Faculty of Engineering and Technology

Civil Engineering Department

Construction Materials Laboratory

ENCE215

Experiment # 8

" Job Mix Design and Beam Casting "

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- **Introduction**

Background information

The concrete job mix design is a set of procedure that enables designation and determination of the percentages and proportions of concrete constituents. There different methods of the job mix design used around the world, usually the procedure of each method is developed by the concerned engineering agencies inside the country. All of the methods are based on the statistical analysis of experimental results which is then represented through empirical curves and tables used for the design process.

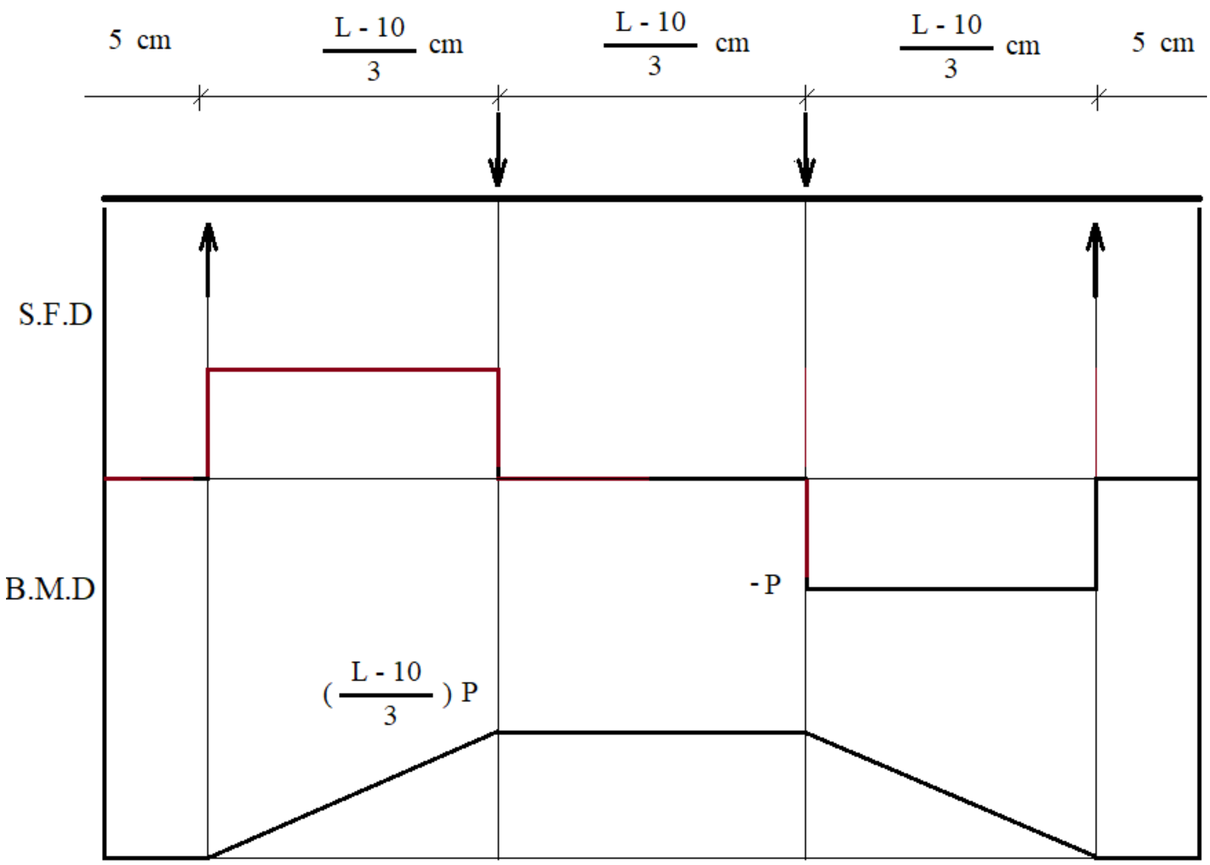
In the process of making concrete it is significantly necessary to correctly determine the proportions of concrete's components, which usually are cement, water, fine aggregates, coarse aggregates and sometimes admixtures. To proportion concrete means to attain the right amounts of each one of the earlier components in order to create concrete that possesses certain predetermined specifications with the least cost possible.

