Strength Characteristic Of M_{25} Grade Cement Concrete By Replacing Water With Crushing Ice Cubes

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Abstract - The objective of this limited study is to provide an overview of the effects of temperature on the behavior of concrete materials and structures. In meeting this objective, the effects of temperatures as it elevates and depresses from ambient temperature, are worked out. This paper also deals with the procedure and precautions to be observed while concreting in extreme weather conditions- hot and cold weather so as to minimize the detrimental effects of weather on concreting in general types of construction, such as - buildings, bridges, highways, pavements and other similar structures. Discussion of results covers, M25 grade concrete at the age of 7days the average compressive strength for all the 2 mixes is nearly same. At the age of 14days marginal increase in compressive strength same as that of 7days.And at 28days curing age decrease in compressive strength was observed. This increase in compressive strength may be due the use crushing Ice for mixing and curing.

Keywords compressive strength, coarse aggregate, concrete, Cement, Fine aggregate, Crushing Ice

I. Introduction

A concrete mix is a combination of five major elements in various proportions: cement, water, coarse aggregates, fine aggregates (i.e. sand), and air. While a concrete mix design is a process of selecting ingredients for a concrete mixture and deciding on their proportions. When designing a mix, you should always consider the desired strength, durability, and workability of the concrete for the project.

Introducing the ice tends to increase the length of time from beginning of batching until delivery and reduces the total daily output of the ready mixed concrete plant. Another problem is controlling the slump. Slump cannot be measured properly until all the ice is melted. Ideally the ice should just finish. Melting at the time the concrete is to be discharged at the jobsite, but the rates of melting and transporting may not coincide. Consequently, there may be a delay before the slump measurement can be made. It may be necessary to vary the amount of ice used per batch, using less in the morning and more as the day grows warmer. This added variation in batching and mixing increases the difficulty of control. The use of ice does effectively accomplish the purpose of cooling the mix in hot weather and is far more effective than cold water. One rule of thumb for determining how much ice to use is that the concrete temperature can be reduced one-degree F for each two percent of total water replaced by ice.

II. Statement of problem

A comparative evaluation of strength characteristics of control concrete of grade M25 and Crushing Ice concrete produced by replacing water.

III. Objective of the study

The following are the main objective of study:

To compare the compressive strength of control concrete of M25 grade and Crushing Ice concrete produced by replacing water.

To determine the effect of crushing Ice on workability

IV. Materials and Methodology

Cement:

The history of cementing material is as old as the history of engineering construction. Cementing materials where used by Egyptians, Romans, and Indians in their ancient constructions. It is believed that the early Egyptians mostly used cementing materials, obtained by burning gypsum. Not must right has been thrown on cementing material, used in the construction of the cities of Harappa and Mohenjo-Daro.

Table I. Compressive strength of Cement

Type of cement	Cooling conditions	Compressive strength MPa		
		3 Days	7 Days	28 Days
Normal cement	Quick	9.9	15.3	26
	Moderate	9.7	21.0	27
	Slow	9.7	19.3	24
	Very slow	8.7	18.7	23
High early strength cement	Quick	10.2	18.8	29
	Moderate	14.2	26.7	33
	Slow	10.2	21.0	29
	Very slow	9.1	18.1	28

Ordinary Portland cement (OPC) is by far the most important type of cement. All the discussions that we have done in the previous chapter and most of the discussions that are going to be done in the coming chapters relate to OPC. Prior to 1987, there was only one grade of OPC which was governed by IS 269-1976. After 1987 higher grade cements were introduced in India. The OPC was classified into three grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 Days when tested as per IS 4031-1988.If the 28 Days strength is not less than 33N/mm2, it is called 33 grade cement, and if the strength is not less than 43N/mm2, it is called 43 grade cement, and if the strength is not less than 53N/mm2, it is called 53 grade cement. But the actual strength obtained by these cements at the factory are much higher than the BIS specifications.

Fine Aggregate:

All along in India, we have been using natural sand. The volume of concrete manufactured in India has not been much, when compared to some advanced countries. The infrastructure development such as express highway projects, power projects and industrial developments etc. have started now. Availability of natural sand is getting depleted and also it is becoming costly. Concrete industry now will have to go for manufactured sand. A company by name Svedala is one of the concrete aggregate manufacturers.

