International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

COPY RIGHT

IJIEMR Transactions, online available on 26th Aug 2017. Link :http://www.ijiemr.org/downloads.php?vol=Volume-6&issue=ISSUE-7

Title: **STRENGTH, PERMEATION AND NANO STUDIES ON FLY ASH BASED MAGNETIC WATER CONCRETE**

Volume 06, Issue 07, Pages: 304-315.
Paper Authors

K.MEENA KANAKA BHARGAVI ,DR.D.VENKATESWARLU,D.S.V.S.RAM SAGAR

Godavari Institute of Engineering &Technology (Autonomous),Rajahmundry,A.P,India .

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

To Secure Your Paper As Per UGC Guidelines We Are Providing A Electronic Bar Code

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

STRENGTH, PERMEATION AND NANO STUDIES ON FLY ASH BASED MAGNETIC WATER CONCRETE

[1]K.MEENA KANAKA BHARGAVI ,[2]DR.D.VENKATESWARLU ,[3]D.S.V.S.RAM SAGAR

[1]PG Scholar,Dept of Civil Engineering,Godavari Institute of Engineering &Technology (Autonomous),Rajahmundry,A.P,India
[2]Professor & Head of the Department of civil Engineering,Godavari Institute of Engineering &Technology (Autonomous),Rajahmundry,A.P,India .
[3]Assistant professor,Dept of civil Engineering, Godavari Institute of Engineering &Technology (Autonomous),Rajahmundry,A.P,India

ABSTRACT The usage of concrete is growing with the exploding scope of construction industry. This called for the extensive production and usage of cement. Among all the ingredients of concrete, cement has deleterious effects on environment. As the usage of concrete is inevitable, pre-emptive measures should be taken to reduce the usage of cement in concrete while maintaining the same engineering properties. To address this cause, research has been carried out on various constituents and parameters of concrete which lead to the realization of new construction materials and practices. But the scope of effects on concrete caused by altering the properties of water has long been neglected. On account of this obscurity, this can be potential area of interest. When water is magnetized, it exhibits structural changes which increase the specific surface area of water. When this magnetized water is used in concrete instead of normal water, it is found that the compressive strength increases considerably. This additional strength attained by the usage of magnetized water can be used to address the need to reduce cement usage. In this attempt to reduce the usage of cement, fly ash which has immense potential to be used in construction industry, can be used to replace cement in concrete to a considerable extent when magnetic water is used. The present research work is carried out to investigate the effect of Magnetic Water on the Compressive strength, Permeation properties and Nano studies on fly ash based magnetic water concrete (M30 & M40 grade). Examine the effect of magnetic water on compressive strength, Permeation

Key Words : Fly ash , Compressive strength , Penetration test, thermo gravimetric analysis.

1. INTRODUCTION

Construction industry is one of the major industries in all countries both in terms of economy and affecting environment. In construction industry, concrete and metal (mostly steel) are majorly used. Concrete is primarily used building material. Concrete is an artificial stone-like material used for various structural purposes. It is made by mixing a binding material (as cement) and various aggregates (inert materials), such as sand, stone chips, brick chips, pebbles, gravel, shale, etc., with water and allowing the mixture to harden by hydration. Approximately four tonnes of concrete is produced for every person on the planet. Concrete is the second most consumed entity after water. This extreme use of concrete is in regard to the various advantages provided by it. Everything

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

about concrete is huge, it's usage, advantages and also disadvantages. One of the major disadvantages of concrete is its impact on environment. Concrete accounts for around 5% of the world's total CO2 emission. Cement manufacturing is high energy and emissions intensive because of the extreme heat required to produce it. Producing a ton of cement requires energy equivalent to about 400 pounds of coal, and generates nearly 0.9 ton of CO2. Given its high emissions and critical importance to society, cement is an obvious place to look, to reduce greenhouse gas emissions. Therefore there arises a need for the effective utilization of existing resources i.e., by maintaining the strength of concrete while reducing the quantity of cement usage in concrete.

2. MATERIALS USED

a) CEMENT

Locally available 53 grade ordinary Portland cement (OPC) of Ultratech brand has been used in the present investigation for all concrete mixes. The cement used was fresh and without any lumps. The cement thus procured was tested for physical and chemical requirements in accordance with IS 12269-1987(21).

