As per UGC guidelines an electronic bar code is provided to seure your paper

International Journal for Modern Trends in Science and Technology, 7(04): 34-42, 2021

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0704006
Available online at: http://www.ijmtst.com/vol7issue04.html

A Study on M40 and M45 grade Ordinary Portland Cement in Marine Environment

Pedapudi Maneendra Acharyulu[1] | J. Lakshmi Sudha[2] | Dr. Dumpa Venkateswarlu[3]

[1]PG Scholar, Department of Civil Engineering, Godavari Institute of Engineering & Technology, Rajahmundry.
[2]Assistant Professor, Department of Civil Engineering, Godavari Institute of Engineering & Technology, Rajahmundry.
[3]Professor & Head, Department of Civil Engineering, Godavari Institute of Engineering & Technology, Rajahmundry.

To Cite this Article
J. Roshan and Dr. D. Ashokaraju, "Compensation of Voltages Sag and Swell using Dynamic Voltage Restorer", *International Journal for Modern Trends in Science and Technology*, Vol. 07, Issue 04, April 2021, pp.:34-42.

Article Info
Received on 25-February-2021, Revised on 24-March-2021, Accepted on 27-March-2021, Published on 31-March-2021.

ABSTRACT

Concrete is the universally accepted building material used for construction purpose and it is the second most used material used in the world next to water. Out of many advantages of using the concrete because of their mechanical properties, yet there were some limitations to the concrete in view of brittleness of the concrete, poor tensile strength properties and low durability under marine environments. Also, there were very limited studies on the mechanical and durability properties or behaviour of concrete subjected to Marine environment or aggressive environment conditions. In the present study, it is proposed to study the strength and the durability properties of the concrete in marine environment for M40 and M45 grade of concrete. Different set of cubes were casted for both M40 and M45 grade of concrete, cured under natural curing condition as well as in saline water of salinity 35 PPM an equivalent salinity of sea water for 7 days, 28 days, 90days, 180 days and the corresponding mechanical and durability properties were compared. The test results showed that, there was no considerable change or difference in the normally cured and saline water cured concrete for both the grades of concrete.

KEYWORDS: *Concrete, M40 grade, M45 grade, curing, saline water curing, mechanical properties, Durability*

I. Introduction

Concrete is the most common constructive material in the world used for around centuries due to its very strong and versatile mouldable nature. There are number of reasons why concrete is preferable i.e. due to its ability to withstand deterioration, resistance to high temperature and it is economically cheapest and readily available constructive material with the mixture of cement, fine aggregate, coarse aggregate, water. Concrete being such strongest material, is also being deteriorated due to environmental problems. The effect due to such pollution is questioning the strength properties of concrete which leads to collapse of the structure.

The pollution here, in this research, refers to the different kinds of chemicals that react with the concrete structure such as different industrial wastes that have been dumped into the land, so when construction in such areas takes place then the chemicals that are present reacts with the concrete structure and may damage the integral properties of concrete. Also, when the construction activity takes place offshore then the salts present in the sea water also may cause damage to the concrete structure not directly but by the prolonged chemical reactions that take place.

Hence it seems necessary to improve the ability or to improve the mechanical properties of concrete in different ways possible so that the chemicals or the salts present in the surrounding environment of concrete does not affect the properties of the concrete structure. The properties of concrete can be enhanced by the use of different fibres, mineral and natural admixtures. Many researches have been made and many developments have been done on the durability and strength properties of concrete so that it should sustain for a long period irrespective of any environmental conditions.

A.Environmental effect on concrete

The role of concrete and how does it fit in this world of construction industry is simple but wide ranging. There may be limitations but the concrete as a construction material is highly used and identified as a provider of nations infrastructure to economic progress and to quality of life. . It is very easily & readily prepared and finished into all sorts of conceivable shapes and structural systems in the realms of infrastructure, habitation, transportation, work and play. Its great simplicity lies in that its constituents are most readily available anywhere in the world; the great beauty of concrete, and probably the major cause of its poor performance, on the other hand, is the fact that both the choice of the constituents, and the proportioning of its constituents are entirely in the hands of the engineer and the technologist.

