Aggregate

Lecture - 3

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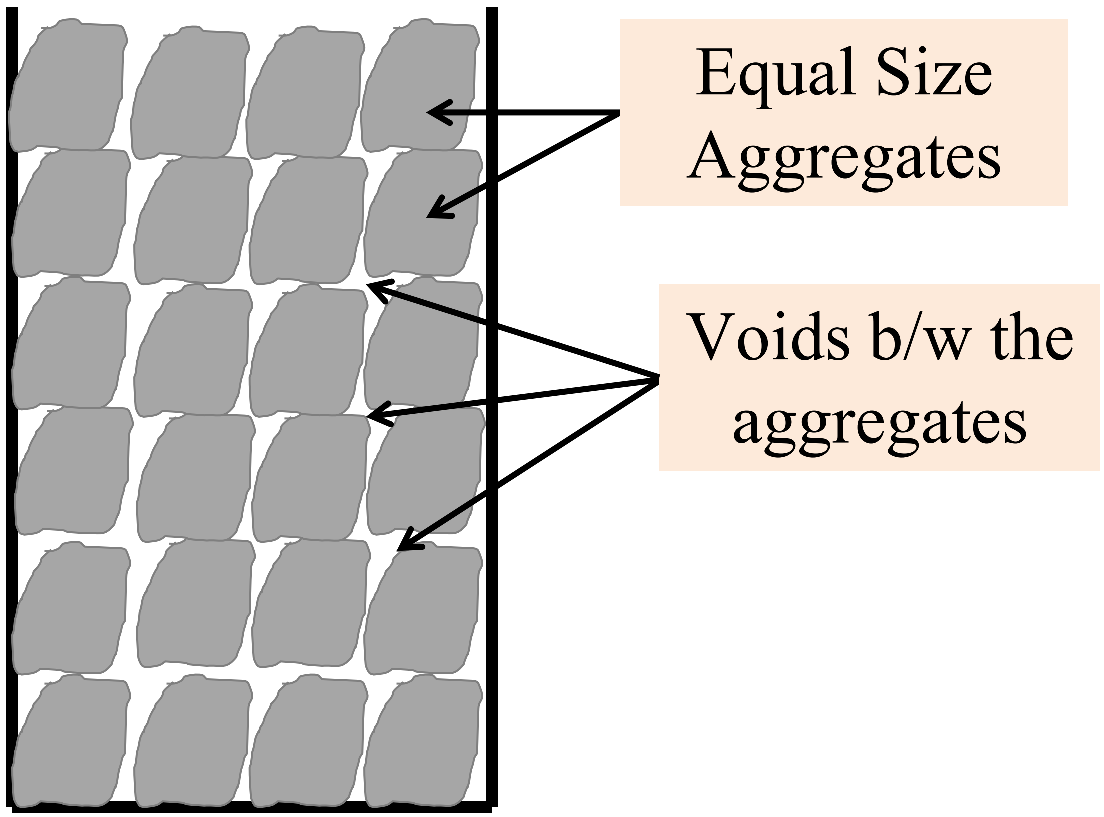
Varying size of Coarse Aggregate

