Gradation

Coarse aggregates used in concrete making contain aggregates of various sizes. This particle size distribution of the coarse aggregates is termed as Gradation. The sieve analysis is conducted to determine this particle size distribution. Grading pattern is assessed by sieving a sample successively through the entire sieves mounted one over the other in order of size, with larger sieve on the top. The material retained on each sieve after shaking represents the fraction of aggregate coarser than the sieve in question and finer than the sieve above. Proper gradation of coarse aggregates is one of the most important factors in producing workable concrete. Proper gradation ensures that a sample of aggregates contains all standard fractions of aggregate in required proportion such that the sample contains minimum voids. A sample of the well graded aggregate containing minimum voids will require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less quantity of water; leading to increased economy, higher strength, lower shrinkage & greater durability. The workability is improved when there is an excess of paste above that required to fill the voids in the sand, and also an excess of mortar (sand plus cement) above that required to fill the voids in the coarse aggregate because the fine material lubricates the larger particles. Cement-paste or the 'Matrix* that links together the coarse aggregates is weaker than the aggregates. It is this matrix that is vulnerable to all ills of concrete. It is more permeable and is susceptible to deterioration by the attack of aggressive chemicals. Therefore lesser the quantity of such weak link in concrete, the better will be the concrete. This objective can be achieved by having well graded aggregates.

As shown in Fig-1, there are three typical range categories of aggregate grading:

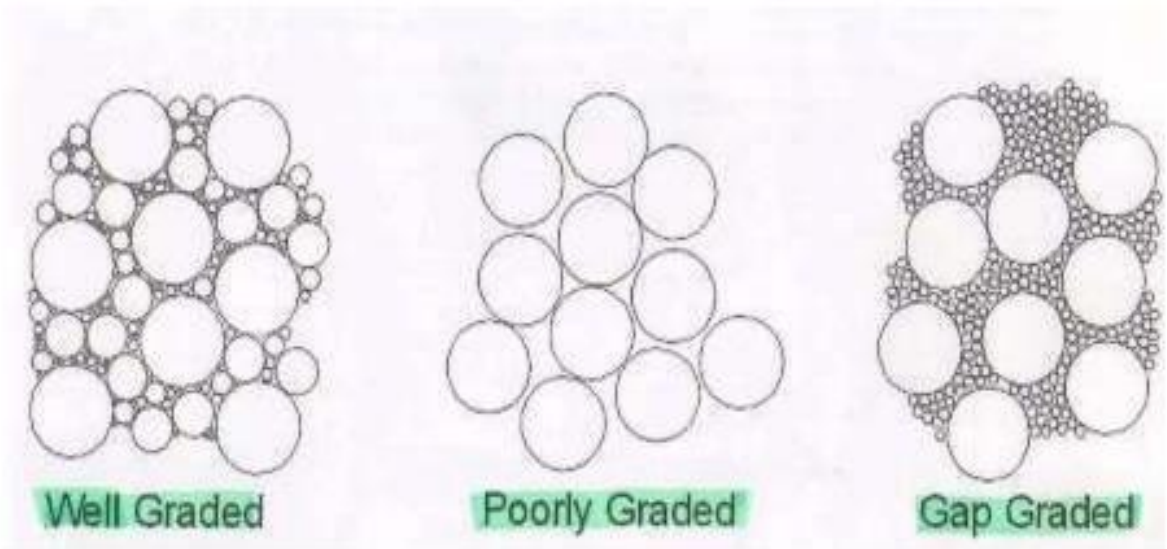
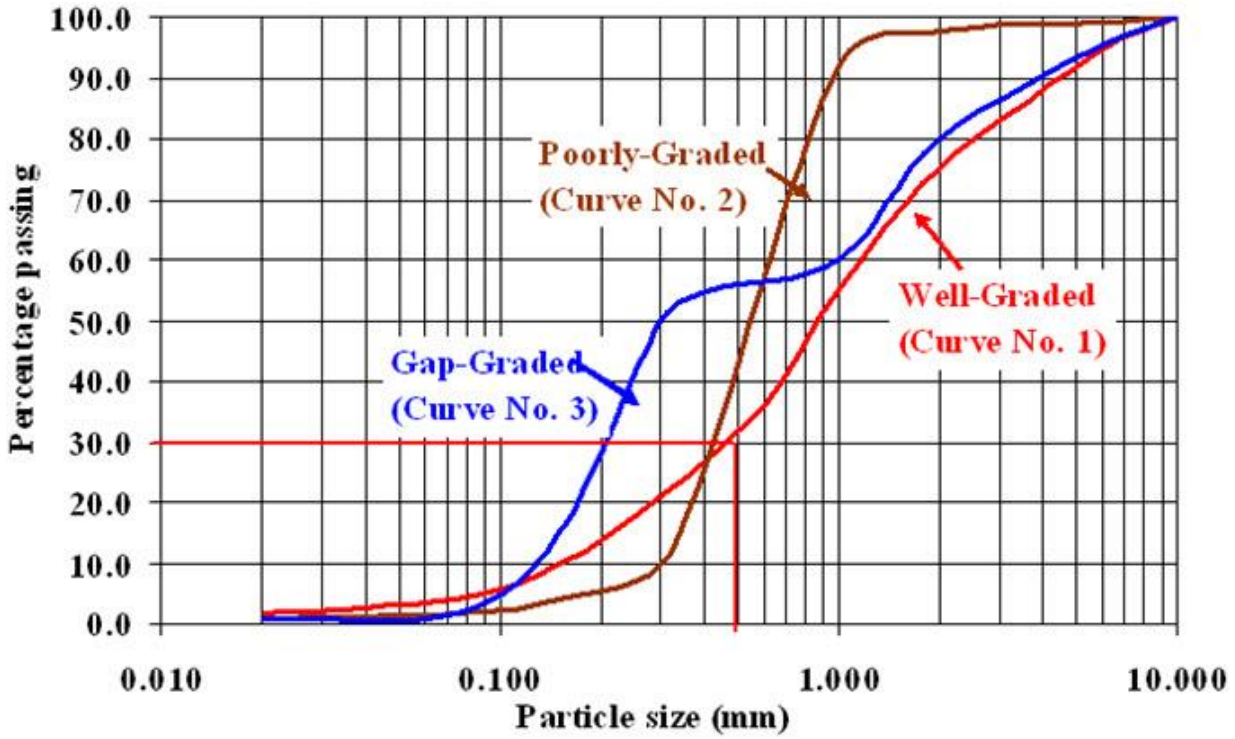


