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A review of Concrete Mix Designs

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Abstract: ***In this paper a study on mix designs of Indian standard method IS 10262: 2009, American concrete institute ACI 211.1-1991 and British standards BS 8500-1:2006 has been made for M15, M30 and M45 grades and comparison of water-cement ratio, water content, cement content, fine aggregate and coarse aggregate content has been done and the observations have been presented. It was observed that water-cement ratio for all the said grade of concrete is more in BS method and less in IS method. And the variation of other parameter has been compared and concluded.***

Keywords: Mix design, IS method, ACI method, BS method, water-cement ratio, water content, cement content, fine aggregate and coarse aggregate content

I. INTRODUCTION

Concrete mix design may be defined as the art of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength & durability as economically as possible

Mix design is a process of specifying the mixture of ingredients required to meet anticipated properties of fresh and hardened concrete. Concrete mix design is a well-established practice around the world. All developed countries, as well as many developing countries, have standardized their concrete mix design methods. These methods are mostly based on empirical relations, charts, graphs, and tables developed as outcomes of extensive experiments and investigations of locally available materials. All of those standards and methods follow the same basic trial and error principles.

The process of selecting suitable ingredients of concrete and determining their relative amount with the objective of producing a concrete of required strength durability and workability as economically as possible is termed the mix design.

Some of the prevalent concrete mix design methods are: a) IS method b) ACI Mix Design Method, c) British Mix Design Method and

A. Design of concrete mixes as per Indian Standard method IS 10260: 2009

The Indian standard code IS 10260: 2009 presents guidelines for the design of normal concretes. The basic assumption made in the mix design is that compressive strength of workable concrete is by large governed by the water/cement ratio. In this method, water/ cement ratio is selected depending on the grade of concrete and type of exposure.

Water content is selected on the basis of nominal coarse size aggregate and slump. And volume of coarse aggregate depends on the zone of fine aggregate as per IS 383 and nominal maximum size of aggregate The batch weight of the material per unit volume is calculated by absolute volume method. There are various other factors which affect the property of concrete such as the grade of cement, quantity of cement, water, aggregate size, and shape, hence the guidelines mentioned in proportioning of concrete should be considered only as a basis of trial which can be changed.

B. Design of concrete mixes as per American Concrete Institute Standards Method ACI 211.1-1991.

The American concrete institute recommends a method of mix design considering the most economical use of available materials to produce concrete of desirable workability, durability, and strength. The design table incorporating the basic relationships between parameters are useful in selecting the optimum combination of the ingredients of the mix. The ACI mix proportioning method is suitable for normal and heavyweight concrete.

The ACI method presumes that the workability of a mix with given maximum size of well-graded aggregates is dependent upon the water content, amount of air entrained and certain chemical admixture, but largely independent of the mix proportions particularly the amount of cementing material. The method also assumes that the optimum ratio of the bulk volume of coarse aggregates to the total volume of concrete depends only on the maximum size expressed as the fineness modulus. The water-cement ratio is selected based on the strength and durability requirement .knowing the volume of water, coarse aggregates, and cement, the quantity of fine aggregates required is determined by the absolute volume method, allowing for the quantity of air entrained in the mix. However, the final mix proportion should be established by trial and necessary adjustments required for the field mix

C. Design of concrete mix as per British standards BS 8500-1:2006

The latest British method replaces the traditional road note No.4 method. In the new method, the use of specific grading curves is discarded along with the mix design table correlating water/cement ratio, aggregate/cement ratio, the maximum size of aggregate, type of aggregate, and degree of workability and overall grading curves of combined aggregates. In this new method only 2 types of aggregates, namely crushed and uncrushed, are recognized. The water content required to give a various level of workability expressed as aslump and vebe time can be determined for the two types of aggregates namely crushed and uncrushed with different maximum sizes varying from 10 to 40 mm. The new British method of mix design results in expressing the mix proportion in terms of quantities of material per unit volume of concrete in line with American practice.

