

Making of concrete mixtures with minimum amount of cement

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ABSTRACT: An experiment program was conducted with the purpose to find minimum cement content with suitable water to cement ratio 0.4, 0.4, 0.39 and content of cement was taken 394,400,410 kg/m³. Aim of this study is to make a design mix to meet the requirement of durability, Strength, workability. By finding the minimum cement content production of carbon dioxide during the manufacturing of cement can be reduced. Strength is the function of water cement ratio after the required cement content is reached. As we come to know as well as we increase the water cement ratio workability can be increase. The ratio of fine aggregate to total aggregate was taken equal to 0.39. It can be said that reduction of cement paste is possible without decreasing the desired strength. As after conducting the test we come to that mixture which containing cement content of 394/m³ did not achieved the high working result. Its result can be increased by addition of supplementary binding materials.

INTRODUCTION

Cement is the main ingredient of concrete. It is one of the most important materials for all kinds of construction. Cement content is required to control concrete strength. Based on this perception, minimum cement content is often specified that may exceed the amount needed prevent its negative impact on costs and environment because: to achieve the desired strength and durability.

- In concrete cement is the most expensive component.
- Cement contributes approx. 90% of the CO₂ burden of a concrete mixture
- Cement production emits approximately 5% of global carbon dioxide (CO₂) and 5% of global energy consumption

Previous studies suggest that a high cement content in Admixture does not contribute to greater strength than the required design strength. In Addition, the high cement content will cause the concrete to become sticky as well as have cracking problems and problems of shrinkage. To avoid these types of problems, cement content should be balanced to achieve performance while minimizing risk of these. Even though published studies and there continues to be a misconception that more cement in a mix design means a better performing mix.

INDUSTRY PROBLEM

Portland cement is the most energy intensive material produced after steel and aluminum. More than 7 percent of world's carbon dioxide emissions are attributed to Portland cement. The burning of Portland cement at high temperature (1450⁰C) is costly in terms of fossil fuel usage. Moreover, by some estimate concrete industry is largest consumer of natural resources such as water, sand, gravel and crushed rock. Thus for sustainable development it is recognized that .considerable improvement are essential in productivity, product performance, energy efficiency, and environmental performance.²(World Business Council for Sustainable Development 2005).

Approximately 7 % of the world carbon dioxide emissions are attributable to Portland cement. Carbon dioxide belongs to the so called greenhouse gases, which give contribution in the global warming. To meet sustainable development and environmental goals, responsiveness to environmental regulations, and waste management should be the part of daily operations in the concrete industry. The industry continually should seek to identify how it can increase its use of environmentally friendly practices and processes.

OBJECTIVE

By this research concrete industry can be helped as they can use less cement with suitable water to cement ratio. Although they can achieve the target, strength and durability. By using less amount of cement manufacturing of cement content can be reduced. As we know there is requirement of huge amount of fuel while manufacturing the cement. Due to this there is great production of carbon dioxide. Due to decrease in the manufacturing of cement production of carbon dioxide. After a required amount of cement amount, when other parameters are kept same, Affection of properties of concrete will not be taken place due to additional cement.

SIGNIFICANCE OF THE RESEARCH

After a required amount of cement is reached for a suitable w/c, strength of concrete is largely independent on content cement. It can be shown after the results of this study . Concrete industries are greatly affected by the result of this experimental project because cost is not the thing which can be reduced. There are also chances of more sustainable methods related to construction of concrete projects.

LITERATURE REVIEW

This research paper presents a review of literature focusing on five major areas:

- workability
- strength
- durability
- shrinkage
- sustainability

The literature is told about how every concrete property is affected by mixture composition. The five mixture characteristics covered include:

- cement content
- water-to-cement ratio (w/c)
- aggregates
- chemical admixtures
- supplementary cementitious materials

It is very important to find fresh and hardened concrete properties that may be affected by the supplementary cementitious materials. The effects on fresh and hardened properties of concrete due to chemical admixtures are not checked in this test. Concrete properties are also affected by the amount of cementitious material in concrete. Maximum free w/c minimum cement content and minimum strength are the parameters by which the durability of concrete is commonly specified. The purpose of these experimental projects is to find out the methods by which cement can be used more effectively. After conducting this experimental project we come to know strength of concrete can be inversely proportional to cement content. By decreasing the w/c strength can be increased. It has been considered for a long time that the amount of cement controls the concrete strength. In this research project Minimum cement content is the main parameter for the desired strength.

