A Thesis on

EXPERIMENTAL STUDY ON CONCRETE USING SALINATED AND DESALINATED WATER

Submitted for partial fulfillment of the requirement for the award of the degree

MASTER OF TECHNOLOGY

In

M.TECH STRUCTURAL ENGINEERING

By

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DECLARATION

I declare that the research thesis entitled " EXPERIMENTAL STUDY ON CONCRETE USING SALINATED AND DESALINATED WATER" is the bonafide research work carried out by me, under the guidance of Mr Tabish Izhar (Assistant Professor), Department of Civil Engineering, Integral University, Lucknow. Further I declare that this has not previously formed the basis of award of any degree, diploma, associate-ship or other similar degrees or diplomas, and has not been submitted anywhere else.

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Place: Lucknow

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CERTIFICATE

*Itis Certified that the thesis entitled "***Experimental study on concrete using salinated and desalinated water***" is being submitted by* **Mr Usman Ahmed Usmani (Roll no 2001431011)** *in partial fulfillment of the requirement for the award of degree of Master of Technology* **(Structural Engineering)** *of Integral University, Lucknow, is a record of candidate's own work carried out by him/her under my supervision and guidance.*

The results presented in this thesis have not been submitted to any other university or institute for the award of any other degree or diploma.

Mr. Tabish Izhar

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ABSTRACT

In today's world increasing industrialization has increased the demand for new buildings. Water plays an important role in making concrete. In this research work comparative study of the effect of saline water, desalinate water and normal water is investigated. For this research work concrete cubes and prism were cast and the mix design was targeted for M-25 grade concrete. For calculation purpose M 25 grade of concrete has been designed on the basis of IS code 10262-2019 by casting and curing salt water in comparision with normal water and desalinated water . For compressive strength of concrete 15 cubes were casted of size 150mm x 150mm x 150mm for 28 days. For flexure strength of concrete prism was casted of size 100mm x 100mm x 500mm for 28 days. The test of compressive and flexure strength of concrete has been shown in graph. Average compressive strength of cube casted and cured with saline water was 31.6 MPa which is greater than the cube casted with desalinated water and cured with normal water is 29.86 MPa which denotes the strength hardening of the concrete accelerated due to the presence of salts in concrete. XRD analysis of the all the specimen shows that the formation C-S-H gel was proper and the mix design is accurate.

CHAPTER 1
INTRODUCTION

1.1 Background

Nowadays, the increasing population had increased industrialization, and urbanization had increased the development of new technology which demands the latest design buildings. Freshwater is majorly used in the making of concrete and regular use of fresh water in concrete has increased the demand for fresh water for drinking. Water scarcity involves water stress, water shortage or deficits, and water crisis. This may be due to both nature and humans. The main factors that contribute to this issue include poor management of resources, lack of government attention, and man-made waste. 18 percent of the world's population which resides in India only has access to 4 percent of usable water sources. Official data in the past decade depicts how annual per capita availability of water in the country has plummeted significantly with 163 million Indians lacking access to safe drinking water.

When contemplating our world's most precious resources, past conversations often centered around fossil fuels and the consequences once those become scarce. However, recent times have given us an abundance of alternative energy options and new technologies either in use or on the horizon. These innovations have turned the conversation to a resource that, on a basic level, is readily abundant and covers two-thirds of the earth's surface. Though 70% of the earth is covered in water, only 2% of it is fresh. Further complicating the issue is that 1.6% of that freshwater is contained in glaciers and polar ice caps. Many third-world and developing countries struggle with ensuring this basic tenant of our existence is both available and safe. Nowhere is this more apparent than in India.

With the planet's second largest population at 1.3 billion, and expectant growth to 1.7 billion by 2050, India finds itself unable to serve the vast majority of that populace with safe, clean water. Supporting 16% of the world's inhabitants is daunting enough, but it is even more so when recognizing that the population is crammed into an area one-third the size of the United States. Then consider that India only possesses 4% of the world's fresh water and the crisis can be more fully realized. India may not be the only nation in this predicament, but theirs is at a stage more critical than most. Severe lack of regulation, over privatization, general neglect and rampant government corruption have led to multiple generations thirsting for more than just a few drops of hazard-free water. The situation has grown to the point that regional disputes have arisen over access to rivers in the country's interior. Those disputes take on a global scale in conflicts with Pakistan over the River Indus and River Sutlej in the west and north and with China to the east with the River Brahmaputra.

Surface water isn't the only source reaching a breaking point. Tracing back several generations, the critical situation in India can be linked to a myriad of causes. In modern times though, the concern has moved from the surface to the ground. And it's there where India's freshwater is under the greatest stress. Over the past 50 years, policies have allowed what amounts to a free-for-all in groundwater development and as the crisis has grown it has been met with continued neglect, mismanagement and overall indifference. Estimates put India's groundwater use at roughly one-quarter of the global usage with total usage surpassing that of China and the United States combined. This unfettered draining of groundwater sources has accelerated over the past two decades. With the aggressive pumping, particularly in rural areas, where agriculture provides the livelihood for upwards of 600 million Indians, Mother Nature is often the difference in a good year and a devastating one. Relying on monsoon rains without proper irrigation or water management techniques has been a recipe for disaster. Mismanagement and corruption often draw the largest headlines, but many of India's leaders have also been slow or unwilling to adapt to newer technologies or cohesive plans to address the issues. The response can at best be described as irresponsible. Consider China, a country with roughly 50 million more people, uses a quarter less freshwater.