Table 1.Basic data considered in concrete mix design of IS, ACI and BS method

Parameter	IS method	ACI method	BS method
Characteristic compressive strength at 28 days	yes	yes	yes
Standard deviation of compressive strength	yes	No	yes
Degree of workability	yes	yes	yes
Type and maximum size of aggregates	yes	yes	yes
Nominal maximum size of coarse aggregates	yes	yes	yes
Dry rodded unit weight of coarse aggregates	No	yes	No
Fine aggregates (sand)	zone	yes	zone
Specific gravity of cement, coarse and fine aggregates	yes	yes	yes
Water absorption and moisture content adjustment	yes	yes	No
Type of construction	No	yes	No
Exposure condition	yes	yes	yes
Air/Non-air entrainment	yes	yes	yes

Table 2 Details of mix proportion

serial no	Grade of concrete	mix design method	mix proportions (by weight)			w/c ratio
			cement	FA	CA	
1	M15	IS	1	3.54	3.940	0.6
		ACI	1	3.45	3.88	0.8
		BS	1	3.37	4.55	0.86
2	M30	IS	1	1.937	2.404	0.45
		ACI	1	2.04	3.32	0.55
		BS	1	2.02	3.83	0.58
3	M45	IS	1	1.705	2.21	0.4
		ACI	1	1.15	2.29	0.38
		BS	1	1.60	3.73	0.44

Table 3 Quantity of materials as per mix proportion

serial no	Grade of concrete	Mix Design Method	mix proportions (by volume kg\m^3)			w/c ratio	Water content
			cement	FA	FA		
1	15	IS	310	1097.4	1221.4	0.6	186.000
		ACI	250	862.5	970	0.8	200.000
		BS	240	808.8	1092	0.86	206.400
2	30	IS	413.33	800.6202	991.99	0.45	185.999
		ACI	336	685.44	1115.5	0.55	184.800
		BS	319	644.38	1079.2	0.58	185.020
3	45	IS	450	767.25	994.5	0.4	180.000
		ACI	487	560.05	1115.2	0.38	185.060
		BS	356	384.48	1217.5	0.44	156.640