Ultra Tech Ordinary Portland cement 53 Grade

Physical properties of OPC used

S.No	Properties	Test Results	Requirements as per IS :12269-1987
1	Normal consistency	30%	--
2	Specific gravity	3.02	--
3	Initial setting time	55 min.	Not less than 30 min.
	Final setting time	565min.	Not more than 600 min.
4	Soundness by Le Chatelier	2 mm	Not more than 10 mm
5	Fineness of Cement	3%	Less than 10%
6	Compressive Strength	54.7 MPa	53 Mpa

b) MAGNETS

In the present investigation work, the Magnets were obtained from scientific store. The shapes of magnets are rounded. We found the strength of magnet by Gauss meter. Three types of strength magnets we used. The average magnetic strength of four magnets is 985 gauss.

Figure 3.2 Magnets used for magnetizing water

c) FINE AGGREGATES

In the present investigations, river sand available in the local market was used as fine aggregate. The physical property of fine aggregate such as gradation, specific gravity and bulk density were tested in accordance with IS: 2386-1963. The various properties of fine aggregate used in

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

the present experimental investigation are given in a table which follows.

Table 3.2 Properties of fine aggregate

S.No	Properties	Result
1	Fineness modulus	2.88
2	Specific gravity	2.6
3	Bulk density in loose state	1550 kg/m^3

d) COARSE AGGREGATE

Coarse aggregate used in the investigations was of two sizes viz. 20mm and 12mm. The crushed coarse aggregate was obtained from the local crushing plants. The physical properties of the coarse aggregate such as gradation, fineness modulus, specific gravity and bulk density are tested in accordance with IS:2386-1963 and IS:383-1970. The results for 20mm aggregate are tabulated below:

S.N	PROPERTIES	RESULT
1	Fineness modulus	7.228
2	Specific gravity	2.60
3	Bulk density in loose state	1361 kg/m^3

e) MAGNETISED WATER

Magnetic water is obtained by placing water over the magnet. A beaker of water is placed over the magnets for a period of 24 hours to obtain magnetic water. During this time magnetic flux passes through the water changing the specific surface area of water which is called as magnetized water. Three different types of magnetic water can be prepared namely.

Type of water	Normal consistency
Normal water	30
North-South magnetized	33

f) FLY ASH

For this study, fly ash is incurred from National Thermal Power Corporation Limited (NTPC), Ramagundam. NTPC have installed facilities for segregation and collection of fly ash into 6 different fields. As the field number increases the fineness of fly ash increases but the quantity decreases. Field-1 fly ash has coarse particles and is not suitable for concrete applications. Fly ash from Field-2 onwards is segregated, packed and used for concrete applications. Since maximum availability of fly ash is from Field-2, same was used for our study. This fly ash conforms to the requirements of IS: 3812 Part 1 and also ASTM C-618 type F. Generally fly ash is assessed on the basis of some of the key parameters like pozzolanic activity, material retained on 45 micron sieve, loss on ignition and other chemical parameters. It is advisable that to qualify a source of fly ash all the test as specified in IS/ASTM shall be conducted initially and only key parameters can be tested for each batch to ensure a consistent quality of fly ash.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Properties of fly ash used

Description Test	Test Value	Acceptable Value	
		IS 3812-2003 Part 1	ASTM C-618 Type – F
Physical Properties			
Specific Gravity	2.14	-	-
Setting Time (min) Intial	130	-	-
Setting Time (min) final	290	-	-
Retained on 45 micron (%)	2.77	Max.34.0	Max.34.0
Specific Surface Area (m2/kg)	328	Min. 320	-
Soundness (Lechatelier) (mm)	0.15	-	-
Soundness (Autoclave) (%)	0.027	Max. 0.8	Max. 0.8
Water requirement (% of control)	96	-	Max. 105
Compressive Strength a) 7 Days b) 28 Days	158.1 160.9	Not less than 80% of the strength of corresponding plain cement mortar cubes	- Min. 75
Chemical Properties			
Silica (SiO2) %	58.74	Min. 35	-
Combined Oxide (SiO2+Al2O3+Fe2O3)%	93.77	Min.70.0	Min.70.0
Magnesium Oxide (MgO)%	0.48	Max. 5.0	-
Sulphur Trioxide (SO3)%	1.8	Max. 3.0	Max. 5.0
Sodium Oxide(Na2O)%	0.16	Max. 1.5	-
Loss of Ignition (%)	0.59	Max. 5.0	Max. 6.0
Moisture Content (%)	0.051	-	Max. 3.0

