than 6.3mm. The sample aggregates were sieved with specified Sieve, flaky and elongated particles were separated by thickness gauge and length gauge respectively. Two tests for each sample were performed for each quarry and average was found out. The testing procedure followed was as per IS: 2386 (Part I)-1963: Methods of Test for Aggregates of Concrete-Particle Size and Shape: -Reaffirmed-2002

## 8.2 Specific Gravity and Water Absorption Test:

**Aim:** To determine the Specific Gravity and Water Absorption of coarse aggregate samples

**Reference:** IS: 2386 (Part III)-1963: Methods of Test for Aggregates for Concrete- for Specific Gravity, Density, Voids, Absorption and Bulking-Reaffirmed -2002.

**Theory and Scope:** The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. The specific gravity test helps in identification of stone.

Water absorption gives an idea of strength of aggregate. Aggregates having more water absorption are more porous in nature and are generally considered unsuitable unless they found suitable in respect of strength, impact and hardness tests.

**Apparatus Required:** Balance, Oven, Glass vessel or Jar, Cloth, Tray and Container.

**Procedure:** From the mixed aggregates from each quarry the test samples were prepared for determination of Specific Gravity and Water Absorption of the coarse aggregate. Two tests for each sample were performed for each quarry and average was noted. The test procedure was followed as stipulated in IS:2386 (Part III)-1963: Methods of Test for Aggregates for Concrete- for Specific Gravity, Density, Voids, Absorption and Bulking-Reaffirmed -2002.

## 8.3 Impact Value Test:

**Aim:** The aim of the test is to determine the toughness or the resistance of the stones aggregates to breaking down under repeated application of impact.

**Reference:** IS: 2386 (Part IV)-1963: Methods of Test for Aggregates for Concrete Mechanical Properties-Reaffirmed –Dec 2016

**Theory:** Toughness is the property of a material to resist impact. Due to moving loads the aggregates are subjected to pounding action or impact and there is a possibility of stones breaking into smaller pieces. Therefore, a test is designed to evaluate the toughness of stone i.e., the resistance of stones to fracture under repeated impacts is called Impact test on aggregate.

**Apparatus required:** Balance, Sieves, Impact Testing Machine

**Procedure:** From the mixed aggregates from each quarry test samples were prepared for determination of Aggregate Impact Value of the coarse aggregate. Two tests for each sample were performed for each quarry

and average was noted. Each test samples were placed in Impact Testing Machine and tested as per IS: 2386 (Part IV)-1963: Methods of Test for Aggregates for Concrete Mechanical Properties, Reaffirmed -2002

#### **8.4 Abrasion Value Test:**

**Aim:** To determine the Abrasion Value of coarse aggregate samples by conducting Los-Angeles Abrasion Test.

**Reference:** IS: 2386 (Part IV)-1963: Methods of Test for Aggregates for Concrete Mechanical Properties-Reaffirmed-2002

**Theory and Scope:** Abrasion is a measure of resistance to wear or hardness. It is an essential property for road aggregates especially when used in wearing course. Due to movements of traffic, the road stones used in the surfacing course are subjected to wearing actions at the top. When traffic moves on the road the soil particles i.e. sand which comes between the wheel and road surface causes abrasion on the road stone.

**Apparatus required:** Balance, Sieves, Los Angeles Abrasion Testing Machine and Abrasive charges.

**Los Angeles Abrasion Test:** The principle of Los Angeles Abrasion Test is to find the percentage wear due to the relative rubbing action between the aggregates and steel balls used as abrasive charge. The pounding action of these balls also exist while conducting the test.

**Procedure:** From the mixed aggregates from each quarry the test samples were prepared to determine the Abrasion Value of the coarse aggregate by Los Angeles Abrasion Test. Here one test for each sample was performed for each quarry and the result is found out. Gradation of each sample was determined and placed in the testing machine along with charges and the machine was rotated as per the procedure stated in IS: 2386 (Part IV)-1963: Methods of Test for Aggregates for Concrete Mechanical Properties, Reaffirmed -2002.

#### **8.5 Aggregate Crushing Value Test:**

**Aim:** To determine the crushing strength of a sample of coarse aggregates under gradually applied loads in terms of 'Aggregate Crushing Value'.

**Reference:** IS: 2386 (Part IV)-1963: Methods of Test for Aggregates for Concrete Mechanical Properties-Reaffirmed –Dec 2002

**Theory:** This is one of the major Mechanical properties required in a road stone. This test evaluates the ability of the aggregate used in road construction to withstand the stresses induced by moving vehicles in the form of crushing. The aggregates should also provide sufficient resistance to crushing under the roller during construction under rigid tyre rims of heavily loaded animal drawn vehicles.

**Apparatus Required:** Balance, Sieve, Steel mould, Tamping rod, Compression Testing Machine and Cylindrical measure.

**Procedure:** From the mixed aggregates of each quarry the test samples were prepared to determine aggregate Crushing Value of the aggregate. Two tests for each sample were performed for each quarry and average was calculated. The prepared sample was placed in Compression Testing Machine as per procedure laid in IS: 2386 (Part IV)-1963: Methods of Test for Aggregates for Concrete Mechanical Properties, Reaffirmed-2002.

**9.0 Test Results:** Table- 9.1 illustrates the comparative results of various tests performed for the selected samples.

