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Experimental Study on Developing Mass Concrete Mixes as per Indian Standard 10262: 2019

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Abstract: In present study attempts to develop M15 grade mass concrete mixes using IS 10262:2019. The number of trial mixes were developed by maintain the cement content about 316 kg/m^3 and Ground Granulated Blast Slag content (15%) for all the mixes. The water content and aggregates content was varied for all the mixes. The maximum size of coarse aggregates restricted to 40 mm. The fresh properties and hardened properties tests on mass concrete mixes were carried out as per IS codes.
The results shows that mass concrete mixes can be developed by using IS 10262:2019 for given grade of concrete. The workability of mixes increases as water-cement ratio increases and also much provide better workability is achieved when cement is partial replaced with GGBS. The compressive strength for both cubes and cylinders and flexural strength values increases when partial replace 15% GGBS with cement. But the tensile strength value decreases when the partial replacement of GGBS with cement.

Key Words: Compressive strength, Flexural strength, IS 10262 2019, Mass Concrete, Split Tensile strength.

I. INTRODUCTION

ACI Committee 116 has defined mass concrete as concrete in a massive structure, for example, a beam, columns, pier, lock, or dam where its volume is of such magnitude as to require special means of coping with the generation of heat and subsequent volume change [1]. The fundamental difference between mass concrete and general concrete is the thermal characteristics. Mass concrete elements generate substantial thermal gradients between the core and the surface of the concrete, which are large enough to pose a considerable risk of thermal damage. Therefore, they are declared to be mass concrete and extra precautions are taken [1]. Designers and builders of large concrete dams were the first to recognize the significance of temperature rise in concrete due to heat of hydration, and subsequent shrinkage and cracking that occurred on cooling [2]. Cracks parallel to the axis of the dam endanger its structural stability; a monolithic structure (that is essentially free from cracking) will remain in intimate contact with the foundation and abutments and will behave as predicted by the design stress distributions. Concrete piers, columns, beams, walls, and foundations for large structures are much smaller than a typical concrete gravity dam. If they are several meters thick and are made of high-strength concrete mixtures (high cement content), the problem of thermal cracking can be as serious as in dams. The ACI Committee 207 has authored comprehensive reports on concrete for dams and other massive structures [3].
Mainly three circumstances contribute to cracking and reduce the durability of mass concrete elements; internal restraint, external restraint, and delayed ettringite formation. Proper understanding and design of mass concrete provides elements free of cracks and thermal damage [3]. Many of the principles in mass concrete practice can also be applied to general concrete work, whereby economic and other benefits may be realized [4].
The main objective of proportioning of mass concrete is to produce economical mixes of required strength, permeability, and durability with proper combination of materials that are available which provide the workability required for placement of concrete and less rise in temperature after placement of concrete [4]. During mix proportioning proper attention must be given to selection of water to cement (w/c) ratio or water cementitious ratio, which is necessary to establish proper durability, strength, and permeability of concrete. Cement must be kept minimum that is lesser weight of cement required to place the concrete to reduce heat of hydration. It is critical to reduce the quantity of cement in the mix [4]. The replacement of cement with slag and fly ash (and now ground glass pozzolans) can help maintain required strengths [5]. Admixtures used for air entrainment, water reduction, set time, and shrinkage reduction, strength, and durability can be adjusted to slow or reduce the heat of hydration [5]. Air content that is assumed should be between 3% to 5%. Fine materials also should be selected to provide proper placeability of concrete. Coarse aggregates should be selected properly because it effects the thermal properties of concrete, aggregates selected should be of larger size varying from 40mm to 150mm. Many recommended changes to the concrete mix for mass concreting reduce or slow the heat of hydration to limit temperature change and thereby lower the amount of crack formation [6]. The ACI 207 Committee reports are published as guidelines for construction of mass concrete [2]. Table 1 shows mass concrete specifications as per different guidelines.

Table 1: Guidelines for Construction of Mass Concrete [2]

	Placement size (ft)	Max. Temp Difference (^{0}F)	Max. Temp of Concrete (^{0}F)	Concrete Placement Temp Range (^{0}F)
Oak Island	>6	<35	----	40-75
Sunset Beach	>6	<35	----	40-75
US 17 Bypass	> 6 ft	< 36	----	52-75
Florida	----	<35	180	----
Texas	>5	<35	160	50-75
South Carolina	>5	<35	----	<80
Louisiana	>4	----	----	----
Maryland	>6	----	----	----
Virginia	>5	<35	160	<95
UFGS	>3	35	158	Based on thermal model

There are very few mix design methods developed to arrive the mass concrete mixes, in general ACI 207 [3] was most widely used for mix proportion method. There was no standard code / guidelines available in India. In recent year BIS has revise the code IS 10262:2019 [7] and hence there is a need to study on fresh and hardened properties of concrete.