Table II. IS Sieve Sizes

I.S. Sieve mm	Percentage passing			Remarks
	As per actual test	I.S Requirements for		
		Zone -1	Zone -2	
10	100	100	100	Falling in Zone -2
4.75	97.58	90-100	90-100	
2.36	82.36	60-95	75-100	
1.18	55.27	30-70	55-90	
600	40.56	15-34	35-59	
300	29.33	5-20	8-30	
150	18.78	0-20	0-20	
75	10.09	Max 15	Max 15	

Coarse Aggregates:

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Earlier, aggregates were considered as chemically inert materials but now it has been recognized that some of the aggregates are chemically active and also that certain aggregates exhibit chemical bond at the interface of aggregate and paste. The mere fact that the aggregates occupy 70-80 per cent of the volume of concrete, their impact on various characteristics and properties of concrete is undoubtedly considerable. To know more about the concrete, it is very essential that one should know more about the aggregates which constitute major volume in concrete.

Table III. Classification Of Aggregates

Classification	Description	Examples
Rounded	Fully water worn or completely shaped by attrition	River or seashore gravels; desert, seashore and wind-blown sands
Irregular or party rounded	Naturally irregular or partly shaped by attrition, having rounded edges	Pit sands and gravels; land or dug flints; cuboid rock
Angular	Possessing well-defined edges formed at the intersection of roughly planar faces	Crushed rocks of all types; talus; screes
Flaky	Material, usually angular, of which the thickness is small relative to the width and/or length	Laminated rocks

Water:

It has been brought out earlier that C3S requires 24% of Water by weight of cement and C2S requires 21%. It has also been estimated that on an average 23% of water by weight of cement is required for chemical reaction with Portland cement compounds. This 23% of water chemically combines with cement and, therefore, it is called bound water. A certain quantity of water is imbibed within the gel-pores. This water is known as gel-water. It can be said that bound water and gel-water are complimentary to each other. If the quantity of water is inadequate to fill up the gel-pores, the formations of gel itself will stop and if the formation of gel stops there is no question of gel-pores being present. It has been further estimated that about 15 per cent by weight of cement is required to fill up the gel-pores. Therefore, a total 38 per cent of water by weight of cement is required for the complete chemical reactions and to occupy the space within gel-pores. If water weight of cement is only used it can be noticed that the resultant paste will undergo full hydration and no extra water will be available for the formation of undesirable capillary cavities. On the other hand, if more than 38 per cent of water is used, then the excess water will cause undesirable capillary cavities. Therefore, greater the water above the minimum required is used [38 per cent], the more will be the undesirable capillary cavities. In all this it is assumed that hydration is taking place in a sealed container, where moisture to and from the paste does not take place.

Ice:

If a water chiller is not available, or the desired reductions in mix temperature involve chilling the water beyond the limitations of available chiller, ice is the obvious answer. The amount of cooling is limited by the amount of mixing water available for ice substitution. For most concrete, the maximum temperature reduction is approximately 20°F. For correct proportioning, the ice must be weighed. Ice has a two-way cooling effect. First it draws heat from the concrete for melting of ice, then the resulting water at 32°F provides continuing cooling capacity.

V. Experimental Investigation

Testing on Cement

Specific gravity of cement:

Specific gravity is defined as the ratio between weight of a given volume of material and weight of an equal volume of kerosene. To determine the specific gravity of cement, kerosene is used which does not react with cement.

Fig 1: Specific gravity test on cement

- The flask shall be filled with kerosene to a point on the stem between the zero and 1 ml of mark. The first reading shall be recorded after the flask has been filled with kerosene
- Take 64gms of given cement sample and pour the sample into the bottle using glass stick.
- Remove the sticked cement with glass stick and observe the final reading kerosene after complete immersion of cement into the bottle.

