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Experimental Studies on Durability of Magnetic Water Concrete

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ABSTRACT
The magnetic water has been used in different fields like agriculture, health care, constructions, dairy production, and oil industries. Concrete mixes designed were prepared using tap water (TW) and another set of concrete mixes designed of the same proportions were also prepared using magnetized water (MW) in the laboratory to prepare the testing specimens. Assessment of the Concrete strength was performed to determine the effect of using magnetized water. The compression parameters included the mechanical properties and the consistency of fresh concrete. The change in water surface tension and the positive results of the concrete evaluation is evidence of the positive effect of using magnetized water in preparing concrete.

Durability of concrete can be defined as the ability to perform satisfactorily in the exposure condition to which it is subjected over an intended period of time with minimum of maintenance while maintaining its desired engineering properties. No material is inherently durable; as a result of environmental interactions the microstructure and, consequently, the properties of materials change with time. A material is assumed to reach the end of service life when its properties under given conditions of use have deteriorated to an extent that the continuing use of the material is ruled either unsafe or uneconomical. Concrete ingredients, their proportioning, interactions between them, placing and curing practices, and the service environment determine the ultimate durability and life of the concrete. The present work is carried out to investigate the effect of Magnetic Water on the Durability of magnetic water concrete (M30 grade and M40 grade). Effect of magnetic water on acid immersion and freezing & thawing of magnetic water concrete are studied. It is observed that, in most cases, concrete made with magnetic water has superior durabilitythan those of normal water concrete although there is no significant difference in its composition.

INTRODUCTION

Concrete in construction industry

Concrete is a composite material composed of aggregate bonded together with a fluid cement which hardens over time. In Portland cement concrete (and other hydraulic cement concretes), when the aggregate is mixed together with the dry cement and water, they form a fluid mass that is easily moulded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix which binds all the materials together into a durable stone-like material that has many uses.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 widely used materials. Concrete is primarily used building material. Approximately four tonnes of concrete is produced for every person on the planet. Concrete is the second most consumed entity after water.

Principle of magnet therapy

All physical and mental functions are controlled by electromagnetic fields produced by the movement of electro chemicals (ions) within the body. When an injury occurs and tissue is damaged, positively charged ions move to the allocated area, causing pain and swelling. In order for healing to take place, the injured site must be restored to its natural negative electromagnetic charge. Pain and inflammatory related electro chemicals must be removed and oxygen and nutrients transferred to the area.

The application of a magnetic field to an injured area helps restore the normal electromagnetic balance. The magnetic field relaxes capillary walls as well as surrounding muscle and connective tissue, allowing for increased blood flow. More oxygen and nutrients are transferred to the injury site, while pain and inflammatory related electro chemicals are more efficiently removed. The overall process restores the normal electromagnetic balance of the area, relieving pain and inflammation, and promoting accelerated healing.

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Figure 1.3 **One litre Beakers placed over the Magnet**

Applying magnetic fields to an injured area improves blood flow and oxygen to enhance the body's natural healing process.

The improved blood flow and fluid exchange to the injured tissue helps reduce pain and inflammation. Dr. U. Warnke's studies showed higher body temperatures under the influence of magnetic fields. His study used infrared thermography, a method that maps increased heat caused by increased blood flow thus proving magnetic fields increase circulation.

Magnetised water

Magnetized water doesn't mean water has acquired magnetic strength but that it has been subjected to a magnetic field which has found to change certain properties of water. These anomalous properties of water are unique for water and may result in many variations of macroscopic properties. Magnetic water treatment has received some attention from the scientific community. The reported effects of magnetic water treatment are varied and often contradictory. In many cases, researchers report finding no significant magnetic treatment effect. In other cases, reasonable evidence for an effect is provided. The Australian Fluid Energy mentions that the molecule groups of magnetic water differ from molecule groups of ordinary water in having lower degree of consolidation and the molecules volume is more uniform.

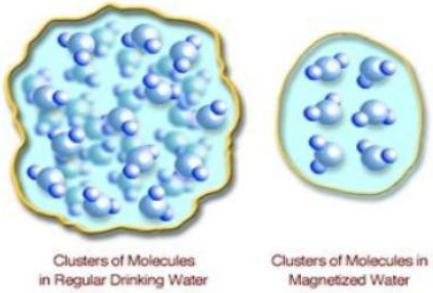


Figure 1.1 Differences in size of normal and magnetic water molecule clusters

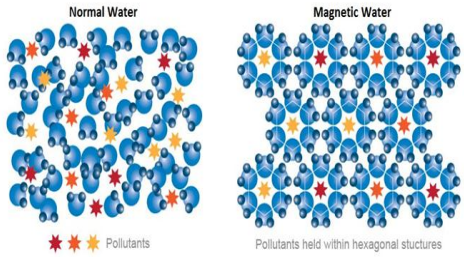
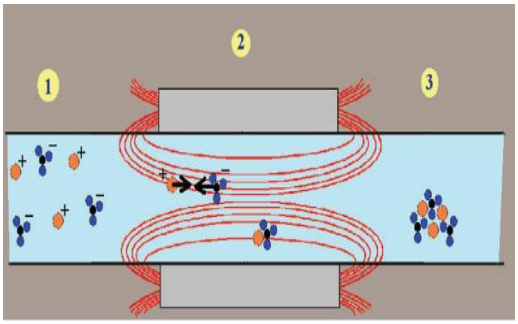


Figure 1.2 Change in water structure after magnetisation

Principles of magnetized water

Natural water contains micro and macro particles of organic and inorganic nature along with different ions. Magnetic treatment of water is based on the principle of "magneto hydrodynamics", where electrical energy is added to charged particles in water that contains ions and small solid particles with electrostatic charges by a magnetic field. The energy is produced by the momentum of the particles and remains attached to the particles as surface energy. Applying a magnetic field to natural water causes a redistribution of flow energy because of a momentum change of charged particles. All the particles and ions are electrically charged such that when magnetic fields are introduced convection and induced currents cause the liquid to spin. This movement then effects changes in gas content and the amount of salt crystallization centres in the water. The quick change of the magnetic field in a properly designed magnetic apparatus loosens hydrate layers and films in a moving liquid, thus enabling coagulation and coalescence.



Magnetised water in concrete

In this magnetic water concrete the concrete is manufactured with magnetised water while mixing. The magnetised water is prepared by keeping the water on

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round magnets taken from scientific store. This phenomenon is based on magnetic therapy in the medical field.