Image Clicked by –Dr. Raju Sharma

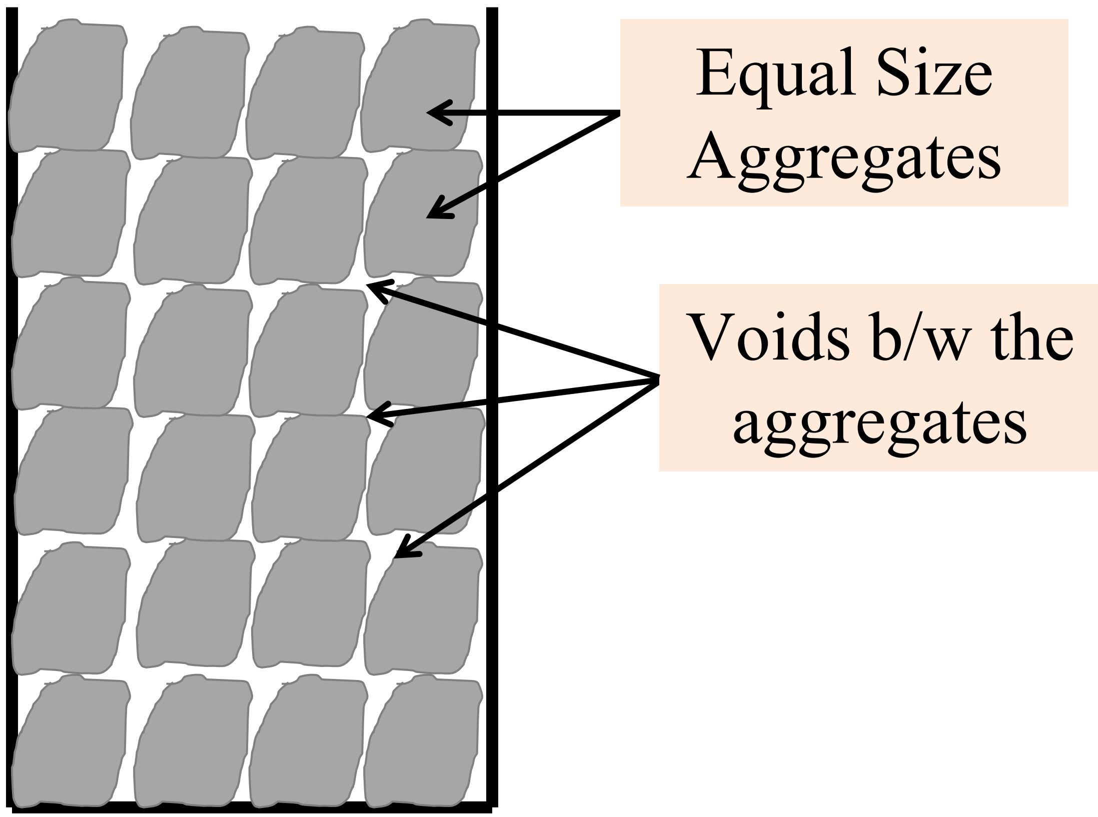
Introduction

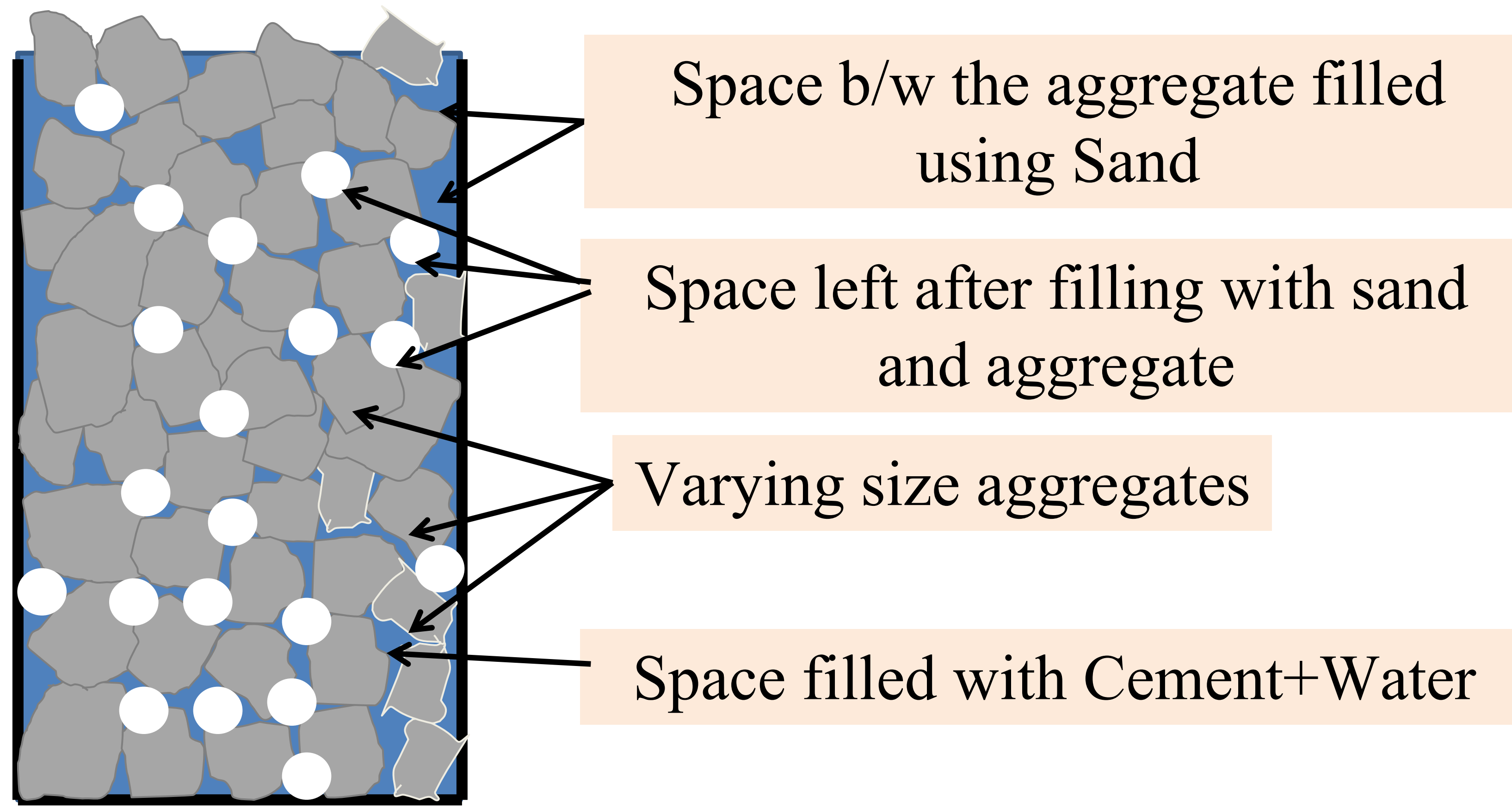


When some material of equal size are placed together, voids or open spaced are always left within the pack. The percentage of voids may be as high as 45% of the total volume of stones. It has been observed that presence of voids is independent of size of stones used in packing, whether coarse, medium or fine. Only stone should be of equal size that is , of same grade.