STUDY AND RESULT

Cement: 43 Grade OPC brand ACC

Specific Gravity of cement: 3.15

Chemical Admixture: FOSROC

Specific gravity of coarse aggregate: 2.74 Specific gravity of fine aggregate : 2.74

Water absorption of coarse aggregate: 0.5

Water absorption of fine aggregate: 1.32

Free Surface moisture Coarse aggregate: Nil

Free surface moisture fine aggregate : Nil

Water: Tap water

Table 1 Sieve Analysis:

1. Coarse Aggregate 20 mm

S. No.	Parameter	Test value	Req.as per IS 383-1970	Method of test performance
	IS sieve	% passing		
1	40	100	100	IS 2386
2	20	100	85-100	Part I 1963
3	10	0	0-20	
4	4.75	0	0-5	

Coarse Aggregate: 10mm

S. NO	Parameters	Test value	Requirement as per 383-1970	Method of test ref.
	IS Sieve	% passing		IS 2386
1	12.5	100	100	Part I
2	10	87.8	85-100	1963
3	4.75	9.8	0-20	
4	2.36	0	0-5	

Mixed coarse aggregate

Fraction I (20 mm) : 67%

Fraction II (10 mm) : 37%

S. NO	Parameters	Test value	Requirement as per 383-1970	Method of test ref.
	IS Sieve	% passing		IS 2386
1	40	100	100	Part I
2	20	100	95-100	1963
3	10	32.5	25-55	
4	4.75	6	0-10	

Fine Aggregate

S. No.	Parameter	Test value	Req.as per IS 383-1970	Method of test ref.
	IS Sieve	% passing		IS 2386
1	10mm	100	100	
2	4.75mm	95.1	90-100	
3	2.36mm	84.3	75-100	
4	1.18mm	67.7	55-90	
5	600micron	49.9	35-59	
6	300micron	27.5	8-30	
7	150micron	8.0	0-10	

Sand sample confirming to Grade Zone 2nd Fineness Modulus 2.675

The particle size distribution of an aggregate as determined by sieve analysis is termed grading of the aggregate. There will be more voids in the compacted mass of concrete if all the particles of aggregate are of uniform size. Whereas aggregate comprising particles of various sizes will give a mass containing lesser voids. The particle size distribution of a mass of aggregate should be such that the smaller particles fill the voids between the larger particles. To produce dense concrete there is great requirement of proper grading of an aggregate and needs less quantity of fine aggregate and cement paste. It is, therefore, essential that the coarse and fine aggregates be well graded to produce quality concrete.

TARGET STRENGTH FOR PROPORTIONING

$$F_{ck} = f_{ck} + 1.65s$$

where F_{ck} = target average compressive strength at 28 days,

f_{ck} = characteristic compressive (at 28 days) strength and

s = standard deviation. Standard deviation,

$$s = 5 \text{ N/mm}^2 \text{ from table 1 of IS 456 Therefore, target strength} = (1.65 \times 5) + 40 = 48.25 \text{ N/mm}^2$$

SELECTION OF WATER CEMENT RATIO:

From table 5 of IS 456 maximum $w/c = 0.4$

SELECTION OF WATER CONTENT:

From table 2 maximum water content for 20mm aggregate = 186 lt. for slump range 25 to 50 mm

Estimate water content for 100 mm slump =

$$186 + 6100 \times 186 = 197 \text{ lt. As superplasticizer is used water content can be reduced up to 20% and above.}$$

Calculation of cement content:

$$\text{Water cement ratio} = 0.4$$

$$\text{Cement content} = 157.6 / 0.4 = 394 \text{ kg/m}^3$$

CONSTITUENTS OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT :

From Table 3, volume of coarse aggregate accordingly to 20 mm size aggregate and fine aggregate (Zone-II) for water cement ratio of 0.50 = 0.62 In the present case water cement ratio is 40%. Therefore, to decrease the fine aggregate content, volume of coarse aggregate as required to be increased. As the water cement ratio is lower by 0.12 proportion of volume of coarse aggregate is increased by 0.024 (at the rate of ± 0.01 for every ± 0.05 change in cement water ratio). Therefore, corrected proportion of volume of coarse aggregate for the water cement ratio of 40% = 0.644. For pumpable

concrete these values should be reduced by 5 %. Therefore, volume of coarse aggregate = $0.644 \times 0.95 = 0.612$ Volume
 offline aggregate content = $1 - 0.612 = 0.388$

MIX CALCULATIONS

The mix solution per unit volume of concrete shall be as follows:

- a) Volume of concrete = 1m^3
- b) Volume of Cement -- mass of cement / (specific gravity of cement * 1000)
 $= 394 / (3.15 * 1000) = 0.125\text{ m}^3$
- c) Volume of water = mass of concrete /
 (Specific gravity of water * 1000)
 $= 157.6 / 1000 = 0.1576\text{ m}^3$
- d) Volume of chemical admixture: super plasticizer
 @ 1.0 % by mass of cementitious materials
 $= \text{mass of chemically admixtures} / (\text{sp. Gr. Of admixture} * 1000) = 3.94 / (1.160 * 1000) = 0.003\text{ m}^3$
- e) volume of all in aggregate = $a - (b + c + d)$
 $= 1 - (0.125 + 0.1576 + 0.003) = 0.7144$
- f) Mass of coarse aggregate = $e * \text{volume of C.A.} * \text{SpG. of C A} * 1000$
 $= 0.7144 \times 0.612 \times 2.74 \times 1000 = 1198\text{ kg}$
- g) Mass of fine aggregate =
 $e \times \text{Volume of fine aggregate} \times \text{Specific gravity of fine aggregate} \times 1000 = 0.7144 \times 0.388 \times 2.74 \times 1000 = 759\text{ kg}$

