Residual Compressive Strength of Ternary Blended Concrete at Elevated Temperatures

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Abstract— The wide utilization of concrete as an auxiliary material for the elevated structures, stockpiling tanks, atomic reactors and weight vessels increment the danger of cement being presented to high temperatures. This has prompted a request to enhance the comprehension of the impact of temperature on concrete. The conduct of cement presented to high temperature is an aftereffect of many components including the uncovered condition and constituent materials. The objective with the study was to examine the Residual Compressive Strength of Ternary Blended Concrete once subjected to high temperatures. To explore the impact of temperature and to assess auxiliary security an endeavor has been made to ponder the Compressive Strength of Ternary Blended Concrete when subjected toward elevated high temperature. The study focuses fundamentally on concentrate the properties of Residual Compressive Strength of Ternary Blended Concrete for various w/b ratios at 2000C, 4000C and 6000C. In the present investigations, the effect of high temperatures of Residual Compressive Strength of Ternary Blended Concrete when subjected to elevated temperatures are studied. The main test parameters involved in this study are Temperature ranges, the time of exposure.The tests were conducted for a total of 180 cubes on various w/b ratios ternary blended concrete by exposing them at different temperatures like Room Temperature, 2000C, 4000C and 6000C and 4 Hrs, 8 Hrs and 12 Hrs duration. The results indicate that the ternary blended concrete is effective in resisting the impact of temperature on the compressive quality.

Key words: Concrete, Temperature, Compressive Strength, Splitting, Spalling

I. INTRODUCTION

A. Fly Ash

Fly cinder is separated into three classes depending upon its calcium content, in affirmation of the qualification in direct among low and high lime fly powder. These classes are according to the accompanying : Sort F, low calcium, 8% CaO Sort CI, center of the calcium, 8– 20% CaO Sort CH, high calcium, .20% CaOLow CaO fly ashes for the most part give great protection from salt silica response (ASR) and sulfate assault. In any case, quality improvement at initial ages is regularly gentler than that in customary Portland concrete substance, particularly at more elevated amounts of substitution. Great CaO fly ashes, then again, are less productive in smothering extension because of ASR or sulfate activity, however for the most part respond speedier than low CaO fly ashes and have more positive effect on the first quality of cement and are less touchy to lacking curing.

B. Micro Silica

Micro silica (also known as silica flour or, depending on how it is source, silica flume) is very fine grains of silica (i.e. the mineral of which sands are usually composed) - typical particle sizes less about a micron or less.

Amid the most recent three decades, some new Pozzolan materials have risen in the building business as an off shoot of research went for vitality protection and strict requirement of contamination control measures to quit scattering the materials into the environment. Small scale Silica (different names have been utilized are silica tidy, dense silica smolder) is one such Pozzolan, which has been utilized as a fractional substitution of Portland bond because of its adaptable properties. The accessibility of high range water-decreasing admixtures (superplasticizers) has opened up new thoughts for the utilization of Micro Silica as a major aspect of the establishing material in cement to create high quality bond (> 100 MPa/15,000 psi).

C. Triple-Blends (Ternary cement system)

It means Micro Silica or other bond substitution added substances are to be utilized with OPC as it were. That isn't entirely valid and ternary blends include proficient - frameworks. The essential motivating force of including restricted sum Micro Silica – for instance 5 percent with Fly-slag bond blends was to guarantee high early quality research has be that as it may, demonstrated that Ternary blends of OPC, Micro Silica and Fly-fiery debris result in synergic activity to enhance the smaller scale structure and execution of cement. At the point when both silica smoke and fly-slag are utilized, the resultant upgrade of quality or pozzolanic movement was more noteworthy than super position of commitments of each, for the individual extents. Such synergic impact comes about because of fortifying the powerless change zone in total bond interface, and additionally division and obstructing of pores.

II. MATERIALS

A. Cement

Nearby accessible 53 review of Conventional Portland Concrete (Ultra Tech Brand.) affirming to IS: 12269 was utilized as a part of the examinations. Table 4.1 gives the physical properties of OPC utilized as a part of the present investigation and they conform to IS specifications.