3. EXPERIMENTAL PROCEDURE

Compressive Strength Test Among the various strengths of concrete, the determination of compressive strength has received a large amount of attention because the concrete is primarily meant to withstand compressive stresses. Generally cubes are used to determine the compressive strength. The cubes are usually of 100 × 100 × 100 mm size. In the present investigation the standard 100 × 100 × 100 mm cubes are used to determine the compressive strength. The compressive strength test procedure is given below. After the required period of curing, specimens are removed from the curing tank just before testing and cleaned to wipe off the surface water. The cube specimen is placed on the lower platen in such a manner that the load is applied centrally on opposite side of the cube and right angles to that has cast. According to BIS 1881: part 116: 1983, the rate of load is applied is equal to 5 KN/sec or 0.22 N/mm2/sec. the oil pressure valve is closed then the compression testing machine is switched on. The top platens of the compression testing machine is brought into contact with the surface of the cube specimen, and then operate the clutch with suitable rate of loading, the load improvements are displayed in digital screen system. The load was applied until the resistance of the specimen to the increasing load broke down and no higher load was sustained, then the digital screen reading starts moving back, at this stage the pressure valve of the compression testing machine is released then automatically the ultimate load is displayed in the digital screen, and the platens are also loosened, now crushed specimen is removed from compression testing machine, and the maximum load applied to the specimen is noted down.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

The same procedure is repeated for testing all other test specimens.

Compression Testing Machine

Permeation test

This test follows the Clam permeability test which was developed originally to determine the coefficient of permeability of concrete on site. In the Auto Clam permeability test, a 50 mm internal diameter metal base ring is glued onto the surface of concrete and after saturating the test area by ponding water in the ring for 24 hours, the rate of penetration of water through the test area at a constant pressure head of 25 psi (1.72 bar) is measured. The measurements are taken for 15 minutes. Capillary pores filled with water require relatively high pressures to cause flow through them and, hence, the pressure used in the test may cause flow through only relatively big pores. This would mean that the test is not capable of Determining the coefficient of permeability of saturated concretes. However, if the ponding is eliminated from the test procedure it would provide the rate of water penetration from a pressurized source of water, i.e., a parameter which can be used to assess the permeability characteristic of concrete can be obtained. Although an apparatus to carry out the Clam permeability test was commercially available it was discontinued when the Auto clam Permeability System was introduced into the market; however, an apparatus similar to the Clam permeability test is commercially available at present with the trade name the Germane Water Permeability Test.

X-ray Diffraction (XRD) Analysis

X-Ray Powder Diffraction is a physico-chemical analysis method commonly used to determine the reticular plane distance and for the identification of crystalline compounds by their diffraction pattern. X-Ray Powder Diffraction (XRD) analysis is powerful methods by which X-rays of a known wavelength are passed through a sample identify different phases of that sample. The sample material should be ground by hand simply sufficiently fine so that it will pass through a 40 μm sieve and the quantity required is also less than 10 gm which should be placed in the sample holder. The XRD Pattern was obtained by scanning from 20º to 80º 2θ using a vertical x-ray diffract meter. As strength tests indicated the 28 day strength was important so XRD studies are conducted on NWFC and MWFC powder samples of the concrete cured for 28 days.

RD Test Equipment

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Thermo gravimetric (TG) Analysis

Thermo gravimetric Analysis (TGA) is a technique which measures a sample's weight as it is heated or cooled in a furnace. TGA thermal curve is drawn between temperature on x-axis and weight (mg) or weight percent (%) on y-axis. The sample size considered is 50 mg. During the Thermo gravimetric analysis the cement mortar present in both NWFC and MWFC(Three poles water) in concrete samples(at 28 days) was exposed to temperatures ranging from 20 °C to 800 °C at a rate of 10 °C/min in an inert nitrogen atmosphere with a purge rate of 20 mL/minute.

TG-DTA Testing Equipment

4. RESULTS AND DISCUSSIONS

This research investigates the influence of magnetic water on strength, permeation and Nano studies on fly ash based magnetic water concrete (M30, M40). Two types of water are used in this study, which are normal water and mixed pole magnetized water (N+S), the results of which are presented in this chapter.

EFFECT OF MAGNETIC WATER ON COMPRESSIE STRENGTH:

The results of the compressive strength at 7,14,21,28 and 60 days M30 grades of Normal water concrete (NWFC) and Magnetic Water concrete (MWFC) are tabulated in Table.