Figure 1.3 Permanent magnets field (Water magnetizer Testing Procedure)

Recently, magnetized water (MW) has been used in several applications including health, environment, agriculture, construction industry. The main target of this project is to study and evaluate concrete produced using MW. An experimental laboratory plan has been established to investigate the physical and mechanical properties of this concrete. Magnetized water is obtained by passing tap water through a magnetic field. Special apparatus to generate the magnetic field has been purchased and assembled with immerse-able water pump, for the laboratory study. The test variables include the magnetic strength of the water, the curing age of the concrete, the MW to cementations material ratio (w/c), and the constituents of the concrete mix usually used in Kuwait. The technology of using MW has been introduced in concrete production. A proposed program was developed to evaluate the feasibility of using MW in concrete by tune down the level of magnetizing to the optimum, and characterizing the concrete produced by MW in both fresh and hardened stages. Various mixes design produced by MW and compared with the control mixes produced by normal water.

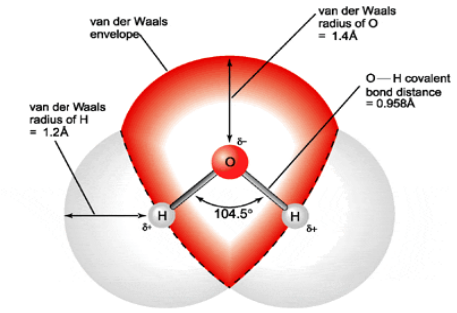

Figure 1.6 Structure of water

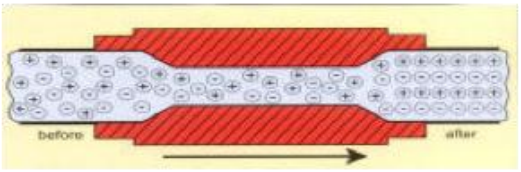

Figure 1.7 Movement of charged particles after magnetism

Workability plays an important role in the concrete quality in the short and long term. It is anticipated that the use of MW would have an effect on the fresh concrete quality that will lead to better quality of the hardened concrete, due to a change in the surface tension (viscosity) of the water used in the mix. Moreover, more water is required for the concrete to be mixed well. Adding more water in concrete will make it workable, but unfortunately adding water will scarify the concrete density. The reduction in water surface tension causes the water molecules to be more dynamic and fluid (**Fig.1.3**). This in turn allows much better bonding between the other materials added to the water.

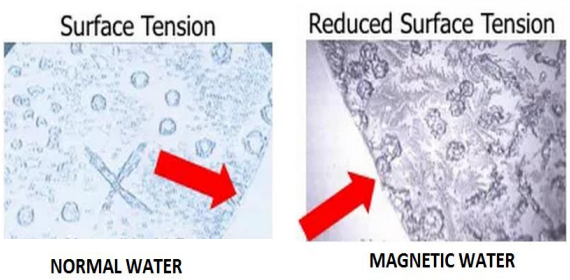

Figure 1.4 Change in Surface Tension of magnetised water

When water is magnetized, it becomes anti-magnetized and inhibits the mineral in concrete from bonding, which causes the minerals of the concrete and additive to repel each other. This fact plays a major role in of mixing, forming, and curing stages which all contribute in

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producing better concrete. All that will contribute in producing a high-quality concrete which can overcome its lack of ability to resist deterioration.

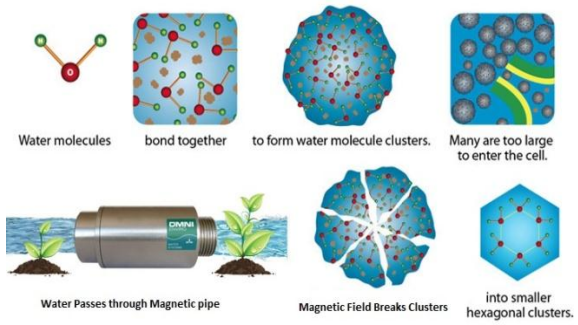

Figure 1.9 Change in water structure after magnetisation

MATERIALS AND METHODS

MATERIALS USED

The following materials are used in the present investigation. A brief description is given below regarding the materials used.

- Cement
- Magnets
- fine aggregate
- coarse aggregate
- Magnetized water
- Normal water
- Hydrochloric acid

CEMENT

Locally available 53 grade ordinary Portland cement (OPC) of Ultra-tech 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). The results obtained are as follows:

Table 3.1 Physical properties of OPC used

S.No	Properties	Test Result
1	Normal consistency	30%
2	Specific gravity	3.02
3	Initial setting time (minutes)	55 min
4	Final setting time (minutes)	560 min
5	Fineness	3%
6	Soundness (lechatlier method)	2 mm
7	Compressive strength (28 days)	54.70 N/mm²

Figure 3.1 Ultra-Tech Ordinary Portland cement 53 Grade

The specifications of the cement provided by the manufacturing company are as follows. As it can be seen the specifications of the cement used by us are in conformance with the data provided by the manufacturer.

Table 3.2 Comparison of specifications of OPC with IS: 12269-1987

S.No	Physical Property	Test results of Ultra tech (OPC 53 grade)	Requirements as per IS:12269-1987
1	Standard Consistency (%)	30	-
2	Setting time (min) a) Initial b) Final	120 320	30 (minimum) 600 (maximum)

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3	Compressive Strength (MPa) a) 3 days b) 7 days c) 28 days	32 44 54	27 (min) 37 (min) 53 (min)
4	Fineness a) By sieving with IS sieve no.9 (%) b) Blains permeability method (m2/kg)	2 320	10 225 (minimum)
5	Specific Gravity	3.15	-

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 965gauss

Figure 3.2 Magnets used for magnetizing water

AGGREGATES

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

Figure 3.3 River sand used in concrete mixes

Table 3.3 Properties of fine aggregate

S.No	Properties	Result
1	Fineness modulus	2.88
2	Specific gravity	2.60
3	Bulk density in loose state	1550 kg/m3

Table 3.4 Sieve analysis of fine aggregate

IS Sieve Size	Weight retained gms	Cumulative weight retained gms	Cumulative % weight retained	Cumulative % weight passing	Grading Limits IS 383-1970 Zone II
10 mm	0	0	0	100	100
4.75mm	30	30	3	97	90-100
2.36mm	50	80	8	92	75-100
1.18m	190	360	27	73	55-90

