1 Lecture 6: Testing of aggregates

This section covers the following topics:
- Strength of aggregates
- Specific Gravity
- Absorption and Moisture Content
- Bulking of fine aggregates
- Aggregate Crushing Value
- Aggregate Impact Value

1.1 Strength of Aggregates

The test for strength of aggregate is required to be made in the following situations:

i. For production of high strength & ultra-high strength concrete.

ii. Aggregates manufactured by industrial process.

1.2 Specific Gravity

In concrete technology, specific gravity of aggregates is made use of in design calculations of concrete mixes. Specific gravity of aggregate is also required in calculating the compacting factor in connection with the workability measurements. Average specific gravity of the rocks vary from 2.6 to 2.8.

1.3 Absorption and Moisture Content

Some of the aggregates are porous and absorptive. Porosity and absorption of aggregate will affect the water/cement ratio and hence the workability of concrete. The porosity of aggregate will also affect the durability of concrete. The water absorption of aggregate is determined by measuring the increase in weight of an oven dry sample when immersed in water for 24 hours. The ratio of the increase in weight to the weight of the dry sample expressed as percentage is known as absorption of aggregate. In making quality concrete, it is very essential that corrective measures should be taken both for absorption and for free moisture so that the water/cement ratio is kept exactly as per the design.

Very often at the site of concrete work we may meet dry coarse aggregate and moist fine aggregate. The absorption capacity of the coarse aggregate is of the order of about 0.5 to 1 per cent by weight of aggregate.

Free moisture in both coarse aggregate and fine aggregate affects the quality of concrete in more than one way. In case of weigh batching, determination of free moisture content of the aggregate is necessary and then correction of water/cement ratio to be effected in this regard. But when volume batching is adopted, the determination of moisture content of fine aggregate does not become necessary but the consequent bulking of sand and correction of volume of sand to give allowance for bulking becomes necessary.
Measurement of Moisture Content of Aggregates

Determination of moisture content in aggregate is of vital importance in the control of the quality of concrete particularly with respect to workability and strength. The water content can be expressed in terms of the weight of the aggregate when absolutely dry, surface dry or when wet. Some of the methods that are being used for determination of moisture content of aggregate are given below:

(i) Drying Method (ii) Displacement Method (iii) Calcium Carbide Method (iv) Measurement by electrical meter (v) Automatic measurement

Drying method

Drying is carried out in an oven and the loss in weight before and after drying will give the moisture content of the aggregate. The oven drying method is too slow for field use. A fairly quick result can be obtained by heating the aggregate quickly in an open pan. The process can also be speeded up by pouring inflammable liquid such as methylated spirit or acetone over the aggregate and igniting it.

Bulking of Aggregates

Bulking phenomenon can be explained as follows:

Free moisture forms a film around each particle. This film of moisture exerts what is known as surface tension which keeps the neighboring particles away from it. Similarly, the force exerted by surface tension keeps every particle away from each other. Therefore, no point contact is possible between the particles. This causes bulking of the volume. The extent of surface tension and consequently how far the adjacent particles are kept away will depend upon the percentage of moisture content and the particle size of the fine aggregate. It is interesting to note that the bulking increases with the increase in moisture content.
upto a certain limit and beyond that the further increase in the moisture content results in the decrease in the volume and at a moisture content representing saturation point, the fine aggregate shows no bulking. It can be seen from Figure below that fine sand bulks more than coarse sand. From this it follows that the coarse aggregate also bulks but the bulking is so little that it is always neglected. Extremely fine sand and particularly the manufactured fine aggregate bulks as much as about 40 per cent.

Due to the bulking, fine aggregate shows completely unrealistic volume. Therefore, it is absolutely necessary that consideration must be given to the effect of bulking in proportioning the concrete by volume. If cognizance is not given to the effect of bulking, in case of volume batching, the resulting concrete is likely to be under sanded and harsh. It will also affect the yield of concrete for a given cement content.