Either all of them should be coarse, or all of them should be medium or of fine grade. This implies that even if sand alone is packed, voids to the tune of 40-45 percent are left.

Introduction



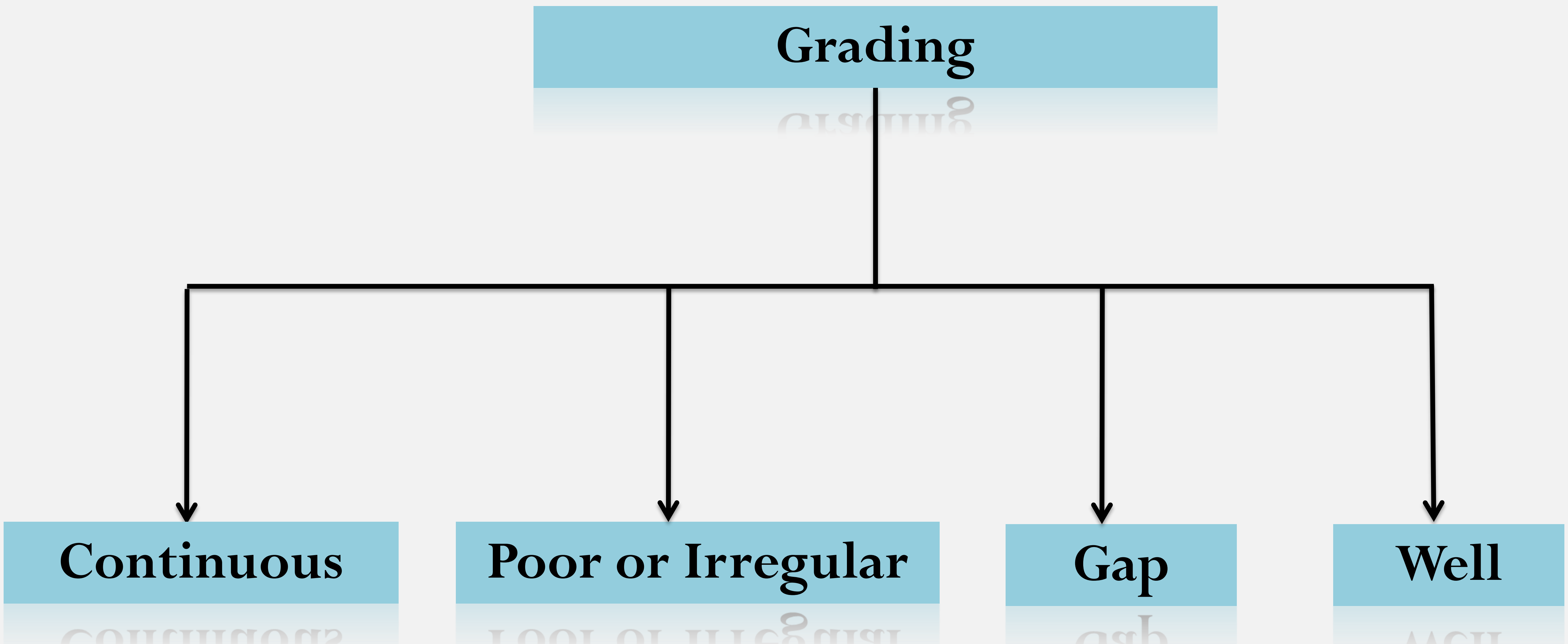


Introduction

when the ***coarse aggregate*** are packed to make the concrete the ***voids*** formed within the mass must be filled by some ***finer material***. ***Sand*** is used for that purpose. But there will be voids left between the sand grains too. These are filled by the ***cement particles***. In this way, the resulting concrete mass is ***void less or dense mass***.

Duggal SK, Building Materials

Types of Grading



Types of Grading

Continuous Grading

Aggregate is said to be continuously graded when it contains all particle size groups from the maximum particle size to the minimum in sizeable proportions. Such grading are said to be coarser or finer accordingly by as they contain a higher proportion of coarser or finer particles with reference to specified grading with which they are being compared.

Types of Grading

Poor Grading

It is the grading in which the proportions of certain intermediate particle sizes are in excess, or deficient and the grading is not continuous.

Types of Grading

Gap Grading

The aggregate is said to be gap graded when certain sizes of particles are missing in the bulk. It was assumed that the voids present in the higher size of the aggregate are filled up by the next lower size of aggregate and similarly, voids created by the lower size are filled up by one size lower than those particle and so on. It was realized later that the voids created by a particular fraction are too small to accommodate the very next lower size. The next lower size being itself bigger than the size of the voids. It will create what is known as " particle size interference" which prevents the large aggregates compacting to their maximum density.