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m					
600microns	330	600	60	40	35-59
300microns	300	900	90	10	8-30
150microns	100	1000	100	0	0-10
Total			**288**		

Fineness Modulus = Cumulative Percentage weight retained / 100

= 288 /100=2.88 (Fine aggregate belongs to Zone II)

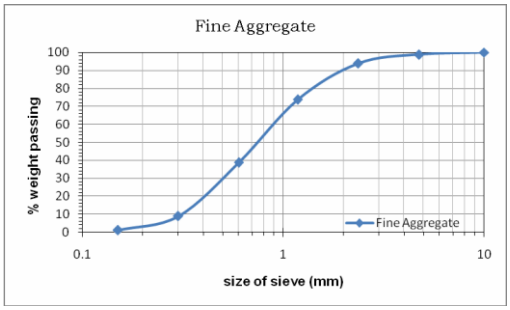

Figure 3.4 Sieve analysis chart for fine aggregate

COARSE AGGREGATE

The coarse aggregate used in the investigations was of two sizes viz. 20mm and 12mm nominal size. The granite crushed angular shaped coarse aggregate was obtained from the local crushing plants. The 12mm aggregates used were first sieved through 10mm sieve and then through 4.75 mm sieve and 20mm aggregates were sieved through 20mm sieve. They were then washed to remove dust and dirt and were dried to surface dry condition. The physical properties of the coarse aggregate such as gradation, fineness modulus, specific gravity and bulk density were tested in accordance with IS : 2386-1963 Parts I to VIII "Methods of test for aggregates for concrete".

Table 3.5 Physical properties of coarse aggregate of size 20mm

S.no	Properties	Result
1	Fineness modulus	7.228
2	Specific gravity	2.60
3	Bulk density in loose state	1361 kg/m³

Table 3.6 Sieve analysis of coarse aggregate (20mm)

S.no	IS sieve size	Weight retained in gms	% weight retained	Cumulative %weight retained	% passing
1	40 mm	0	0	0	100
2	20 mm	1140	22.8	22.8	77.2
3	10 mm	3860	77.2	100	0
4	4.75 mm	0	0	100	0
5	2.36 mm	0	0	100	0
6	1.18 mm	0	0	100	0
7	600 µm	0	0	100	0
8	300 µm	0	0	100	0
9	150 µm	0	0	100	0

Fineness Modulus = 722.80/ 100= 7.23

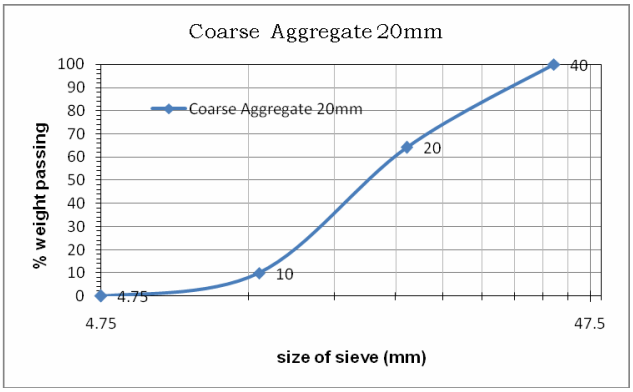

Figure 3.5 Sieve analysis chart for coarse aggregate (20mm)

The various physical properties of 12mm aggregate are tested and the corresponding results are as follows

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Table 3.7 Physical properties of coarse aggregate of size 12mm

S.no	Properties	Result
1	Fineness modulus	5.314
2	Specific gravity	2.58
3	Bulk density in loose state	1332 kg/m3

Table 3.8 Fineness modulus of coarse 12mm aggregate

S.no	IS sieve size	Weight retaine	% Weight	Cumulative % weight	% Passing
1	40 mm	0	0	0	100
2	20 mm	0	0	0	100
3	10 mm	200	4	4	96
4	4.75 mm	1170	23.4	27.4	72.6
5	2.36 mm	3630	72.6	100	0
6	1.18mm	0	0	100	0
7	600 µm	0	0	100	0
8	300 µm	0	0	100	0
9	150 µm	0	0	100	0

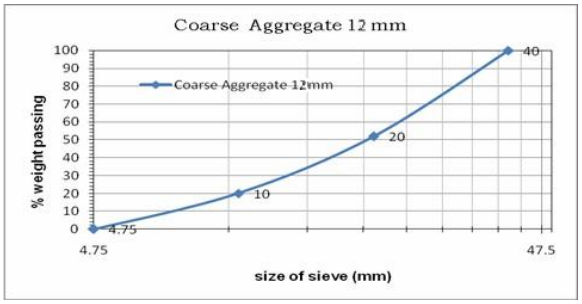

Figure 3.6 Sieve analysis chart for coarse aggregate (12mm)

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:

1) North pole water
2) South pole water
3) North south pole water or mixed pole magnetized water.

North Pole and South Pole water can be prepared using respective magnets.Whereas mixed pole water is prepared by mixing equal quantities of north and South Pole waters.

Figure 3.7 Water in 1liter beaker placed on magnets

Various physical tests have been conducted on different waters like North Pole water, South Pole water, north &South Pole water and normal water.

The results obtained are tabulated below.

Table 3.9 Properties of water

Tests performed	Normal water	Magnetic Water
PH	7.2	7.9
Turbidity	7	7
Alkalinity	20	20
Chlorides	28	28
Hardness	112	84

Due to the magnetization of water various changes have been observed in different properties of cement. One such change observed is in the normal consistency of cement. A comparative study for normal consistency of cement using various waters has given the following results.

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Table 3.10 Normal consistency of cement for different waters

Type of water	Normal consistency (%)
Normal water	30
North-South magnetized water	33

MIX DESIGN

The material quantities obtained as per mix design method, (i.e., IS: 10262-2009) arrived in trial mix are given in Table3.11 as per mix proportion for M30 is 1:1.98:3.22:0.48 and M40 is 1:1.89:3.06:0.46. The quantities of materials required per one cubic meter of concrete. The detailed mix design procedure of M30 & M40 grades of concrete is given in Appendix.