The extent of bulking can be estimated by a simple field test. A sample of moist fine aggregate is filled into a measuring cylinder in the normal manner. Note down the level, say $h_1$. Pour water into the measuring cylinder and completely inundate the sand and shake it. Since the volume of the fully saturated sand is the same as that of the dry sand, the inundated sand completely offsets the bulking effect. Note down the level of the sand say, $h_2$ which shows the bulking of the sample of sand under test.

Percentage of bulking $= \frac{h_1 - h_2}{h_2} \times 100$

In a similar way the bulking factor can be found out by filling the wet sand in a water tight measuring box up to the top and then pour water to inundate the sand. Then measure the subsidence of sand and express it as a percentage. This gives a more realistic picture of the bulking factor.

The field test to find out the percentage of bulking is so simple that this could be conducted in a very short time interval and the percentage of bulking so found out could be employed for correcting the volume of
fine aggregate to be used. This can be considered as one of the important methods of field control to produce quality concrete. Since volume batching is not adopted for controlled concrete, the determination of the percentage of moisture content is not normally required. The quantity of water could be controlled by visual examination of the mix and by experience. The percentage of free moisture content is required to be determined and correction made only when weigh batching is adopted for production of quality concrete.

1.5.2 Test for determination of aggregate crushing value

The standard aggregate crushing test is made on aggregate passing a 12.5 mm I.S. Sieve and retained on 10 mm I.S. Sieve. About 6.5 kg material consisting of aggregates passing 12.5 mm and retained on 10 mm sieve is taken. The aggregate in a surface dry condition is filled into the standard cylindrical measure in three layers approximately of equal depth. Each layer is tamped 25 times with the tamping rod and finally levelled off using the tamping rod as straight edge. The weight of the sample contained in the cylinder measure is taken (A). The same weight of the sample is taken for the subsequent repeat test.

The cylinder of the test apparatus with aggregate filled in a standard manner is put in position on the base-plate and the aggregate is carefully levelled and the plunger inserted horizontally on this surface. The apparatus, with the test sample and plunger in position, is placed on the compression testing machine and is loaded uniformly upto a total load of 40 tons in 10 minutes time. The load is then released and the whole of the material removed from the cylinder and sieved on a 2.36 mm I.S. Sieve. The fraction passing the sieve is weighed (B),

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\text{Aggregate crushing value} = \frac{B}{A} \times 100
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where, \( B \) = weight of fraction passing 2.36 mm sieve,  
\( A \) = weight of surface-dry sample taken in mould.

The aggregate crushing value should not be more than 45 per cent for aggregate used for concrete other than for wearing surfaces, and 30 per cent for concrete used for wearing surfaces such as runways, roads and air field pavements.
1.5.3 Test for determination of aggregate impact value

The aggregate impact value gives relative measure of the resistance of an aggregate to sudden shock or impact. The test sample consists of aggregate passing through 12.5 mm and retained on 10 mm I.S. Sieve. The aggregate shall be dried in an oven for a period of four hours at a temperature of 100°C to 110°C and cooled. The aggregate is filled about one-third full and tamped with 25 strokes by the tamping rod. A further similar quantity of aggregate is added and tamped in the standard manner. The measure is filled to over-flowing and then struck off level. The net weight of the aggregate in the measure is determined (weight A) and this weight of aggregate shall be used for the duplicate test on the same material.

The whole sample is filled into a cylindrical steel cup firmly fixed on the base of the machine. A hammer weighing about 14 kgs. is raised to a height of 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 15 such blows each being delivered at an interval of not less than one second. The crushed aggregate is removed from the cup and the whole of it is sieved on 2.36 mm I.S. Sieve. The fraction passing the sieve is weighed to an accuracy of 0.1 gm. (weight B). Two tests are made.

The ratio of the weight of fines formed to the total sample weight in each test is expressed as percentage.

Therefore, Aggregate Impact Value = \( \frac{B}{A} \times 100 \)

where, \( B \) = weight of fraction passing 2.36 mm I.S. Sieve.

\( A \) = weight of oven-dried sample.

The aggregate impact value should not be more than 45 per cent by weight for aggregates used for concrete other than wearing surfaces and 30 per cent by weight for concrete to be used as wearing surfaces, such as runways, roads and pavements.