Alkalinity is the most important and best quality of the cement making it for having the safe mechanism and anti-corroding environment for the proposed steel reinforcement in the structures. This was understood from a vast experience and clear understanding of the properties of the material from the collection if the various experimental data and it has confirmed that concrete will be very effective in the strength and durability point of view unless it was exposed to aggressive environments or materials that exhibit the aggressive properties. There is also a sufficient evidence, even though concrete is exposed to a aggressive environment, it's inherent strength and durability properties can be safeguarded by means providing sufficient fabrication to the concrete followed by well-planned maintenance practices.

B. Deterioration and cracking of concrete

The concrete is one of the best material in the practicing construction industry and it is having a everlasting durability property which can be completely impaired without any fault from the concrete itself and it is because of the chemical reactivity of the aggressive materials with changing environmental conditions and the exposure conditions of the concrete. the use of reinforcing steel in the concrete leads to the development of some of the serious problems in the concrete unless a proper cover is provide to the steel. If sufficient cover is not provided to the steel reinforcement, the protection layer named as the passive layer will start depleting and then the steel reinforcement will start corrosion by means of ionisation of the ferrous ions which results in the volume expansion of the concrete resulting in the spalling if the concrete on the faces of the structural members. Lack of sufficient methods to protect and assess the premature failure of the section is very difficult in the case of concrete sections. After the damage has occurred, a details investigation is required in order to identify the reasons behind the distress and to estimate the intensities or the quantities of the material damaged by means of visual methods, destructive and non-destructive methods. Also the problems in the concrete will be associated with so many factors including the practice of material production, design, expertise of the construction, environmental condition during and after the construction, maintenance schemes and practices, repair and rehabilitation strategies.

The important and major three factors that accommodate the travel of the aggressive natured materials or agents through the concrete, and influencing its service life, design life period and safety are cracking of concrete, depth and quality of reinforcement cover, and the overall quality of the concrete. These three are the factors responsible for the entry of the aggressive and deterioration causing agents like water, chloride, air and sulphatic ions. Carbon dioxide, Chloride and sulphatic ions are the responsible for the mechanism of the carbonation, chloride ingress and sulphate attack on the reinforced concrete elements.

Figure. 1 deterioration of concrete due to aggressive conditions

III. RELATED WORK

Akinsola Olufemi Emmanuel et al., (2012) published a paper on "Investigation of Salinity Effect on Compressive Strength of Reinforced Concrete." This paper includes:_The laboratory controlled experiment approach, in order to induce the worst scenario of concrete mix and determine the consequent effect on reinforced concrete element; a mix ratio of 1:3:6 was adopted for the experiment. Reinforced concrete elements were cast using both lagoon and ocean water while fresh water was used as a control experiment. These samples were buried at a depth of 1.5m below the ocean and lagoon bed soil characteristics and observed for a period of 150 days. Both the ocean and the lagoon samples increases in compressive strength from 10.65N/mm2 and 10.57N/mm2 on 7th day to 17.05N/mm2 and 18.04N/mm2 on the 21st day respectively as against the 14.20N/mm2 on 7th day to 17.05N/mm2 and 18.04N/mm2 fresh water sample. On 14th day fresh water sample has 17.48N/mm2 as against 12.10N/mm2 and 12.55N/mm2 recorded for both ocean and lagoon water samples. The findings revealed that concrete sample cast and cured with fresh water gained appreciable compressive strength over 150 days period while sample cast and cured with ocean and lagoon water slowly increase in strength but lower when compared with fresh water reinforced concrete element. Therefore the study recommended that a rich mix other than 1:3:6 and 1:3:5 i.e. after trials 1:2:4 be strictly enforced on construction sites for concrete under saline attack, increase concrete cover be used for protection against corrosion, and that non-destructive test be carried out on all formworks under vertical loads like slabs and beams before they are stripped.

Akshat Dimri et al., (2015) published a paper on "A Review on Strength of Concrete in Seawater." This paper includes: _As there is a scarcity of fresh drinkable water around the world; so there is a need to save fresh water and hence possibilities of using seawater as mixing as well as curing water should be investigated seriously. However; most of the reinforced concrete codes do not permit the use of seawater due to risk of early corrosion of reinforcement. The effect of seawater on concrete deserves special attention as the coastal and offshore structures are exposed to simultaneous action of a number of physical and chemical deterioration processes. Moreover, 80 percent of the earth is covered by seawater either directly or indirectly (e.g. winds can carry sea water spray up to a few miles in land from the coast). Concrete piers, decks, break-water, and retaining walls are widely used in the construction of harbours and docks. The use of concrete offshore drilling platforms and oil storage tanks is already on the increase. This paper illustrates the various research and their results that were carried out earlier on the experimental studies on the strength of concrete in seawater.