Specimen calculation for M30 design mix

Design stipulations

Characteristic compressive strength required

In the field at 28 days 30 N/mm^2

Maximum size of aggregate 20 mm (angular)

Degree of workability medium

Degree of quality control Good

Type of exposure mild

Test data of materials

Cement 53 Grades OPC

Specific gravity of cement 3.02

Specific gravity of CA 2.59

Specific gravity of FA 2.60

Target mean strength of concrete

(from Table 1 & Table 2 of IS: 10262-2009)

$F_t = f_{ck} + 1.65\ S$

For M30 grade Standard Deviation, s= 5 N/mm^2

$F_t = 30 + 1.65 \times 5.0$

$= 38.25$ N/mm^2

Selection of water -cement ratio

(from Table 5 of IS 456)

W/C ratio = 0.48

Selection of water content

(from Table 2 of IS: 10262-2009)

Maximum water –cement ratio = 186 litre (for 25 to 50mm slump range)

Water content = 170.5 kg/m^3

Determination of cement content

Water-cement ratio = 0.48

Water content = 170.5 litre

Quantity of cement = 355.21 kg/m^3

Proportion of volume of F.A and C.A content

(from Table 3 of IS: 10262-2009)

Volume of coarse aggregate for the water cement ratio = 0.62

Mix Proportions

a) Volume of concrete = 1m^3

b) Volume of Cement(b)= (355.21/3.02) X (1/1000)

= 0.1176 m^3

c) Volume of all Aggregate (e) = [a-(b + c + d)]

= 1-(0.1176+0.170+0)

= 0.7124 m^3

d) Mass of coarse Aggregate= 0.7124x0.62x2.59x1000

= 1143.97 kg.

e) Mass of fine aggregate = 0.7124x0.38x2.60x1000

= 703.85 kg

RESULTS AND DISCUSSION

This research investigates the influence of magnetic water on Workability, durability characteristics of magnetic water concrete (M30&M40). Two types of water are used in this study, which are normal water and mixed magnetic north and south pole water (MTW-N+S), the results of which are presented in this chapter.

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EFFECTS OF MAGNETIC WATER ON WORKABILITY OF CONCRETE

Immediately after mix is prepared, slump test is done for to assess workability. Slump test is conducted for all the mixes used in this study. The results obtained (in mm) for various M30 grade of concrete are tabulated below.

Table 5.1 Workability of NWC and MWC of M30 grade concrete

S.No.	Type of Water	Slump Value
1	Normal Water	65
2	Magnetic Water (N+S)	70

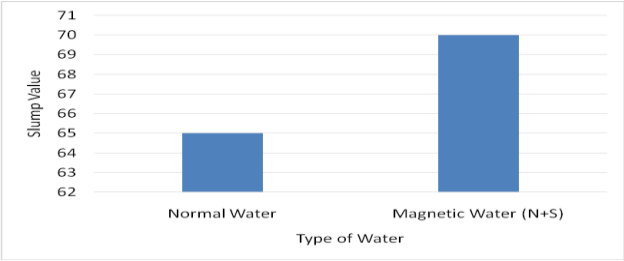

Figure 5.1 Workability of NWC and MWC of M30 grade concrete

From **Table 5.1**, it is clear that the workability of concrete increases when magnetic water is used. It is clear that there is very less change in consistency of concrete for the concrete mixes but how ever magnetic water is showing more workability compared to normal water concrete mixes and concrete made with this water was more cohesive compared to normal water concrete mixes.

EFFECT OF MAGNETIC WATER ON ACID IMMERSION-M30 GRADE

The amount of percentage loss in M30 grade concrete when cubes immersed in 5%, 10%, 15% HCL for 28 days are presented in **Table 5.2**and variation is shown in **Figure 5.2, 5.3**and percentage strength loss is presented in **Table 5.3**and variation is shown in **Figure 5.4**, **5.5**

5.2.1PERCENTAGE WEIGHT LOSS FOR M30

Table 5.2 Percentage Weight Loss for M30 grade NWC and MWC

	Normal water concrete	Magnetic water concrete

Percentage of HCL	Average weight of cube before immersion (kg)	Average weight of cube after immersion (kg)	Weight loss in %	Average weight of cube before immersion (kg)	Average weight of cube after immersion (kg)	Weight loss in %
5%	2.547	2.497	2.00	2.612	2.587	0.92
10%	2.593	2.500	3.57	2.626	2.580	1.73
15%	2.577	2.435	5.50	2.588	2.384	2.67

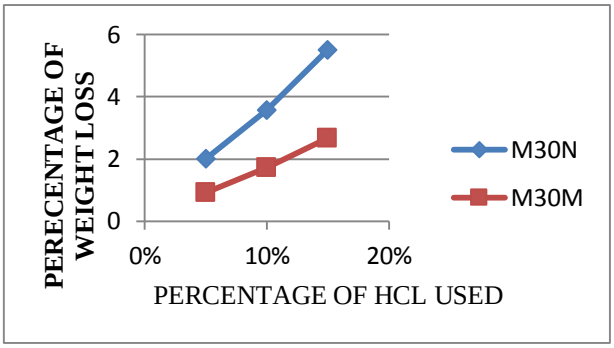

Figure 5.2 Percentage of weight loss for M30 grade NWC and MWC

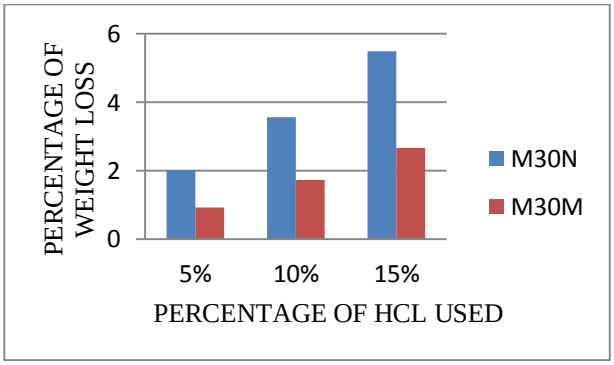

Figure5.3 Comparison of % weight loss for M30 grade NWC and MWC

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From **Tables 5.2** and **Figure 5.2 and 5.3** it is evident that percentage weight loss for M30 grade is more in NWC compared to MWC when cubes are subjected to different % of HCL. Since more hydration of cement takes place in MWC makes the microstructure of concrete dense thus results in less amount of scaling of surface and less reduction in weight of the concrete. As seen from **Table 5.2**and**Figure 5.2 and 5.3**, the % weight loss in NWC is in between2.00%, 3.57% and 5.50% and in MWC is 0.92%, 1.73% and 2.67%when immersed for 28 days in 5%, 10% and 15% of HCL respectively.