Types of Grading

- *It has seen that the size of voids existing b/w a particular size of aggregate is of the order of 2 or 3 size lower than that fraction*. In other words, void size existing b/w 40 mm aggregate is of the size equal to 10 mm or possibly 4.75 mm or the size of voids occurring when 20 mm aggregate is used will be in the order to say 1.18 mm or so. Therefore, along with 20mm aggregate, only when 1.18 m aggregate size is used, the sample will contain least voids and concrete requires least matrix. The following advantages are claimed for gap graded concrete.

Types of Grading

- ✓ Sand required will be of the order of about 26% as against about **40%** in the case of continuous grading.
- ✓ **Specific surface area** of the gap graded aggregate will be low, because of high percentage of coarse aggregate and low % of FA.
- ✓ Require less cement and lower w/c ratio
- ✓ Because of point contact b/w CA to CA and also on account of lower cement and matrix content, the drying shrinkage is reduced.

Types of Grading

It was also observed that gap graded concrete needs close supervision, as it shows greater proneness to segregation and change in the anticipated workability. In spite of many claims of the superior properties of gap graded concrete, this method of grading has not become more popular than conventional continuous grading.

Types of Grading

Well Graded

One of the most important factors for producing workable concrete is good gradation of aggregate. A sample of the well graded aggregate containing minimum voids will require minimum paste to fill up the voids in the aggregate. Minimum paste will mean less quantity of cement and less quantity of water, which will further mean increased economy, higher strength, lower shrinkage and greater durability.

Types of Grading

The advantages due to good grading of aggregate can also be viewed from another angle. If concrete is viewed as a two phase material, paste phase and aggregate phase. it is the paste phase which is **vulnerable to all ills of concrete**. Paste is **weaker** than average aggregate in normal concrete with rare exceptions when very soft aggregate are used. The paste is **more permeable** than many of the mineral aggregate. It is the **paste** which is **weak** link in a mass of concrete.

Types of Grading

The lesser the quantity of such weak material the better will be the concrete. This objective can be achieved by having well graded aggregates. Hence the importance of good grading.

Effect of Grading

Effect of Grading

Voids

The well graded aggregates has less number of voids than the aggregate having all particles of same size. Thus proper grading of aggregate produces dense concrete and needs less quantity of cement thus making the concrete economical

Strength of Concrete

Grading have no direct effect on the strength but it influence the strength indirectly. In concrete where water-cement ratio is low (high strength concrete) continuous coarse grading offers less specific surface area and is desirable. But for high water-cement ratio finer grading is permitted.

Segregation

Coarser grading always tend to segregate, If sufficient finer material is not available in the mix to maintain cohesiveness.

Bleeding

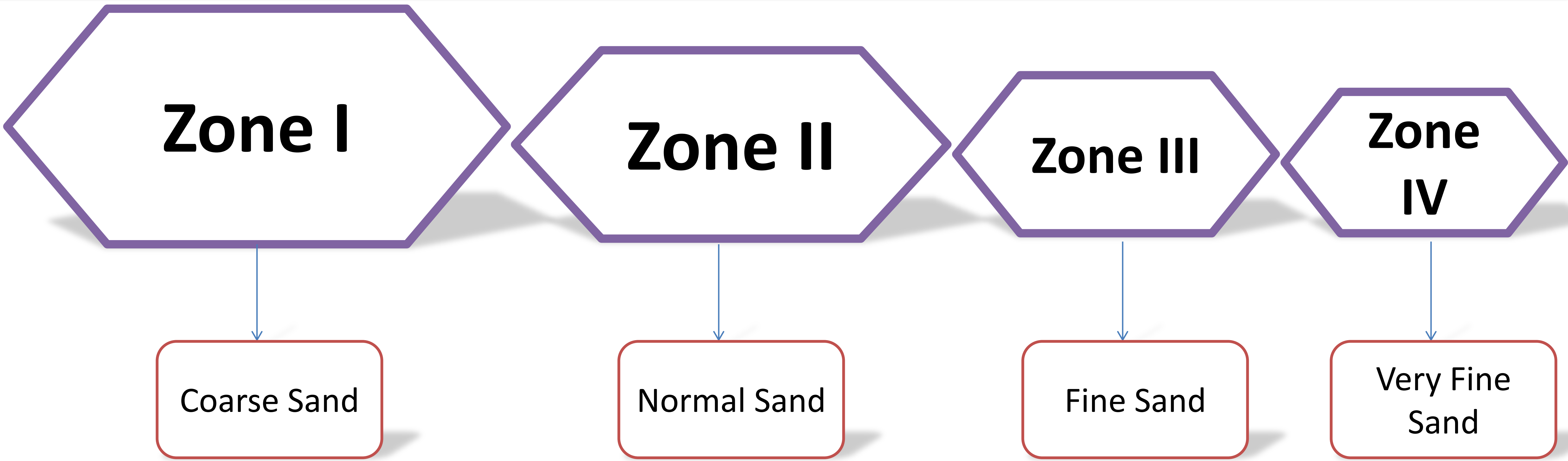
Coarser grading will lead to bleeding and finer grading will prevent bleeding.