Normal Consistency is defined as the percentage of water requirement for the preparation of cement paste, the viscosity of which will be such that the Vicat plunger penetrates up to a point 5 to 7 mm from the bottom of the Vicatmould. When water is added to the cement the resulting paste starts stiffening and gaining strength, simultaneously losing its consistency. Two stiffening states are identified as initial and final setting timings of the cement sample respectively. Initial setting time is defined as the time taken by the paste to stiffen to an extent such that the Vicat needle is not permitted to move down through the paste within 5 ±0.5 mm measured from the bottom of the mould. Final Setting time is the time when the paste becomes so hard that the annular attachment to the needle, understand the fails to leave mark on the hardened cement paste. Thus, normal consistency and setting times are theological properties since these concepts are defined corresponding to the standard flow of cement paste under standard force exerted by the weight of relevant plunger.

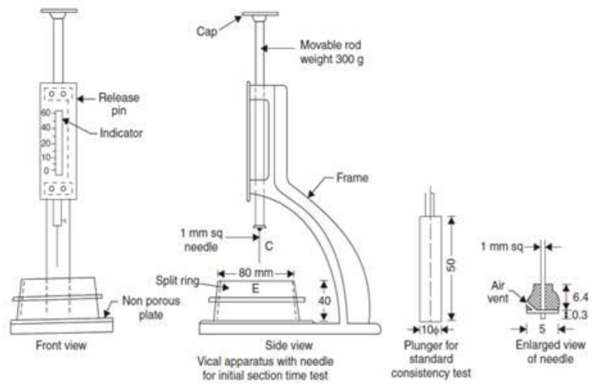

Fig 2: vicat apparatus.

Fig 3: testing for normal consistency & Setting times cement.

Soundness of cement:

Hardened cement paste may undergo an undesirable large expansion due to the delayed hydration of some oxides which had not combined at the time of formation of clinker. Unsoundness in cement is due to the presence of excess of lime in core composition than that could be combined with acidic oxide at kiln. This is also due to the inadequate burning or insufficiency in fineness of grinding or through mixing of raw materials.

Fig 4: soundness of cement

Table IV. Types of Cements

Type of Cement	1 day	3 day	7 days	28 days
OPC 33 grade 43 grade 53 grade	-- -- --	160 230 270	220 330 370	330 430 530
LHPC	--	--	220	310
RHPC	160	275	--	--
PPC	--	--	220	310
HAC	300	350	--	--

Testing Of Sand: -

Specific Gravity of Fine Aggregate: -

Specific gravity is the ratio of the weight of a volume of the substance to the weight of an equal volume of the reference substance. The specific gravity of an aggregate is generally required for calculations in connection with cement concrete design work for determination of moisture content and for the calculations of volume of concrete. The specific gravity also gives information on the quality and properties of aggregate. The specific gravity of an aggregate is influencing to evaluate the strength of the concrete mix.

Fig 5: Pycnometer with collar

Sieve Analysis and Fineness Modulus of Fine Aggregate: -

This is the name given to the operation of dividing a sample of aggregate into various fractions each consisting of particles of the same size. The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which is called as gradation. Many a time, fine aggregate is designated as coarse sand, medium sand, and fine sand. These classifications do not give any precise meaning. What the supplier terms as fine sand may be medium or even a coarse sand. To avoid this ambiguity fineness modulus could be used as a yard stick to indicate the fineness of sand. The following limits may be taken as guidance.

Fine sand: Fineness Modulus: 2.2 - 2.6,

Medium sand: Fineness Modulus: 2.6 - 2.9,

Coarse sand: Fineness Modulus: 2.9 - 3.2

Sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

Light brushing with a fine camel hairbrush may be used on the 150-micron and 75-micron IS Sieves to prevent aggregation of powder and blinding of apertures.

Table V. Sieve Analysis of Coarse Aggregates

I S Sieve No	**Weight of sample retained on sieve**	**Percentage of weight retained (%)**	**Percentage of Passing (%)**	**Cumulative percentage of passing (%)= M**	**Remarks**
4.75 mm	6	0.6	0.6	99.4%	**OK**
2.36 mm	10	**1**	**1.6**	**98.4%**	**OK**
1.18 mm	**107**	**10.7**	**12.3**	**87.7%**	**OK**
600 Micron	**280**	**28**	**40.3**	**59.0%**	**OK**
300 Micron	**507**	**50.7**	**91**	**9%**	**OK**
150 Micron	**67**	**6.7**	**97.7**	**2.3%**	**OK**
75 Micron	**21**	**2.1**	**99.8**	**0.2%**	**OK**
Pan	**2**	**0.2**	**100**	**0%**	**OK**