PERCENTAGE OF STRENGTH LOSS -M30

Table 5.3 Percentage strength loss for M30 grade NWC and MWC

Percentage of HCL	Normal water concrete			Magnetic water concrete		
	Average strength of cube before immersion in N/mm^2	Average strength of cube after immersion in N/mm^2	Strength loss in %	Average strength of cube before immersion in N/mm^2	Average strength of cube after immersion in N/mm^2	Strength loss in %
5%	38.8	36.47	6.00	46	44.92	2.34
10%	38.8	34.09	12.13	46	43.09	6.31
15%	38.8	27.00	29.00	46	38.74	15.78

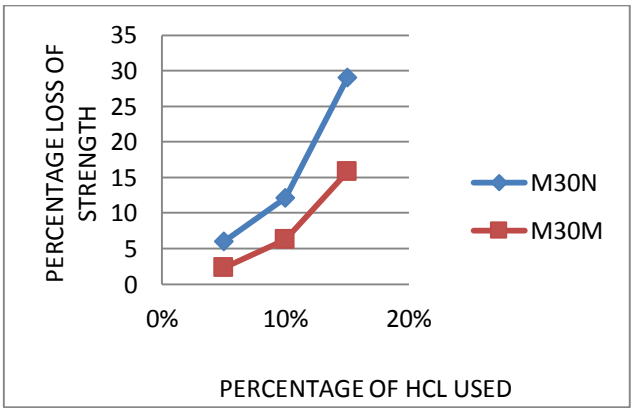

Figure 5.4 Percentage strength loss for M30 NWC and MWC

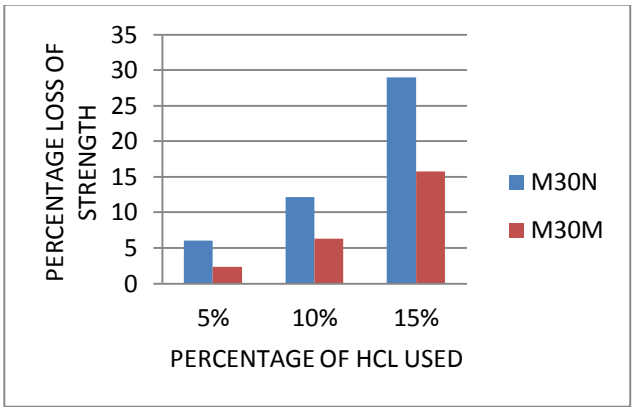

Figure 5.5 Comparison of % strength lossfor M30 grade NWC and MWC

From **Tables 5.3** and **Figure 5.4 and 5.5** it is evident that percentage strength loss for M30 grade is more in NWC compared to MWC when cubes are subjected to different % of HCL. Since more hydration of cement takes place in MWC makes the microstructure of concrete dense thus results in less amount of scaling of surface and less reduction in strength of the concrete. As seen from **Table 5.3** and **Figure 5.4 and 5.5**, the % strength loss in NWC is in between 6.00%, 12.13% and 29.00% and in MWC is 2.34%, 6.31% and 15.78%when immersed for 28 days in 5%,10% and 15% of HCL respectively.

5.3 EFFECT OF MAGNETIC WATER ON FREEZE & THAW CYCLES - M30 GRADE

The effect of freeze-thaw cycles on the weight forM30 grade NWC and MWC are presented in **Tables 5.4 to 5.6**and in **Figures 5.6 to 5.11**

Tables 5.4 Effect of freeze-thaw cycle on properties of M30 grade NWC and MWC (28 DAYS OF CURING)

No. of Freeze-thaw cycles	NWC		MWC	
	Weight	% weight loss	Weight	% Weight loss
0	2.616	0.00	2.608	0.00
3	2.608	0.34	2.603	0.20
6	2.594	2.84	2.581	0.91
9	2.527	3.33	2.561	1.83
12	2.490	4.51	2.548	2.30
15	2.459	6.03	2.530	3.10

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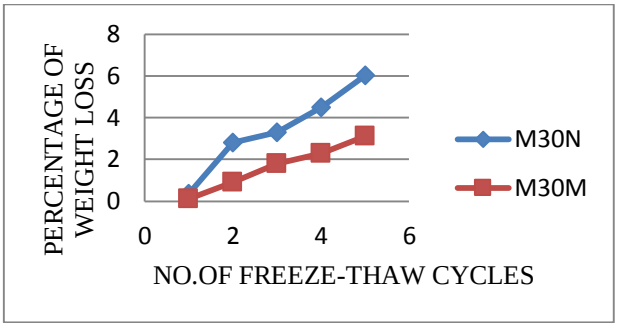

Figure 5.6 Percentage weight loss for M30 grade NWC and MWC (28 DAYS OF CURING)

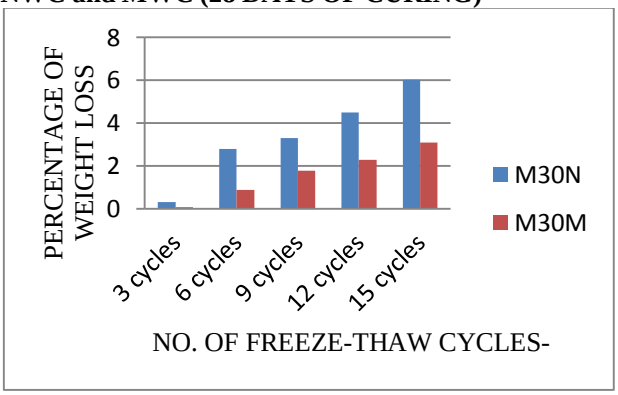

Figure 5.7 Comparison of % weight loss for M30 grade NWC and MWC(28 DAYS OF CURING)

Table 5.5 Effect of Freeze-Thaw Cycles on properties of M30 grade NWC and MWC (60 DAYS CURING)

No. of Freeze-Thaw cycles	NWC		MWC	
	Weight	% weight loss	Weight	% weight loss
0	2.640	0.00	2.626	0.00
3	2.631	0.22	2.621	0.19
6	2.614	0.98	2.615	0.40
9	2.584	2.10	2.602	0.91
12	2.532	4.09	2.584	1.61
15	2.497	5.40	2.573	2.02

