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# Study of Evaluation Probability of Aggregate Testing – Review

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**ABSTRACT:** This study aims to testing the coarse aggregate and evaluate the probability results of lab testing. In this research we studied about 20mm size coarse aggregate which are tested in laboratory these testing are specific gravity test, water absorption test, crushing value test, impact value test. Also, we study about the proficiency testing scheme is organised on the lines of ISO/IEC 17043:2010 read with ISO 13528:2015 and the performance of the laboratories is evaluated in terms of Z'-Score as per ISO 13528:2015, if the Z'-Score is less than or equal to 2 then results are satisfactory, greater than 2 and less than 3 that means these are questionable and greater than 3 then results are unsatisfactory.

**KEYWORDS:** specific gravity, Impact value, crushing value, Z'-Score.

## I. INTRODUCTION

Aggregates are the inert materials that are mixed in fixed proportions with a binding material to produce concrete. Aggregates are classified according to aggregate source, according to unit weight and aggregate size [1]. Nowadays, with the rapid urbanization and growth in population, the construction industry is booming, and hence the demand for high-rise buildings is displaying an upward trend. This development in building construction has led to an increase in demand for better performing building/construction materials such as high strength concrete and its components like cement, sand, and aggregates. For long-lasting performance, each and every building material should be checked for their desired properties include durability. Maintaining top quality is of utmost importance in the present times. Due to this emphasis on quality, construction has to satisfy pre-decided benchmarks and standards. For aggregates, 7 important tests are identified which determine the quality of aggregate. The tests are Crushing Test on Aggregates, Abrasion Test on Aggregates, Impact Test on Aggregates, Soundness Test on Aggregates, Shape Test on Aggregates, Specific Gravity and Water Absorption Test on Aggregates, Bitumen Adhesion Test on Aggregates.

Aggregate is the second most important ingredient which forms the skeleton for concrete. Aggregates influence, to a greater extent, the load transfer capability of pavements and slabs. Therefore, before using for construction, it is necessary that they should be completely tested. Not only the aggregates should be strong and durable, but also have proper shape and size to make the element slab/pavements act monolithically. Hence, it is important to perform the test on aggregates to ensure the quality of aggregates and check the properties.

Paper is organized as follows. Section II describes the concept of probability and Z'-Score. The tests such as specific gravity test, water absorption test, crushing value test and impact value test which are performed in laboratory that are described in Section III. Section IV presents the evaluation of Z'-Score. Finally, Section V presents conclusion.

## II. RELATED WORK

Probability means possibility. It is a branch of mathematics that deals with the occurrence of a random event. The experimental probability is based on the basis of the observations of an experiment and this type of probability uses in this paper. The experimental probability can be calculated based on the number of possible outcomes by the total number of trials. The probability formula is defined as the possibility of an event to happen is equal to the ratio of the number of favourable outcomes and the total number of outcomes.



A Z-score is a numerical measurement that describes a value's relationship to the mean of a group of values. Z-score is measured in terms of standard deviations from the mean. If the Z'-Score is less than or equal to 2 then results are satisfactory, greater than 2 and less than 3 that means these are questionable and greater than 3 then results are unsatisfactory. A Z-Score is a statistical measurement of a score's relationship to the mean in a group of scores. The formula for calculating a z-score is  $z = (x - \mu) / \sigma$ , where  $x$  is the raw score,  $\mu$  is the population mean, and  $\sigma$  is the population standard deviation. As the formula shows, the z-score is simply the raw score minus the population mean, divided by the population standard deviation.

### III. MATERIALS AND METHODS

**3.1 Materials:** The materials used for this study includes coarse aggregate, IS sieves, clean water, density basket, weighing balance, trays, aggregate impact apparatus, tamping rods, compressive testing machine, crushing mould with plunger of 15cm diameter and base plate.

#### 3.2 Methods:

**3.2.1 Specific Gravity Test and water absorption test on aggregate:** Specific gravity of aggregate is defined as the ratio of the weight of aggregate to the weight of equal volume of water. It shows the strength of aggregate. Aggregates having a low specific gravity are generally weaker than those with having high specific gravity. The specific gravity of aggregates generally used in construction ranges from about 2.5 to 3.0. Water absorption of aggregate gives an idea about the internal structure of aggregate. If aggregates have more absorption capacity, they are called porous in nature. Such aggregates are unsuitable and generally not preferred for any construction.