The extraction of freshwater has significantly increased dramatically over the past century and continues to increase in most parts of the world. Between 1950 and 1980, the growth rate was particularly high due to the increase in population and the rapid development of groundwater. The largest share of the world's fresh water intake is in Asia.

Water had been globally increased six-fold over the last 100 years and continues to grow steadily at a rate of about 1% per year as the population grows, economic development, and consumption patterns change. The OECD (Organization for Economic Co-operation and Development) 2012 stated that global water demand is projected to increase by 55% between 2000 and 2050, primarily in response to increased demand from manufacturing, thermal power generation and family unit use. In a study, it was concluded that the world could face a 40 % global water deficit by 2030.

Water is one of the most important fundamental needs of human beings. Water consists of three phases solid, liquid and gaseous state. Solid-phase is present in the form of glaciers and ice caps, the liquid phase is present in the form of oceans, rivers and lakes and the gaseous state is present in the atmosphere in the form of moisture. The total amount of water in the earth's atmosphere is the hydrosphere and it contains an enormous amount of water. From the United States Geological Survey (USGS) total earth's water, nearly of about 97.5 % of water is present in the sea as seawater which is saline in nature and the left 2.5 % of total water is fresh. The freshwater is further divided into the solids phases and liquid phases. Solid phases are in the form of icecaps and glaciers located in the Arctic and Antarctic regions and cover 68 % of freshwater. On the other hand in liquid phases, groundwater is 29.9 % of groundwater and the rest amount of the water is found in lakes, rivers and ponds.

1.2 Water Scarcity

Water scarcity can be defined as a lack of sufficient water or not having access to safe water supplies. Water is a pressing need in many areas of the world. Scarcity is spreading as water is needed to grow and process food, create energy, and power industry for a continually growing population. Clean, potable water is an essential ingredient of a healthy human life, but 1.2 billion people lack access to water according to recent estimates from the International Water Management Institute. By 2025, two-thirds of the world's population may be facing water shortages, according to World Wildlife Fund. Available freshwater supplies worldwide continue to decline. By 2030, water demand is forecast to increase by 40 percent. The world population is expected to reach 9 billion, placing pressure on water supplies. Water scarcity involves water crisis, water shortage, water deficit or water stress. There are two types of water scarcity: (1.) Physical water scarcity occurs when there is not enough waterto meet demand. Roughly 20 percent of the world's population now lives in physical water scarcity. (2.) In the developing world, finding a reliable source of safe water is often time consuming and expensive. This is known as economic scarcity. According to An estimated 1.6 billion people around the world live in areas of economic water scarcity, with 780 million people living in areas with no basic water services. The NITI Aayog on June 18, 2018 released the result of a study warning that India is facing its 'worst' water crisis in history and that demand for portable water will outstrip supply by 2030 if steps are not taken.Nearly 600 million Indians faced high to extreme water stress and about 2,00,000 people died every year due to inadequate access to safe water. 21 cities, including Delhi, Bengaluru, Chennai and Hyderabad will run out of groundwater by 2020, affecting 100 million people, the study noted