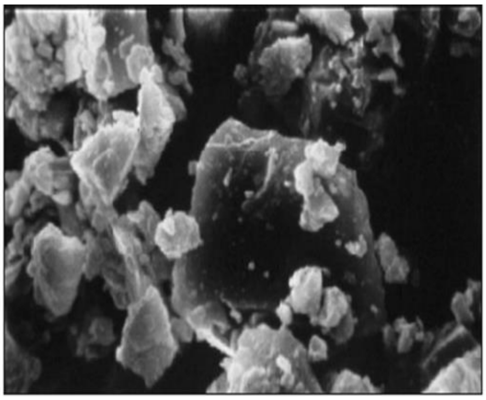


Fig. 1: Photomicrograph of Portland cement (Curtsy Micro Silica Manual)

B. Fly Ash

The fly ash obtained from Hyderabad Industries, Andhra Pradesh is used in the present experimental work.

Table 4.4.1 gives properties of fly ash.

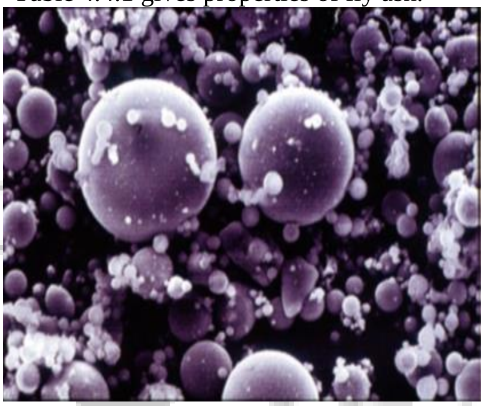


Fig. 2: SEM micrograph showing: Fly Ash (Courtesy ACI Journal)

C. Micro Silica

Micro silica (also known as silica flour or, depending on how it is source, silica flume) is very fine grains of silica (i.e. the mineral of which sands are usually composed) - typical particle sizes less about a micron or less.

Table 4.5.1 gives properties of Micro Silica. The chemical composition of Micro Silica is rich in silica.

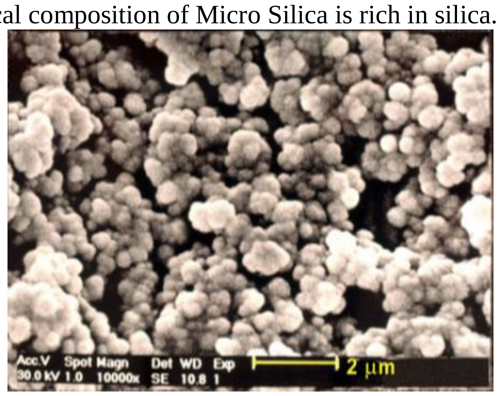


Fig. 3: Micrograph showing: Micro Silica (Courtesy by Micro Silica Manual)

III. AGGREGATE

The size, shape and degree of the total assume an essential part in accomplishing an appropriate cement. The flaky and stretched particles will prompt blocking issues in limited zones. The sizes of totals will rely on the extent of rebar dividing.

The coarse total decided for Ternary Mixed Cement is regularly precise fit as a fiddle, is all around reviewed, and littler in most extreme size that suited for customary cement; normal traditional cement ought to have a greatest total size of 20mm. Degree is a critical factor in picking a coarse total, particularly in average employments of Ternary Mixed. Hole evaluated coarse total elevates isolation to a more noteworthy degree than the all-around reviewed coarse total.

Tables 4.2.1, 4.2.2, 4.3.1, 4.3.2 give the properties of total utilized as a part of present examination. The fineness modulus of fine total is discovered 2.48.

A. Fine Aggregates

The locally accessible sand is utilized as fine total in the present examination. The sand is free from clayey issue, salt and natural contaminations. The sand is tried for different properties like particular gravity, mass thickness and so on. And as per IS 2386-1963. The fine total is adjusting to standard details.

