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IMPACT OF COLD WEATHER ON WORKABILITY, COMPRESSIVE AND FLEXURAL STRENGTH OF CONCRETE

Junaid Bashir[1], Showkat Ahmad Rather[2], Fayaz Ahmad Laherwal[3], Vikas Garg[4]

[1]P.G Student of Structural Engineering,
[2]Contractual Lecturer Govt. Polytechnic College Ganderbal J&K,
[3]Lecturer G.P.C Ganderbal J&K
[4]Assistant Professor, Department of Civil Engineering, GRIMT Radaur, Haryana India.

Abstract - *There are several places around the world where the temperature remains below 0°C in few to several months in a calendar year. Kashmir is one of the places where the temperature in winter is extremely low and where I have done many practicals regarding my thesis as well as in this research. In these places the concrete processes like mixing, transportation and placement are hard to execute in a very efficient manner and resulting in the less strength structure and very less durability. The effects or damages caused by these extreme low weather conditions are hard to eliminate but by using several procedures of cold weather concreting these conditions can be minimized to a larger extent. So, in this paper main focus is developed on the properties of cold concrete and influence of temperature on strength of concrete. Various tests are done and analyzed at below 5°C and at 25°C to get the desired results so that a proper procedure of cold concreting is achieved with desired strengths. After analyzing various tests at comparative study of two different temperatures it has been seen that there are serious effects on the strength, workability and durability of the concrete. To avoid these ill effects an engineer should apply all the possibilities like to check the quality of material, quantity and admixtures and especially site of mixing without the damage of getting early freezing conditions.*

Key Words: Cold weather concreting, workability test, flexural strength test, compression strength test.

1. INTRODUCTION

The development of world is known by a single word that is Concrete which had made revolutionary changes in the construction industry in all the phases of development and infrastructure. Concrete is a material which can be molded in any desired shape, size, quality and many more and due this property of concrete it is accepted all over the world. Where concrete has such a big advantage and being accepted all over the world. As concrete is having many advantages and are economical still some concrete structures are submitted to various temperature changes during its life time in different locations where there is much temperature change in the respective seasons. Concrete develops its best strength when cured at 100% relative humidity and at temperatures between 10 and 21ºC but low-temperature conditions create a problem in winter in the temperate zones and are almost always a problem in the cold regions of the world. The process of pouring and curing concrete at these low temperatures is detrimental to the strength of the concrete and expensive when a great amount of protection is required. On the other hand, Construction process management is based on brief scheduling of the on-site performance of construction works. Therefore, it is frequently necessary to perform concrete works in wintertime when the air temperature is below 0°C. Thus, the necessity of the assessment of low temperature conditions on the properties of concrete should be assessed in order to plan proper procedures of curing of the concrete constructions. Also, new developments, mainly offshore, take place in very cold regions. Conventionally, researchers have used strength properties of concrete as criteria for evaluating its performance. A concrete having high strength does not necessarily imply that it will have long service-life. Now the concrete performance was determined in terms of both strength and durability under anticipated cold weather conditions.

2. OBJECTIVE

The objective of this study was to provide an overview of the effects of cold weather on the properties like strength and workability of concrete. In meeting this objective, the effects of low temperatures on the properties of ordinary Portland cement concrete were summarized. Then these results were compared with the properties of ordinary Portland cement concrete at standard temperatures. The defects produced in the concrete during both the states i.e. fresh as well the hardened state of concrete by the cold temperature like in Kashmir is really a big task to overcome the difficulties during the different processes of concrete placement. In cold places, the role of temperature is quite essential to understand in all the stages of concrete placement that may include water cement ratio, hydration and curing which are the key factors for the durability of concrete. The experiments were carried out to investigate the effect of cold weather on concrete by determining its

(1) Workability

(2) Compressive Strength

(3) Flexural Strength

3. METHODOLOGY

3.1 Ordinary Portland cement (OPC)

In this experimental work, the cement used is 43 grades Ordinary Portland Cement. All properties of cement are tested by referring IS 12269 - 1987 Specification for 43 Grade Ordinary Portland cement. The specific gravity of the cement is 3.13. Standard consistency of cement was 31%.