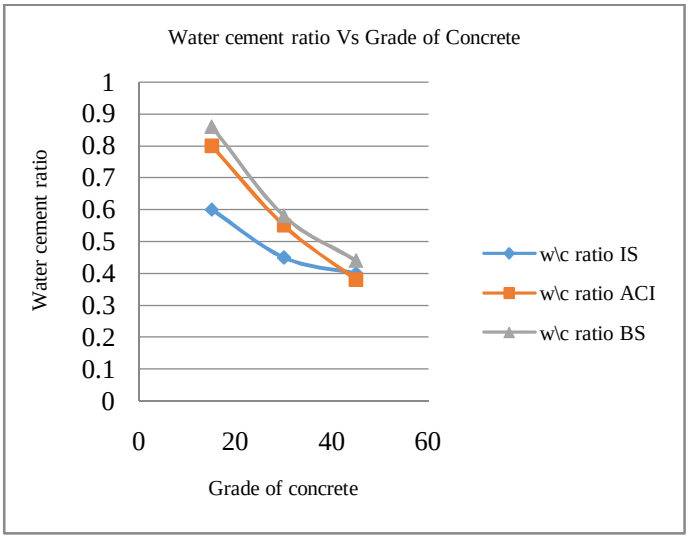

Figure 1 Water cement ratio Vs. Grade of Concrete

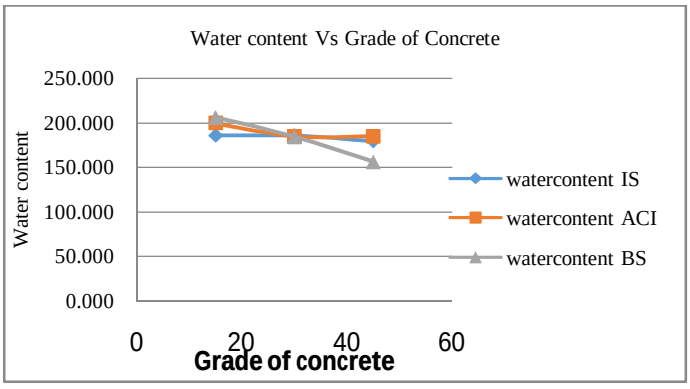

Figure 2 Water content Vs. Grade of Concrete

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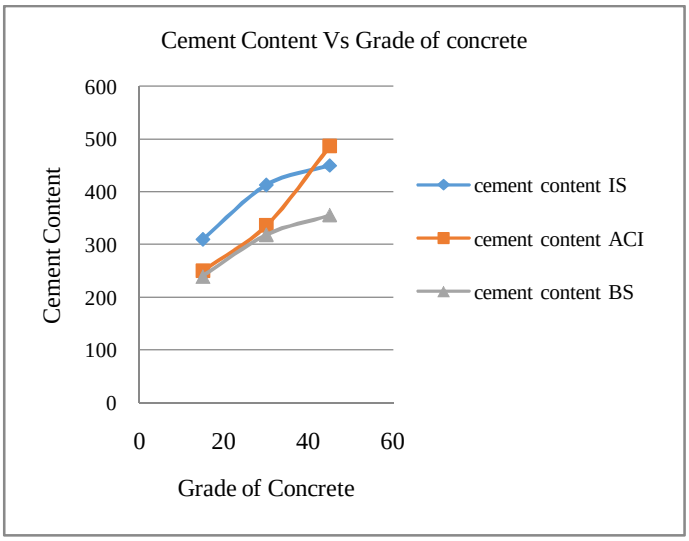

Figure 3 Cement Content Vs. Grade of Concrete

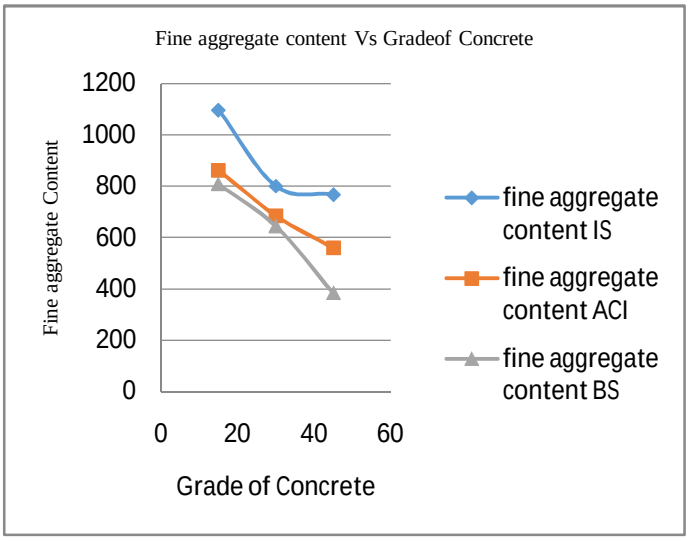

Figure 4 Fine aggregate content Vs. Grade of Concrete

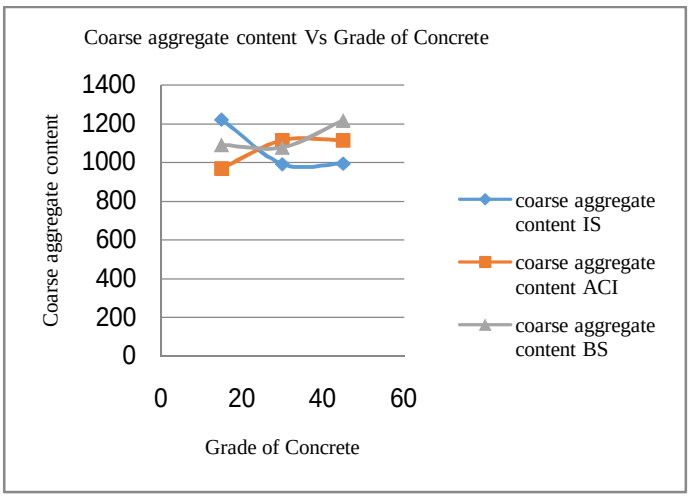

Figure coarse aggregate content Vs. Grade of Concrete

II. CONCLUSION

Comparing the mix design proportion by IS, ACI and BS method the under said points were observed

A. Water-cementratio: The water-cement ratio is maximum for the three grade of concrete for BS method and minimum for IS method

B. Water content: water content for M15 grade of concrete is maximum in BS method and minimum in IS method

1) For M30 Grade of concrete is almost equal in all three methods of mix design

2) For M45 Grade of concrete is minimum for BS method and maximum for ACI method

3) Overall water content will be minimum in BS method for all grade of concrete

C. Cement content: cement content will be minimum in BS method and maximum in IS method for M15 and M30 grade of concrete but for M45 as maximum quantity of cement is restricted to 450 kg/m^3 in IS method minimum cement content will be by ACI method

D. Fine Aggregate content: The fine aggregate content will be minimum in BS method and maximum in IS method for all three methods of mix design

E. Coarse Aggregate content: for M15 concrete coarse aggregate content is minimum for ACI method and maximum for IS method

1) For M30 concrete minimum for IS method and maximum for ACI method

2) For M45 concrete minimum for IS method and maximum for IS method

F. In all the three mix design producers the following general observations were observed.

1) Strength increases as Water cement ratio decreases.