B. Coarse Aggregates

Mechanism pounded precise stone metal of 20mm ostensible size from the neighborhood source is utilized as coarse total. It is free from contaminations, for example, clean, earth particles and natural issue and so forth. The course total is additionally tried for its different properties. The particular gravity, mass thickness and fineness modules of coarse total are observed to be 2.70, 1560 kg/cum and 7.1 individually.

C. Water

Locally accessible water utilized for blending and curing which is consumable, should be perfect and free from damaging measures of oils, acids, antacids, salts, sugar, natural materials or different substances that might be harmful to cement or steel.

D. Super Plasticizer

Great plasticizer CONPLAST 430 of Fosroc Chemical India Ltd was used as water reducing admixture. It increases workability.

IV. MIX PROPORTION IN THE LABORATORY

The proportion used in preparation of mix is calculated as per BIS Method.

$$V = \left[\{\mathrm{Wt.\,of\,water} + \left\{\frac{\mathrm{Wt.\,of\,cement}}{\mathrm{sp.\,gr.\,of\,cement}}\right\} + \frac{1}{\mathrm{p}}\left\{\frac{\mathrm{Wt.\,of\,F.A}}{\mathrm{sp.\,gr.\,of\,F.A}}\right\}\right] * \frac{1}{1000}$$

$$V = \left[\{Wt.of\ water + \left\{\frac{Wt.of\ cement}{sp.gr.of\ cement}\right\} + \frac{1}{(1-p)}\left\{\frac{Wt.of\ C.A}{sp.gr.of\ C.A}\right\}\right] * \frac{1}{1000}$$

The ratio between F.A and C.A is p: (1-p).

V. ILLUSTRATIVE EXAMPLE FOR MIX DESIGN

A. Mix Design for W/C ratio = 0.55

- Text data for materials
  Specific gravity of cement =2.95
  Specific gravity of Coarse Aggregate=2.70
  Specific gravity of Fine Aggregate=2.53

- Selecting W/B ratio =0.55
- Determination of cement content
  Water=178 Ltr.
  Cement=323.6 Kg.
- Determination of F.A and C.A
  Fine Aggregate0.98= [178+ (323.6/2.95) + (1/0.42)*(F.A/2.53)]*1/100=736 Kg.
  Coarse Aggregate0.98= [178+ (323.6/2.95)+ (1/1-0.42)*(C.A/1-2.2.7)]*1/100= 1084 Kg.
- Mix Proportion = 1.00:2.27:3.34:0.55

S.No	W/C Ratio	Cement	F.A.	C.A
1	0.55	1.00	2.27	3.34
2	0.45	1.00	1.78	2.73
3	0.35	1.00	1.26	2.11

Table 1: Mix proportions for Ordinary concrete

S. No	W/B Ratio	Cement	Micro Silica	Fly ash	F.A.	C.A
1	0.55	0.8	0.05	0.15	2.27	3.34
2	0.45	0.8	0.05	0.15	1.78	2.73
3	0.35	0.8	0.05	0.15	1.26	2.11

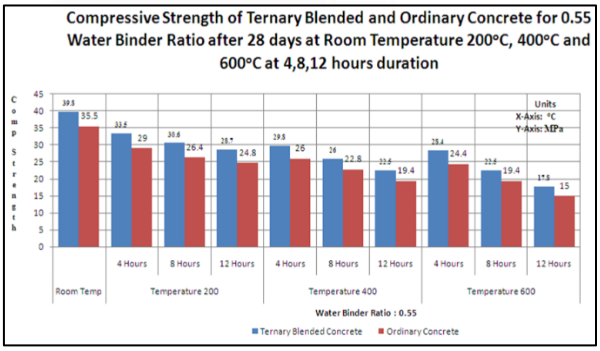
Table 2: Mix proportions for Ternary Concrete