Haseeb Khan et al., (2016) published a paper on "Effect of Saline Water in Mixing and Curing on Strength of Concrete." This paper includes:_The effects of sodium chloride (NaCl) solutions as mixing and curing at concentrations of 1g/l, 2g/l, 4g/l, 6g/l and 8g/l .A total of 72 concrete cubes, using metal mould of 150 X 150 X 150mm size, were cast with, chemicals and fresh water. 12 cubes of concrete were mixed and cured in fresh water. 60cubes were mixed and cured in sodium chloride. The compressive strength of the cubes determined through crushing at 7, 28 and 48 days respectively. These cubes were cured for 7, 28 and48 days and were tested for compressive strength respectively. For this concrete cubes were cast for a design mix of M-30, 1: 1.46: 2.64 by weight and 0.42 water cement ratio.

Qingyong Guo et al., (2017) published a paper on "The Effect of Mixing and Curing Sea Water on Concrete Strength at Different Ages." This paper includes:_In the research, the effects of sea water for mixing, curing on the gain in strength of different grades of concrete was investigated. A total of192 concrete cubes were tested for their compressive strength. The study shows that sea water affects the rate of gain in strength of concrete when used for mixing or curing. The strength of concrete made by using sea water was observed to be decreased by about 15% as compared to the similar concrete specimens made and cured with fresh water at 90 days. The concrete with higher strength showed poorer resistance against strength deterioration as compared to the lower strength concrete which used sea water for curing. And the concrete made with sea water decreased the stability of concrete properties.

LATEEF IGE RAIMI et al., (2010) carried out research work to investigate the effect of seawater concentration, as mixing or curing, on the compressive strength of concrete. They found the result of the action of salt water from Lagos Barbeach, in Nigeria, on concrete compressive strength. They took a total of 144 concrete cubes of 150 X 150 X 150 mm size, mixing ratio of 1:2:4 and a water cement ratio of 0.6, were cast with seawater, fresh water and blending of seawater. The cubes were divided in two and cured in seawater and fresh water respectively. The compressive strength of the cubes determined through crushing at 7, 14, 21 and 28 days respectively. The weekly pH and temperature readings of curing seawater and fresh water were taken at interval of time, including the pH and temperature of unused seawater. They observed the pH value and percentage composition by mass of compounds: NaCl, CaS04, KBr, K2S04 and MgS04. They found that compressive strength of concrete cast with seawater showed an increase in strength at 7, 14, 21 & 28 days. A remarkable rapid increase was noted in concrete cubes cast and cured with seawater at 7, 14, 21& 28 days respectively. Also, concrete cubes cast with fresh water and cured with seawater have their strength increased at 7, 14, 21 & 28 days as well. At 7days of curing, concrete cast with seawater and cured with seawater has attained strength of about 79% of the 28days compressive strength of the control test. So that at 28days, SS (cubes cast with seawater and cured with seawater) has attained strength of about 114% of 28days compressive strength of control.

III.EXPERIMENTAL STUDY MATERIALS AND METHODS

In this section, materials properties and concrete mix design calculations for M40& M45 grade concrete in detail was presented. Mix design summary for M40 and M45 under study are covered in this section.

A.Materials and their properties:

Materials adopted in this study are:

- CEMENT - OPC 53 grade for mix of M40 and M45 grade of concrete
- FINE AGGREGATE - ZONE II
- COARSE AGGREGATE - Well graded aggregates (20mm-40%, 16mm-40% & 10mm-20%)
- CHEMICAL ADMIXTURE – Conplast sp-430 superplasticizer is used.
  CHEMICAL SOLUTIONS – HCl (hydrochloric acid), $MgSO_4$, Saline Water.

Now, the compressive strength can be calculated as:

Compressive strength of concrete= (max load carried by specimen/top surface area of specimen)

Table 1Physical properties of cement

S. No	Property	Test results
1	Normal consistency	32%
2	Specific gravity	3.15
3	Initial setting time	45 minutes
4	Final setting time	545 minutes
5	Compressive strength at	
	3days	21.40 N/mm^2
	7days	35.12 N/mm^2
	28days	55.06 N/mm^2

IV. TEST RESULTS AND DISCUSSION

In this section the results of the mechanical properties of the concrete are shown. The concrete specimens of M40 and M45 grade of concrete are casted and are cured in fresh water as well as the same cubes are cured in the saline water of salinity 35PPM which is an equivalent to the salinity of sea water and the test results for those different curing conditions is compared.