II. Mix Proportioning of Mass Concrete as per IS 10262:2019

A brief procedure for mix proportioning of mass concrete is as per revised code is discussed here. Based on the required grade of concrete to be proportioned, a target strength of mass concrete is determined (cl. 4.2). Depending on the maximum size of aggregate, air content is determined (cl. 9.3). The water content is selected from the Table 12 of IS code (cl. 9.4) which is based on size of coarse aggregate. The water content is selected from a particular range and further may be reduced based on use of superplasticizer (SP). The SP content may be determined using Marsh cone test. The cement content is determined using the w/c ratio (Figure 1 of IS code) and further the filler may be used to replace cement based on the type of filler. Then determine the volume of coarse and fine aggregates, starts the trial mixes.

III. EXPERIMENTAL PROGRAM

3.1 Materials

The list of constituent materials and their corresponding properties are tabulated in Table 2.

Table 2: Material properties

Materials	Specific Gravity	Specific Surface (m^2/kg)	Water Absorption (%)	Remarks
Cement	3.14	265	-	OPC-53 grade; (conforming IS:12269-2013 [8])
Fine aggregate	2.76	-	1.4	Manufacturing sand used as fine aggregates; (confirming Zone-II - IS 383-2016 [9])
Coarse aggregate	2.8	-	0.20	Crushed angular coarse aggregate passing 40 mm
GGBS	2.85	425	-	Confirming to IS 16714-2018[10]
Water	1.00	-	-	Portable water – pH 7.7 (Conforming to IS 456 – 2000 [11])

All the materials were procured from a single source in sufficient quantity to ensure enough availability of material throughout the experimental program and stored in air-tight containers. The natural coarse aggregate used was crushed granite stone which was angular, and all marginal materials were procured form nearby market place. The maximum size of the aggregates used was 40mm. Manufactured sand confirming zone-II requirements was used as a fine aggregate and its gradation curve is presented in Figure 1.

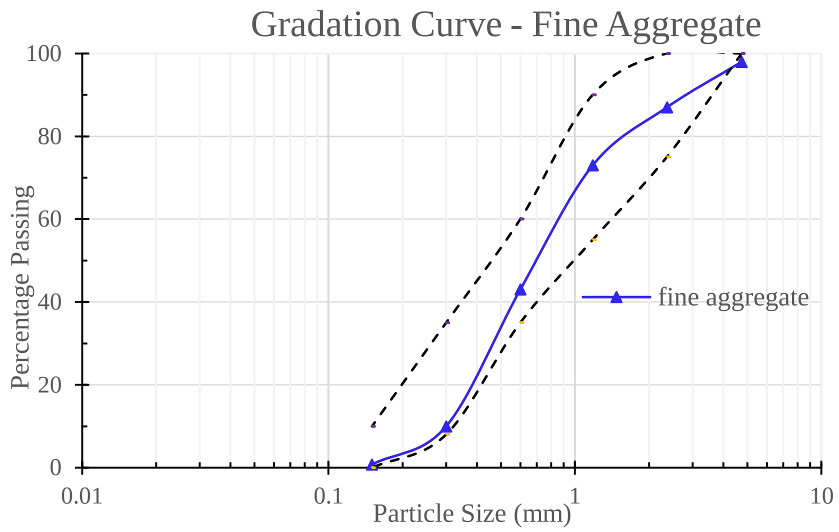

Figure 1. Grading Curve of Fine Aggregate

3.2 Mix Design

The M15 grade of mass concrete mix has been designed based on Indian standard IS: 10262-2019 [7]. The typical mix design procedure along with example shown below.

A) Grade designation- M15
B) Type of cement- OPC 53 grade conforming to IS 269
C) Maximum nominal size of aggregate :40mm
D) Type of mineral admixture: GGBS
E) Minimum cement content and maximum water-cement ratio: Moderate (Plain concrete)
To be adopted and /or exposure conditions as per Table 3 and Table 5 of IS 456
F) Workability – 50mm
G) Degree of supervision: Good
H) Type of aggregate: Crushed aggregate

Step 1. Target strength for mix proportioning

Fck = fck +1.65 * S = Fck = 15 + (1.65 x 3.5) = 20.77 N/mm^2

Step 2. Approximate air content

Approximate air content = 0.8% for 40mm nominal size of concrete. (Ref: Table 11 from IS Code)

Step 3. Selection of w/c ratio

From Figure 1 of IS 10262: 2019 [2] the free w/c ratio required for the target strength 20.775N/mm^2 is 0.65 for OPC 53 grade curve. It is greater than maximum w/c ratio of IS 456:2000 [11].
Hence w/c ratio = 0.60.