VI. PREPARATION OF TEST SPECIMENS

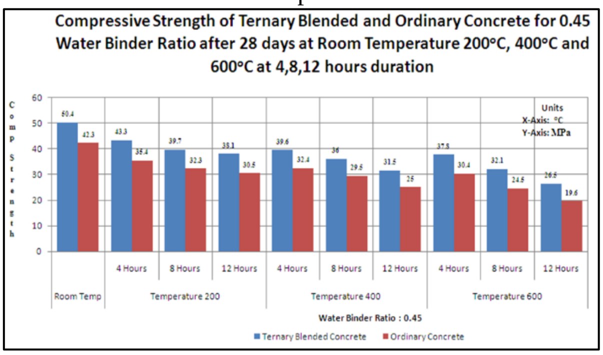
- Mixing
- Workability Test
- Compaction
- Casting of Specimens
- Curative of the Specimen
- Testing of Specimen

VII. EXPERIMENTAL RESULTS

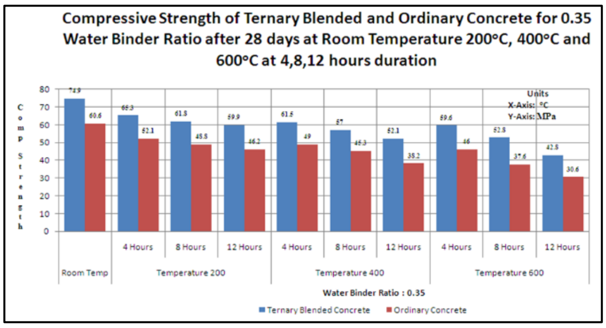
A. *List of Graphs*



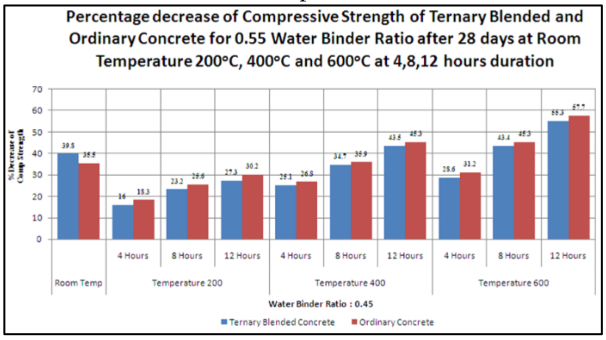
Graph 1



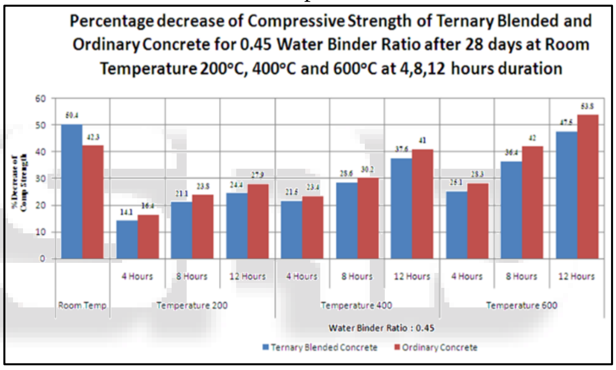
Graph 2



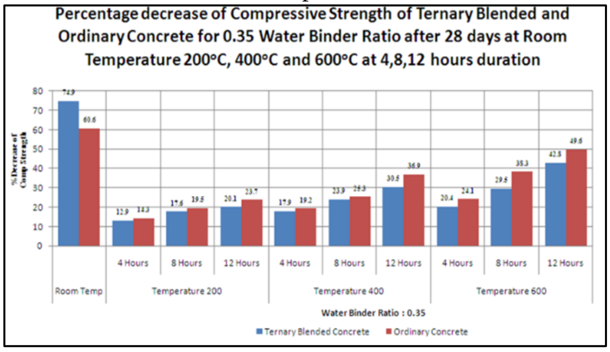
Graph 3



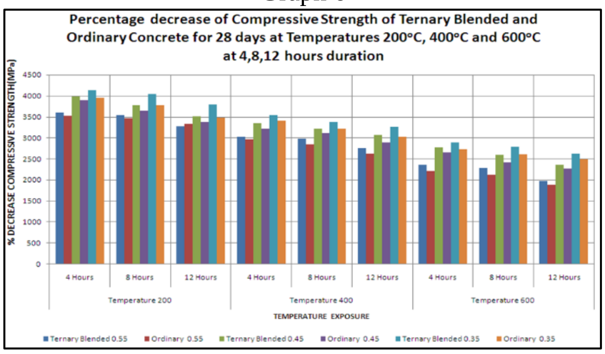
Graph 4



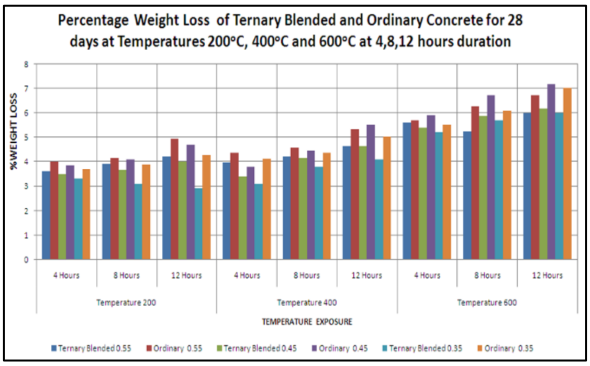
Graph 5



Graph 6



Graph 7



Graph 8

VIII. DISCUSSION OF TEST RESULTS

A. Properties of cement

Table 4.1 gives the physical properties of ordinary Portland cement used in the present investigation and they confirm to IS specifications.

B. Properties of Aggregates

Table 4.2 and 4.3 gives the properties of aggregates used in the presentation investigation. The finesses module of coarse aggregate is found to be 7.17. The fineness modules of fine aggregate is found to be 2.48, which indicates it is medium sand.

C. Properties of fly ash

The properties of fly ash obtained from Hyderabad Industries Ltd, Andhra Pradesh are shown in table 4.4. The principle product of the reaction of fly ash with alkali and calcium hydroxide in concrete is essentially the same as that of the hydration of Portland cement calcium-silicate-hydrate(C-S-H) gel. Fly ash which is rich in silica content reacts with calcium hydroxide to form C-S-H gel. This C-S-H is responsible for the strength of mortar or concrete.
The reaction of fly ash continues to consume calcium hydroxide to form C-S-H as long as calcium hydroxide is present in the cement paste.