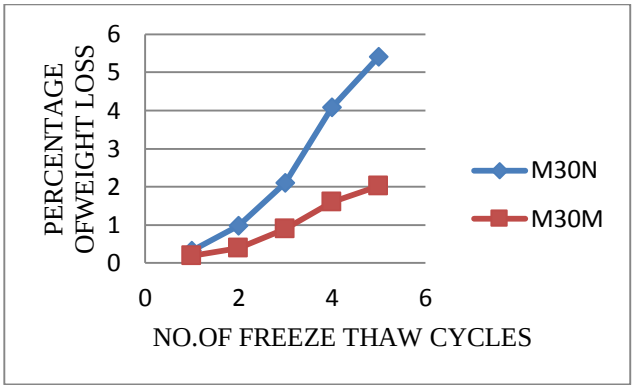

Figure 5.8 Percentage weight loss for M30 grade NWC and MWC (60 DAYS OF CURING)

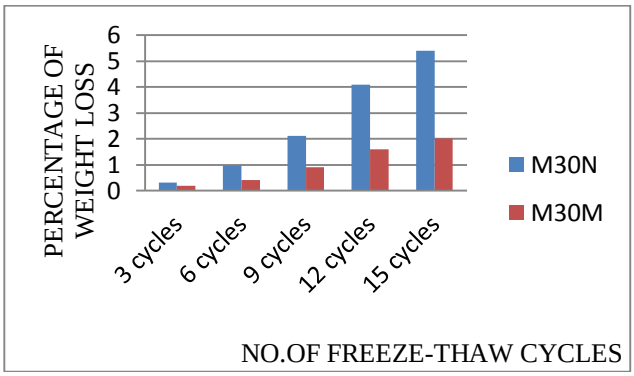

Figure 5.9 Comparison of % weight loss for M30 grade NWC and MWC (60 DAYS OF CURING)

Table 5.6 Effect of Freeze-Thaw cycles on properties of M30 grade NWC and MWC (90 DAYS OF CURING)

No. of Freeze-Thaw cycles	NWC		MWC	
	Weight	% weight loss	Weight	% weight loss
0	2.524	0.00	2.629	0.00
3	2.515	0.33	2.625	0.23
6	2.501	0.91	2.6184	0.41
9	2.478	1.80	2.607	0.82
12	2..465	2.32	2.602	1.13
15	2.448	3.00	2.597	1.20

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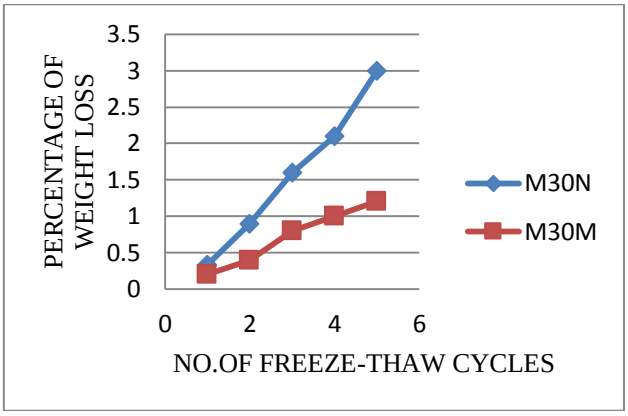

Figure 5.10 Percentage weight loss for M30 grade NWC and MWC
(90 DAYS OF CURING)

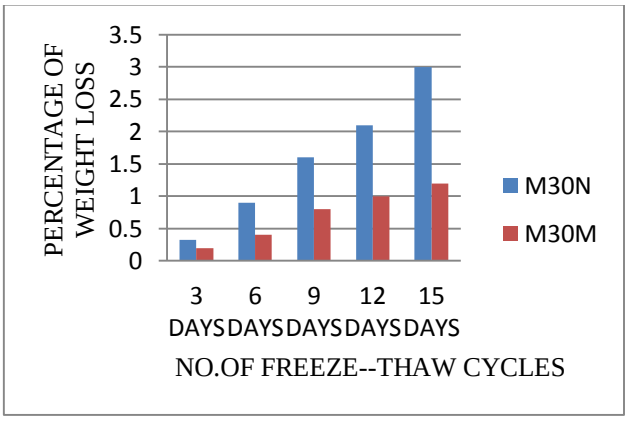

Figure 5.11 Comparison of % weight loss for M30 grade NWC and MWC
(90 DAYS OF CURING)

The experimental results showed that the loss of weight are more in NWC than in MWC specimens. It was observed that loss of weight of MWC when subjected to 15 cycles of freezing and thawing is less when compared to the NWC. This may be due to the fact that MWC may give rise to an optimal quantity of voids which can resist the freezing pressures successfully thus indicating better resistance to freezing and thawing. As seen from **Tables 5.4 to 5.6** and **Figures 5.6 to 5.11**, after 15 cycles of freeze-thaw, the Weight loss in NWC is in between 6.03%, 5.40%, 3.00% and in MWC specimens is 3.10%, 2.02%, 1.20% at 28, 60 and 90 days of curing respectively.

5.4 EFFECT OF MAGNETIC WATER ON ACID IMMERSION - M40 GRADE

The amount of percentage weight loss in M40 grade concrete when cubes immersed in 5%, 10%, 15% HCL for 28 days are presented in **Table 5.7** and variation is shown in **Figure 5.12, 5.13**and percentage strength loss is presented in **Table 5.8** and variation is shown in **Figure 5.14,5.15**

5.4.1 PERCENTAGE WEIGHT LOSS FOR M40 GRADE

Table 5.7 Percentage Weight loss for M40 grade NWC and MWC

Percentage of HCL	Normal water concrete			Magnetic water concrete		
	Average weight of cube before immersion (kg)	Average weight of cube after immersion (kg)	Weight loss in %	Average weight of cube before immersion (kg)	Average weight of cube after immersion (kg)	Weight loss in %
5 %	2.593	2.560	1.24	2.690	2.674	0.43
10 %	2.611	2.540	2.45	2.593	2.568	0.95
15 %	2.670	2.555	4.27	2.625	2.565	2.27