As part of durability studies the same set of cubes which were cured in fresh water and saline water for 28 days were subjected to cure in 5% HCl and 5 normality $MgSO_4$solutions for further 28 days and the percentage weight loss and the loss of compressive strength are presented.

Experimental results on fresh concrete:

The tests that are conducted on the fresh concrete here are slump test, compaction factor test, flow test, Kelly ball test, vee- bee consistometer test. The tests and their procedures as discussed are conducted and the test results are explained in detail below.

Slump cone test:

The slump cone test is done for the determination of workability of concrete, the consistency indicates how much the water is used in the mix. The consistency and the stiffness of the concrete mix should be matched to the requirements of finished concrete and the test is conducted and the material presentation is shown below.

Figure Slump cone test

Height = 30cms

Top diameter = 10cms

Bottom diameter = 20cms

V = $\pi/3[(0.05)^2+(0.1)^2+(0.05 \text{ X } 0.1)]0.3$

= 0.0054 m^3

(Cement : fine aggregate : coarse aggregate = 1 : 1.73 : 3.13)

cement = 1/ 1+ 1.73+ 3.13 x 1440 x 1.52 x 0.00549 = 2.050

fine aggregate = 1.73 x 2.050 = 3.546kg

coarse aggregate = 3.13 x 2.050 = 6.416kg

the slump value = 100mm.

Experimental results on hardened concrete:

The tests that are basically and mainly conducted after the hardening of concrete are compressive strength test and split tensile strength test. By doing these tests the strength properties of the hardened concrete are revealed. The cubes and the cylinders with the dimensions 150x150x150mm and 300x150x150mm respectively, are cast and cured in both the normal water conditions and acidic and aggressive conditions and are checked for their strength properties and they are explained below.

Compressive strength test:

The compressive strength of cubes is calculated by using a compressive testing machine and after testing the cubes with different percentages of steel and glass fibres added to it at the age of 28days and 56days, the results are shown below with a graphical representation as well.

Calculations:

Size of the cube =150mm x150mm x 150mm

Area of the specimen (calculated from the mean size of the specimen) x c=225cm^2

Cube compressive strength = load / cross-section area

1) 6.3.2 Flexural strength test:

The modulus of rupture is the main property for the flexural members. To improve the flexural strength of concrete is one main task in present construction activities.Flexuralstrengthforconcreteisdetermined bycastingbeamspecimens.The beam dimensions are of 500mm x 100mm x 100mm.

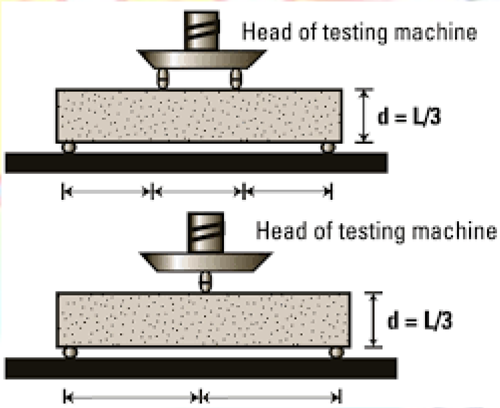


Figure Flexural Test

2) 6.3.3 Split Tensile Strength

Out of all the properties of concrete, tensile strength is very important one.The tensilestrengthiscalculatedbytestingcylindricalspe cimensofsize300mmheightand 150mm diameter. Here each set of specimens are tested for 28 days of curing.

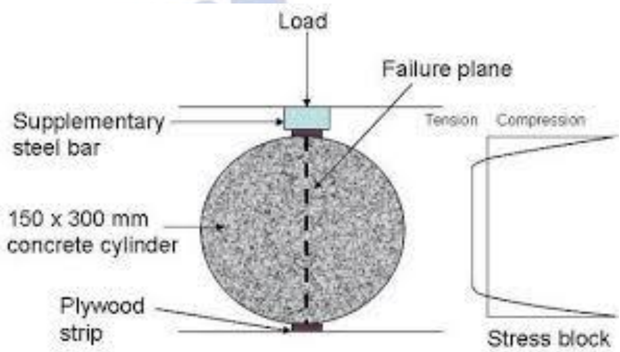


Figure Split tensile strength

COMPRESSIVE STRENGTH RESULT :