D. Properties of Silica Fume

The Micro Silica obtained from ‘Oriental Trexim Pvt. Ltd. Table 4.5.1 gives properties of Micro Silica. The chemical composition of Micro Silica is rich in silica.

E. Mix Designing

Fly ash and Silica fume are used as additional ingredient by weight 15% and 5% of the weight of cement respectively.
Table 4.6 gives the design mix proportion and material required for the various w/b ratios with fly ash as an additional ingredient.
Compressive Strength of Ternary Blended and Ordinary Concrete exposure at 200°C
Table 4.7 and graphs 1-3 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 200^0C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 28.7, 38.1 and 59.9 MPa and 2 4.8, 30.5 and 46.2 MPa respectively.

F. Compressive Strength of Ternary Blended and Ordinary Concrete exposure at 400°C

Table 4.8 and graphs 1-3 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 4000C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 22.5, 31.5 and 52.1 MPa and 19.4, 25.0 and 38.2MPa respectively.

G. Compressive Strength of Ternary Blended and Ordinary Concrete exposure at 600°C

Table 4.9 and graphs 1-3 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 6000C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 17.8, 26.5 and 42.8 MPa and 15.0, 19.6and 30.6 MPa respectively.

H. Percentage decrease of Compressive Strength of Ternary Blended and Ordinary Concrete exposure at 200°C

Table 4.10 and graphs 4-6 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 2000C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 27.3, 24.4 and 20.1 MPa and 30.2, 27.9and 23.7 MPa respectively.