Compressive strength of NWFC and MWFC in N/mm2 (M30)

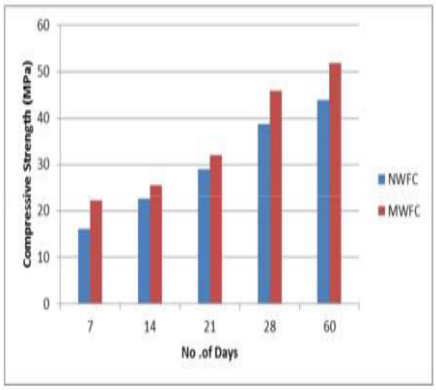
S. No.	Age in Days	NWFC	MWFC	% increase
1	7	16.11	22.25	38.1
2	14	22.62	25.5	12.73
3	21	28.97	32.1	10.8
4	28	38.8	45.9	18.3
5	60	43.8	51.74	18.13

Compressive strength of NWFC and MWFC in N/mm2 (M40)

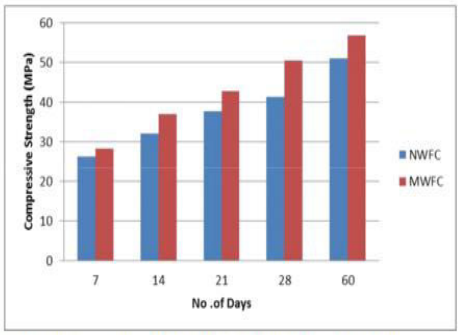
S. No.	Age in Days	NWFC	MWFC	% increase
1	7	26.33	28.3	7.5
2	14	32.11	37.01	15.3
3	21	37.7	42.9	13.8
4	28	41.3	50.4	22.03
5	60	51.03	56.81	11.3

The cube compressive strengths of concrete with and without magnetic water at 7,14,21,28 and 60 days are given in Tables It is observed that with the addition of Magnetic water for mixing in concrete showed increase by 38.1% & 7.5 5 in cube specimens at 7 days, and at 28 days there was significant increase by 18.3% and 22.03 % in M30 & M40 respectively. The increase in strength of concrete is due to more hydration of cement in MWFC, which fills up the pores in the concrete making the concrete microstructure dense.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org



Compressive strengths for N.W.F.C and M.W.F.C for M30 grade concrete



Comparison of compressive strength at Different ages for M30 grade

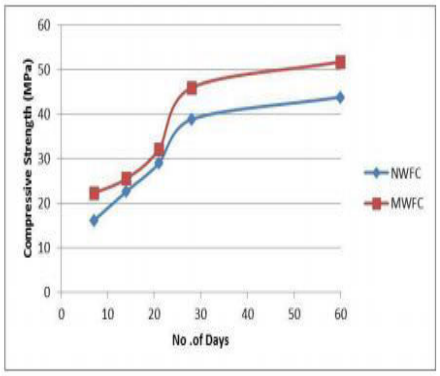


Figure - Compressive strengths for N.W.F.C and M.W.F.C for M40 grade concrete

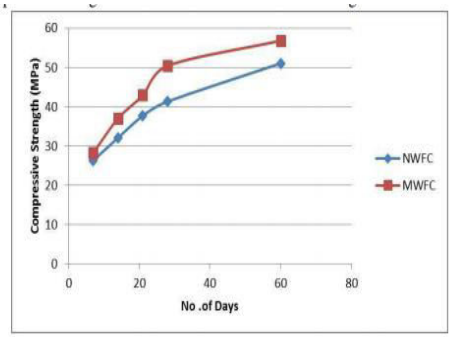
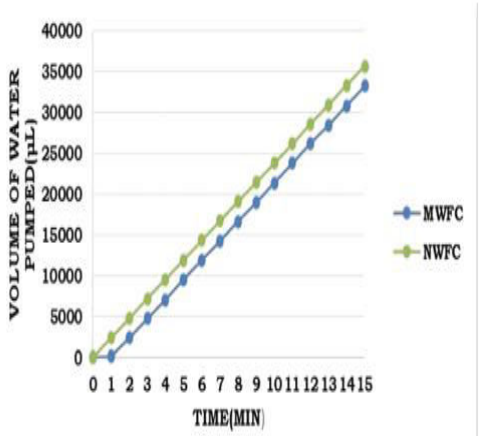


Figure -Comparison of compressive strength at Different ages for M40 grade



volume of water pumped in µ liters Vs Time (mins) at 28 Days (M40 Grade)

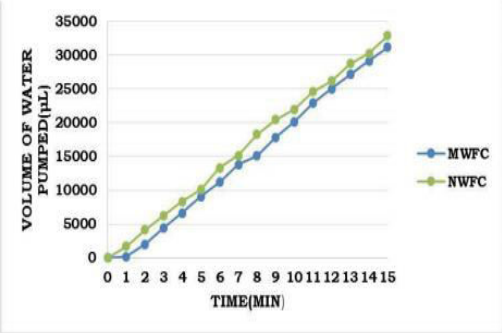
From the results obtained it is inferred that the compressive strength of M30 & M40 grades of concrete is attained at different days with magnetic water has higher strength than normal water concrete.