Step 4. Selection of Water Content

From Table 12, water content = 165 kg (for 50 mm slump) for 40 mm aggregate.

Step 5. Calculation of Cement Content

w/c= 0.6
cement content = 165/0.6=275 kg/m^3
Total Cement Content = 275 * 15% (cement) = 316 kg/m^3
Replace the 15% of GGBS replace by weight of cement.
GGBS Content = 316 * 15% = 47 kg/m^3

Cement Content = 316 – 47 = 269 kg/m^3 > Minimum cement content (225 kg/m^3)
w/c = 165/316 = 0.52

Step 6. Proportioning of Coarse Aggregate and Fine Aggregate

Volume of coarse aggregate =0.67 m^3
Volume of fine aggregate= 0.33 m^3
Volume of all in aggregate = 0.7328m^3

Step 7. Mix Proportions for Trial

Cement = 269 kg/m^3
GGBS = 47 kg/m^3
Water = 165 lt/m^3
Fine aggregate (SSD) = 606 kg/m^3
Coarse aggregate (SSD) = 1426 kg/m^3

Based on the above procedure, carried out more than 12 different trial mixes to obtain desired slump value. The trial mixes values are not situated. Based on the trial mixes, keep the replace the 15% of GGBS content by weight of cement three mixes. The water content and W/C ratio varied as per design requirements. The reference mix details are given in Table 3.

Table 3: Details of Mix Proportions of Mass Concrete Mixes (by Mass)

Mixes	Cement (kg/m^3)	GGBS (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (lt/m^3)	w/c
M1	316	0	570	1552	126	0.40
M2	316	0	601	1413	165	0.52
M3	316	0	600	1347	190	0.60
M4	269	47	569	1550	126	0.40
M5	269	47	607	1426	165	0.52
M6	269	47	600	1343	190	0.60

3.3 Test Details

The fresh properties of mass concrete mixes were ascertained by slump test as per IS 1199: 1959 [12]. The strength properties tests like compressive strength test on cube and cylinder specimen, split tensile test and flexural test were conducted as per IS 516-1959 and IS 5816-1999[13,14].

IV. RESULTS AND DISCUSSION

4.1 Fresh Properties

Workability of concrete is determined by slump test as per IS 1199: 1959 [12]. Table 4 shows the different values of slump for different mix proportion.

Table 4: Fresh Properties of Mass Concrete Mixes

Mixes	Cement (kg/m^3)	GGBS (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (lt/m^3)	w/c	Slump (mm)
M1	316	0	570	1552	126	0.40	10
M2	316	0	601	1413	165	0.52	60
M3	316	0	600	1347	190	0.60	80
M4	269	47	569	1550	126	0.40	20
M5	269	47	607	1426	165	0.52	80
M6	269	47	600	1343	190	0.60	130