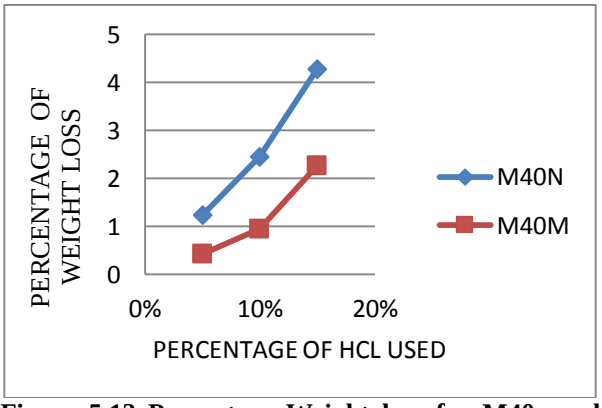

Figure 5.12 Percentage Weight loss for M40 grade NWC and MWC

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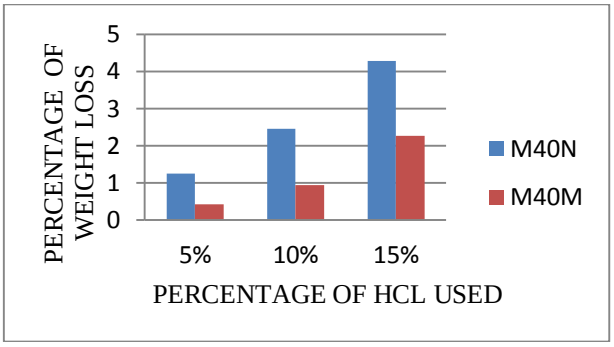

Figure 5.13 Comparison of % weight loss for M40 grade NWC and MWC

From **Tables 5.7** and **Figure 5.12 and 5.13** it is evident that percentage weight loss for M40 grade is more in NWC compared to MWC when cubes are subjected to different % of HCL. Since more hydration of cement takes place in MWC makes the microstructure of concrete dense thus results in less amount of scaling of surface and less reduction in strength of the concrete. As seen from **Table 5.7 and Figure 5.12 and 5.13**, the % weight loss in NWC is in between 1.24%, 2.45% and 4.27% and in MWC is 0.43%, 0.95% and 2.27%when immersed for 28 days in 5%, 10%and 15% of HCL respectively.PERCENTAGE STRENGTH LOSS FOR M40 GRADE

Table 5.8 Percentage strength loss for M40 grade NWC and MWC

Percentage of HCL	Normal water concrete			Magnetic water concrete		
	Average strength of cube before immersion (N/mm^2)	Average strength of cube after immersion (N/mm^2)	Strength loss in %	Average strength of cube before immersion (N/mm^2)	Average strength of cube after immersion (N/mm^2)	Strength loss in %
5%	41	38.65	5.71	50.4	49.10	2.56
10%	41	37.56	8.37	50.4	48.00	4.76
15%	41	32.10	21.70	50.4	44.30	12.10

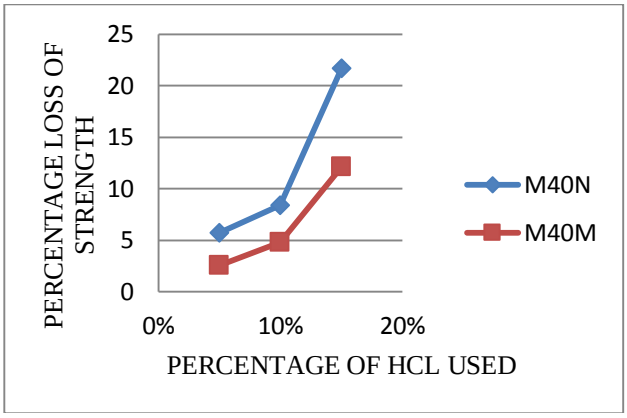

Figure 5.14 Percentage strength loss for M40 grade NWC and MWC

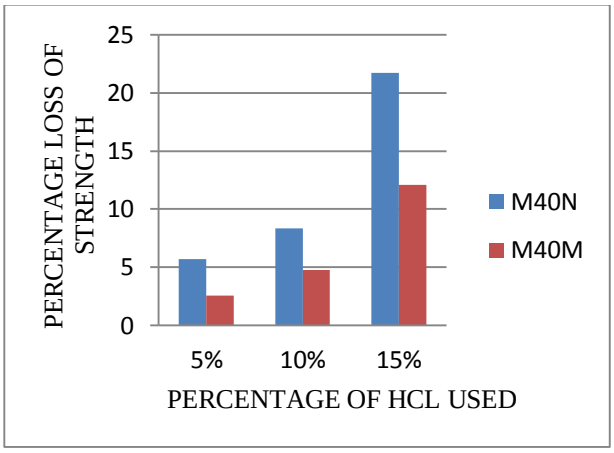

Figure 5.15 Comparison of % strength loss for M40 grade NWC and MWC

From **Tables 5.8** and **Figure 5.14 and 5.15** it is evident that percentage strength loss for M40 grade is more in NWC compared to MWC when cubes are subjected to different % of HCL. Since more hydration of cement takes place in MWC makes the microstructure of concrete dense thus results in less amount of scaling of surface and less reduction in strength of the concrete. As seen from **Table 5.8** and **Figure 5.14 and 5.15**, the % strength loss in NWC is in between 5.71%, 8.37% and 21.70% and in MWC is 2.56%, 4.76% and 12.10%when immersed for 28 days in 5%,10%, 15% of HCL respectively.

5.3 EFFECT OF MAGNETIC WATER ON FREEZE & THAW CYCLES - M40 GRADE

The effect of freeze-thaw cycles on the weight for M30 grade NWC and MWC are presented in **Tables 5.9 to 5.11**to and in **Figures 5.16 to 5.21.**

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Tables 5.9 Effect of freeze-thaw cycle on properties of M40 grade NWC and MWC (28 DAYS OF CURING)

No. of Freeze-Thaw cycles	NWC		MWC	
	Weight	% weight loss	Weight	% weight loss
0	2.621	0.00	2.598	0.00
3	2.612	0.33	2.593	0.25
6	2.595	0.80	2.588	0.41
9	2.559	2.33	2.559	1.55
12	2.526	3.68	2.544	2.13
15	2.474	5.60	2.536	2.40

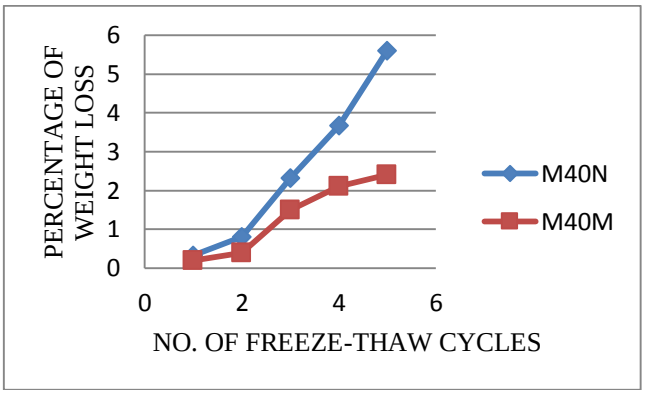

Figure 5.16 Percentage of weight loss for M40 grade NWC and MWC (28 DAYS OF CURING)