3.2 Aggregates

The aggregates are normally divided into two categories, namely fine and coarse. Fine aggregate consists of natural, crushed, or manufactured sand. Coarse aggregates can be made of natural gravel or crushed stone.

3.2.1 Fine aggregates

In this experimental program, fine aggregate was locally procured and conformed to Indian standard specifications IS: 383-1970. The sand was sieved through 4.75mm sieve to remove any particles greater than 4.75 mm and conforming to grading zone II. It was medium sand light brown in color. Sieve analysis and physical properties of fine aggregate are tested as per IS: 383-1970 and results are shown in Tables below.

Table -1: Properties of fine aggregates

S. No.	Characteristics	Value
1	Specific gravity	2.68
2	Fineness modulus	2.62
3	Bulking of sand, (%)	4
4	Water absorption, (%)	0.9
5	Moisture content, (%)	1.51

3.2.2 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 20mm was used in this work. The aggregates were tested as per IS: 383-1970. Specific gravity and other properties of coarse aggregate was done. Tables below shows the result of properties and sieve analysis of Coarse Aggregates. Proportioning of coarse aggregate was done and fineness modulus was obtained.

Table -2: Properties of Coarse Aggregates

S. No.	Characteristics	Value
1	Color	Grey
2	Shape	Angular
3	Maximum size	20mm
4	Specific gravity	2.79
5	Water Absorption in Percent	0.44%

4. RESULTS

4.1 Workability Test Results

The value for workability at 25°C temperature = 80mm

Effect of cold weather temperature on slump flow:

The cold weather conditions as the temperature below 5°C affected the workability of the concrete are shown in the table below:

Table -3: Effect on slump flow

S. No.	Sample No.	Slump Test Value (mm)
01	Sample 1	94
02	Sample 2	93

Average Slump (in mm) = (94+93)/2 =93.5mm

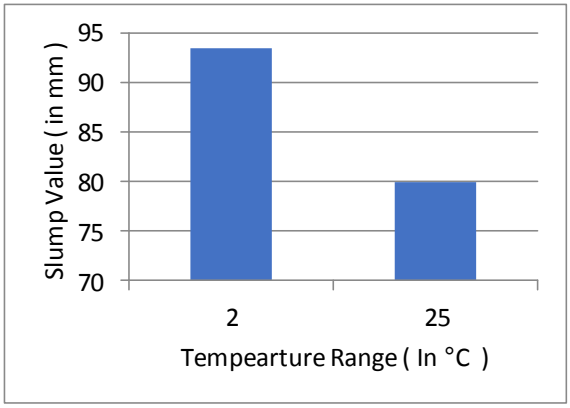

Chart -1: Graph Showing change in slump value due to low temperature

4.2 Compressive strength Test Results:

Table -4: Compressive strength of specimen

S. NO.	Age at test (in days)	Compressive strength in MPa (At Standard Temperature) 25°C	Compressive strength in MPa (Cold Weather Condition) Below 5°C
01	3days	12.35	9.82
02	7-days	20.28	16.21
03	14-days	28.64	22.43
04	28-days	31.40	26.06

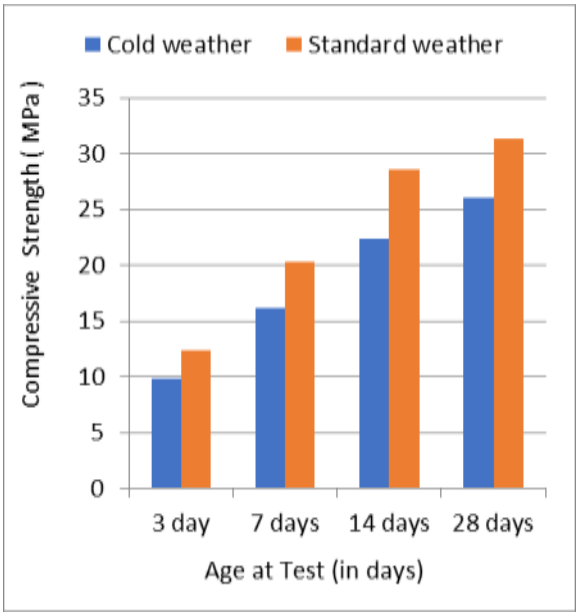

Chart -2: Comparison of compressive strength between cold weather & standard weather

