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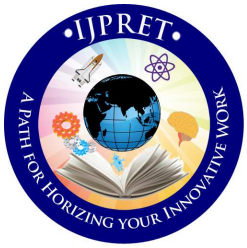

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PREDICTION OF COMPRESSIVE STRENGTH OF CONCRETE USING ACCELERATED CURING

N.L.SHELKE[1], SANGEETA GADVE[2]

1. Research Scholar, Structural Engineering, Sardar Patel College of Engineering, Andheri (W), Mumbai-400 058
2. Faculty in Applied Mechanics, Visvesvaraya National Institute of Technology, Nagpur-440 010

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Abstract

The increase in strength with increased curing temperature is due to the speeding up of the chemical reactions of hydration. This increase affects only the early strengths without affecting ultimate strengths. Hence, curing of concrete and its gain of strength can be expedited by raising the temperature of curing, thereby reducing the curing period. This type of curing called accelerated curing. The proposed work is aimed at studying the short term performance of concrete by using accelerated curing. The outcome of this project will set a guideline for effective concrete making so as to estimate the strength with reasonable accuracy.

Corresponding Author
Mr. N. L. Shelke

1. Introduction

The increase in strength with increased curing temperature is due to the speeding up of the chemical reactions of hydration. This increase affects only the early strengths without affecting ultimate strengths. Hence, curing of concrete and its gain of strength can be expedited by raising the temperature of curing, thereby reducing the curing period. This type of curing called accelerated curing has many applications in the manufacturing of precast concrete products. The method is typically used for pre-cast concrete products called accelerated curing. The various methods of accelerated curing are Warm-water method, Boiling-water method, Autoclave curing, Steam curing, Electrical curing, Microwave heating etc. [25].

As per normal curing procedures one has to wait for 28 days to obtain the strength of concrete. However under certain conditions such as shortage of time, weather conditions, on the spot changes in project and expedition of construction it becomes necessary to obtain early strength rather than waiting for entire period of curing which proves to be uneconomical. The answer to this problem is to obtain the actual strength of the concrete at earlier by employing accelerated curing methods. The proposed research focuses on effective approach by using elevated temperature of water for curing of concrete to obtain the expected grade of concrete at earlier stages.

2. Literature Review

The methods for earlier determination of concrete strength with satisfactory reliability had been researched for over 30 years [17]. After a dormant period of about 30 years, systematic efforts on the subject were made in many research centers [35, 36].

M.V. Krishna Rao *et al.* (2010) has proved the parameters of the study include the curing period [1, 3, 7, 14 and 28 day], curing method [conventional wet curing, membrane forming compound curing and accelerated curing] and the type of cement [(OPC) 43 grade, (PPC) 43 grade and (OPC) 43 grade +10% Silica Fume(SF) replacement for cement[24]. I˙lker Bekir Topcu *et al.* (2004) summarized the effects of

accelerated curing temperature and fine aggregate on early strength as well as the relationships between early strength-28days strength and strength maturity [12]. D.W.S. Ho *et al*. (2002) this paper explores the potential benefits of steam-cured concrete, particularly on mix incorporating mineral admixtures [4].

M. Hulusi Ozkul (2001) Presented the relation between 28-day strength of normal cured concrete and accelerated strength is investigated by using an ordinary Portland cement and tars cement under two different accelerated curing conditions, warm water and boiling water [20]. Majid Izzeddin Abdullah Almukhtar (2001) investigated the development of the compressive strength for concrete by using different curing regimes. Accelerated curing system within 28 hours can be estimate 28 day strength [19]. Thanakorn Pheeraphan *et al*. (2001) investigated microwave energy can accelerate the hydration of cement, resulting in rapid strength development of concrete in an early period [34]. M. Tokyay (1999) investigated relationships between standard compressive strength at 7, 28, and 90 days and early strength attained by (1) autogenously curing, (2) warm water curing, and (3) boiling water curing were obtained and a regression expression to predict the strength of concretes containing high-lime and low-lime fly ashes as partial cement replacement are proposed [22]. R. Musa Resheidat *et al.* (1996) investigated accelerated strength testing using the boiling water method. Correlation between the28-day compressive strength and the corresponding accelerated strength was established for prediction of concrete strength at 28 days [23].

3. Materials and Methods

3.1 Materials used for Experimental Study

a) Cement

b) Aggregates

c) Water

3.2 Experimental Procedure

As per the IS10262:2009, mix designs were prepared of M40 by using 53 Grade OPC.

Various physical tests of cement and properties of aggregates are given in Table1 and Table2.