The standard guidelines for the specific gravity and water absorption test on aggregates are IS 2386(Part 3):1963 and BS 812-2:1995. Take a sample of aggregates of 2kg. Place the aggregates in a wire basket and immerse it in distilled water for 24 hours. Then, take the weight of aggregates and basket in water as A1. After that, remove the basket and aggregates from water and take the weight of basket suspended in water as A2. Dry those aggregates with a dry cloth and then take the weight of these dry aggregates, and denote it as B. Next, place the aggregates in the oven for 24 hours and measure the weight of oven-dried aggregates as C.

Now calculate, Specific gravity =  $C / (B - A)$  and water absorption according to this formula

#### Scope of specific gravity and water absorption:

Specific Gravity is important for several reasons. Some deleterious particles are lighter than the good aggregates. Tracking specific gravity can sometimes indicate a change of material or possible contamination. Differences in specific gravity may be used during production to separate the deleterious particles from the good using a heavy media liquid.

Specific gravity is critical information for the Hot Mix Asphalt Design Engineer. The value is used in calculating air voids, voids in mineral aggregate (VMA), and voids filled by asphalt (VFA). All are critical to a well performing and durable asphalt mix. Water absorption can also be an indicator of asphalt absorption. A highly absorptive aggregate may lead to a low durability asphalt mix.

In Portland Cement Concrete the specific gravity of the aggregate is used in calculating the percentage of voids and the solid volume of aggregates in computations of yield. The absorption is important in determining the net water-cement ratio in the concrete mix. Knowing the specific gravity of aggregates is also critical to the construction of water filtration systems, slope stabilization projects, railway bedding and many other applications.

#### 3.2.2 Impact Test on Aggregates:

Aggregate may be subjected to a sudden shock or impact during as well as after the construction. These loads are different from the gradually applied compressive loads. Due to such kind of loads, aggregate breaks down into smaller pieces. In order to evaluate the resistance to impact of aggregate, the aggregate impact test is conducted. Aggregate impact value gives the idea about how much impact load can be resisted by aggregate. Actually, aggregate should be sufficiently tough to resist their disintegration due to impact. This distinctive property is measured by impact value test. Aggregate impact value is the same as the abrasion test result. Impact value of aggregate should not exceed 30 percent for aggregate used for surface wearing course and should not exceed 45 percent for surface other than wearing course. the standard guidelines for the impact test on aggregate. IS 2386(Part 4):1963. Take a sample of aggregate passing through a 12.5 mm sieve and retained on a 10 mm sieve. Fill the sieved aggregates in a cylindrical cup. Place the mould in the aggregate impact testing machine and administer 15 numbers of blows of a metal hammer. After that, remove the crushed aggregate and sieve it through a 2.36 mm sieve. The aggregate impact value is measured as % of aggregates passing through the 2.36mm sieve (W2) to the total weight of the sample (W1).

**Scope of impact test:** The aggregate impact value gives a relative measure of the toughness or the resistance of aggregate sudden shock or impact is not proportional to the resistance to a slowly applied compressive load. To determine the impact value of the aggregates used in pavement construction (Road); To assess their suitability in road layers (base course, surface course) construction on the basis of impact value.

**3.2.3 Crushing Test on Aggregates:**

The aggregate crushing value test indicates the strength of aggregate which is the most essential property of coarse aggregate. The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. For achieving a high quality of pavement, aggregate of higher crushing strength i.e. low crushing value should be preferred. Lower crushing value means higher strength as it indicates a lower crushed fraction under load. This gives a longer service life and a more economical performance. If the aggregate crushing value is less than 10, it signifies an exceptionally strong aggregate. Whereas, if the crushing value is 35 or above, it would normally be considered as weak aggregate. The standard guidelines for the crushing test on aggregate are IS 2386(Part 4):1963 BS 812-110:1990. The crushing mould is filled in three layers with aggregates. Then the weight (W1) of the aggregate in the crushing mould is noted. After that, the mould is placed in the compression testing machine and loaded at gradually applied load so that it reaches a load of 40 tons in 10 minutes. The load is then released and the aggregates are then removed from the mould. Aggregates are then sieved through a 2.36 mm sieve and weight (W2) is measured. The crushing value of aggregates is calculated as  $(W1/W2) * 100$  and value are expressed in %.