4.3 Flexural strength Test Results:

Table -5: Flexural strength of specimen

S. NO.	Age at test (in days)	Flexural strength in MPa (At Standard Temperature) 25°C	Flexural strength in MPa (Cold Weather Condition) Below 5°C
02	7-days	3.20	2.12
03	14-days	3.71	2.85
04	28-days	3.92	3.22

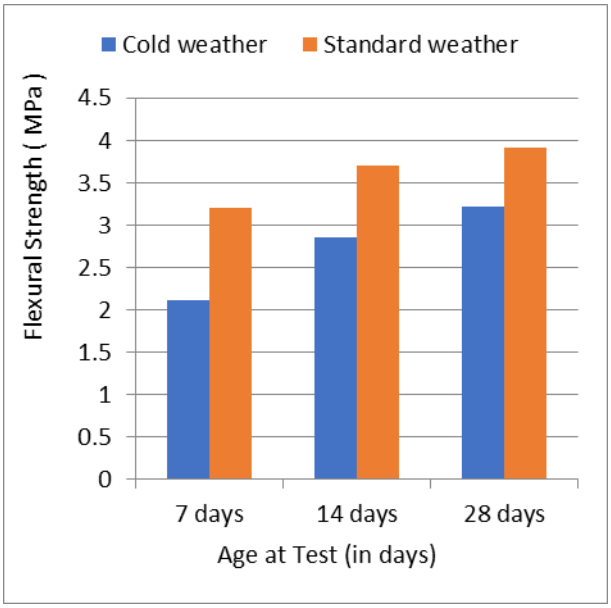

Chart -3: comparison of flexural strength between cold weather and standard weather

5. CONCLUSIONS

When we think of curing concrete, the first thing that usually comes to mind is that we need to prevent excessive moisture loss. The results obtained from various samples of the mix design were analyzed and obtain some useful conclusions regarding with the strength characteristics of Cold Weather Concrete (CWC) for M25 grade concrete mix. There were many results and conclusions that can be described in the following lines:

- The Workability gets affected in cold weather concrete when compared to Workability in standard Temperature property. The Workability at lower temperature has shown 17% increase when compared to same mix at standard temperature.
- The compressive strength gets mostly affected in cold weather concrete as it is the only property which is very important regarding with the structures constructed in colder regions. The lower temperature has shown decline in the compressive strength to a greater extent as compared to the same mix in the normal temperature. After 3 days the compressive strength in cold weather shows 20% decrease when compared to compressive strength in standard temperature. After 7 days the compressive strength in cold weather shows same percentage of decrease as in 3 days when compared to compressive strength in standard temperature. After 14 days the compressive strength in cold weather shows 21% decrease when compared to compressive strength in standard temperature. After 28 days the compressive strength in cold weather shows 17% decrease when compared to compressive strength at standard temperature.
- The flexural strength in the lower temperature has also been reduced as compared to the normal temperature flexural strength in the same mix design. The flexural Tests were done after 7, 14 and 28 days respectively. After 7 days the flexural strength in cold weather shows 25% decrease when compared to flexural strength in standard temperature. After 14 days the flexural strength in cold weather shows 19% decrease when compared to flexural strength in standard temperature. After 28 days the flexural strength in cold weather shows 14% decrease when compared to flexural strength at standard temperature.
- All the tests done at site were being executed according to the guidelines set by IS 7861 part-II 1981 (Indian standard code of practice for Extreme Weather conditions).

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