I. Percentage decrease of Compressive Strength of Ternary Blended and Ordinary Concrete exposure at 400°C

Table 4.11 and graphs 4-6 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 400^0C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 43.5, 37.6and 30.5 MPa and 45.3, 41.0 and 36.9MPa respectively.

J. Percentage decrease of Compressive Strength of Ternary Blended and Ordinary Concrete exposure at 600°C

Table 4.12 and graphs 4-6 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 600^0C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 55.3, 47.5 and 42.8 MPa and 57.7, 53.8 and 49.6 MPa respectively.

K. Percentage weight loss of Ternary Blended and Ordinary Concrete exposure at 200°C

Table 4.13 and graphs 6-9 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 2000C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 4.23, 4.02 and 2.92 and 4.96, 4.72 and 4.30 respectively.

L. Percentage weight loss of Ternary Blended and Ordinary Concrete exposure at 400°C

Table 4.14 and graphs 6-9 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 4000C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 4.65, 4.64 and 4.12 and 5.33, 5.51and 5.03 respectively.

M. Percentage weight loss of Ternary Blended and Ordinary Concrete exposure at 600^oC

Table 4.15 and graphs 6-9 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 600^0C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 5.02, 5.10 and 5.03 and 6.73, 7.18 and 7.03 respectively.

N. Pulse velocity (m/sec) of Ternary Blended and Ordinary Concrete exposure at 200^oC

Table 4.16 and graphs 10 -12 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 200^0C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 3280, 3510 and 3790 (m/sec) and 3340, 3380 and 3485 (m/sec) respectively.

O. Pulse velocity (m/sec) of Ternary Blended and Ordinary Concrete exposure at 400^oC

Table 4.17 and graphs 10 -12 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 4000C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 2760, 3065 and 3260(m/sec) and 2625, 2890 and 3030 (m/sec) respectively.

P. Pulse velocity (m/sec) of Ternary Blended and Ordinary Concrete exposure at 600^oC

Table 4.18 and graphs 10 -12 shows the compressive strength of Ternary Blended and Ordinary Concrete for 0.55, 0.45, 0.35 w/b ratios after exposure to 4,8 and 12 hours duration for 6000C. The compressive strength of Ternary Blended and Ordinary Concrete for 12 hours exposure are 1970, 2360 and 2620 (m/sec) and 1890, 2265 and 2490 (m/sec) respectively.

IX. SCOPE OF FURTHER STUDIES

The present investigation can be carried out to study the flexural strength, split tensile strength of Ternary Blended Concrete at elevated temperatures.

X. CONCLUSION

1) The percentage decrease of compressive strength is higher for higher exposure time for ordinary concrete at all temperature.
2) The rate of percentage decrease of compressive strength is less for ternary blended concrete at all temperature for all exposure of time.
3) A gradual reduction in strength was found in ternary blended concrete and ordinary concrete with increase in temperature and increase in exposure time.
4) The ternary blended concrete has shown improved resistance for higher temperatures for all w/b ratios compared to ordinary concrete.
5) The percentage decrease of weight loss is higher for higher time for ternary blended concrete compared to ordinary concrete.
6) The percentage decrease of weight loss is lower for ternary blended concrete for lower w/b ratio compared to ordinary concrete.
7) The pulse velocity of ternary blended concrete is lower for higher exposure time compared to ordinary concrete.

ACKNOWLEDGMENT

At this moment of accomplishment, first of all I pay homage to my guide, Miss. Shivangi Bharadwaj. This work would not have been possible without his guidance, support and encouragement. Under his guidance I successfully overcame many difficulties and learned a lot.

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XI. PHOTOGRAPH

Fig. 4: Cured and Numbered Specimen

Fig. 5: Weighing of Specimen

Fig. 6: Oven

Fig. 7: Heated and Cooled Specimen

Fig. 8: Testing Of Specimen in CTM