Fig: 1 Aggregate Gradation

Well graded: Well-graded aggregate has a gradation of particle size that fairly evenly spans the size from the finest to the coarsest. A slice of a core of well-graded aggregate concrete shows a packed field of many different particle sizes. It is characterized by the S- shaped in gradation curve. As shown in Fig 2 Curve No 1

Poor graded: Poor-graded aggregate is characterized by small variation in size. It contains aggregate particles that are almost of the same size. This means that the particles pack together, leaving relatively large voids in the concrete. It is also called 'uniform-graded'. It is characterized by steep curve. As shown in Fig 2 Curve No 2

Gap graded: Gap-graded aggregate consists of aggregate particles in which some intermediate size particles are missing. A core slice of gap-graded, or skip grade, concrete shows a field of small sized- aggregate interspersed with slightly isolated, large aggregate pieces embedded in a small sized aggregate. It is characterized by a gradation curve with a hump in between. As shown in Fig 2 Curve No 3



Poorly graded concretes generally require excessive amounts of cement paste to fill the voids making them uneconomical. Gap-graded concretes fall in between well-graded and poorly-graded in terms of performance and economy. Gap graded is viable gradation, but not optimal. Well-graded aggregates are tricky in proportion. The goal of aggregate proportioning and sizing is to maximize the volume of aggregate in the concrete while preserving the strength, workability and finishing. This balance the proportions of each so there are just enough of each size to fill all the voids, while preserving workability and cast-surface quality.