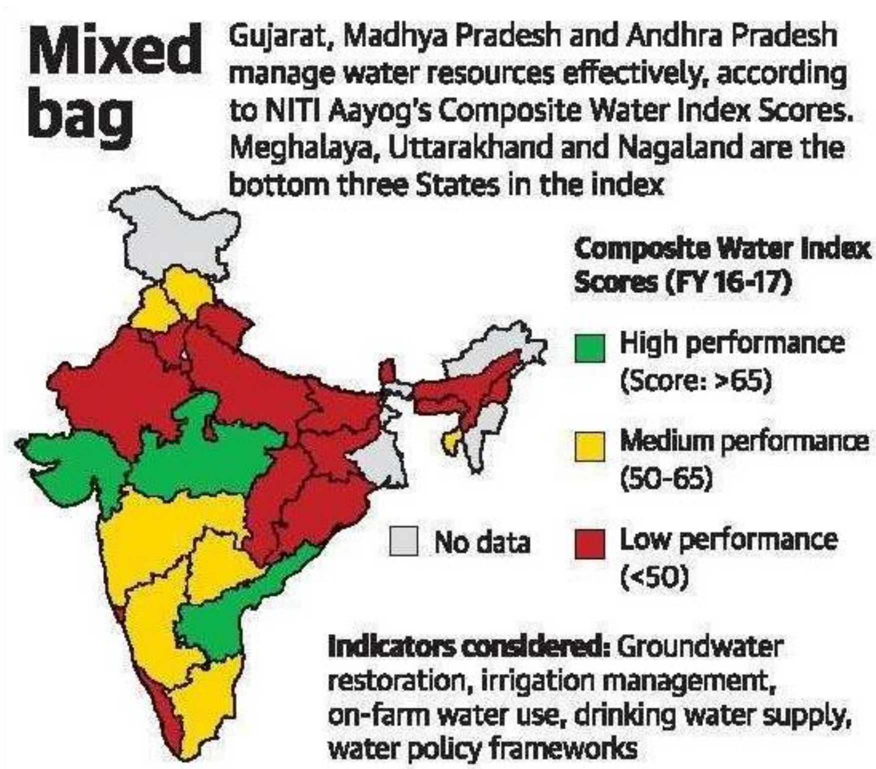


Figure 1 NITI Ayog's Composite Water Index Scores

1.3 Concrete

Concrete is the most-used construction material worldwide whose production globally consumes over two billion tons of freshwater every year. Concrete is the most common and one of the best materials for construction and is widely used material in the world. Concrete is a composite material composed of cement, coarse aggregate, fine aggregate, and water in specified proportions, and 60% - 80% of the concrete volume is represented by aggregates. All the building materials in concrete are held together by a binder called cement. In concrete hardening, aggregates help to reduce shrinkage and heat dissipation and also help to increase the mechanical strength of concrete. As a structural material concrete has good structural performance and durability.

Concrete is an engineering material that is widely used in construction. The concrete industry is one of the leading industries in the world. Concrete requires a large amount of portable water for production of concrete. Concrete is the material in which the consumption rate of concrete water is the same as that of the consumption rate of water.

1.4 Properties of Concrete

Properties of concrete depens upon following factors-

1) Grade of concrete

Concrete is known by its grade which is designated as M15, M20 etc. in which letter M refers to concrete mix and number 15, 20 denotes the specified compressive strength (f_{ck}) of 150mm cube at 28 days, expressed in N/mm^2. Thus, concrete is known by its compressive strength. M20 and M25 are the most common grades of concrete, and higher grades of concrete should be used for severe, very severe and extreme environments.

2) Compressive strength of concrete

Like load, the strength of the concrete is also a quality which varies considerably for the same concrete mix. Therefore, a single representative value, known as characteristic strength is used.

3) Characteristic properties of concrete

It is defined as the value of the strength below which not more then 5% of the test results are expected to fall (i.e. there is 95% probability of achieving this value only 5% of not achieving the same). The characteristic strength of concrete in flexural member is taken as 0.67 times the strength of concrete cube.

Design strength and partial safety factor for material strength

The strength to be taken for the purpose of design is known is known as design strength and is given by Design strength (fd) = characteristic strength/ partial safety factor for material strength The value of partial safety factor depends upon the type of material and upon the type of limit state. According to IS code, partial safety factor is taken as 1.5 for concrete and 1.15 for steel. Design strength of concrete in member = 0.45fck

4) Tensile strength of concrete

The estimate of flexural tensile strength or the modulus of rupture or the cracking strength of concrete from cube compressive strength is obtained by the relations fcr = 0.7 fck N/mm^2. The tensile strength of concrete in direct tension is obtained experimentally by split cylinder. It varies between 1/8 to 1/12 of cube compressive strength.

5) Creep in concrete

Creep is defined as the plastic deformation under sustained load. Creep strain depends primarily on the duration of sustained loading. According to the code, the value of the ultimate creep coefficient is taken as 1.6 at 28 days of loading.

6) Shrinkage of concrete

The property of diminishing in volume during the process of drying and hardening is termed Shrinkage. It depends mainly on the duration of exposure. If this strain is prevented, it produces tensile stress in the concrete and hence concrete develops cracks.

7) Modular ratio

Short term modular ratio is the modulus of elasticity of steel to the modulus of elasticity of concrete.

8) Poisson's Ratio

Poisson's ratio varies between 0.1 for high strength concrete and 0.2 for weak mixes. It is normally taken as 0.15 for strength design and 0.2 for serviceability criteria.

9) Durability of concrete

Durability of concrete is its ability to resist its disintegration and decay. One of the chief characteristics influencing durability of concrete is its permeability to increase of water and other potentially deleterious materials. The desired low permeability in concrete is achieved by having adequate cement, sufficient low water/cement ratio, by ensuring full compaction of concrete and by adequate curing.

10) Unit Weight of concrete

The unit weight of concrete depends on percentage of reinforcement, type of aggregate, amount of voids and varies from 23 to 26 kN/m^2. The unit weight of plain and reinforced concrete as specified by IS:456 are 24 and 25 KN/m^3 respectively.

1.5 Seawater

Oceans contain 97.5 % of the total amount of water that exists on earth which covers about 70% of the total earth's surface. Seawater consists of different types of dissolved salts such as chlorine, sodium, magnesium, sulfur, calcium, potassium, minor constituents and trace compounds. In this composition of seawater, chlorine contains 56% of the total salts present in seawater and sodium contains 31 % of the total salts present in seawater as shown in Table1.

