# 3.4 PHYSICAL PROPERTIES OF MATERIALS REQUIRED TO MIX DESIGN

**Based on IS: 456 – 2000 and IS: 1343 – 1980, the factors required for the design of concrete mix are as follows.**

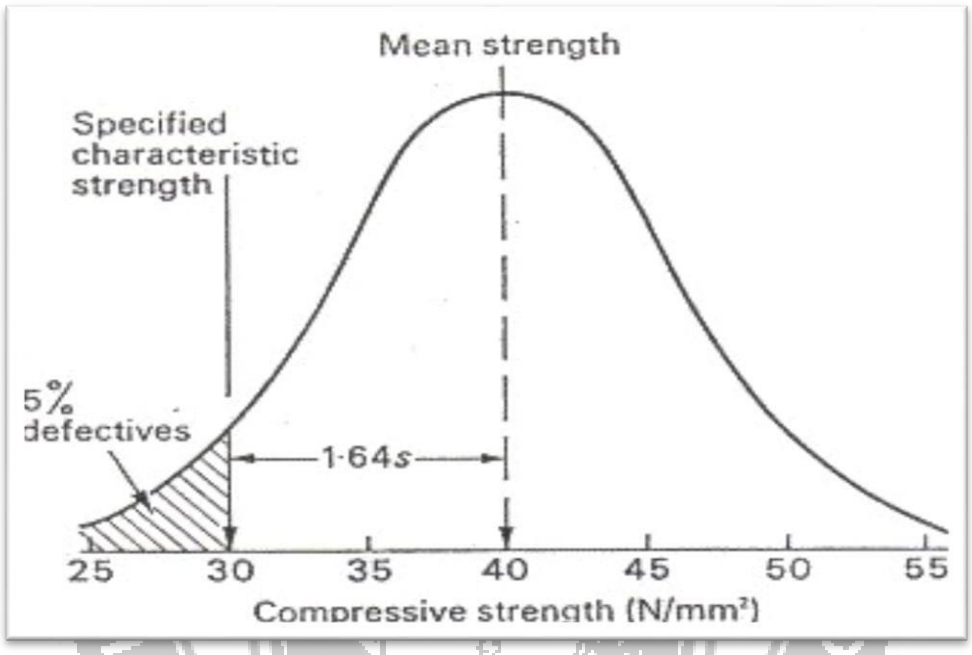
- Grade of Concrete
- Maximum Water – Cement Ratio
- Type of Cement
- Grading of combined Aggregate
- Maximum nominal size of the Aggregate
- Workability
- Durability
- Quality Control etc.

**Grade of Concrete**

The grade of concrete is an important factor influencing the mix design and it gives the characteristic compressive strength of the concrete.

The compressive strength of the concrete is the most important concrete property, which influences other describable properties of the hardened concrete. The average compressive strength required at 28 days. Determines the nominal water – cement ratio of the mix.

Higher grade (strength) concrete is used for the structures, which resist high compressive loads. Such as bridges and high rise structures. It has been used in components such as columns, shear walls and foundations.




Compressive strength (vs.) Characteristic compressive strength

**Maximum Water – Cement Ratio**

Maximum water cement ratio decides the workability and it is decides by the cement – aggregate ratio, which affects the strength. Mix design is entirely based on strength and hence w / c ratio is one of the parameter in the mix design.

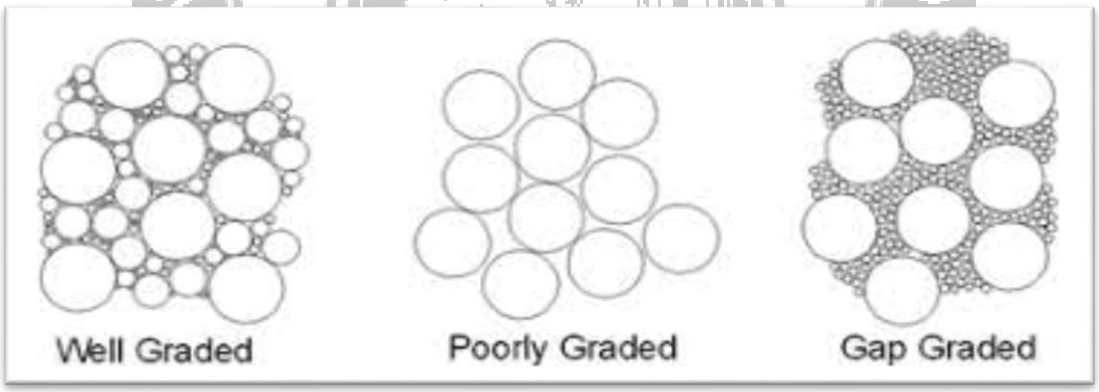
**Type of Cement**

The rate of development of compressive strength of the concrete varies with type of the cement, and choices of the type of cement depends on the strength and other requirements. The higher the strength of the cement used in concrete, lesser will be the cement content.

**Grading of Aggregate**

For dense concrete, the proportions of fine and coarse aggregate should be well graded. The relative proportions of the fine and coarse aggregate in a mix is an important factor affecting the strength.

Aggregate grading influences the mix proportions for a specified workability and water – cement ratio. The relative proportions between coarse and fine aggregate in concrete mix influence concrete strength. Well graded fine and coarse aggregate produce a dense concrete because of the achievement of ultimate packing density. If available aggregate, which obtained from natural source, does not confirm to the specified grading, the proportioning of two or more aggregate become essential. Additionally, for specific workability and water to cement ratio, type of aggregate affects aggregate to cement ratio.




**Aggregate Grading Types**

**Maximum Nominal Size of the Aggregate**

The maximum nominal size of the aggregate should be as large as possible (within its specified limit). However it should not be more than ¼ of the minimum thickness of the structural member. The maximum size of the coarse aggregate is determined by sieve analysis, it is designated by the sieve size higher than the largest size on which 15 percent of the aggregate is retained.

Maximum aggregate size is determined and controlled by spacing of reinforcement. Aggregate size is inversely proportional to cement requirement for water – cement ratio. This is because workability is directly proportional to size of aggregate. However, the compressive strength tends to increase with the decrease in size of aggregate. Smaller sized aggregates provide greater surface area for bonding with mortar mix that give higher strength. IS 456:2000 and IS 1343:1980 recommends that the nominal size of the aggregate should be as large as possible.

**Workability**

Workability affects the quality and cost of the concrete. Concrete mixes that are possible to segregate and bleed are more expensive to finish and it will yield less durability.

Workability depends on the size and shape of the section to be concreted, the amount and spacing of reinforcement, and concrete transportation, placement, and compaction technique. In addition to this, high workability concrete is required for the narrow and complicated section with numerous corners or inaccessible amount of effort. Generally, slump test values are used to evaluate concrete workability.

**Durability**

Durability of the structural member is also an important factor that decides the mix design.

**Physical Properties of materials required for mix design**

Durability is the ability of concrete to withstand harmful environment conditions, and high strength concrete is generally more durable than low strength concrete. In the situations when the high strength is not necessary but the condition s of exposure are such that high durability is vital, the durability requirement will determine the utilized water – cement ratio.

**Quality Control at Site**

The degree of control could be evaluated by the variations in the properties of the mix ingredients, in addition to lack of control of accuracy in batching, mixing, placing, curing, and testing. The factor controlling this difference (variations) is termed as quality control.