Grading of Aggregate

IS Sieve Designation	Percentage passing by weight			
	Grading (Zone I)	Grading (Zone II)	Grading (Zone III)	Grading (Zone IV)
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

IS 383:1970 specification for coarse and fine aggregates from natural sources for concrete

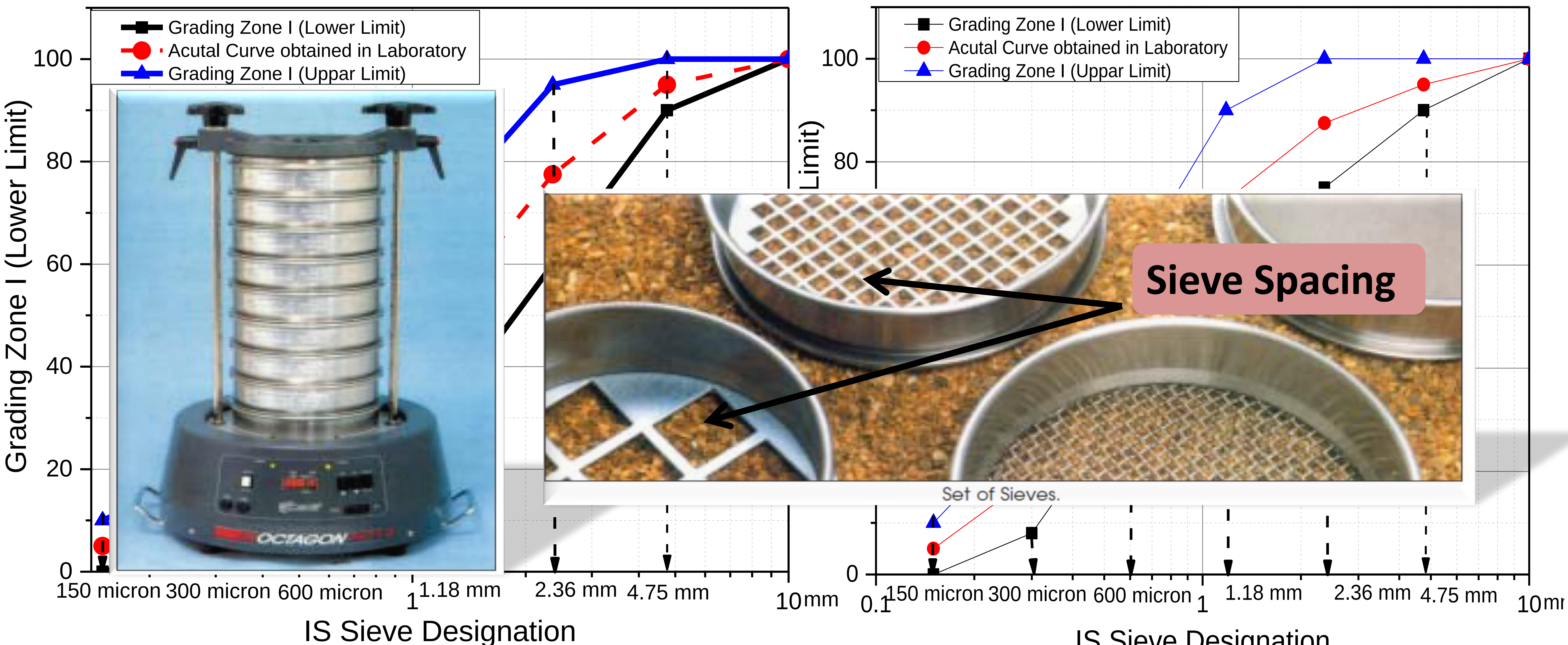
Grading of Aggregate



- Very coarse sand or very fine sand is unsatisfactory for concrete making
- Coarse Sand results in harshness, bleeding and segregation
- Fine Sand requires a comparatively greater amount of water to produce the necessary fluidity.

For fine aggregates, a total departure of 5% from zone limits may be allowed. But this relaxation is not permitted beyond the coarser limit of zone I or the finer limit of zone IV