Table 1 Composition of seawater

Dissolved Salts	Weight in grams
Major constituents	
Chlorine	19.10
Sodium	10.62
Magnesium	1.28
Sulfur	2.66
Calcium	0.40
Potassium	0.38

Salts mainly cause damage to the concrete mainly chloride and sulfate ions as these salts have deleterious effects on the strength and durability of concrete as shown in Table 1.

Sea water contains dissolved salts which have different types of effects on the production of concrete. Seawater is the mixture of salts that affects the strength and durability of concrete. Normally the average concentration of salts in seawater is 3.5%.

1.6 Concrete in seawater

The durability of concrete is regarded as its ability to resists the effects and influences of the environment while performing its desired functions. Over the year it has become very necessary and imperative to ascertain the qualities of properties of coastal structures (oil platform, sea wall, buck head etc) in contact with sea water as they tend to perform their functions during the period of their design life. The properties of concrete structures such as strength, durability, stability,resistance to frost & thaw action etc require thorough investigation. The effect of seawater on concrete has remained a major problem associated with structures either built in sea water or cast or cured with sea water. The presence of sodium chloride in sea water accelerates the attack on other compounds on the concrete. The chemical action of seawater on concrete is mainly due to attack by Magnesium sulphate ($MgSO_4$). This attack is by crystallization. It has been established that potassium and magnesium sulphates (K_2SO_4 & $MgSO_4$) present in seawater can cause sulphate attack in concrete as a result of initial reaction with calcium hydroxide ($Ca(OH)_2$) which present in set cement and form by hydration of C_3S & C_2S.

1.7 Desalination

Desalination is process of removing dissolved salts and contaminants from seawater or saline water.

1.8 Types of desalination technology

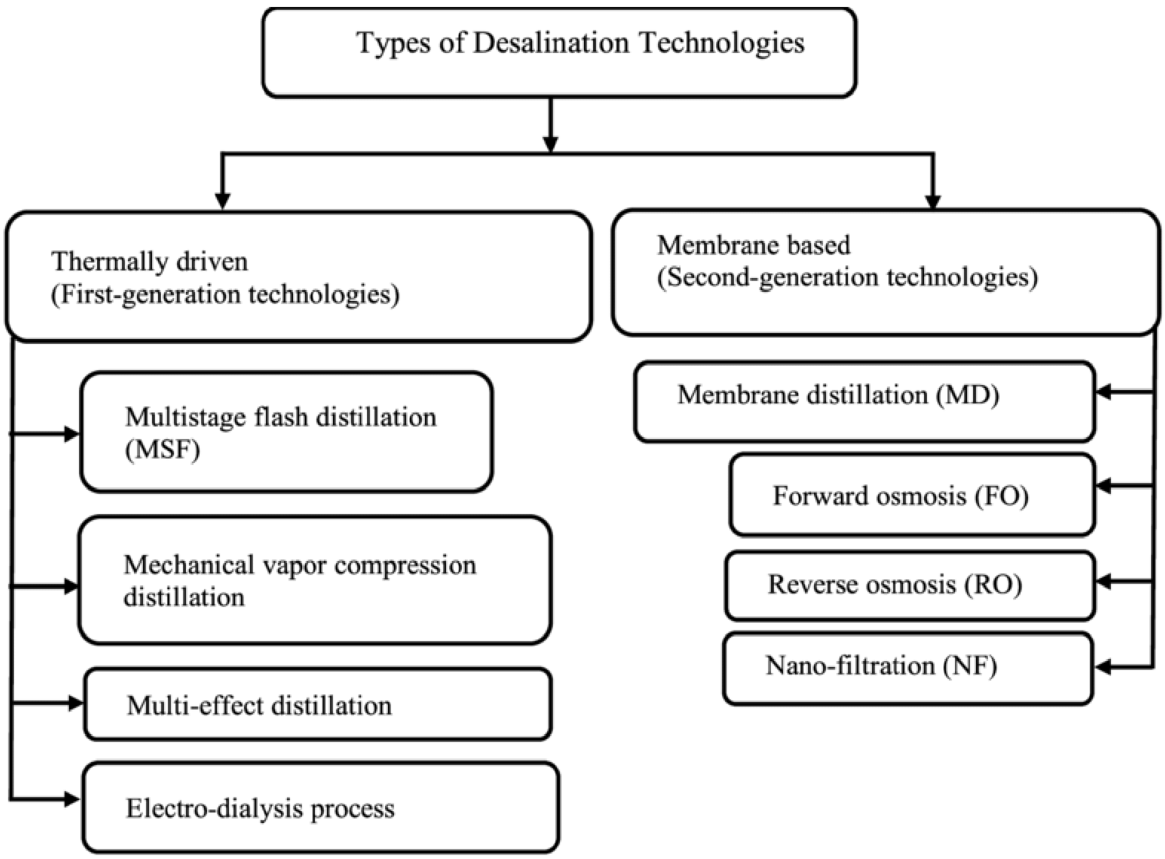


Figure 2 Types of Desalination Tehnology

1.9 Thermal driven desalination

1) Multistage Flash Distillation (MSF)

Multi-stage flash distillation (MSF) is a water desalination process that distills sea water by flashing a portion of the water into steam in multiple stages of what are essentially countercurrent heat exchangers.