Table Compressive strength for M40 grade concrete

Compressive Strength (MPa)				
S.NO	**Curing Period**	**Normal Curing**	**Saline Curing**	**% Variation of Strength**
1	7 days	32.35	31.89	1.42
2	28 days	49.53	48.26	2.56
3	90 days	51.21	50.3	1.78
4	180 days	51.96	50.98	1.89

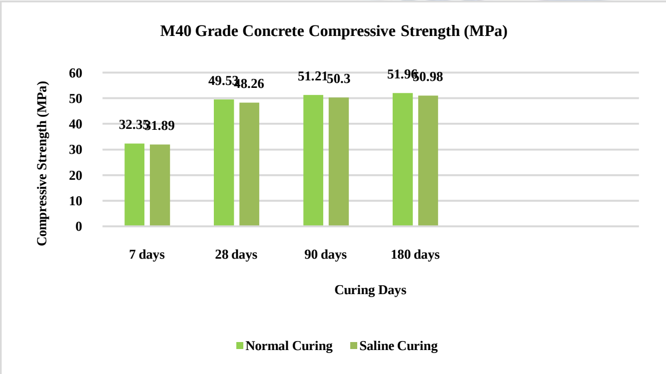


Figure Compressive strength for M40 grade concrete

Table 2Compressive strength for M45 grade concrete

Compressive Strength (MPa)				
S.NO	**Curing Period**	**Normal Curing**	**Saline Curing**	**% Variation of Strength**
1	7 days	35.45	34.89	1.58
2	28 days	53.86	52.84	1.89
3	90 days	53.97	53.02	1.76
4	180 days	54.31	53.35	1.77

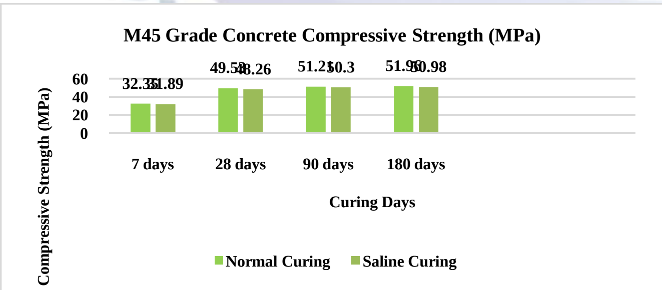


Figure 2Compressive strength for M45 grade concrete

FLEXURAL STRENGTH RESULT :

Table Flexural strength for M40 grade concrete

Flexural Strength (MPa)				
S.NO	**Curing Period**	**Normal Curing**	**Saline Curing**	**% Variation of Strength**
1	7 days	4.55	4.48	1.54
2	28 days	6.95	6.76	2.73
3	90 days	7.09	6.98	1.55
4	180 days	7.21	7.09	1.66

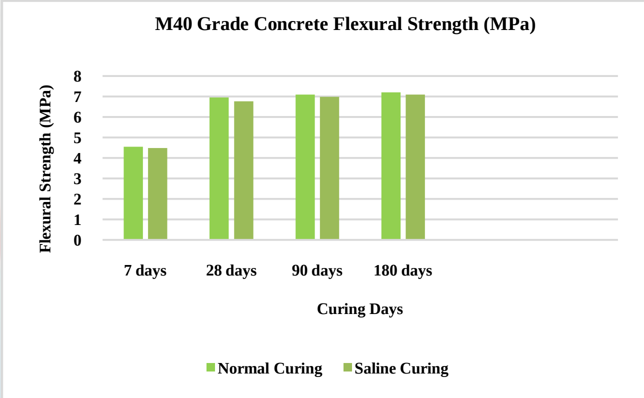


Figure Flexural strength for M40 grade concrete

Table 3Flexural strength for M45 grade concrete

Flexural Strength (MPa)				
S.NO	**Curing Period**	**Normal Curing**	**Saline Curing**	**% Variation of Strength**
1	7 days	35.45	34.89	1.58
2	28 days	53.86	52.84	1.89
3	90 days	53.97	53.02	1.76
4	180 days	54.31	53.35	1.77

