JOURNAL OF INFORMATION, KNOWLEDGE AND RESEARCH IN CIVIL ENGINEERING
ISSN: 0975 – 6744| NOV 16 TO OCT 17 | Volume 4, Issue 2

"COMPARATIVE EXPERIMENTAL STUDY ON CYLINDRICAL COMPRESSIVE STRENGTH OF CASTED & CORED CYLINDERS OF FLY ASH CONCRETE BY USING NDT"

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ABSTRACT:─
Nondestructive testing (NDT) has the potential to be a powerful investigative tool due in part to its ability to detect problems without inducing further damage or through those where the concrete surface is slightlydamaged topartially destructive tests, such as core tests and pullout and pull off tests, where the surface has to be repaired after the test, but also because it does so with minimal expenditures of time and manpower The range of properties that can be assessed using nondestructive tests and partially destructive tests is quite large and includes such fundamental parameters as density, elastic modulus and strength as well as surface hardness and surface absorption, reinforcement location, size and distance from the surface. In some cases it is also possible to check the quality of workmanship and structural integrity. In this project work, three grades of fly ash concretes M20, M25 &M30 are used for the testing purpose with thereplacement of cement by 10% of fly ash. The tests for compressive strengths of two types of sizes 100 x 200 mm for cored & 150 x 300mm for casted cylinders carried out. Thetests results are recorded for the 7, 14, 21, & 28 days. The compressive strength & quality of concrete is found by variousNDT tests available. Both the results for casted cylinders and cored cylinders are compared and validated with modeling fromsoftware ABACUS.

KEYWORDS─*Fly ash Concrete, Compressive strength, Cylinders, Abaqus analysis.*

I. INTRODUCTION

It is a great deal of the quality assurance and forensic work performed on civil engineering structures revolves around the use of destructive testing techniques.
In the past, NDT has usually been approached in an entirely empirical manner. Typically, this was done by performing large numbers of tests with a particular piece of equipment and then analyzing the results in an attempt to find some pattern that represents the expected damage. There are a number of advantages associated with this approach. It will allow proper correlation of NDT Such information is essential in establishing acceptable performance of new structures and also gives the rough idea about the concreting..
By combining a laboratory testing program that simulates the strength mechanisms in concrete with nondestructive testing technologies this research will identify the parameters related with compressive strengths. Knowledge of these key will allow for the selection of appropriate NDT technologies for monitoring changes. This effort will thus provide the groundwork for future research aimed at using nondestructive testing.
Knowledge of the condition of newly constructed structures will provide the quality assurance data necessary to ensure compliance with the performance-based specifications approach currently being adopted. Similarly, the ability to detect, identify and quantify existing damage at an earlier age than conventional techniques will minimize the costs associated with rehabilitation. Finally, a comprehensive NDT based evaluation program will set the stage for a rational framework for actual service life modeling of structures, with an emphasis on providing information for the development of optimum maintenance regimes and rehabilitation techniques.

The tests available for testing concrete range from the completely non-destructive, where there is no damage to the concrete, through those where the concrete surface is slightly damaged, to partially destructive tests, such as core tests and pullout and pull off tests, where the surface has to be repaired after the test. The range of properties that can be assessed using non-destructive tests and partially destructive tests is quite large and includes such fundamental parameters as density, elastic modulus and strength as well as surface hardness and surface absorption, and reinforcement location, size and distance from the surface. In some cases it is also possible to check the quality of workmanship and structural integrity.
The application of NDT techniques to the solution of civil engineering problems has sometimes been disappointing. This has arisen from either using a method which lacked the precision required in a particular structural investigation or by specifying a method that is inappropriate to the problem under consideration. In some cases, these problems could have been avoided by taking expert advice before initiating the survey.

II. MATERIALS

A. Cement:
The cement used in all mixtures was commercially available"Ultra-tech 53 grade Ordinary Portland Cement conforming to IS 12269-1987 was used in this study.
B. Fine aggregate:
Locally available river sand passed through 4.75mm IS sieve as per the IS 383 is used as fine aggregate. The river sand is washed & screened to eliminate deleterious materials.
C. Coarse aggregate:
The both 20mm and 10 mm Coarse aggregate are obtained from a local basalt rock quarry as per the IS 383 is used.
D. Fly ash:
Fly ash is very much similar to volcanic ashes used in production of the earliest known hydraulic cements about 2,300 years ago. Those cements were made near the small Italian town of Pozzuoli - which later gave its name to the term "pozzolan". A pozzolan is a siliceous or siliceous material which when mixed with lime and water forms a cementitious compound..In this project we used the Class F fly ash generated by the built company Bhigwan.
E. Water:
Water is important ingredient which helps to form the strength giving cement gel & it is looked into very carefully W/c ratio are mentioned in table no