2) Strength increases as Cement content increase.

3) Strength increases as the Fine aggregate content decrease.

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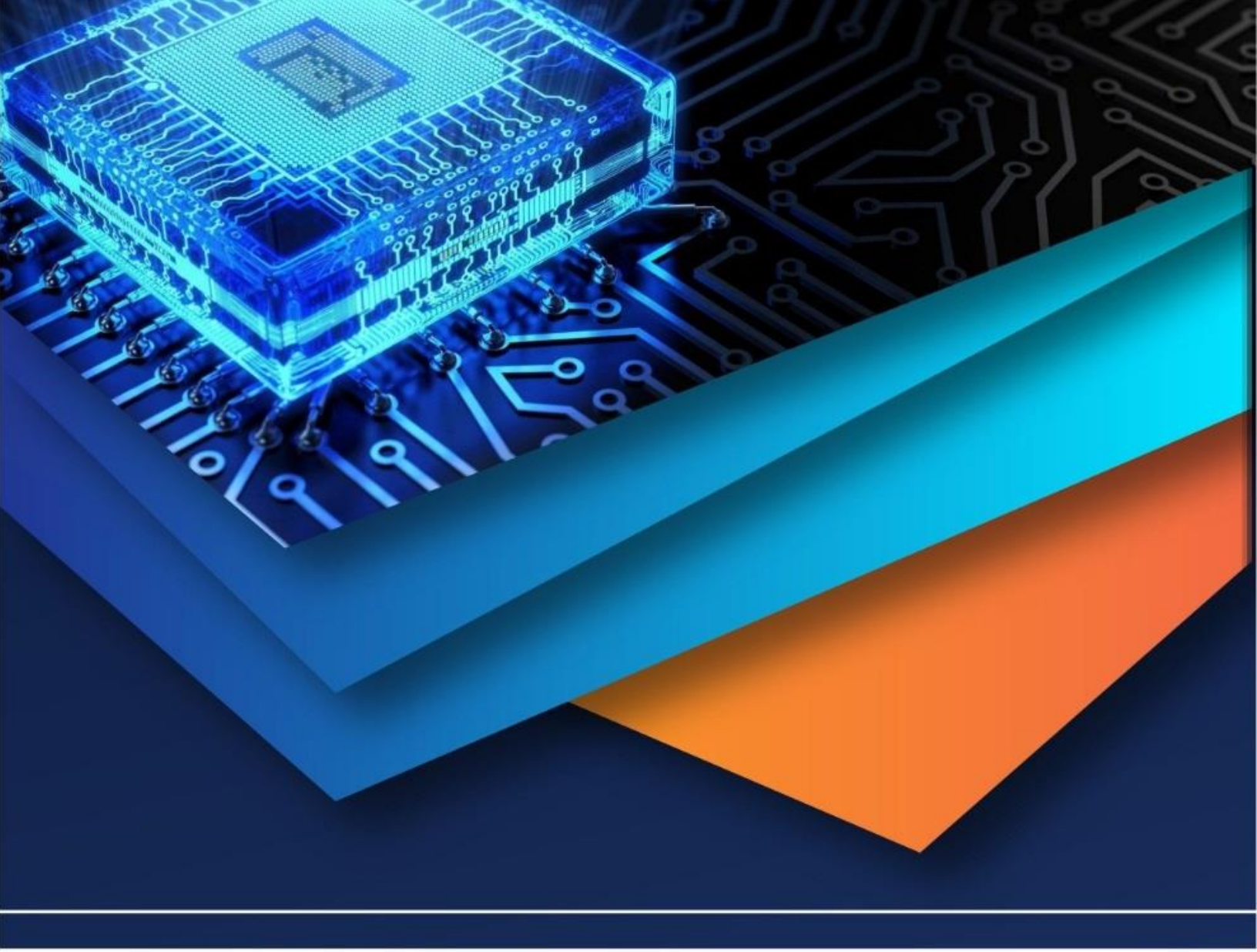

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