EFFECT OF MAGNETIC WATER ON PERMEATION PROPERTIES:

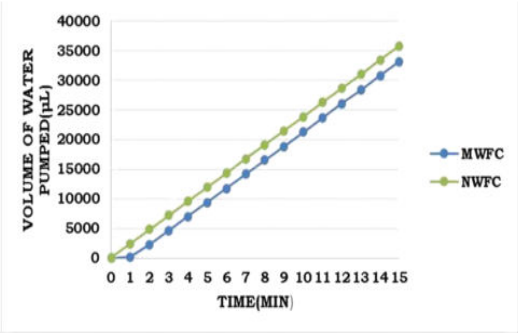
A total of 12 sets of cylinders of size 150mm x 150mm are cast and cured. Auto clam Concrete water permeability as per ISO 7031.In Auto Clam permeability test, a 50 mm internal diameter metal base ring is glued onto the surface of concrete on which the test is to be performed and water at a pressure of 500 m bar is pumped in to the concrete. The inflow of water through a test area of 50 mm diameter through a surface mounted ring is measured at this pressure at every one minute interval for a period of 15 minutes. The T a b l e 5.3, Figure 5.5 and Figure 5.6 presents the amount of water pumped in to the concrete for a period of 15 min at 28 and 60 Days for M30 grade. Table -volume of water pumped in µ liters at 28 and 60 ages (M30 Grade)

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

DAYS	28 DAYS		60 DAYS	
TIME (min)	NWFC	MWFC	NWFC	MWFC
0	1	0	1	0
1	2385	163	1616	150
2	4833	2264	2142	1500
3	7209	4651	4124	3269
4	9534	6976	6312	5286
5	11919	9345	8142	7347
6	14314	11741	12313	10884
7	16703	14148	12313	10884
8	19069	16511	15116	13654
9	21466	18842	16721	14269
10	23858	21259	19582	17436
11	26245	23650	21143	19765
12	28604	26046	24626	22538
13	30980	28372	27193	25988
14	33399	30747	29316	28176
15	35813	33134	31172	30582

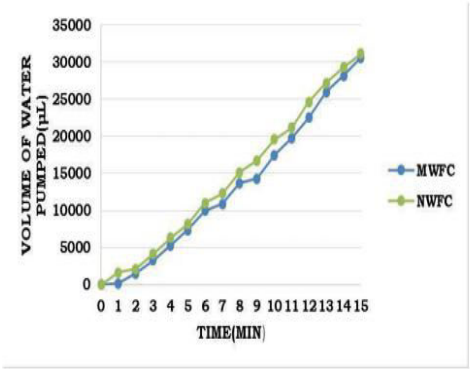


Volume of water pumped in µ liters Vs Time (mins) at 28 Days (M30 Grade)



volume of water pumped in µ liters Vs Time (mins) at 60 Days (M30 Grade) The Table, Figures presents the amount of water pumped in to the concrete for a period of 15 min at 28 and 60 Days for M40 grade. volume of water pumped in µ liters at 28 and 60 ages (M40 Grade)

DAYS	28 DAYS		60 DAYS	
TIME (min)	NWFC	MWFC	NWFC	MWFC
0	3	3	1	0
1	2344	170	1682	155
2	4753	2354	4143	1983
3	7190	4728	6258	4428
4	9536	7012	8313	6642
5	11923	9568	10128	9054
6	14312	11872	13336	11175
7	16721	14206	15162	13785
8	19069	16635	18243	15116
9	21399	18957	20457	17824
10	23808	21347	21993	20168
11	26187	23782	24582	22884
12	28574	26208	26173	24992
13	30930	28457	28731	27155
14	33340	30818	30234	29178
15	35717	33284	32845	31169



volume of water pumped in µ liters Vs Time (mins) at 60 Days (M40 Grade)