		Material Results (As per required IS specifications)				
Sr no	Physical properties	Cement	F.A.	C.A.	FLY	Water
1	Specific Gravity	3.15	2.63	2.91	2.23	…..
2	Fineness modulus	……	2.50	3.06	…...	…..
3	Initial setting time	32 min	…..	……	143 min	…..
4	Final setting time	395 min	……	……	302 min	…..
5	Standard consistency	26%	....	……	…….	….

The all material properties are summarized in table below:-

TABLE 1:Physical properties of Material

III. METHODOLOGY

The mix design is produced for maximum size of aggregate is 20mm conventional aggregate. The variation of strength of hardened concrete using solid wastes as partial replacement of cement by fly ash is studied by casting & cored cylinders. The concrete was prepared in the laboratory using mixer. The cement, fine aggregate and coarse aggregate in dry state and then the desired water quantity is added and the whole concrete is mixed for 5 minutes, the concrete is poured in the required moulds which are closed tightly. The concrete is poured into the moulds in 3 layers by poking with tamping rod for cylinders of 150×300 mm size& also for slabs sizes 500 x 500 x 300 mm is casted for cored cylinders sizes 100 x 200 mm and both Sizes was tested for compression strengths. The cast specimens are removed after 24 hours and cores from slabs are taken after 6 days with the help of coring machine by proper curing of slabs these are immersed in a water tank for curing and testing purpose. After a curing period of 7, 14, 21 and 28 days the specimens are tested for compression

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strengths and the results are compared with abacus mathematical modeling results. These results are corrected by correction factor 1.25. [IS: 516 – 1959]

a) Design mix
a concrete mixes of M-20, M-25 & M-30 were used to examine the cylindrical compressive strength of fly ash concrete& were designed as per the 10262:2009. Cement is replaced by 10% of fly ash by weight. Details of the mixes are given in Table 1

TABLE 2:Details of mix proportions

	Mix design proportion (By Weight)				
Mix ID	**Cement**	**N.F.A**	**N.C.A**	**Water**	**Fly ash**
M-20	0.90	1.86	3.98	0.50	0.10
M-25	0.90	1.65	3.54	0.45	0.10
M-30	0.90	1.57	3.40	0.42	0.10

Targeted compressive strength is also finding by cube casting of sizes 150 x 150 x 300 mm&tested. results are given below. In order that not more than the specified proportion of test results is likely to fall below the characteristic strength, the concrete mix has to be proportioned for higher target mean compressive strength f'$_{ck}$. The margin over characteristic strength is given by the following relation.

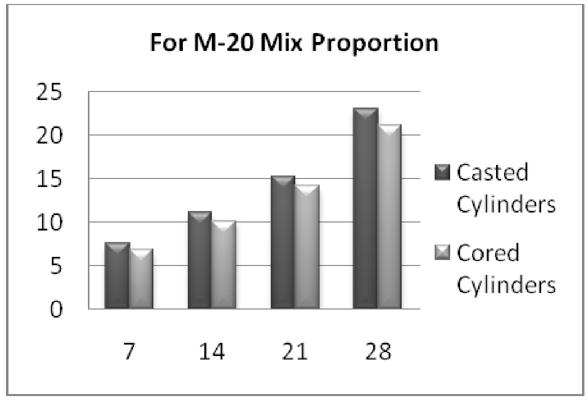
$$f'_{ck} = f_{ck} + 1.65 \times s$$

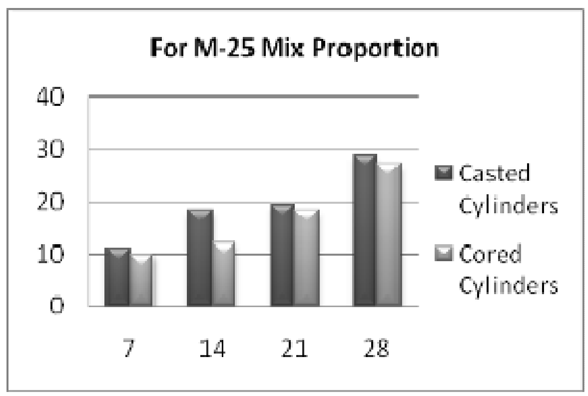
		Compressive strengths N/mm2		
Sr no	**Days**	**M-20**	**M-25**	**M-30**
1	7	8.12	12.42	14.02
2	28	27.37	37.27	38.19