Table 1 Physical properties of cement

Sr.No.	Properties	Result
1	Fineness(specific surface m^2/kg)	340
2	Compressive strength(mpa)	
	3 days	41.00
	7 days	52.00
	28days	67.00
3	Setting time(minutes)	
	Initial	130
	Final	215
4	Soundness	
	Le-chatelier(mm)	1.5
5	Normal consistency %	29

Table 2 Properties of aggregates

Property	Fine aggregate	Coarse aggregate	
		M1	M2
Specific gravity	2.79	2.81	2.82
Fineness modulus	4.38	6.10	7.01

The experimental program includes testing of a total 10 trials in which each trial 9 test specimens were carried out i.e. 90 test specimens of standard cubes of size 150×150×150mm cast and tested the three parameters viz., age of curing (7,28 days compressive strength and accelerated compressive strength by boiling water method as per IS 9013-2004). The procedures of boiling water curing and Normal water curing methods were followed.

A) Boiling water curing: After the cube specimens is prepared, they were left to stand undisturbed in their moulds in place free from vibration at a temperature of 27±2^{0}C for 23 hrs ±15 minutes from the time addition of water to the ingredients. The specimens shall then be gently lowered into the curing tank and shall remain totally immersed for a period of 3½ hrs ±5 minutes. The temperature of water in the curing tank shall be at boiling (100^{0}C) at sea level. The temperature of water shall not drop more than 3^{0}C after the specimens were placed and shall return to boiling within 15 minutes. After curing for 3½hrs ±5 minutes in the curing tank the specimen shall be removed from the boiling water,

the moulds were cooled by immersing in cooling tank at 27±2^{0}C for 2hr.

Then results were observed.

B) Normal (cooling) water curing: After the cube specimens were prepared, they left to stand undisturbed in their moulds in place free from vibration at a temperature of 27±2^{0}C for 1 day from the time of addition of water to the ingredients. Then remove from the mould and specimens are lowered into the curing tank and it is remain totally immersed for a period of 7 & 28 days. Then results were observed.

4. Result and Discussion

The results obtained from the experimental investigations includes various parameters were carefully analyzed. Table 3 shows the details of compressive strength for 7 &28 days compressive strength and Accelerated Strength as per IS9013-2004. In case of accelerated curing, the 28 days strength is predicted based on equation: 28-days compressive strength=1.64×(accelerated concrete strength) + 8.09 Mpa.

Table 3 Trial Results for M40

Proportion	**ACC-OPC 53 Grade**			
	Normal compressive Strength for 7 days in N/mm^2	Normal compressive Strength for 28 days in N/mm^2	Accelerated Compressive Strength in N/mm^2	% Difference
(Cement400kg+160kgwater) 1 : 1.60 : 1.08 : 2.19 (W/C=0.4)	43.34	52.94	62.82	15.72
(Cement430kg+159kgwater) 1 : 1.52 : 1.06 : 2.14 (W/C=0.37)	46.50	52.81	62.07	14.91
(Cement408kg+159kgwater) 1 : 1.56 : 1.06 : 2.14 (W/C=0.39)	43.37	56.07	61.51	8.85
	49.25	52.34	63.23	17.22

(Cement450kg+162kgwater) 1 : 1.39 : 0.94: 1.89 (W/C=0.36)				
(Cement402kg+157kgwater) 1 : 1.59 : 1.07 : 2.18 (W/C=0.39)	39.65	48.27	46.35	-4.14
(Cement421kg+160kgwater) 1 : 1.50 : 1.01 : 2.06 (W/C=0.38)	42.88	52.72	54.19	2.71
(Cement410kg+160kgwater) 1 : 1.55 : 1.05 : 2.12 (W/C=0.39)	40.47	54.44	46.93	-16.00
(Cement510kg+173.4kgwater) 1 : 1.77 : 0.71 : 1.066 (W/C=0.34)	43.51	50.85	58.16	12.56
(Cement 471kg+160kgwater) 1 : 1.32 : 1.07 : 1.59 (W/C=0.34)	44.31	50.56	66.13	23.54
(Cement 385kg+155kgwater) 1 : 1.68 : 115 : 2.3 (W/C=0.4)	39.00	48.54	54.18	10.40
				Av:+13.23%(8) Av:-10.07%(2)

* Target strength for M40 =48.25 N/mm^2

The percentage variation between the normal compressive strength and the accelerated strength one is found to be in the range of -10.07% & +13.23% which indicates the satisfactory agreement in the results. In case of 02 trials, the accelerated strength is found to underestimate the actual strength by an average 10.07% and for the remaining 08 trials overestimate by13.23% on an average.

4 Conclusions

The results state that both strength i.e. the normal compressive strength and accelerated strength achieved the target strength of M40.The compressive strength obtained by using accelerated curing method is higher than normal compressive strength obtained by using accelerated curing method is higher than normal compressive strength.

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