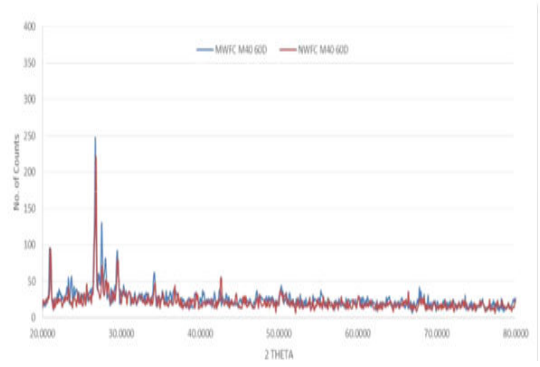
In this study determination of water permeability of concrete is carried out by Auto Clam Water Permeability. It is of great importance to study the permeability of concrete. The test was carried out on M30 & M40 grade of NWFC and MWFC specimens after 28 and 60 days age. The test results shows that MWFC were less permeable than the NWFC the reason is that the Magnetic water added concrete has less no. of pores due to high rate of

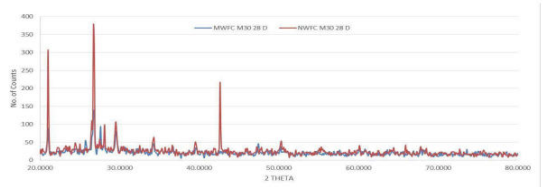
International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

hydration subsequently it reduces the permeability of concrete.

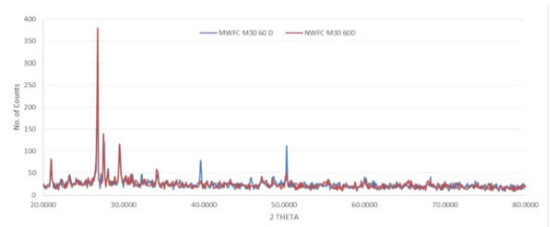
X-Ray Diffraction Analysis:

Powder diffraction patterns are typically plotted as the intensity (Counts per second) of the diffracted X-rays vs. the angle 2θ. By measuring the 2θ values for each diffraction peak, we can calculate the d-spacing (the distance between the diffracting planes) for each diffraction peak. By using Debey-Scherrer's we can calculate the average size of the particle, from the above equation as and values are constant in the present XRD studies, it is clear that the size of the particle is inversely proportional to the base width of the XRD peaks.

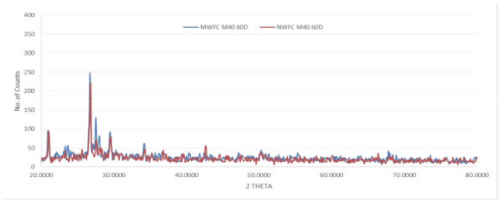




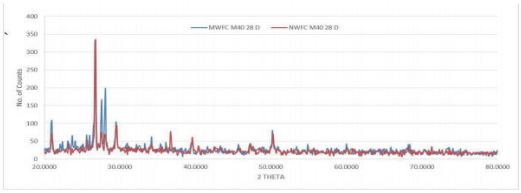
X-ray powder Diffraction Analysis for MWFC and NWFC at 60 Days (M30 Grade)



X-ray powder Diffraction Analysis for MWFC and NWFC at 60 Days (M40 Grade



X-ray powder Diffraction Analysis for MWFC and NWFC at 60 Days (M40 Grade



X-ray powder Diffraction Analysis for MWFC and NWFC at 60 Days (M40 Grade)

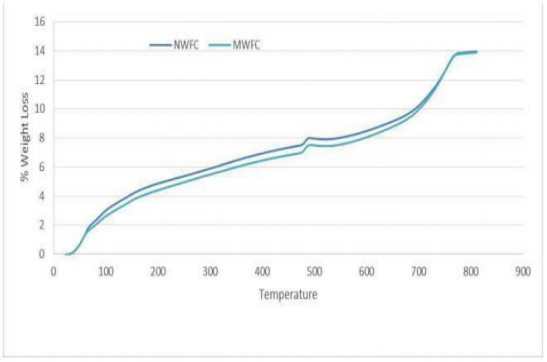
Figures depict the profiles of XRD patterns of NWFC and MWFC samples of M30 & M40 Grade Concrete at 28 Days and 60 Days. The widths of the peaks in a particular pattern provide an indication of the average crystallite size. The peak width increases as crystallite size reduces. We know that the size of hydrated cement particle will be large than partial hydrated cement particle, so in XRD patterns of NWFC as the peak width is large the diameter of the particle will be less this shows that normal water concrete is less hydrated to that of MWFC .