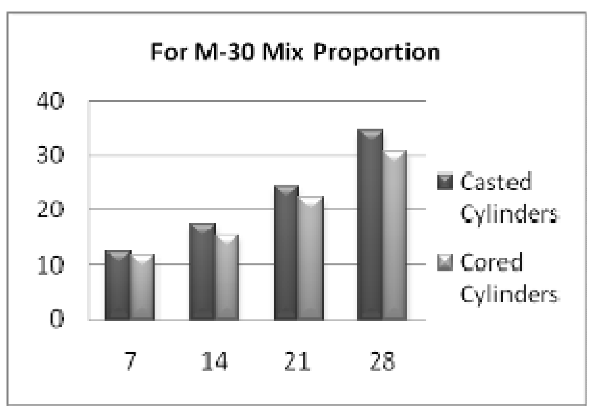
IV. RESULTS AND DISCUSSIONS

Basically this paper is based on various NDT methods available in our lab. The various NDT test are carried at the end of 7, 14, 21, & 28 days. For cylindrical compressive strength of specimen there are two tests are available in our lab that is Rebound hammer test & compressive testing machine. The all results by these tests are summarised in table

A. Rebound Hammer test:-
The rebound hammer is a surface hardness tester for finding the strength.Hear we used Digital rebound hammer which shows the compressive strength on screen & is also suitable for both laboratory and field work. The test surface can be horizontal, vertical or at any angle.

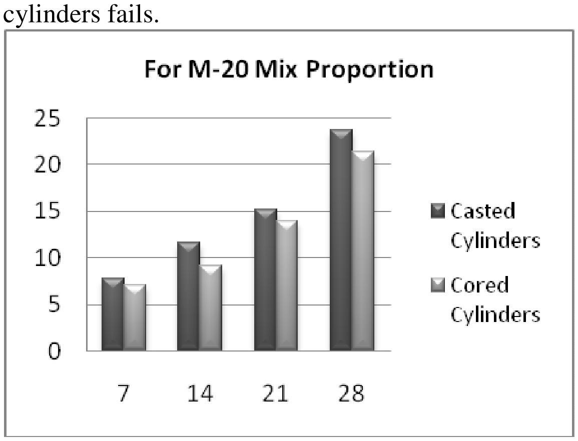


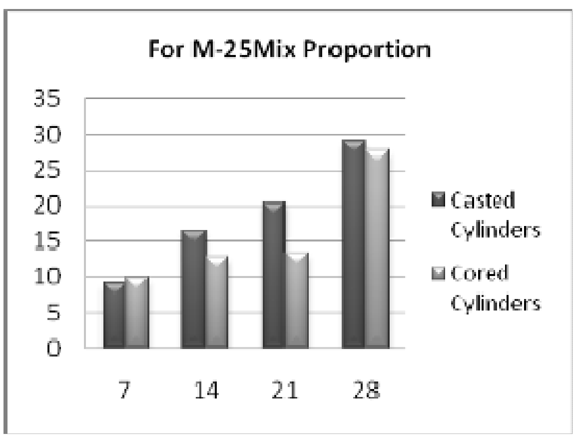


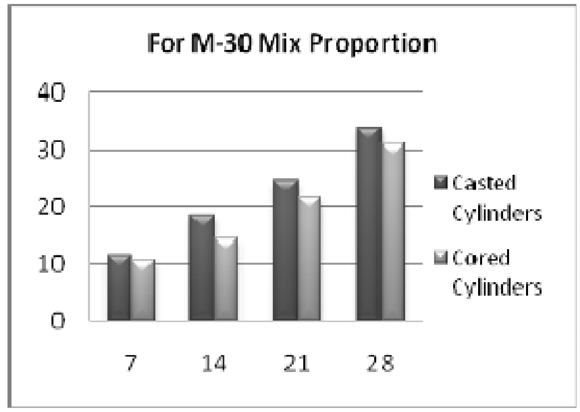


B. compressive testing machine test:-

Compressive strength is the capacity of a material to withstand axially directed pushing forces. When the limit of compressive strength is reached, materials are crushed. The cylindrical concrete specimen is placed on the platform of compression testing machine without any packing between the cube and the steel plates of the testing machine. The load is then applied on a smooth surface on the cube steadily and uniform starting from zero at smooth rate till the cylinders fails.