Table VI. Percentage passing by weight for Zone

I.S Sieve designation	**Percentage passing by weight for**				
	Grading Zone 1		**Grading Zone 2**	**Grading Zone 3**	**Grading Zone 4**
10 mm	100	100	100	100	
4.75 mm	90 – 100	90 – 100	90 – 100	95 – 100	
2.36 mm	60 – 95	75 – 100	85 – 100	95 – 100	
1.18 mm	30 – 70	55 – 90	75 – 100	90 – 100	
600 micron	15 – 34	35 – 59	60 – 79	80 – 100	
300 micron	5 – 20	8 – 30	12 – 40	15 – 50	
150 micron	0 - 10	0 -10	0 – 10	0 – 15	

Fig 6. Sieve Analysis of Aggregates

Bulking of Sand

Fitness, after wThe volume of a given quantity of sand increase with increase in moisture content in the initial stage. Certain stage has reached, when percentage increases in the volume is reached to maximum at a hich the increase in volume starts decreasing with further increase in moisture content and finally drops to zero. The bulking is due to the volume occupied by the absorbed films of water on fine particles; these films keep the fine particles apart. Bulking is drops to zero when moisture content is such that the mix represents a suspension of sand in water.

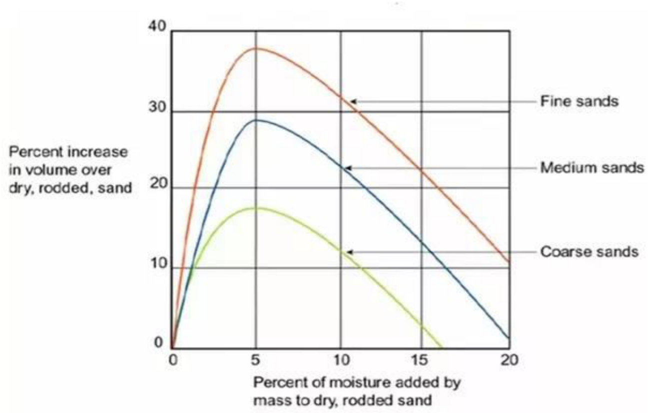

Fig 7. Bulking of sand

VI. Experiment of CTM

Concrete mix design:

Concrete mix design is often mistakenly referred to as “cement mix design.” However, cement is simply one of the ingredients of concrete. It is a binding substance that allows concrete to set, harden, and adhere to other materials. Therefore, it cannot and should not be used interchangeably with concrete mix design.

Slump Flow

The first step of the application requires you to define the maximum and minimum slump for the fresh mix properties.

- If the flow dimensions are unknown, you can use the Help icon to define the type of element that outputs the associated slump requirements.
- The concrete slump represents the flowability/workability of a concrete mix. For example, a higher slump allows for better placement in congested reinforced elements.

Aggregate Size

You will also need to define the aggregate size required for the mix design.

- In general, the maximal dimension of the coarse aggregate is governed by the limitations of the structure cross-section and reinforcement design.
- Increasing the aggregate size is usually more economical as it reduces the amount of cement per unit of volume; however, it may affect the workability of the mix. In contrast, reducing the maximal size of the coarse aggregate allows your concrete mix to reach higher strength at an equivalent water-cement ratio.

Mixing Water and Air Content

Now you get the first estimation of the amount of water required to obtain the appropriate workability for your mix, based on the slump flow and aggregate size.

- The Concrete Hub app also suggests the amount of entrapped air required for non-air-entrained or air-entrained concrete.
- The entrapped air is an important parameter when the concrete structure is exposed to freezing or de-icing salts. In such conditions, increased air content will increase concrete durability because it allows the water to expand in the entrapped air when it freezes. This reduces the internal pressure caused by the formation of ice.

Concrete Strength and Water/Cement Ratio

- The water/cement ratio is the most important parameter of the concrete mix design; it governs the strength, durability, and workability of the concrete mix. Here, you will need to enter the required compressive strength and associated water/cement ratio.
- For example, reducing the water/cement ratio will increase the strength of the concrete and provide better durability. However, decreasing the water/cement ratio can also significantly reduce the workability of the concrete. In these cases, one possible solution is adding water reducer to the mix.