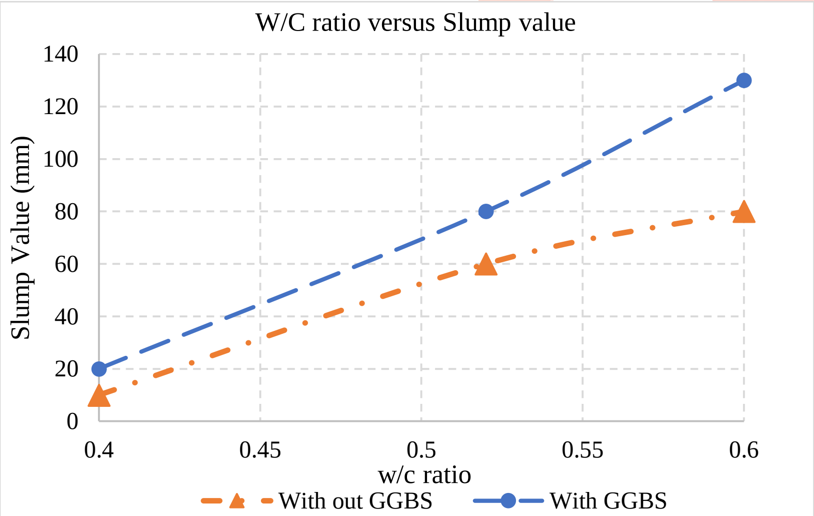

Figure 2. Relationship between W/C Ratio versus Slump Values

The Figure 2 shows the relation between W/C ratio versus slump values for mass mixes. It can be observed that mix M1 and M4 shows the lower slump value about 10mm and 20mm respectively. Gradually slump increases by replace the GGBS content with respect to cement. It is clearly showing the as w/c ratio increases the workability of mixes increases for both with and without GGBS content. The workability of mixes is improved when GGBS (15%) is replaced with cement.

4.2 Compressive Strength Test

Compression strength test were performed on compression testing machine of 2000 KN capacity. Cube and cylinder specimens casted to determine compressive strength at the age of 7 and 28days. The specimens were de-moulded 24 hours after casting and were cured under water at 27 ± 2oC until the test age. The tests were conducted as per the codal provisions of IS 516-1959[13]. Table 5 shows the cube compressive strength at different ages of curing period of 7 and 28days respectively.

Table 5: Average Compressive Strength of Cubes and Cylinder at 7 and 28 days

Mix No	W/C Ratio	Cube Compressive Strength (MPa)		Cylinder Compressive Strength (MPa)	
		7 days	28 days	7 days	28 days
M1	0.40	25	30	20	24
M2	0.52	22	28	18	23
M3	0.60	17	22	13	17
M4	0.40	28	34	20	25
M5	0.52	23	31	18	23
M6	0.60	21	27	17	21

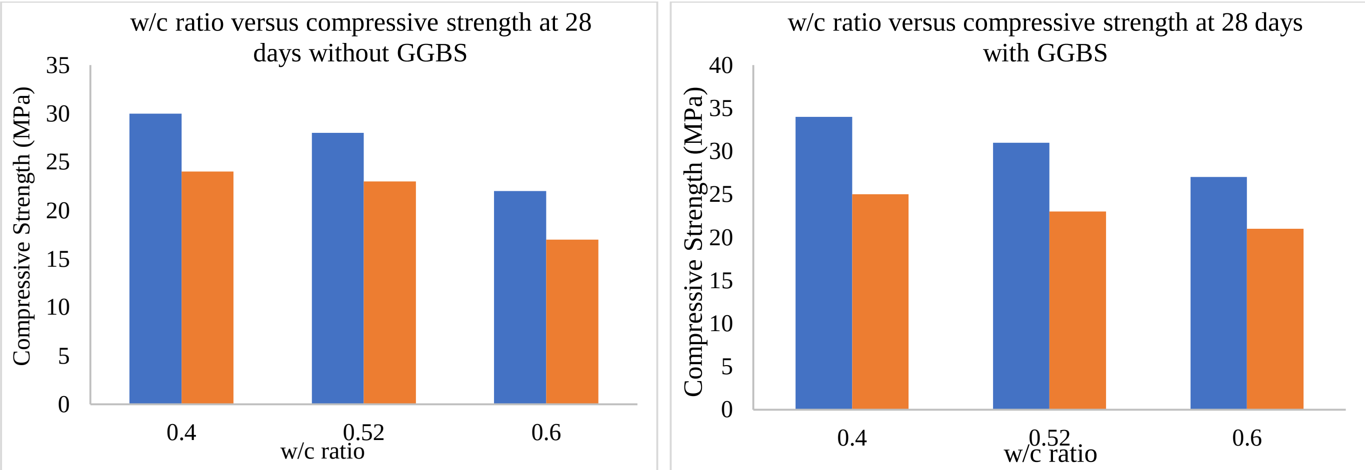

Figure 4. Relationship between w/c ratio versus Compressive Strength at 28 days

Figure 4 clearly shows that 28 days cube and cylinder compressive strength being higher for partial replacement of 15% GGBS with cement mix than without GGBS mixes. And also cube strength value is higher than cylinder strength in both with and without GGBS content mixes. It is purely because due to the platen effect [1]. Mixes with partial replacement of GGBS with cement have greater strength than the regular cement mixes.

From the above Figure 4, it can be noticed that at 28 days cube and cylinder compressive strength of concrete is increases as w/c ratio increase, so it is following the Abram's law [5]. From the above Table 5, it can be observed that 7 days and 28 days compressive strength of mass concrete with and without GGBS have reached the expected values. There is increase in 7 days and 28 days strength when cement is replaced by 15% GGBS considerably and also when water cement ratio is higher that is. 0.6 then the effect of GGBS is clearly seen, there is much increase in compressive strength when compared to 0.4 and 0.52 water cement ratios.