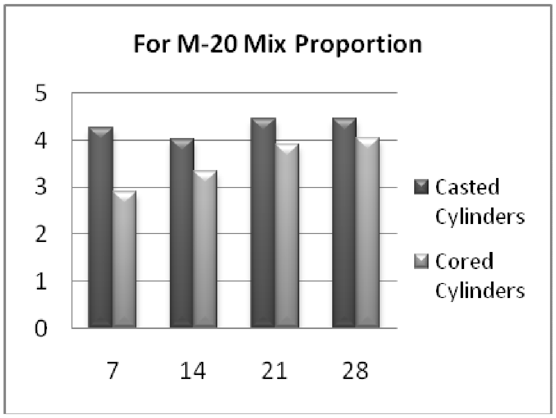


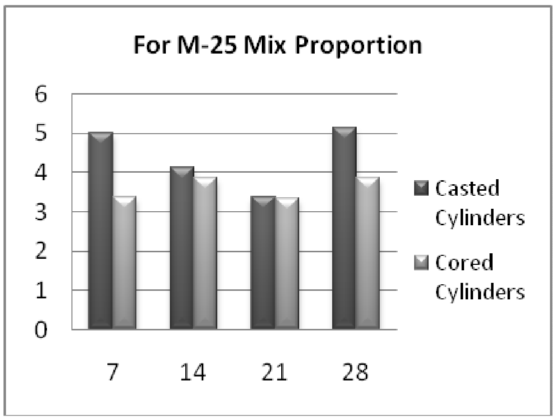
B. USPV Test:-
In this method the ultrasonic pulses generated by electro-acoustical transducer are transmitted through the concrete. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete.

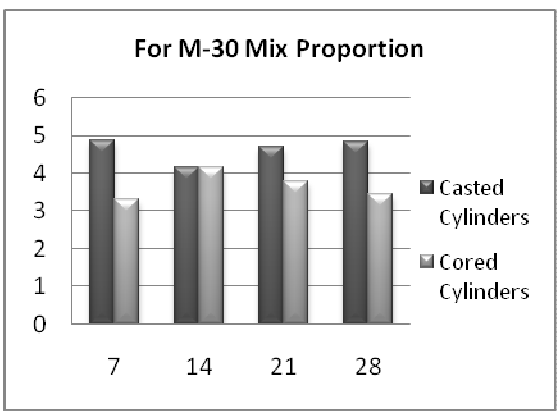
Fig. 1: USPV Machine

Velocity Criteria for Concrete Quality Grading As per Table 2 of IS 13311 (Part1): 1992

Sr. No.	**Pulse Velocity by Cross Probing (km/sec)**	**Concrete Quality Grading**
1.	Above 4.5	Excellent
2.	3.5 to 4.5	Good
3.	3.0 to 3.5	Medium
4.	Below 3.0	Doubtful







ANALYSIS

A. Abaqus software

The Abaqus finite element system includes

- Abaqus/Standard, a general purpose finite element program.
- Abaqus/Explicit, an explicit dynamics finite element program.
- Abaqus/CAE,aninteractive environment used to create finite element models, submits Abaqus analyses, monitor and diagnose jobs, and evaluate results.
- Abaqus/Viewer,asubset of Abaqus/CAE that contains only the post processing capabilities of the Visualization module.

During pre-processing user has to work hard while solution step is the turn of computer to do the job. User has to just click on solve icon & enjoy a cup of tea! Internally software carries out matrix formation, inversion, multiplication and solution for unknown e.g. displacement and then find strain and stress for static analysis .today we are using FEA just because of availability of computers .FEM has been known to mathematician and engineers right from late 50.s but since solving so many equation manually was not possible, in true sense FEA got recognition only after emergence of high capacity computers.