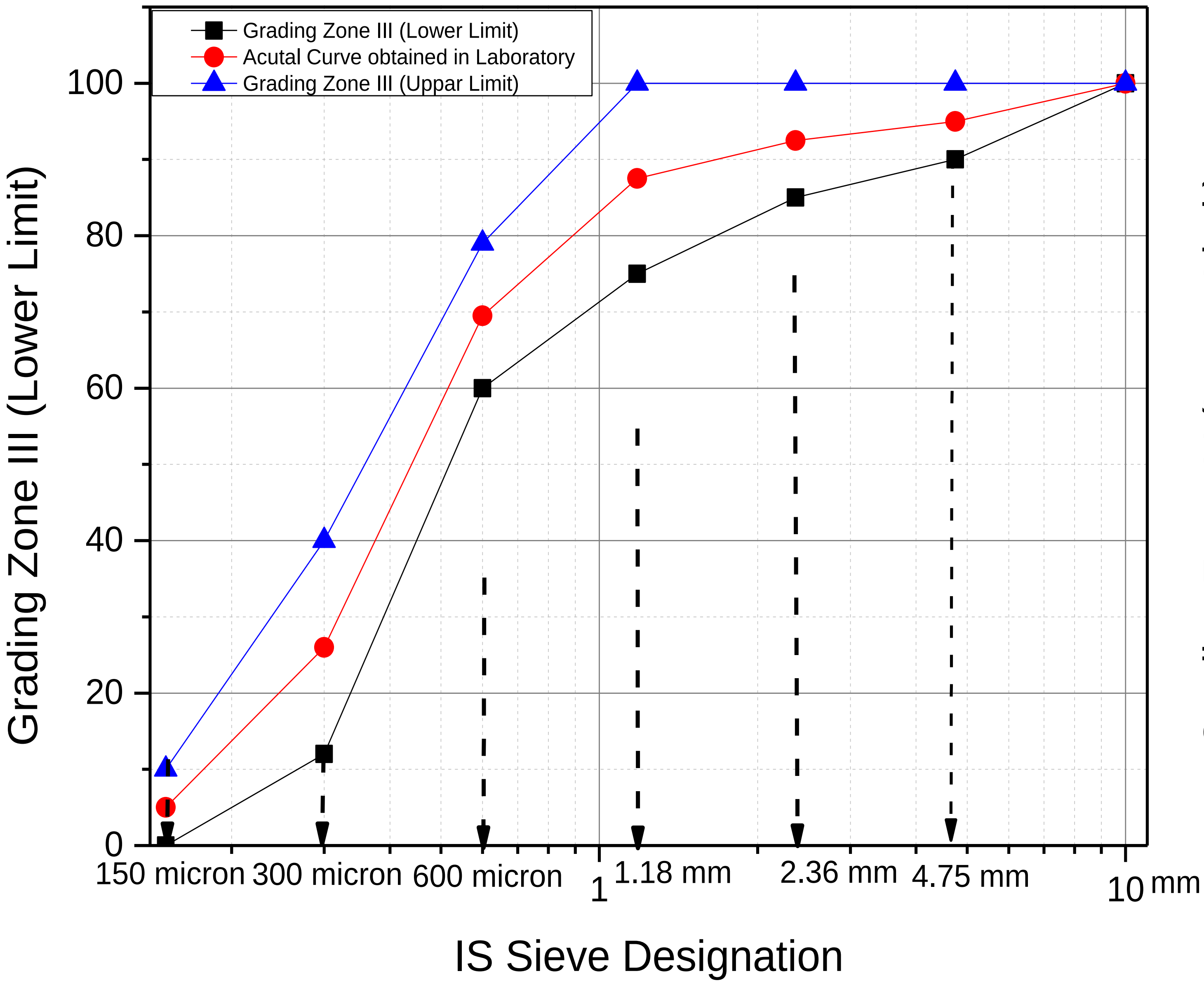
Zone I & Zone II Upper and Lower Limit



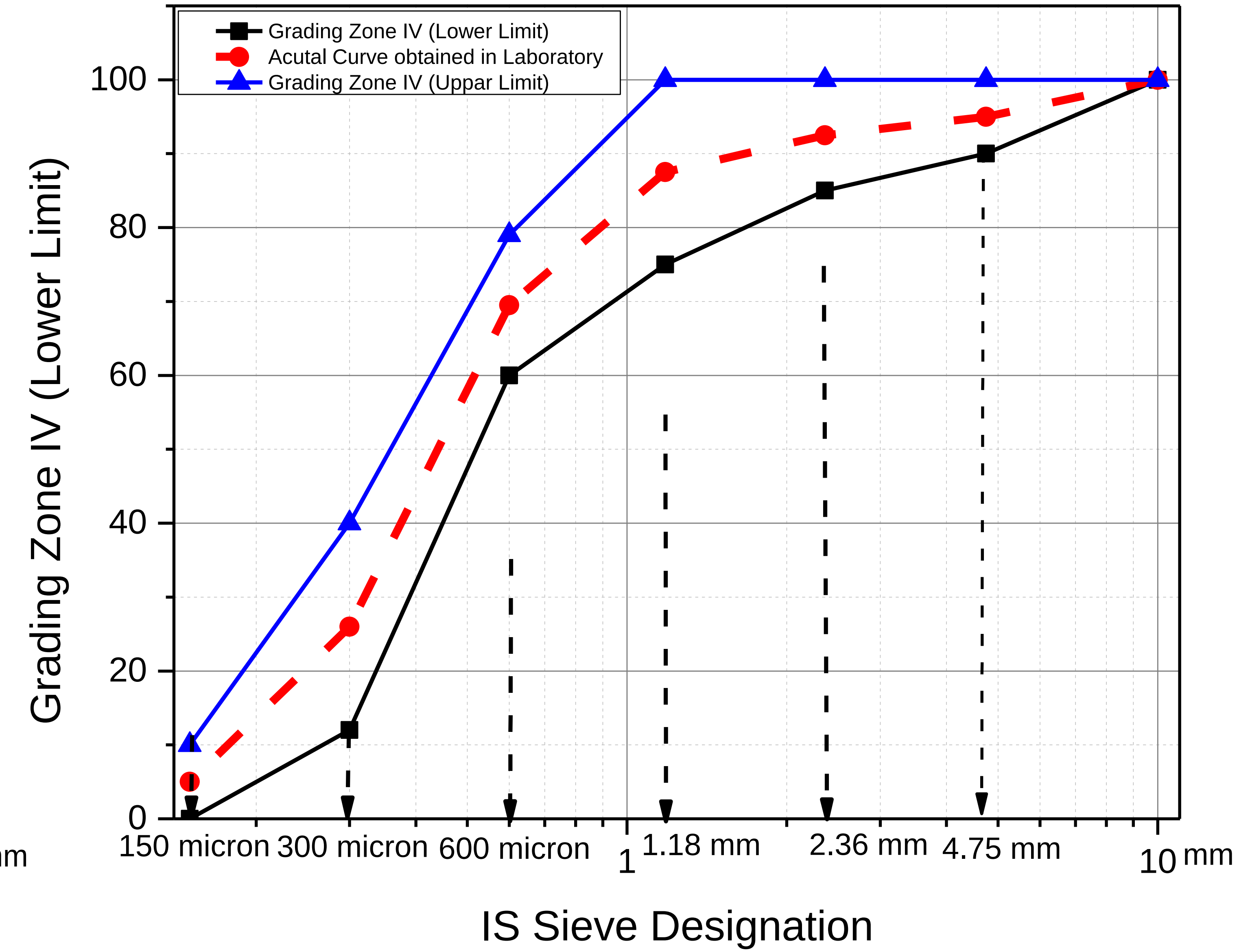
Zone I Sieve Analysis

Zone I Sieve Analysis

Zone III & Zone IV Upper and Lower Limit



Zone III Sieve Analysis



Zone IV Sieve Analysis

Grading of Aggregate

Zone I is ***coarsest*** and ***Zone IV*** is the ***finest*** .