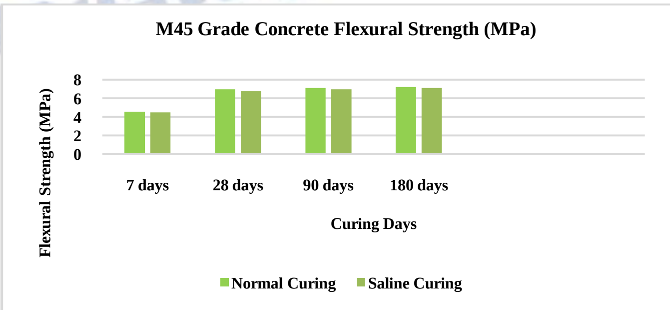


Figure Flexural strength for M45 grade concrete

SPLIT TENSILE STRENGTH RESULT :

Table 4Split tensile strength for M40 grade concrete

Split Tensile Strength (MPa)				
S.NO	**Curing Period**	**Normal Curing**	**Saline Curing**	**% Variation of Strength**
1	7 days	2.43	2.36	2.88
2	28 days	3.74	3.67	1.87
3	90 days	3.76	3.69	1.86
4	180 days	3.81	3.72	2.36

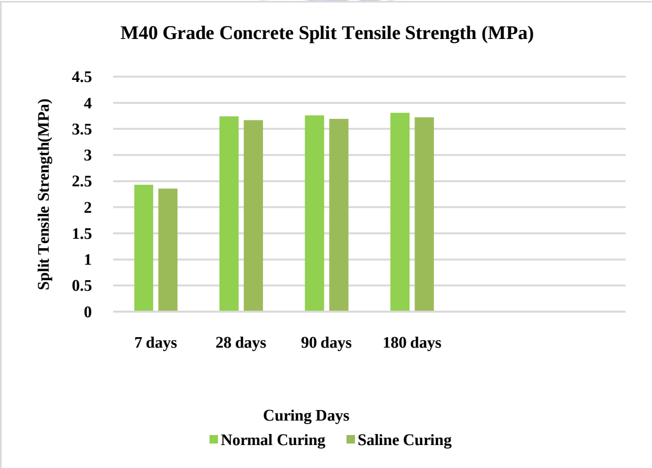


Figure Split tensile strength for M40 grade concrete

Table 5Split tensile strength for M45 grade concrete

Split Tensile Strength (MPa)				
S.NO	**Curing Period**	**Normal Curing**	**Saline Curing**	**% Variation of Strength**
1	7 days	2.46	2.39	2.85
2	28 days	3.85	3.79	1.56
3	90 days	3.87	3.81	1.55
4	180 days	3.9	3.83	1.79

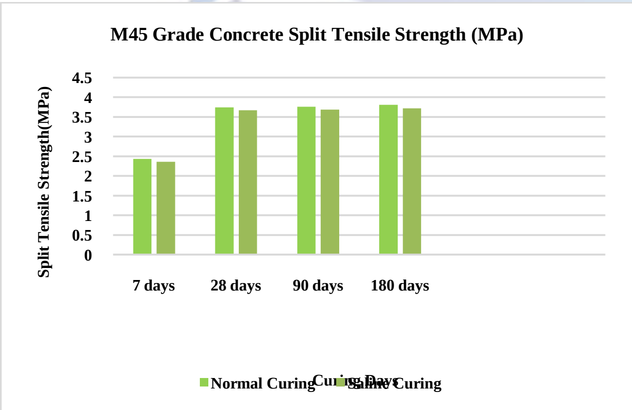


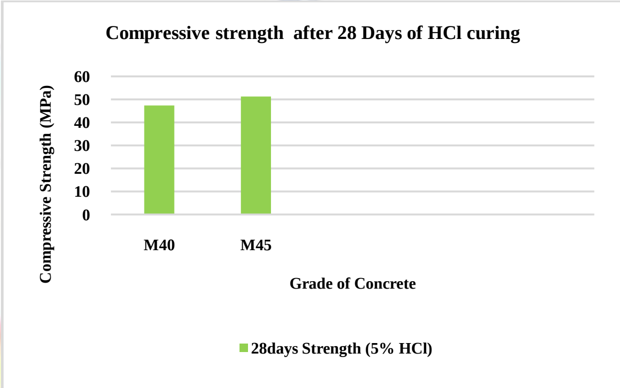
Figure Split tensile strength for M45 grade concrete

Durability Studies

5% HCl Curing:

Table 6% Compressive strength and % weight loss after 28days of 5% HCl Curing

% Weight loss and Compressive strength(N/mm^2)					
S.NO	**Grade of Concrete**	**% weight loss after 28 days**	**28 days strength**	**28days Strength (5% HCl)**	**% Strength loss**
1	M40	2.26	49.53	47.32	5.23
2	M45	2.27	53.86	51.23	4.88