**Table-9.1 Comparative Test Results for the Two sources and Requirements**

| Tests                                     | Test method        | Location |           | Requirements   |
|---|--------------------|----------|-----------|--|
|   |                    | Bihubor  | Uriumghat |  |
| Flakiness Index                           | IS 2386 (Part I)   | 15.73%   | 13.44%    | For <u>WBM</u> (IRC:19-2005)<br>Base course with bituminous surfacing:<br>Max. 20%<br>Surfacing course: Max. 15%   |
| Elongation Index                          | IS 2386 (Part I)   | 18.75%   | 17.52%    | MORTH and IRC specification: For roads Max. 30%<br>For concrete works: Max. 25%  |
| Flakiness and Elongation Index (Combined) | IS 2386 (Part I)   | 34.48%   | 30.96%    | IS:2386, Max.35%<br>Dense Graded Bituminous mixes: (IRC:111-2009):Max. 35%<br>Bituminous macadam:(FPC, Aug-2007): Max.40%<br>Wet mix macadam:(IRC:109-2015) max. 35%   |
| Specific Gravity                          | IS 2386 (Part III) | 2.65     | 2.72      | 2.5-3.0 (MORTH and IRC requirement)<br>2.4-3.0 (Ref:16)  |
| Water Absorption                          | IS 2368 (Part III) | 0.38%    | 0.26%     | <u>Dense Graded Bituminous mixes:</u> (IRC:111-2009)<br>Max. 2%<br>Bituminous macadam: (FPC, Aug-2007): Max. 2%<br>Surface dressing: (IRC:110-2005) Max. 1%  |
| Aggregate Impact Value                    | IS 2386 (Part IV)  | 21.19%   | 19.59%    | For <u>WBM</u> : (IRC:19-2005)<br>Sub base: Max. 40%<br>Base course with bituminous surfacing: Max. 30%<br>Surfacing course: Max. 30%<br><u>Dense Graded Bituminous mixes:</u> (IRC:111-2009)<br>BC: Max. 24%<br>Others: Max. 27%<br><u>Bituminous Macadam:</u> (FPC, Aug-2007): Max.30%<br>Surface dressing: (IRC:110-2005) Max. 30%<br>Wet mix macadam: (IRC:110-2005) |

|                            |                   |        |        |  |
|----------------------------|-------------------|--------|--------|--|
|                            |                   |        |        | Max. 30%<br><u>Aggregate to be used in Concrete (IS 383 :2016)</u><br>Wearing surfaces: Max. 30%<br>Other than wearing surfaces: Max.45%   |
| Los Angeles Abrasion Value | IS 2386 (Part IV) | 24.70% | 21.20% | <u>For WBM: (IRC:19-2005)</u><br>Sub base: Max. 50%<br>Base course with bituminous surfacing: Max. 40%<br>Surfacing course: Max. 40%<br><u>Dense Graded Bituminous Mixes: (IRC:111-2009)</u><br>Bituminous Concrete: Max. 30%<br>Others: Max. 35%<br><u>Bituminous Macadam: (FPC, Aug-2007): Max. 40%</u><br>Surface dressing: (IRC:110-2005) Max. 40%<br>Wet mix macadam: (IRC:110-2005) Max. 40%<br><u>Aggregate to be used in Concrete (IS 383 :1970)</u><br>Wearing surfaces: Max. 30%<br>Other than wearing surfaces: Max.50% |
| Aggregate Crushing Value   | IS 2386 (Part IV) | 28.69% | 27.71% | <u>Aggregate to be used in Concrete (IS 383 :1970)</u><br>Wearing surfaces: Max. 30%<br>Other than Wearing surfaces: Max.45%   |

### 10.0 Inferences:

10.1 From Table-9.1 it is seen that combined flakiness and elongation index, flakiness index and elongation index results for both the samples satisfy the required specification for different types of pavements.

10.2 From Table-9.1, it is seen that specific gravity of both the samples are within specified limits. Water absorption values of both Bihubor and Uriumghat sample are found satisfactory. Water absorption values for both the samples are much lower than required allowable limits for different types of pavement construction as per Indian road Congress (IRC) and Flexible Pavement Committee (FPC) requirements.

10.3 From Table-9.1, it is seen that for both the samples the test values for flakiness index and Elongation Index shows satisfactory results. The aggregates may be used for almost all types of pavement construction.

10.4 It is also observed from Table-9.1 that the sample from both the quarry shows satisfactory results in terms of Aggregate Impact Value, Abrasion Value and Crushing Value as per Indian standards.

**11. Future scope:** This study was solely focused on only few regular tests to determine the quality of aggregate. The future study may include the following:

- (i) Soundness test to study resistance of aggregates to weathering action.
- (ii) Bitumen adhesion test to determine the adhesion of bitumen binder to an aggregate in the presence of water.

(iii) Coarse aggregate from more locations, situated nearby Jorhat district, may be considered for quality assessment.

**12. Conclusion:** In conclusion, Quality Assessment and Quality Control (QA/QC) is an integral part of construction industry to ensure safety, durability and structural integrity of the structure. The process requires judicious selection of materials, precise testing and inspection of the materials followed by proper construction methods for a project to be viable in all respects. Due to advancement of digital technology now the way of quality control in the field of engineering has expedited a lot with more accuracy. Besides, emergences of new building materials, use of recycled material in the field of engineering requires advancement of quality assessment methods. Therefore, quality control for construction industry is a continuous and dynamic field for sustainable development considering environmental aspects.

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