As mentioned above, the mix design mainly aims to produce a concrete mix that acts based on predesigned requirements determined by the designer engineer. Two key-designing values for a concrete mix are the workability for fresh concrete and the strength of hardened concrete. The workability often decides the ease of handling concrete through placing, consolidating and finishing. One more desired property of concrete is durability, however, in most of the normal conditions concrete is assumed to have sufficient durability if it succeeds to hit the specified strength.

The other main aim of using the job mix design procedure is related to economical concerns. Generally speaking, it is easy to create concrete with high strength by increasing the cement content for example, but this would create an absolutely noneconomic concrete. Hence, by using the job mix design procedure one can achieve concrete that performs in accordance with the desired requirements at the lowest cost possible.

Concrete has many advantageous properties that gave it its popularity as a structural material, yet it has a main downside which is heterogeneity. Concrete is a heterogeneous material, this means that its properties including strength is altered depending on the direction. It is a known fact that hardened concrete is a strong material under the act of compressive loads, while it has a very low capacity of holding tensile loads, and that the main reason behind the cracks that appear on the surface of concrete structures. This disadvantage of concrete lead to the creation of steel reinforced concrete. Unlike concrete, steel is considered very good at holding tension, thus to reinforce concrete with steel, the regions that are susceptible to tension must be strengthened with steel.

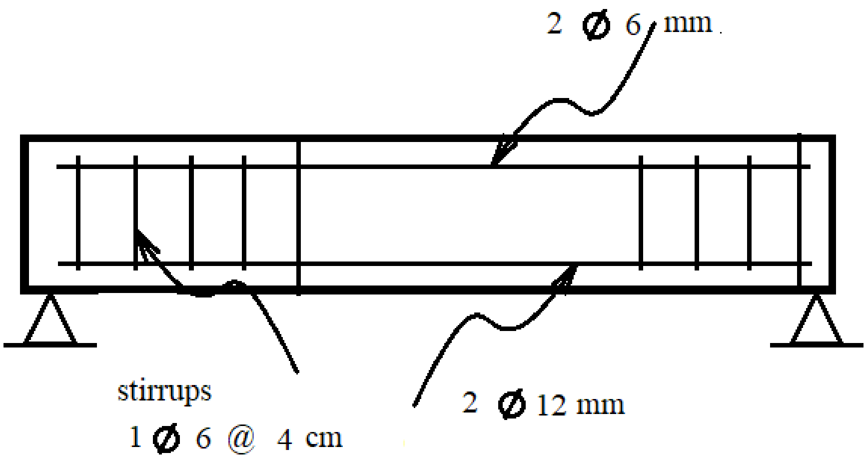
In the case of analyzing beams, (which are structural elements having large length relative to the other two dimensions) it is convenient to draw shear and bending moment diagrams to determine where the tension is and thus how to properly reinforce the beam. The beam in this experiment is tested using the four point flexural strength test (two supports and two point loads), with diagrams shown below:



fig(1): Beam shear force and bending moment diagrams for the 4 point test

From these diagrams it is observed that there will be internal shearing in the regions from 5 cm to (L-10)/3 cm from left and right, this means that it is necessary to reinforce concrete within these regions, and the best way to do so is to use 'Stirrups' which are reshaped bars in the form of rectangles.

Also one can conclude from the bending moment diagram that there is a positive moment along the majority of the beam's length. This positive moment causes the beam to compress at the upper part (above the neutral axis) and to elongate at the bottom (below the neutral axis), the elongation means that the beam will be under tension at the lower part, hence the concrete beam must be reinforced at this part using steel bars. Figure 2 illustrates the reinforcement of the beam:



Fig(2): beam reinforcement

- **Purpose**

1) To determine the proportions of concrete mix based on specifications, and test samples of the mix to make assurance.
2) To reinforce and cast a beam with concrete, and conduct the four point flexural test on it.

- **Hypotheses**

1) Expectations suggest that the fresh mix slumps within the specified range and that the samples taken from the job mix should be able to achieve the specified strength.
2) Concrete should be able to resist the flexural loading since it is reinforced, and it might crack intensively due to tension.