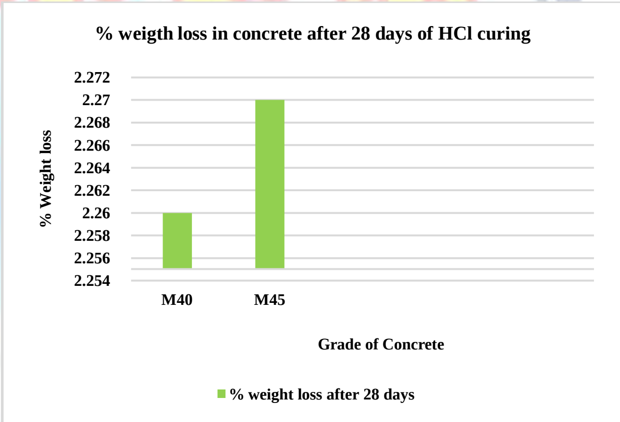
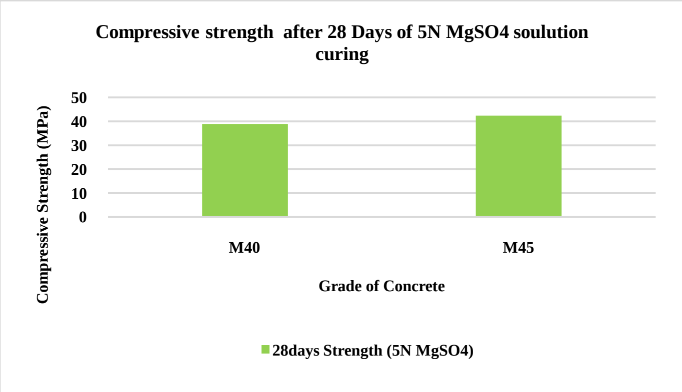


Figure % Compressive strength and % weight loss after 28days of 5% HCl Curing

5N $MgSO_4$ Curing:

Table 7 % Compressive strength and % weight loss after 28 days of 5N $MgSO_4$ Curing

% Weight loss & Compressive strength(N/mm^2)					
S.NO	**Grade of Concrete**	**% weight loss after 28 days**	**28 days strength**	**28days Strength (5 N MgSO4)**	**% Strength loss**
1	M40	3.86	49.93	38.91	22.07
2	M45	3.95	53.86	42.36	21.35



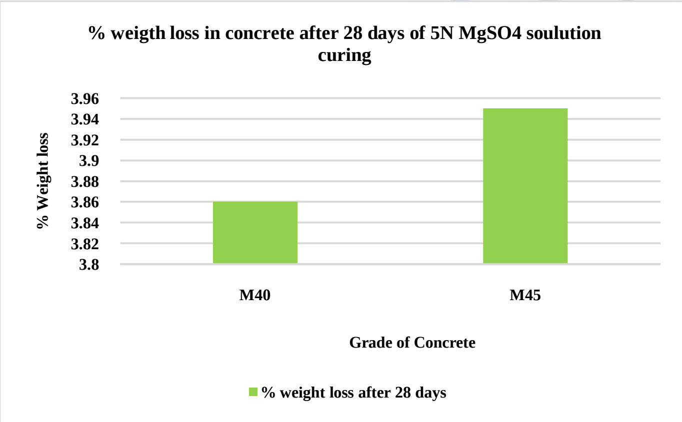


Figure **Compressive strength and % weight loss after 28 days of 5N $MgSO_4$ Curing**

V. CONCLUSION

- Compressive strength, Flexural strength and the Split tensile strength of the mix is not differing much when the concrete is cured in fresh water or in saline water.
- The average percentage loss of strengths are 1.91, 1.87 and 2.24 in compression, flexure and split tensile strength respectively for M40 grade concrete when cured in potable water and saline water of salinity 35PPM.
- The average percentage loss of strengths are 1.75, 1.75 and 1.94 in compression, flexure and split tensile strength respectively for M45 grade concrete when cured in potable water and saline water of salinity 35PPM.
- Loss of Compressive strength of the concrete is more under the action of $MgSO_4$ than HCl as sulphate ions reacts with the components of cement which leads to the decrease in strength.
- Average percentage loss of compressive strength for HCl curing and $MgSo_4$ curing is 5.06 and 21.71 respectively.
- Deterioration of concrete is observed more when it is cured in saline water than the potable water curing.
- % of weight loss is more when the concrete is cured in $MgSO_4$ solution when compared with 5% concentration of HCl curing.
- % Weight loss is more in M45 grade concrete is more when cured in both 5% HCl and $MgSO_4$.