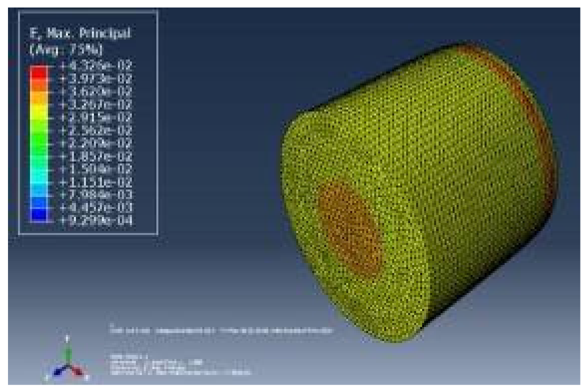


Fig 2: Max strain of Grade M-30

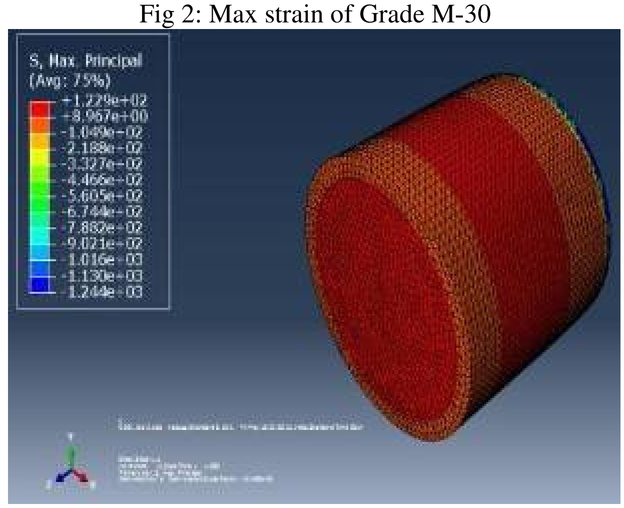


Fig. 3: Final model with results Max Stress

V. SOFTWARE RESULTS

JOURNAL OF INFORMATION, KNOWLEDGE AND RESEARCH IN CIVIL ENGINEERING
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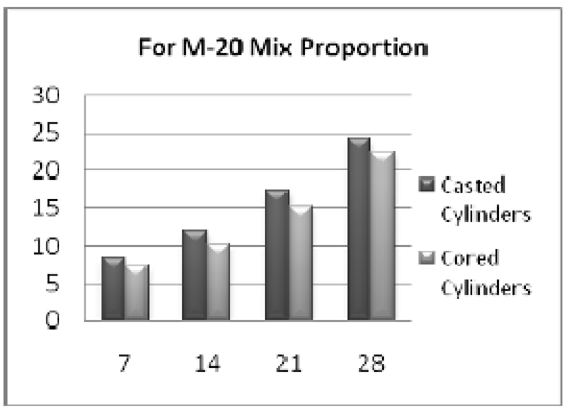
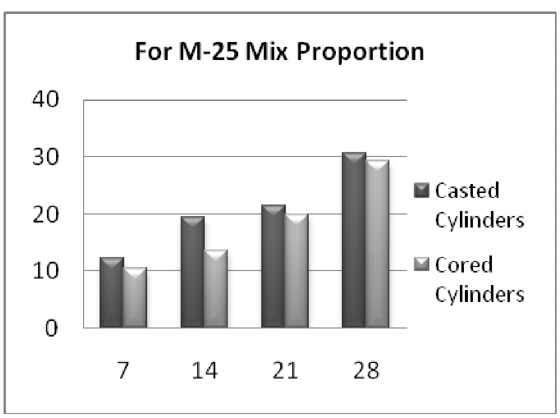
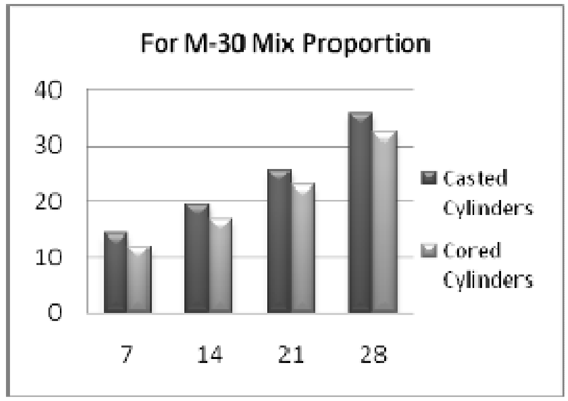
By using Abaqus software find out the first maximum principal stress and using normal stress formula evaluate the compressive strength.