- **Procedure**

  1) The job mix design calculations were carried out (as in the calculations section).
  2) All the components were weighed and prepared.
  3) The components were mixed together in the mixer starting with the half the amount of water, coarse then fine aggregates, cement the rest of

water.(two additional liters of water were added because the mix was too harsh).

4) After mixing until homogeneous, the mix was poured into a container.
5) The slump test was made: a truncated cone was secured by feet, then it was filled using a trowel at three layers with 25 rod blows for each, excess concrete was removed using two trowels in a shearing action, the truncated cone was removed upwards gently and slump was measured.
6) Then six cubical specimens were cast into 10cm cubic molds at three layers and each one was mechanically vibrated.
7) The day after the molds were removed, and the cubes were cured by submerging for a week.
8) At days 7, 14 and 28 The cubes were weighed in air and in water and then crushed using the compressive machine (we only crushed at 14 and 28 and our samples were cured for two weeks because we forgot them).
9) The beam reinforcement was assembled as follows: two 6mm diameter bars were put at top, and two 12mm diameter bars were put at the bottom, 6 mm diameter bars were reshaped as stirrups, and placed at 4 cm spacing from each other.
10) Then the reinforcement assembly was placed inside a beam mold(150*15*10 cm), and the concrete was placed inside the mold at three layers using a spike vibrator for compaction.
11) The mold was detached the day after, and the 4 point flexural test was conducted on day 28 as follows: lines were marked at 5 cm offset from each end of the beam, then the remaining distance was divided into 3 segments (140/3 = 46.7 cm), the beam was placed in the machine scuch

that the supports are at the 5cm lines, and another two supports were put at the 46.7 cm lines (over two rubber caps to concentrate the loads), an I-beam was placed over the upper two supports, and the jack of the machine was placed at the middle of the I-beam, then the load was increased gradually until failure using the lever arm.

- **Instruments**

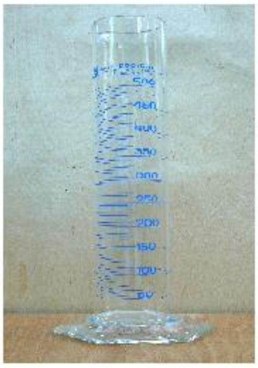
Apparatus and Tools:

fig(3): compressive machine

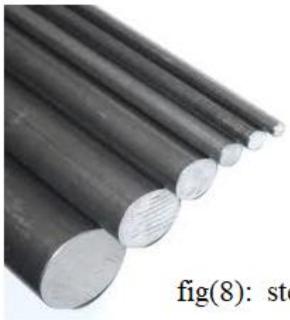
fig(4): containers

fig(5): balance

fig(6): 10cm cubic molds



fig(7): measuring cylinder



fig(8): steel bars

fig(9): trowels

fig(10): beam mold

fig(11): concrete mixer

fig(12): flexural machine setup

- **Data & Calculations:**

Four specifications were given as follows:

1) f''_c = B250 .
2) Max aggregate size = 20 mm .
3) Minimum cement content = 350 Kg/cm^2.
4) Slump = 30 – 60 cm.

1) B250 is the strength of an American cylinder in (Kg/cm^2), and must be converted to the strength of a British cube in (MPa) using this formula:

$$\frac{250 * 0.8}{10} = 20\ MPa$$

2) The target mean strength is found by taking a standard deviation (S = 8) and (k = 1.64) using:

$$f_m = f_c + ks$$

$$f_m = 20 + (1.64)(8) = 33.12\ MPa$$

3) Using table(2) (in the procedure) the approximate strength at the age of 28 days for a cube for crushed aggregates and an ordinary Portland cement was 49 MPa at W/C = 0.5.
4) This point (0.5,49) was plotted using figure(4)(in the procedure), and a parallel curve was drawn, then W/C was determined as 0.65.
5) The water content was determined as 210 kg/m^3 using table(3)(in the procedure).
6) The calculated cement content is 323 kg/m^3 but this value is rejected since the min cement content is 350 kg/m^3.
7) WC is adjusted to be 0.6.

8) The wet density of concrete is determined through figure(5)(in the procedure) to be 2425 kg/m^3 using a specific gravity of 2.7.

9) The total aggregate content was found using:

Agg_{total} = D – C – W = 1865 Kg/m^3.