REFERENCES

[1] Akinkurolere,O.O., iang, and Shobola O. M. (2007) "The Influence of Salt Water on the Compressive Strength of Concrete", Journal of Engg. and Applied Sciences, Vol.2 No.2, pp.412-415.

[2] Akinsola Olufemi, Emmanuel., Fatokun Ajibola, Oladipo & OgunsanmiOlabode E., (2012) "Investigation of salinity effect on compressive strength of reinforced Concrete", Journal of Sustainable Development; Vol.5, No.6; Published by Canadian Center of Science and Education.

[3] Bella, M.&Fabuss, T.(1989).Properties of Seawater. 1st Edition of Academic Press Boston.

[4] Bryant, M. (1964). Effects of the Seawater on Concrete. Miscellaneous paper no6-690, US.-Army-Engineers, Waterways-experiment-station, Corps of Engineers, Vicks berg, Mississippi.

[5] E. M. Mbadike (2011),"Effect of saltwater in production of concrete",Nigerian Journal ofTechnology, Vol. 30, No. 2.FalahM.Wegian; (2010), "Effects of seawater for mixing and curing on structural concrete Studies", The IES Journal Part A:Civil&Structural Engineering, Vol.3, No.4,pp235 –243.

[6] Gani,S.J.(1997).Cement and concrete (1st Ed)Chapman & Halls. Pp:149-169.

[7] Gayner. J.F.C. (1979) "Concrete in hot climates".Precast concrete Vol.10,No.4,pp.169-172.

[8] Hoff,G.C.(1991).Durabilityof offshore andmarine concrete structures; 2nd internationalconference,1991 pp.33-64.

[9] Kaushik, S. K. and IslamS. (1995), "Suitability of seawater formixing structural concreteexposed to a marine environment", Cement & concrete composites, Vol.17, No.3, pp.177-185.

[10] LangfordP,Broomfield J.Monitoring the corrosion of reinforcing steel. Constr Repair 1987;1(2):32–6.

[11] Broomfield J, Rodrıguez J, Ortega L, Garcıa M. Corrosion rate measurement and life prediction for reinforced concrete structures. In:Proceedings of Structural Faults and Repair'93. University of Edinburgh:Engineering Technical Press;1993. p.155–64.

[12] Tuutti K.Corrosion of steel in concrete. Stockholm: Swedish Cement and Concrete Research Institute; 1982.

[13] Gonzalez J, Andrade C, Alonso C, Feliu S. Comparison of rates of general corrosion and maximum pitting penetration on concrete embedded steel reinforcement. Cem Concr Res 1995;25(2):257–64.

[14] LeeS,Reddy D,HarttW,Arockiasamy M,O'Neil E. Marine concrete durability. Condition survey of certain tensile crack exposure beams at Treat Island, ME,US. In:Malhotra VM,editor. Proceedings of the Third CANMET/ACIInternational Conference on Durability of Concrete, ACISP-145.1995.p.371– 88.

[15] Andrade C,AlonsoC. Corrosion rate monitoring in laboratory and on-site. Constr Build Mater 1996;10(5):315–28.

[16] Broomfield J.Corrosion of steel in concrete – understanding, investigation and repair.London:E&FN Spon;1997.

[17] CostaA, AppletonJ. Chloride penetration into concrete in marine environment – Part II:Prediction of long term chloride penetration.Mater Struct1999;32(6):354–9.
[18] Strategies for testing and assessment of concrete structures.Comitte of Euro-International du Beton,Bulletin 243,1998.
[19] ChessP,Gronvold F.Corrosion investigation:a guide to half-cell mapping.London: Thomas Telford;1996.
[20] Corrosion of metals in concrete.ACI222R-85.ACI J 1985;(January–February):3–31.
[21] Durable bonded post-tensioned concrete bridges.Concrete Society of Technical Report 47,1996.
[22] Andrade C,Alonso C,Molina F.Cover cracking as a function of bar corrosion:Part I– Experimental test.Mater Struct 1993;26:453–64.