I] Compressive strength by software(Example)

Formula,
$\sigma_n = [(\sigma_X + \sigma_Y)/2] + [(\sigma_X - \sigma_Y)/2\ (\cos 2\theta)]$
Where,
σ_n – Normal stress
σ_x –Experimental stress in X-direction
σ_y – Experimental stress in Y-direction
Now, consider a casted M-20 grade cylinder for analysis its max stress is 33.66 N/mm2
$\sigma_n = [(0 + 33.66)/2] + [(0 – 33.66)/2\ (\cos 2\times30)]$
$= [16.83] – [(8.415)]$
$= 8.42$







Comparisons of all results:-

TABLE- 3: Test results for **Casted cylinders by Abacus Modeling**

Sr no	Days	Compressive strength		
		M-20	M-25	M-30
1	7	8.42	12.285	14.33
2	14	12.03	19.453	19.453
3	21	17.405	21.50	25.60
4	28	24.315	30.725	35.825

TABLE- 4: Test results for **Cored cylinders by Abacus Modeling**

Sr no	Days	Compressive strength		
		M-20	M-25	M-30
1	7	7.313	10.445	12.013
2	14	10.185	13.58	16.713
3	21	15.238	19.845	22.98
4	28	22.458	29.25	32.375

TABLE- 5: Test results for **Casted cylinders By RHT**

Days	Compressive strength for casted cylinders sizes 150 x 300 mm in N/mm2		
	For M-20	For M-25	For M-30
7	7.60	9.10	11.35
14	11.10	13.30	17.70
21	15.25	18.35	21.30
28	22.00	27.80	31.65

TABLE- 6: Test results **for Cored cylinders By RHT**

Days	Compressive strength for cored cylinders sizes 100 x 200 mm in N/mm2		
	For M-20	For M-25	For M-30
7	6.90	8.75	9.65
14	10.10	12.05	18.45
21	14.15	16.35	19.40
28	21.10	26.30	29.85

TABLE- 7: Test results for **Casted cylinders By CTM**

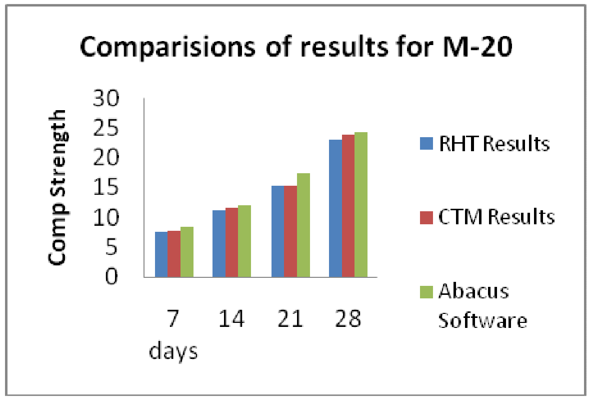
Days	Compressive strength for casted cylinders sizes 150 x 300 mm in N/mm2		
	For M-20	For M-25	For M-30
7	7.77	90.2	11.66
14	11.67	19.453	19.453
21	17.405	21.50	25.60
28	24.315	30.725	35.825

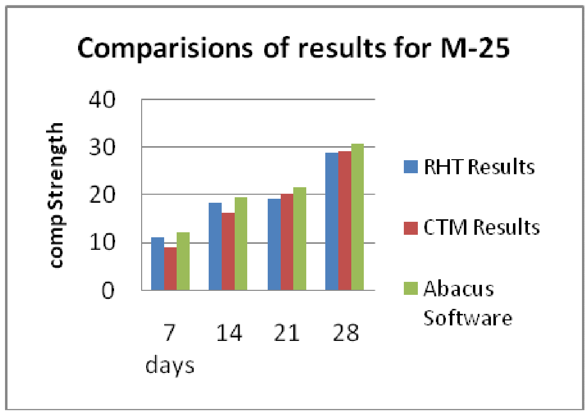
TABLE- 8: Test results for **Cored cylinders By CTM**

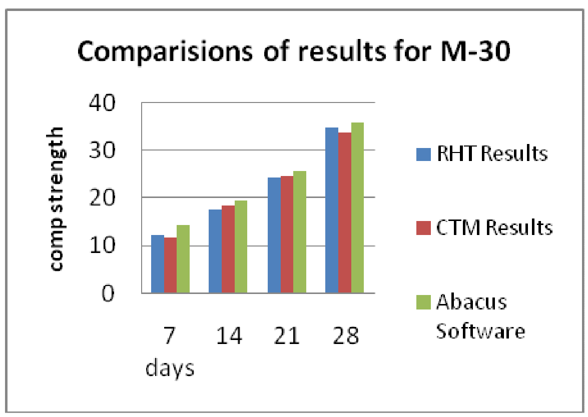
Days	Compressive strength for cored cylinders sizes 100 x 200 mm in N/mm2		
	For M-20	For M-25	For M-30
7	7.01	9.77	10.66
14	9.12	12.83	14.44
21	13.98	17.33	21.73
28	21.42	27.67	31.09

These tables shows the various results came from NDT test it is clearly shown that the CTM & RHT are both NDT tests are effective in some manner but results came from CTM machine is more similar to results came from ABACUS modeling.