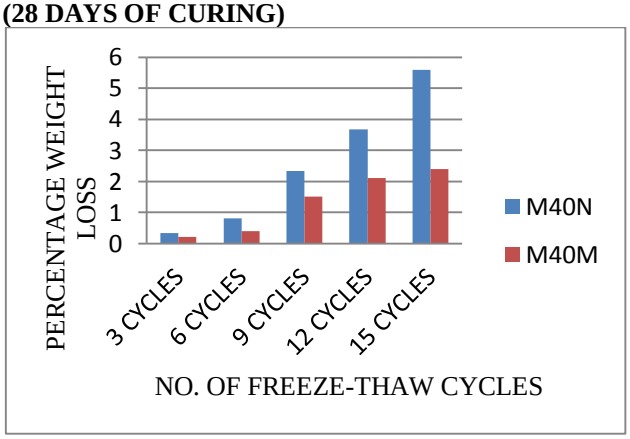

Figure 5.17 Comparison of % weight loss for M40 grade NWC and MWC (28 DAYS OF CURING)

Tables 5.10 Effect of freeze-thaw cycle on properties of M40 grade NWC and MWC (60 DAYS OF CURING)

No. of Freeze-Thaw cycles	NWC		MWC	
	Weight	% weight loss	Weight	% weight loss
0	2.615	0.00	2.574	0.00
3	2.605	0.41	2.569	0.25
6	2.565	1.93	2.561	0.52
9	2.555	2.36	2.551	0.91
12	2.526	3.41	2.543	1.21
15	2.511	4.20	2.525	1.90

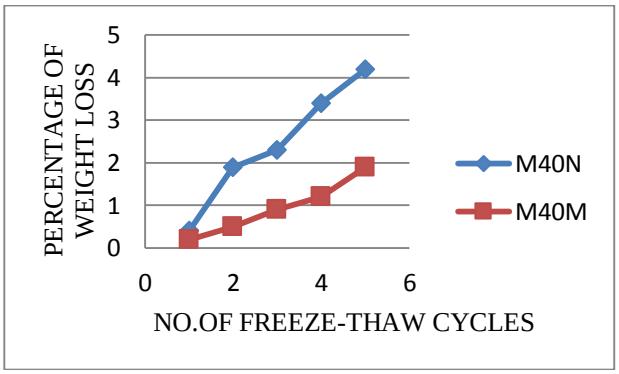

Figure 5.18 Percentage of weight loss for M40 grade NWC and MWC (60 DAYS OF CURING)

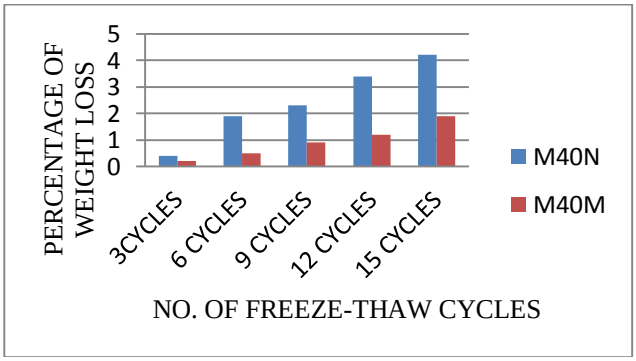

Figure 5.19 Comparison of % weight loss for M40 grade NWC and MWC (60 DAYS OF CURING)

Tables 5.11 Effect of freeze-thaw cycle on properties of M40 grade NWC and MWC (90 DAYS OF CURING)

No. of Freeze-Thaw cycles	NWC		MWC	
	Weight	% weight loss	Weight	% weight loss
0	2.632	0.00	2.582	0.00

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3	2.624	0.30	2.579	0.10
6	2.610	0.80	2.577	0.19
9	2.589	1.60	2.575	0.26
12	2.574	2.20	2.572	0.38
15	2.558	2.80	2.596	0.50

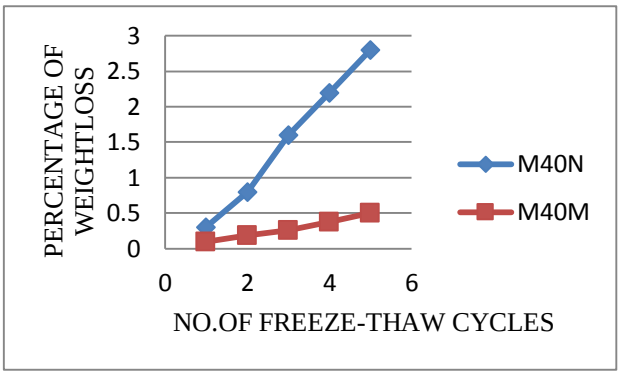

Figure 5.2 Percentage of weight loss for M40grade NWC and MWC
(90 DATYS OF CURING)

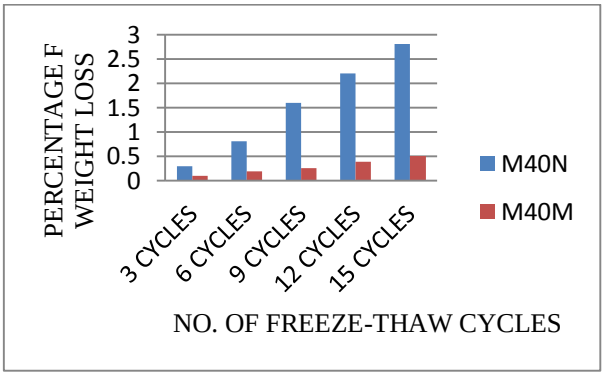

Figure 5.21 Comparison of % weight loss for M40 grade NWC and MWC
(90 DAYS OF CURING)

The experimental results showed that the loss of weight are more in NWC than in MWC specimens. It was observed that loss of weight of MWC when subjected to 15 cycles of freezing and thawing is less when compared to the NWC. This may be due to the fact that MWC may give rise to an optimal quantity of voids which can resist the freezing pressures successfully thus indicating better resistance to freezing and thawing. As seen from **Tables 5.9 to 5.11** and **Figures 5.16 to 5.21**, after 15 cycles of freeze-thaw, the Weight loss in NWC normal is in between 5.60%, 4.20%, 2.80% and in MWC specimens is 2.40%, 1.90%, 0.50% at 28, 60 and 90 days of curing respectively.

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