2) Mechanical Vapour Compression Distillation

Vapor-compression desalination (VC) refers to a distillation process where the evaporation of sea or saline water is obtained by the application of heat delivered by compressed vapor.

3) Multieffect Distillation

Multiple-effect distillation or multi-effect distillation (MED) is a distillation process often used for sea water desalination. It consists of multiple stages or "effects". In each stage the feed water is heated by steam in tubes, usually by spraying saline water onto them. Some of the water evaporates, and this steam flows into the tubes of the next stage (effect), heating and evaporating more water. Each stage essentially reuses the energy from the previous stage, with successively lower temperatures and pressures after each one.

4) Electrodialysis Process

Electrodialysis reversal desalination, commonly abbreviated EDR, is a water desalination process in which electricity is applied to electrodes to pull naturally occurring dissolved salts through an ion exchange membrane to separate the water from the salts.

1.10 Membrane based desalination

1) Membrane Distillation

Membrane desalination is the process by which salt and minerals are removed from water solution when it passes through a semipermeable membrane.

CHAPTER 2
LITERATURE SURVEY

2.1 Review of Literatures

1. D Wijaya, R A Kusumadewi, A Wijayanti, R Hadisoebroto 2021 : This study tested multilevel distillation to desalinate artificial water, found that Distilled Water Volume can be affected by light intensity, water temperature, and glass temperature. Removal of parameters from desalination process hardness and salinity reaches 100% and Removal for ion Cl^-, electric conductivity, and total dissolved solid about 98% and 99%, removal turbidity between 18.50% until 98.37%. This can be said that high removal.

2. Jie Ren, Hongfang Sun, Kun Cao, Zhili Ren, Bo Zhou, Wenshen Wu, Feng Xing 2021: A series of experiments were conducted to investigate the effect of seawater on the properties of alkali-activated slag (AAS) binders to seek further potentiality of these binders in marine environments. The experimental results show that on the one hand, seawater may lead to increased setting time, reduced compressive strength after 3 days and a less compact microstructure. On the other hand, however, it could also slightly improve the early age strength, flexural bending strength (after 28 and 56 days) and fractural toughness, and shows almost no impact on the fluidity of AAS binders. Moreover, with the formation of some new hydration products due to seawater mixing, the water absorption and volume of permeable voids had small decreases while the capillary sorptivity obtained a small increase.

3. Ahmed I. Ghazal, Mohamed Y. El-Sheikh, Ahmed H. Abd El-Rahim 2021 : In this study another beneficial effect of seawater over tap water was concluded. Setting tests of cement paste mixed with seawater was determined using Vicat apparatus and compared to tap water. Compressive strength tests at the age of 28 days of Portland cement concretes with varied quantity of cement i.e. 300, 350, 400, 450, and 500 kg, and mixed with seawater was also performed and compared to tap water. The results show that seawater affects standard consistency of cement paste and two percent increase was required in order to attain the same consistency as tap water. It shows also seawater slightly accelerates initial setting of cement but the effect is not so pronounced so as to cause a trouble in concrete and final setting time almost remains unaltered.

4. Yamei Caia, Dongxing Xuana, Pengkun Houb, Jie Shib, Chi Sun Poon 2021 : This study explored the mechanism of the effect of seawater on tricalcium aluminate (C3A) hydration. The results showed that seawater retarded C3A hydration and reduced the reaction degree of C3A. The co-existence or ion pairing of Ca2+and SO42onto the surface of C3A poisoning the reactive sites is the main reason for this retardation. Besides, the precipitation of Mg (OH)2 on the surface of C3A would prolong the induction period for another 30 min and then consequently decrease the dissolution rate of C3A hydration. Trace amounts of MgSO40 and Mg2+present in the alkaline solution had little retardation effect.

5. Hung Cong Duong, Lan Thi Thu Tran, Hoa Thi Truong, Bart Nelemans 2021 : This study focuses on the pilot MD system was based on air gap membrane distillation (AGMD), which is considered the most energy-efficient configuration of MD. The AGMD configuration allowed for the utilization of the latent heat of water vapor condensation to pre-heat the seawater feed, thus reducing the energy consumption of the pilot system. This energy-efficient configuration, however, had a small temperature difference between the hot feed and the coolant streams and therefore exhibited low water flux. Nevertheless, the low water flux of the pilot system was compensated by the large membrane surface area of the spiral-wound AGMD membrane modules. Equipped with a total membrane surface of 77.7 m2, the pilot AGMD process operated at the evaporator inlet and coolant inlet temperature of 70 C and 25 C respectively could produce 46 L h1of pure distillate that met the Vietnamese potable water standards.

