Lecture 3:

Concrete Mix Design Factors, Blending of Aggregates, Statistics, Mix Design Methods, Old Methods

CONCRETE MIX DESIGN:

1. What is mix design?
2. Purposes of mix design
3. Methods to suit purposes for mix design
4. Aspects to be covered by mix design
5. Concrete strength variability and quality control
6. Basic factors in the process of mix design
7. Mix ratios
8. Mix design old methods

Mix design:

Concrete mix design is the process of finding right proportions of cement, sand and aggregates for concrete to achieve target strength in structures. So, concrete mix design can be stated as Concrete Mix = Cement:Sand:Aggregates.

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

Purposes and objective of mix design:

The purpose of concrete mix design is to ensure the most optimum proportions of the constituent materials to fulfill the requirement of the structure being built. Mix design should ensure following objectives:

1) To achieve the designed/ desired workability in the plastic stage.
2) To achieve the desired minimum strength in the hardened stage.
3) To achieve the desired durability in the given environment conditions.
4) To produce concrete as economically as possible.

Methods to suit purposes for mix design:

- American Method of Mix Design: ...
- Graphic Method of Mix Design: ...
- Mix Design by Indian Standard Method: ...
- American Concrete Institute Method of Mix Design: ...
- Rapid Method of Mix Design:

Blending of Aggregates:

Blending of aggregates means combining aggregates of different grading to get a type or specified grading. This can be done by

- Trial and error method
- Graphical method
- Equation method

Reference: Dr. MA Aziz, AM Nevile Chapter 10

Concrete Strength:

The strength to be developed in a hardened concrete is a variable quantity. The source of variability are:

- Variations in mix ingredients
- Variations in concrete
  - Making
  - Placing
  - Curing and
  - Testing
- Variations in sampling procedure
- Variations in testing procedure

Q. Why does the concrete strength vary?

Quality Control:

The process of taking measures in order to minimize the variability in the resultant product of any construction material is called quality control.

Strength requirement for mix design:

In ideal condition, strength of concrete at any point of the structure should be higher than the minimum required strength.

In UK, this minimum strength is called f_{min}, the specified characteristic strength or characteristic strength.

In USA, the minimum strength is called f'_c, the specified design strength or specified compressive strength.

- **The first step in designing a concrete mix is** to decide on a strength higher than the minimum required strength. This higher strength is called
  - Target mean strength, f_m in UK and [British Method]
  - Reqd. avg. strength or reqd. avg. comp. strength, f'_{cr} in USA [ACI method]

** i.e. the higher strength
= minimum strength + some additional strength

Additional strength is the result of the statistical behaviour of hardened concrete which is the reflection of the quality control of concrete manufacturing.

Statistical Behaviour of Concrete:

Statistical Terms:

- Normal distribution curve, comp. strength of concrete
- Mean strength
- Variance
- Standard deviation
- Coefficient of variance

Basic Factors in the Process of Mix design:

- Water / Cement ratio
- Cement content, Cement/Aggregate ratio
- Gradation of aggregate
- Consistency, workability

Mix ratios:

- Real mix
- Field mix
- Nominal mix

**** Mix ratios are always as - Cement : Fine Agg. : Coarse Agg.**

Mix Design Methods:

- Old methods
  - Fineness modulus method
  - Minimum voids method
  - Trial mix method
  - Arbitrary method
- New methods
  - BS method
  - ACI method

Fineness Modulus Method:

- Fineness modulus of a mix
- Volume of combined aggregate
- Design chart: hand compaction, vibratory compaction
- From chart, FM of combined agg. and ratio of cement to total agg.
- From shrinkage factor, find loose volume of aggs.

Minimum Voids method

Trial Mix Method

Arbitrary method

Ref. M A Aziz

Questions:

- What is mix design? What are the methods of mix design?
- What is agg. blending? Why and how are aggs. Combined to get a type grading?
- What are the basic factors for concrete mix design?
- What are the different mix ratios? What are the old methods of mix design?
- What is the statistical behavior of concrete? Why do you need to add additional strength?