It is recommended that ***fine aggregate conforming to zone IV should not*** be used in reinforced concrete unless the required tests are made to ascertain the suitability of the proposed mix proportions.

Interpretation of Grading Chart

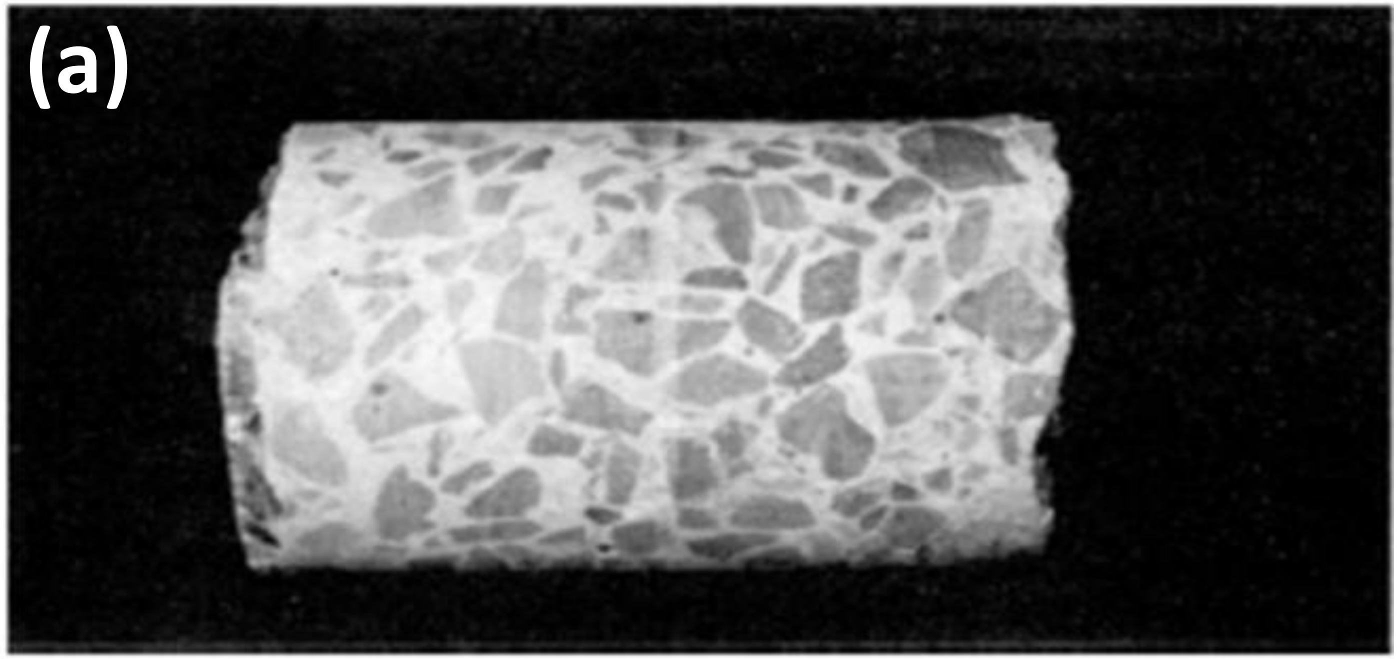
- In case actual grading curve is lower than the specified grading curve, aggregate is coarser and segregation of the mix might take place.