6. V. Baskaranand & Saravanane 2020 : In this study the seawater is partially treated with the help of Montmorillonite clay to make it meet up with IS 2296: 1992. The Trial 6 at a detention time of 40min, has an efficiency of removing 89.83% Total Dissolved Solids, 96.62% of Chloride and 98% of Sodium compared to untreated seawater. Thus, it is concluded that the partial seawater desalination treatment could be a promising alternative way to face the challenges generated by clay and seawater, which also satisfy some of the socio-economic issues in the coastal areas. Various sorbents like activated carbon, industrial by products, agricultural solid waste, biochar and others can also be used instead of Montmorillonite and the results can be assessed after treating Saline water.

7. Sajjad Ali Mangi &Ashwani Makhija & Muhammad Saleem Raza & Shabir Hussain Khahro & Ashfaque Ahmed Jhatial 2020 : This study aimed to summarize and analyze the previous findings and recommendations. It was noticed that the natural seawater has both positive and negative implications on concrete. Thus, resistance of concrete against the seawater can be improved by adding supplementary cementitious materials (SCM) like copper slag, coal bottom ash, fly ash and others with appropriate proportions. Moreover, the problem of corrosion of reinforcement due to seawater influence, can be avoided using corrosion inhibitor and/or corrosion resistant reinforcement. It was also noticed that the addition of SCM could increase the performances of concrete like strength and durability of concrete exposed to the marine environment.

8. Amir Mohammad Javidani, Hassan Pahlavanzadeh and Hamid Ganji 2020 : The present research aimed to investigate the ability of R410aor R410a + cyclopentane hydrates for the desalination of synthesized seawater. The ion removal efficiency and water recovery as two important parameters of desalination were studied. The effects of water-to-hydrate conversion and salinity on the above-mentioned parameters were also investigated. The experiments were performed in a stirred reactor at initial conditions of 11, 10, and 9 bar and 275.15 K. The pressure variations during hydrate formation indicated that the final equilibrium pressure increases with an increase in the salinity of the solution. The results showed that the case of R410a +cyclopentane at a pressure of 9 bar had the highest ion removal efficiency, which was in the range of 82.4−86.9%. However, the case of R410a at a pressure of 11 bar had the best performance on water recovery (39.9%).

9. Muhammad Saad Khan, Bhajan Lal, Khalik Mohamad Sabil, Iqbal Ahmed 2020 : This study provides a brief review of the recent researches accomplished on the desalination of saline water through gas hydrate technology. It is evident from the literature that small amount of additives or hydrate promoters either significantly enhance the thermodynamic conditions of hydrate formation above the freezing point of water or increase the hydrate crystallization by improving the hydrate formation rates. The use of gas hydrates in the desalination process is attractive because gas hydrates will form from seawater such that salt ions are excluded.

10. G.B. Ramesh Kumar and V. Kesavane 2019: This study focuses the previous studies carried over replacing the normal water used for mixing the cement binder with aggregates, with sea water in sample mixes. This study also includes the testing and analysis of M20 and M30 mixes with different proportions of sea water content. Previous studies include casting and testing of samples for 3, 7 and 28 days of time period and the basic strength proper-ties were determined and results were recorded. The results recorded exhibits a healthy growth in concrete properties and also emphasizes on the potential importance of using seawater concrete matrix.

11. Rihab Miladi, Nader Frikha , Abdelhamid Kheiri, Slimane Gabsi 2019 : This study of the energy performance of a solar powered vacuum membrane distillation was investigated on four typical days that represent the four seasons of the year namely : the equinoxes (March 21st and September 21st)and the solstices(June 21st and December 21st). The results indicate that the energy performance of the process is strongly linked to the solar irradiation and as long as the VMD is coupled with solar energy, the process could be competitive with industrialized desalination technologies such as RO, MSF and MED.

12. **Sa’d Shannak and Malak Alnory 2019 :** In this study, the classical economic analysis model has been modified to assess the penetration of solar technology to power desalination plants at different periods during the project lifetime. Furthermore, the environmental and financial values were combined to assess the incentive of powering desalination plants with solar energy in Saudi Arabia. Three systems of solar technologies accompanied with water desalination based on technical applicability were modeled and economically analyzed to understand the impact of various design and operation parameters.

13. Adel Younis, Usama Ebead, Prannoy Suraneni, Antonio Nanni 2018 : This paper reports on the results of an extensive experimental study to compare the fresh and hardened properties of freshwater- and seawater-mixed concretes. The experimental program included the following tests: (a) characterization of fresh concrete (slump flow, density, yield, air content, and setting time); (b) mechanical characterization of hardened concrete (compressive strength, splitting tensile strength, and shrinkage); and (c) permeability performance of hardened concrete (rapid chloride permeability, chloride migration, and water absorption). The use of seawater had a notable effect on the fresh concrete properties. Mechanical performance of sea-water concrete was slightly lower than that of the freshwater-mixed concrete. The permeability performance of hardened concrete in the two mixtures was similar.