MIX PROPORTIONS FOR TRIAL NUMBER 1

- a) Cement = 394 kg/m^3 • b) Water = 157.6 kg/m^3 • c) Fine Aggregate = 759 kg/m^3 • d) Coarse Aggregate = 1198 kg/m^3 • e) Chemical Admixture = 3.94 kg/m^3 • t) Water cement ratio = 0.4 g) Slump = 105 mm
- b) Mix Proportion for trial No. -2

Mi x no	Cem ent Kg	Wat er Kg	F. A. kg	C A kg	Ad mix ture	w / c	Slu mp mm
2	400	160	755	1191	4%	0 . 4	115

Mix Proportion for trial No 3

Mix no.	Cement Kg	Water Kg	F. A. Kg	C.A.k g	admixture	w/c
3	410	160	756	1182	4.1% /	0.39

Compressive Strength

Trial No.	7 days (N/mm ²)	28 days (N/mm ²)
1	3.48	4.93
2	3.56	5.02
3	3.78	5.29

Benefits of Mix design:

1. The first object is to achieve the stipulated minimum strength and durability.
2. The second object is to make the concrete in the most economical manner.
3. The mix concrete is designed keeping in mind the side exposure condition.
4. The concrete mix design is prepared as per standard of supervision available at the site of work to achieve the minimum strength and durability.
5. The concrete mix design is prepared to arrive the value of standard deviation of coefficient of variation to be used in mix design.

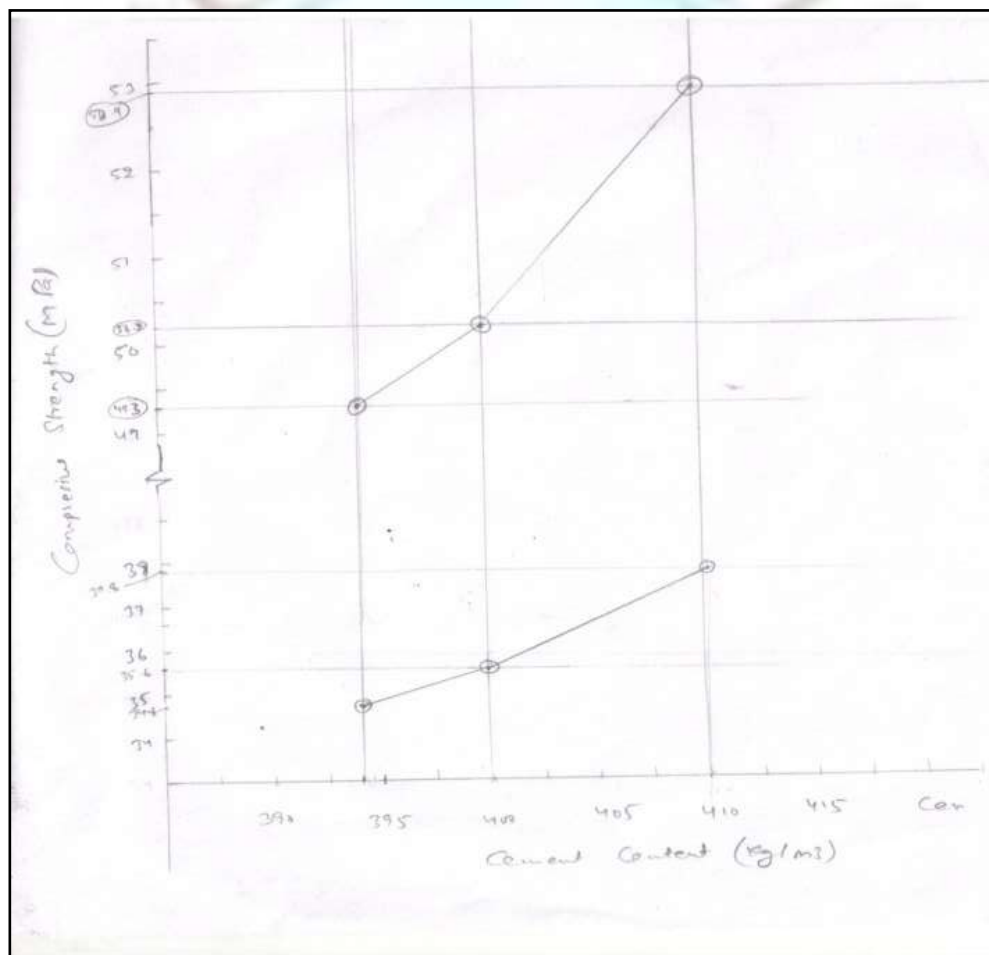


Fig. 1

6. The mix concrete is designed keeping in mind the side exposure condition.

7. The concrete mix design is prepared as per standard of supervision available at the site of work to achieve the minimum strength and durability.
8. The concrete mix design is prepared to arrive the value of standard deviation of coefficient of variation to be used in mixdesign.

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