Thermo gravimetric (TG) Analysis

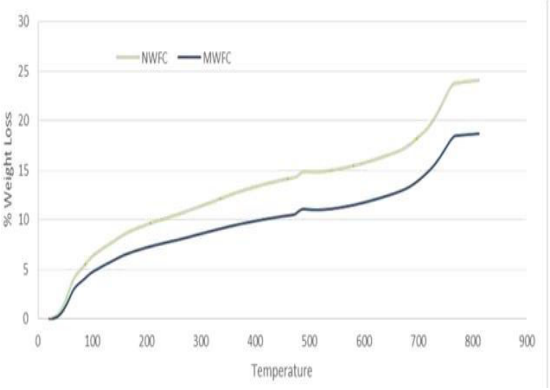
The TGA results for NWFC and MWFC with mixed Pole water (N+S) are Presented in Figure 5.13 & Figure 5.14 of M30 Grade at 28, 60 Days and in Figure 5.15 & Figure 5.16 of M40 Grade at 28 & 60 Days respectively. The behavior is almost same for all the concretes since chemical composition is same for all of them. From the graphs it is clear that as the temperature in the experiment is increasing the % weight loss is increasing gradually and the weight loss at the end of the experiment at 800°C is found to be

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

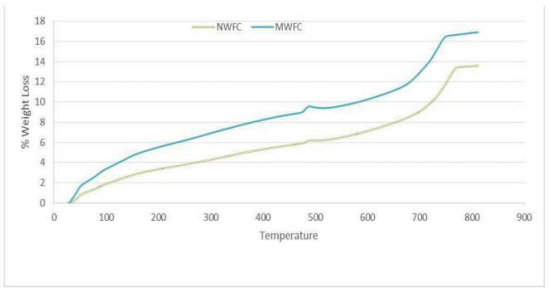
Maximum for NWFC and Minimum for the MWFC. A clear difference in weight loss can be observed between the samples prepared with and without Magnetic water. These results provide evidence that in MWFC there are more hydrated particles which are tightly bonded together which requires lot amount of heat to break this bonds. As concrete is heated to 800°C only, this heat is not sufficient to break this bond and to evaporate the cement mortar particles. So % weight loss is less to compared to NWFC. In NWFC as discussed earlier the hydration is relatively less compared to that of MWFC, So 800°C heat is sufficient to break the bonds and to evaporate the partially hydrated particles.



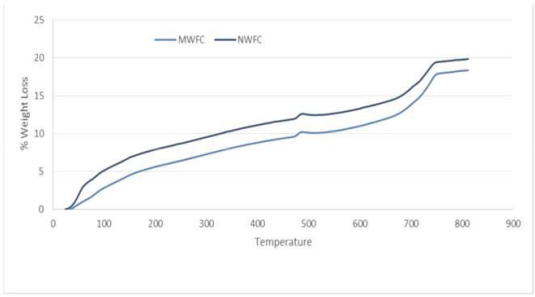
Comparison of % Weight Loss vs Temperature (TGA) for NWFC AND MWFC (M30) at 28 Days



Comparison of % Weight Loss vs Temperature (TGA) for NWFC AND MWFC (M30) at 60 Days



Comparison of % Weight Loss vs Temperature (TGA) for NWFC AND MWFC (M40) at 28 Days



Comparison of % Weight Loss vs Temperature (TGA) for NWFC AND MWFC (M40) at 60 Days

5.CONCLUSIONS

In this investigation the influence of magnetic water on Compressive strength, Permeation properties and Nano studies on concrete. For this the magnetic water of 985 gauss strength is used. The conclusions obtained from this work are as follows:

1. The Compressive strength of Magnetized water concrete is more than Normal water concrete by 38.1%, 12.7%, 10.8%, 18.3% and 18.1% of M30 Grade at 7,14, 21, 28 and 60 Days respectively.

2. The Compressive strength of Magnetized water concrete is more than Normal water concrete by 7.5%, 15.3%, 13.8%, 22.03% and 11.3% of M40 Grade at 7,14, 21, 28 and 60 Days respectively.

3. Auto Clam water permeability test shows that MWFC specimens were less permeable than the NWFC the reason is that the use of Magnetized water has

improved pore structure due to formation of Dense gel structure subsequently reduction in the porosity of the concrete which substantially reduces the permeability of the concrete.