14. Kazi P. Fattah, Adil K. Al-Tamimi, Waseem Hamweyah, Fatima Iqbal 2018 : This study was carried out to determine the effect of using reject brine as the source of water and the use of ground granulated blast furnace slag (GGBS) as a replacement for cement. Concrete samples having three different cement contents were prepared with normal tap water and reject brine. Results showed that the use of GGBS and reject brine improved the strength of concrete produced by 16.5%. Replacing 50% of the cement with GGBS and using reject brine as the source of water has a potential for reducing 176 kg CO2and 1.7–3.4 kg of CO2 equivalents per one cubic meter of concrete, respectively.

15. A.M.K. El-Ghonemy 2018 : The present study is applied on the seawater multi-stage flash (MSF) desalination plant that is currently under operation in Al-Khafji operations plant located in Saudi Arabia (KSA). The plant contains 20 evaporator stages at capacity of 600,000 gallon per day (GPD). The presented operating data has been collected during a visit of the plant. The objective is to present field results of this MSF plant operation in order to measure and evaluate the performance at 70% and 100% capacity during summer (case-1) and winter (case-2) operation. Then, the plant overall performance indica-tors are presented to compare between the studied two cases in terms of specific cooling water flow-rates and performance ratio. Finally, the seasonal performance variation of the plant is included. The results showed that, for the same plant output, the main cooling water flow rates is decreased from 47.1% to 20.1% for case-1 and case-2 respectively, which in turns directly reduces the pumping power by the same ratio.

16. A. M. Saravanan, Asma Said Al-Kharusi, Anna Jesil and Shabib Rashdi 2017 : The study has shown an important way for using the renewable energy and producing drinkable water without effect to the environment and at less cost. The results deduced a direct proportional relation-ship between the atmospheric temperature and water productivity. The atmospheric temperature can be effected by the presence of clouds. Intensity of solar radiation that varies throughout the day also plays every significant role.

17. Daiki Tsutsui and Takaaki Wajima 2017 : In this study, we investigated the desalination properties of calcined hydrotalcite by the reformation process. As a result, Mg – Al oxide peak in all calcined products confirmed and peak intensity of Mg/Al oxide increased with increasing Mg/Al ratio of the product. The salinity decreased in the all seawater after treatment with calcined hydrotalcite. The highest desalination from seawater were treated with the product with approximately Mg/Al = 3, because the structure of calcined hydrotalcite can remove high amounts of Cl^- and Mg^{2+} from seawater by reformation reaction.

18. Jie Song, Tian Li , Lucía Wright-Contreras and Adrian Wing-Keung Law 2017: This study reviewed the current status of small-scale desalination (produced water capacity of 100 m3 /day or less) for the recent six-year period of 2010–2015. Reverse osmosis was the most common technology applied in this market segment. Compared to large-scale desalination, where seawater is the dominant feedstock, small-scale desalination is more adaptive to diverse sources, including both brackish water and seawater. In view of its wide usability and high adaptability, the application of small-scale SWRO is far from fully developed at the moment. The main reason is presently attributed to its relatively high cost. According to the survey, the use of ERDs remains rare in small-scale SWRO. Since SWRO without ERDs has high energy consumption, the implementation of ERDs should be a high priority for the development of cost-effective small-scale SWRO in the future.

19. S. Manju, Netramani Sagar 2017: Fossil fuels such as coal, petroleum, and natural gas have been used as the major sources of energy in the recent past. However, the negative environmental impacts associated with the emission of greenhouse gases from these conventional energy sources forced us to realize the importance of renewable energy resources. At the same time, the average annual exponential rate of population growth in India needs increasing amounts of fresh water for the basic necessities. This might result in water scarcity as the overall population in India is expected to increase to 1.60 billion by 2050. It has been forecasted that, by the year 2040, India will rank 40th in the world in terms of water scarcity. To meet the rising fresh-water demand, desalination is an intelligent and sustainable option for India, which has a very long coastline measuring 7517 km. In this paper, an attempt has been made to provide a comprehensive review of water scarcity in India and suggest a possible solution, which is implementing desalination technologies coupled with renewable resources. The paper reviews the ground water scenario in India and the global desalination market. We summarize the energy consumption in various desalination processes and provide a brief outlook of the desalination techniques in India. Apart from this, desalination using non-conventional sources such as solar, wind, and geothermal energy is discussed. In addition, factors affecting the environment due to desalination and the potential countermeasures are presented.

20. Caecilia Pujiastuti, Ketut Sumada, Yustina Ngatilah, Prasetyo Hadi 2016 : This study shows that it is possible to remove Mg2+,K+ and SO4-2 ions in seawater by precipitation method using Na2HPO4 and CaCl2. The removal efficiencies of Mg2+, K+ and SO4-2 ions in seawater were 97%, 96%, and 92%, respectively.