Comparison for Casted cylinders:-

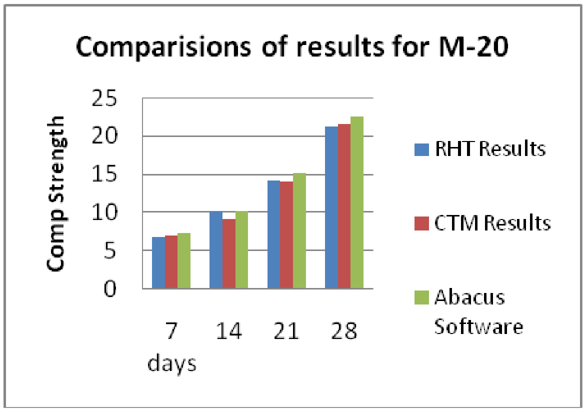


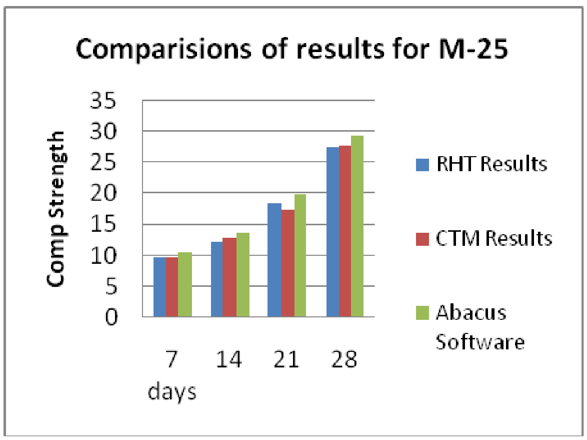


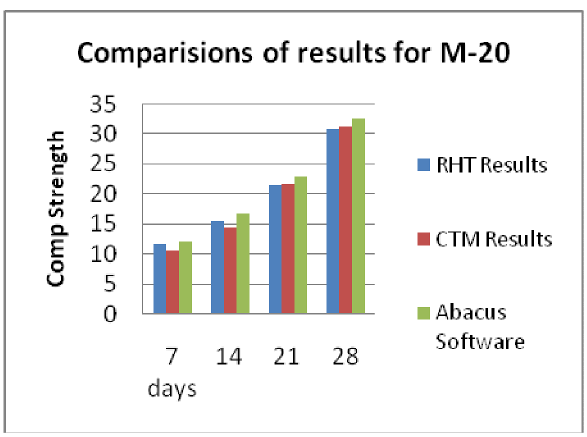


Comparison for Cored Cylinders:-

This shows the strengths variation due to affecting factors in following graphs;-







These comparison shows that the compressive strength came from NDT method is less than compressive strength came from software but it reaches up to the optimum level with targeted strength.

VI. CONCLUSIONS

1. From the above study concluded that replacement of cement by 10% fly ash decreases the cylindrical compressive strength of concrete.
2.It is also shows that the cored cylinders which sizes by 100 x 200mm gives less compressive strength as compared to casted which sizes by 150 x 300mm cylinders in both the testing .
3. For M-20, M-25, & M-30 grade correction coefficients that is according to cylindrical compressive strength tested by Abacus modeling for casted & cored cylinder is 0.998, 0.968, and 0.999 respectively.
4. For M-20, M-25, & M-30 grade correction coefficients that is according to cylindrical compressive strength tested by CTM for casted & cored cylinder is 0.993, 0.918, and 0.9917 respectively
5. Also by comparing the CTM & Abacus modeling strength we found the correction coefficients near about 1.
6. Cored cylinders gives less compressive strengths due to various affecting factors.
7. From the above study concluded that software compressive strength is greater than experimental compressive strength.

ACKNOWLEDGEMENT

I express my sincere thanks to all those who have helped me directly or indirectly in completing this project.

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