10) The fine proportion was determined as 29% using figure(6)(in the procedure) with a percentage 96% finer than 600µ sieve .

11) The Fine content was determined using:

Fine = Aggtotal * fine proportion = 1865 * 0.29 = 541 kg/m^3.

12) The corce content was determined using:

Coarse = Agg_{total} - fine = 1325 kg/m3.

13) The coarse was devided to (33% 5-10mm) and (67% 10-20mm), $Coarse_{5-10}$ = 437kg/m3 and $Coarse_{10-20}$ = 875 kg/m3.

14) The effective absorption was calculated as 1.21% for 5-10 mm agg, and 1.67% for 10-20 mm agg.

15) The absorbed water was calculated using W_{abs} = W_{agg}* Effective absorption

(5-10mm)W_{abs} = 437 * 1.21% = 5.29 Kg.

(10-20mm)W_{abs} = 875 * 1.67% = 14.61 Kg

Total W_{abs} = 5.29 + 14.61 = 20 kg.

Adjusted water content = 210 + 20 = 230 Kg

Adjusted $Coarse_{5-10}$ = $Coarse_{5-10}$ + (5-10mm) W_{abs} = 442.29 Kg/m3

Adjusted $Coarse_{10-20}$ = $Coarse_{10-20}$ + (10-20mm) W_{abs} = 889.61 Kg/m3

Table(1): crushing cubes data at 28 days							
Specimen	Weight In Air (gm)	Weight In Water (gm)	Area (mm2)	Volume (m3)	Density (kg/m3)	Force (KN)	Strength (MPa)
1	2174	1181	10000	993	2.12	335.3	33.53
2	2217.5	1210.5	10000	1007	2.20	345.2	34.52
3	2202	1199	10000	1003	2.19	335.7	33.57
4	2184.5	1185.5	10000	999	2.19	326.8	32.68

- **Results & Conclusion**

The final amounts for 1 cubic meter of concrete are

The slump was measured to be: 5 cm.

- W = 230 kg/m3
- C = 350 kg/m3
- Fines = 541 kg/m3
- $\text{Coarse}_{5\text{-}10}$ = 442.29 kg/m3
- $\text{Coarse}_{10\text{-}20}$ = 889.61 kg/m3

The final amounts for 80 kg mix are found by multiplying each previous amount by $\frac{80}{2453}$:

- W = 7.5 kg/m3
- C = 11.4 kg/m3
- Fines = 17.6 kg/m3
- $\text{Coarse}_{5\text{-}10}$ = 14.4 kg/m3
- $\text{Coarse}_{10\text{-}20}$ = 29.0 kg/m3

The beam flexural strength = 12000 LBS.

All the specimens passed the strength test, since all gave a higher strength than the minimum(33.12 MPa).

But for the density the values were 2.17 in average, this value is deviated from the one obtained using the Job Mix Design procedure which is 2.43, still the 2.17 is considered within the range of concrete's normal density which is: 2.1 - 2.45.

For the beam, after applying the flexural loading, small vertical cracks started to appear at its bottom due to the positive moment effect, then a diagonal cracking started to occur at the right and left regions of the beam, this could be explained through the complementary property of shear (transverse and longitudinal shear). As the load increased the cracks got bigger and increased in number. When the strength of the beam was hit, the concrete at the upper part of the beam crushed due to compressive forces.

It is also worth mentioning that the two top bars are only used to hold the stirrups not to resist any tension since the moment is positive that is why they were chosen to be small in diameter, while the two bottom bars were bigger in diameter, and that is why they were chosen to have a larger diameter.

The importance of reinforcement appears if a comparison between the beam and the prism test is made, in the prism test concrete failed at only one crack in the middle due to the absence of steel to resist tension, while in the beam many cracks appeared because steel gave the beam the enough ductility to resist tension, and thus the failure was not sudden.

Sources of error:

- Calculations errors.
- Inaccurate weighing.
- Too long mixing mixing problems (segregation).

- The addition of the two liters of water (lowers strength and increases slump).
- Curing the cubes for two weeks instead of one week (higher strength).
- Inappropriate reinforcement of concrete.
- Poor practice in using the spike vibrator, too long time causes segregation and too short time leaves voids.

- **References:** the procedure manual.