**Scope of crushing test:** This is one of the major Mechanical properties required in a road stone. The test evaluates the ability of the Aggregates used in road construction to withstand the stresses induced by moving vehicles in the form of crushing. With this the aggregates should also provide sufficient resistance to crushing under the roller during construction and under rigid tyre rims of heavily loaded animal drawn vehicles. The crushing strength or aggregate crushing value of a given road aggregate is found out as per IS-2386 Part- 4. The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. To achieve a high quality of pavement aggregate possessing low aggregate crushing value should be preferred.

The aggregate crushing value of the coarse aggregates used for cement concrete pavement at surface should not exceed 30% and aggregates used for concrete other than for wearing surfaces, shall not exceed 45% as specified by Indian Standard (IS) and Indian Road Congress (IRC).

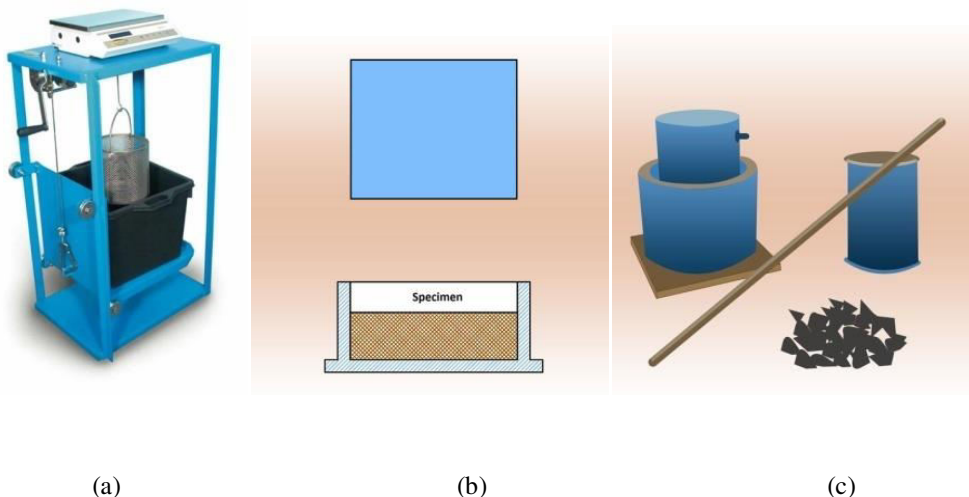


Fig. (a) Apparatus for Specific Gravity and Water Absorption Test. (b) Apparatus of impact test. (c) Apparatus of crushing value of aggregate

**IV. EVALUATION OF Z'-SCORE**

The results are evaluated as per ISO/IEC 17043:2010 and CI 9.4 of ISO13528:2015 by calculating the robust assigned value, SDPA & Z'-Score of the test parameters for individual participating laboratory. Performance evaluation for test:

Performance is evaluated by calculating Z'-Score in the given expression as the uncertainty of the assigned value



$u(x_{pt}) > 0.3\sigma_{pt}$ . the Z'-Score is calculated as follows:

$$Z' \text{-Score} = \frac{(x - x_{pt})}{\sqrt{(\sigma_{pt}^2 + u^2(x_{pt}))}}$$

Where,

X= participants reported value

$X_{pt}$  = assign value

$\sigma_{pt}$  = standard deviation for proficiency assessment

1.  $|Z'| \leq 2.0$ .....Satisfactory
2.  $2.0 < |Z'| < 3.0$ .....Questionable
3.  $|Z'| \geq 3.0$ .....Unsatisfactory

$$u(x_{pt}) = \frac{1.25 * s^*}{\sqrt{p}}$$

Where, S\* is robust standard deviation and P is number of participants

$u(x_{pt})$  = uncertainty of assigned value

Note: The standard uncertainty was calculated for assigned value and was compared with robust standard deviation and due to a smaller number of participants, the measurement uncertainty of assigned value significant to be considered in performance analysis. It was included to the denominator of the performance score, for the evaluation of performance of the participants, and score was calculated as per the requirement of 9.5.1 of ISO 13528:2015 using the formula stated above

## V. CONCLUSION

From this study, it can be concluded that, the tests are performed are within the IS limit. Also concluded that calculating the probability and Z'-Score are important for aggregate testing because of checking the quality of material, efficiency of machine. if the Z'-Score is less than or equal to 2 then results are satisfactory, greater than 2 and less than 3 that means these are questionable and greater than 3 then results are unsatisfactory. The material which are tested in this study are satisfactory according to IS Code.

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