4. The XRD patterns, it is very clear that the peak width is very small for Magnetic water compared to normal water has large peak width.

5. Thermo gravimetric analysis of MWFC samples improved by 2% and 6% for M30 grade and by 3% and 4% for M40 grade when Magnetic water is used instead of Normal water for preparing concrete at 28 and 60 Days respectively.

ACKNOWLEDGEMENT

I am grateful to my guide Mr.D.S.V.S.RAM SAGR, Assistant Professor, for having given me the opportunity to carry out this project work. I take this opportunity to express my profound and whole heartfelt thanks to my guide, who with her patience, support and sincere guidance helped me in successful completion of the project. I would like to thank Dr.D. VENKATESWARLU, Professor and Head of the Department of CIVIL ENGINEERING, for valuable suggestions throughout my project which have helped in giving definite shape to this work. I would like to express my deep sense of gratitude to Dr.D.V. RAMA MURTHY Principal, for providing me a chance to undergo the course in the prestigious institute. I am very much obliged to Dr.L.S. GUPTA, Director and Dr.M.VARA PRASADA RAO, Dean of Godavari Institute of Engineering and Technology for giving opportunity to undergo this project. Finally I would like to thank all the faculty members and non teaching staff from Department of Civil Engineering, GIET for their direct and indirect help during the project work. I owe my special thanks to the MANAGEMENT of our college for providing necessary arrangements to carry out this project. The euphoria and satisfaction of completing this project will not be completed until I thank all the people who have helped me in the successful completion of this euthusiastic task. Lastly I thank my parents for their ever-kind blessings. KASIREDDY MEENA KANAKA BHARGAVI

DECLARATION

I, Kasireddy Meena kanaka Bhargavi, hereby declare that the project entitled "STRENGTH, PERMEATION AND NANO STUDIES ON FLY ASH BASED MAGNETIC WATER CONCRETE" under the guidance of Mr.D.S.V.S.RAM SAGAR, submitted in partial fulfilment of the requirements for the award of the degree of Master of Technology in Structural Engineering is a record of bonafide work carried out by me and the results embodied in the project have not been reproduced. The results embodied in this project have not been submitted to any other university or institution for the award of any degree.

6.REFERENCES

1. IS: 383-1970 Specification for coarse and fine aggregates from natural sources for concrete (second revision). 2. IS: 456 – 2000 Code of practice for plain and reinforced concrete (fourth revision). 3. IS: 516 – 1959 Method of test for strength of concrete (Reaffirmed 1999). 4. IS: 650-

1991 Specification for standard sand for testing of cement (second revision). 5. IS: 1641-1988 Code of practice for fire safety of buildings (general): General principles of fire grading and classification. 6. IS: 2386(Part 1-8)-1963 Methods of test for aggregates for concrete. 7. IS: 3025- 1986 Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water. 8. IS: 3085 – 1965 Method of test for permeability of cement mortar and concrete. 9. IS:12269 – 1987 Specification for 53 grade ordinary Portland cement. 10.IS: 5515-1983 Specification for compaction factor apparatus 11. IS: 5816 – 1999 Method of test for splitting tensile strength of concrete . 12.IS: 7320-1974 Specification for concrete slump test apparatus. 13. S: 9399 – 1979 Specification for apparatus for flexural testing of concrete. 14. IS: 10262-2009 Recommended Guidelines for concrete mix proportioning. 15.IS: 14858-2000 Requirements for compression testing machine used for testing of concrete and mortar-requirements. 16.SP 23 - 1982 Handbook on concrete mixes (BIS). Ation for 53 grade ordinary Portland cement.

REFERRED BOOKS

1. “Properties of Concrete”, by Neville. A. M. – Pearson Education Asia Pte.Ltd, Fourth Edition, First Indian reprint 2000. 2. “Concrete – Microstructure, Properties and Materials”, by P. K. Mehta and Paulo J. M. Monteiro, Tata McGraw Hill Education Private Limited,Fourth reprint 2011. 3. “Design of Concrete Mixes”, 4e, by N. Krishna Raju, CBS Publishers & Distributors, Delhi, 2010. 4. Shetty M S, “Concrete technology (Theory and Practice)”, 5th Edition, 2002, published by S. Chand and Company Ltd. Ram Nagar, New Delhi – 110055. 5. Advanced Concrete Technology, John Newman and Ban Seng Choo , ButterworthHeinemann publication(Elsevier),UK,2003.