4.3 Split Tensile Strength Test

The tests were conducted as per the codal provisions of IS 5816-1999 [14]. Table 6 shows the split tensile strength of concrete mixes at 28 days.

Table 6: Average Split Tensile Strength Values at 28 days

Mix No	W/C Ratio	Split Tensile Strength (MPa)
M1	0.40	3.3
M2	0.52	3.1
M3	0.60	2.9
M4	0.40	3.1
M5	0.52	2.9
M6	0.60	2.7

Table 4 clearly indicates that, the 28 days tensile strength values decreases as w/c ratio increases that is 3.3 MPa to 2.9 MPa. When the cement replaced by GGBS about 15% the tensile strength is also decreasing as w/c ratio increases from 3.1 MPa to 2.7MPa, so the GGBS content is not contributing to improve the tensile strength.

4.4 Flexural Strength Test

The tests were conducted as per the codal provisions of IS 516-1959 [13]. Table 7 shows the flexural strength of concrete mixes at 28 days.

Table 7: Average Flexural Strength Values at 28 days

Mix No	W/C Ratio	Split Tensile Strength (MPa)
M1	0.40	3.8
M2	0.52	3.7
M3	0.60	3.2
M4	0.40	4.1
M5	0.52	3.9
M6	0.60	3.6

Table 7 clearly indicates that, the 28 days flexural strength values decreases as w/c ratio increases that is 3.8 MPa to 3.2 MPa. When the cement replaced by GGBS about 15% the flexural strength is also increasing as w/c ratio increases from 4.1 MPa to 3.6MPa, so the GGBS content is contributing towards improve the flexural strength.

V. CONCLUSIONDING REMARKS

The main aim of the work is to be developing the mass concrete mixes using new code IS 10262:2019. In these direction, the experiments on mass concrete were developed to determine both fresh and hardened properties under controlled laboratory conditions. The results shows that mass concrete mixes can be developed by using IS 10262:2019 for given grade of concrete. The workability of mixes increases as water-cement ratio increases and also much provide better workability is achieved when cement is partial replaced with GGBS. The compressive strength for both cubes and cylinders and flexural strength values increases when partial replace 15% GGBS with cement. But the tensile strength value decreases when the partial replacement of GGBS with cement.

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REFERENCES

[1] Kumar Mehta.P and Paulo J. M. Monteiro. 2006. Concrete – Microstructure, Properties and Materials, Third Ed, McGraw-Hill, DOI: 10.1036/0071462899.
[2] Mang Tia, Christopher F, Adrain L, Samuel S and Eiji O.2010. Development of Design Parameters for Mass Concrete using FE Analysis, Report, University of Florida.
[3] ACI 207.1R-05. 2007. Guide To Mass Concrete Reported By ACI Committee 207, American Concrete Institution.
[4] Xie Nianxiang and Liu Wenyan. 1989. Determining Tensile Properties of Mass Concrete by Direct Tensile Test, ACI Materials Journal, 86(3): 214-219.
[5] Neville.A. M. 1996. Properties of Concrete, New York, Wiley.
[6] Houghton.D.L.1976. Determining Tensile Strain Capacity of Mass Concrete, Journal Proceedings, 73(12): 691-700.
[7] IS: 10262-2019, Guidelines for Design and Development of Different Types of Concrete Mixes, Indian Standards, New Delhi, 2019.
[8] IS: 12269-2013, Ordinary Portland Cement – 53 grade Specification, Indian Standards, New Delhi, 2013.
[9] IS: 383-2016, Coarse and Fine Aggregate for Concrete – Specification, Indian Standards, New Delhi, 2016.
[10] IS: 16714-2018, Ground Granulated Blast Furnace Slag for use in Cement, Mortar and Concrete – Specification, Indian Standards, New Delhi, 2018.
[11] IS: 456-2000, Plain and Reinforced Concrete - Code of Practice, Indian Standards, New Delhi, 2000.
[12] IS: 1199-1959, Methods of Sampling and Analysis of Concrete, Indian Standards, New Delhi, 1959.
[13] IS: 516-1959, Method of Test for Strength of Concrete, Indian Standards, New Delhi, 1959.
[14] IS: 5816-1999, Splitting Tensile Strength of Concrete - Method of Test, Indian Standards, New Delhi, 1999.