- Using the Help option, you can select the desired compressive strength and receive the corresponding water/cement ratio. In addition, you will receive guidelines for the maximum permissible water/cement ratio based on the structure exposition.
- Using your input data, the app will calculate the amount of cement required. Note that the amount of cement can be reduced by introducing pozzolanic materials to the mix.

Procedure

The concrete mix was prepared based on the mix design in a mixer machine. Moulds of size 150x150x150mm for cubes were used to cast the samples. The concrete batch is mixed on a watertight, non-absorbent steel platform with a shovel, trowel and similar suitable equipment using the following procedure. The ingredients of concrete are mixed in the required proportion in a concrete mixer machine after adding the required quantity of water. The mixing is continued until concrete appears to be homogenous and has the desired consistency. After mixing the cube molds are filled in layers, compacted, and allowed to harden for a period of 24 hours. All the specimens are demolded and immersed in a curing tank to attain the required strength.

Fig 8. Curing Concrete Cubes

In the main study reclaimed rubber replaces coarse aggregates in increments of 3 percent from zero up to 24 percent in concrete along with optimum SF percent obtained. Cubes were cast and cured for 7,14 and 28 days and tested for compressive strength in Universal Testing Machine (UTM) which has a capacity of 50 tons.

Fig 9.CTM on Cube

VII. Results of CTM

Days	Conventional Concrete mix(M_{20})	Modified Concrete Mix(M_{20})
3	809	507
7	695	610
28	716	609

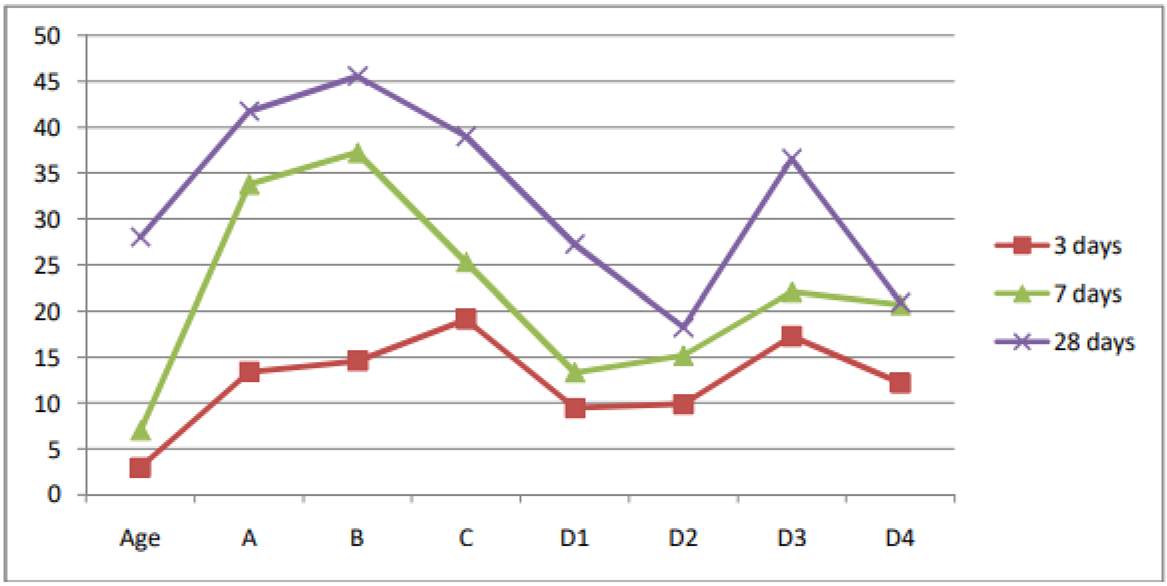

Fig 10. Graph showing compressive strength.

VIII. Conclusion

1) According to the test results of the compressive strength, Crushing Ice Concrete cube shows a not better result than the control concrete for M25 grade of concrete.

2) According to the results of the Compressive strength, Crushing Ice Concrete cube shows a not better result in compressive strength at 28 days of curing.
3) As the replacement of water by Ice in concrete decreases, the workability of concrete increases.
4) The optimum strength is obtained at the level of 5 % of OPC replaced by Ice for M25 grade concrete.
5) The replacement of water with ice results in reduction of density of concrete

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