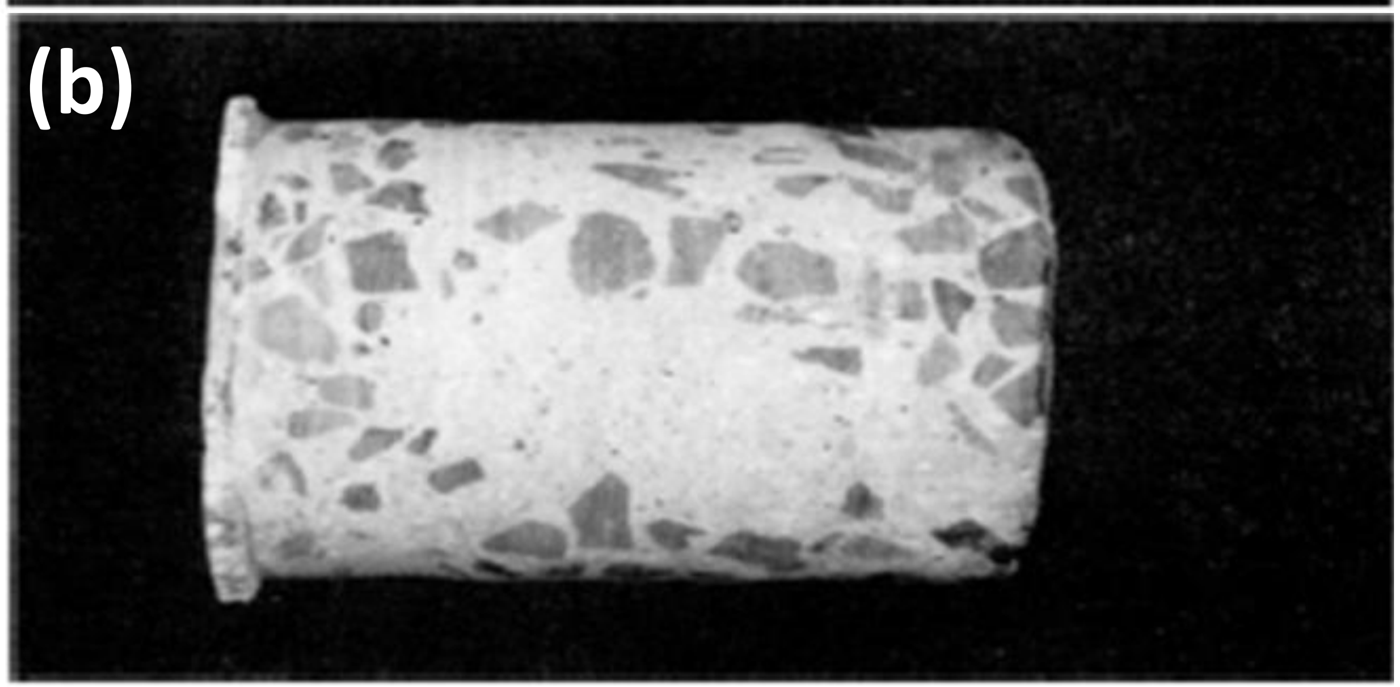
- In case actual grading curve lies well above the specified grading curve aggregate is finer and more water will be required, thus increasing the quantity of cement also for a constant water-cement ratio and is uneconomical.

- If the actual grading curve is steeper than the specified grading curve it indicates an excess of middle size particles and will lead to harsh mix

- If the actual grading curve is flatter than the specified grading curve the aggregate will be deficient in the middle size particles

Concrete Core with Different Graded Aggregates





Photograph of concrete core, illustrating three different appearances; (a) Evenly graded and distributed coarse aggregate; (b) unevenly distributed coarse aggregate; (c) Apparently gap-graded coarse aggregate (although this concrete has the appearance of being gap-graded, the coarser sand sizes are similar in colour to the cement matrix and thus not easily discernible)

Soundness of Aggregate

An aggregate is considered ***unsound*** when the ***volume changes in aggregate*** induced by ***weather*** (e.g., alternate cycles of wetting and drying, or freezing and thawing), result in the deterioration of concrete. Concretes containing some cherts, shales, limestones, and sandstones have been found susceptible to damage by frost action or by salt crystallization within the aggregate particle.

Although ***high moisture absorption*** is often used as an ***index*** for ***unsoundness***, many aggregates such as ***pumice and expanded clays*** can absorb large amounts of water but remain sound.

Soundness of Aggregate

Unsoundness is therefore related to ***pore size distribution*** rather than to the ***total porosity of aggregate***. A ***pore size distribution*** that allows the aggregate particles to get ***saturated on wetting*** (or thawing in the case of frost attack), but ***prevent easy drainage on drying*** (or freezing) is capable of causing ***high hydraulic pressure*** within the ***aggregate particles***.

Soundness of aggregate to weathering action is determined by ***ASTM Method C 88***, which describes a standard procedure for directly determining the resistance of aggregate to disintegration on exposure to five wet-dry cycles; a saturated sodium or magnesium sulfate solution is used for the wetting cycle.

Summary

1. Grading of Aggregate

2. Effect of Grading

3. Soundness of Aggregate

THANK YOU