21. Kyle N. Knust, Dzmitry Hlushkou, Robbyn K. Anand, Ulrich Tallarek, and Richard M. Crooks 2013 : This study demonstrated a membraneless and energy efficient technique for seawater desalination. EMD relies on the oxidation of Cl, which generates an ion depletion zone and local electric field gradient to redirect sea salts into a brine stream. This result is important fora number of reasons. First, the technique is membraneless, and therefore does not suffer from membrane fouling or damage and does not require extensive pre-treatment prior to desalination. Second, EMD achieves energy efficiencies of25 mWhL1for 255% salt rejection at a 50% recovery of desalted water.

22. Sung Jae Kim, SungHeeKo, Kwan Hyoung Kang and Jongyoon Han 2010 : This research have demonstrated a new, efficient and fouling-free desalination process based on the ICP phenomenon, for direct desalination of sea water. This process has several unique and attractive features for such applications. It has a power efficiency that more or less matches that of current state-of-the-art RO plants. In a single-step operation, 99% of the salt contained in the sea water is removed, with 50% of the incoming sea water being recouped as desalted water(with a salinity less than 180 mg l21). In addition, it can eliminate any charged species, ranging in size from small salt ions to large particles or cells, without membrane fouling and clogging. This can significantly reduce the complexity and cost of direct seawater desalination.

23. Takaaki Wajima, Tomoe Shimizu , Takehiko Yamato : This study was carried out to find removal of NaCl using natural zeolite, which isa well-known adsorbent and is available in large quantities at low cost. We investigated the NaCl reduction process with combination of anion reduction treatment and natural zeolite treatment, and the obtained water was applied to a growth test for radish sprouts. The treatment of water by natural zeolite could neutralize seawater to pH 5, and reduce Na in seawater by ion exchange of natural zeolite. Radish sprouts did not grow in seawater, Z-solution, A-solution, ZA-solution, AZ-solution, and CHT-solution, due to the high content of Na, Cl, and NO3, or high pH. By combination of an anion reduction process using CHT, radish sprouts can be grown in CZ-solution. These results suggest that it is possible to make irrigation water from seawater using natural zeolite by combination of an anion reduction using CHT.

24. Marian Turek a & Marzena Chorążewska 2009 : This research focuses on applying NF membranes with high rejection coefficients of scale-forming ions as a pretreatment in seawater desalination opens the possibility for significant increase of water recovery in both RO and MED processes, and results in the pronounced increase in overall water production in the integrated system. From the presented economical analysis, it is seen that salt obtaining as a valuable product leads to decrease of the total unit cost of desalted water. Moreover, salt production causes re-duction of waste products, thereby making the process more friendly to the marine environment.

25. Fichtner GmbH and Heinz Ludwig 2009 : Seawater desalination with reverse osmosis has taken a noteworthy upturn in recent years. One of the reasons for the success of the membrane process is its lower energy consumption in comparison to the thermal desalination processes. The individual systems of an SWRO plant - in particular its pre-treatment stage as well as its first and second passes are very closely cross-linked systems in regard to its energy consumption. During energy optimisation in design and operation of an SWRO besides the choice of the manner of the energy recovery in the 1st pass special attention must also be directed to the pre-treatment process and the interaction of these systems. Ways to optimize design and operation of a seawater reverse osmosis plant under the aspect of lowering its energy consumption are investigated.

26. Toraj Mohammadi, Anita Kaviani 2003 : This paper focuses on effects of operating conditions like concentration, flow rate and voltage on the electrodialysis cell performance have been studied. Results show that for solutions with concentration of less than 10000 ppm, the amount of applied voltage is very effective within the range of 2-6 V. The slope of the line is greater at a voltage of 6 V for 5000 and 10000 ppm solutions. This is due to the fact that these solutions are not very conductive.

2.2 Inference

- 28 day Compressive strength of concrete was improved by increasing the quantity of cement from 400Kg to 450Kg and 500Kg with sea water as compared to tap water.
- Hydration in cement delayed due to mixing of sea water because seawater reacts with cement and forms friedal salts
- Use of Energy Reducing Devices reduce the energy consumption in Vaccum Membrane Distillation.
- Conversion of seawater into drinking water using solar energy is effective and suitable where temperature is constant as required for solar radiation.
- Disodium phosphate serves to bind magnesium ions and potassium, $CaCl_2$ serves to bind the sulfate ion.
- Combined use of natural zeolite and calcined hydrotalcite removes NaCl from seawater.

2.3 Research Gap

- Fresh Water scarcity is increasing day by day.
- Reverse osmosis process is majorly used in desalination industry for desalinating sea water but it is very costly and requires a large framework.
- Most coastal areas like small islands and beach areas are the area that has a scarcity of freshwater.
- Concrete made with desalinated water in not been studied.

2.4 Objective

To study the following properties of concrete using chemical desalinated water as mixing and curing is being studied:

- Compressive strength of concrete
- Flexure strength of concrete
- Microstructure study of concrete
- Durability of concrete

CHAPTER 3

MATERIALS

3.1 Cement

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together.

3.2 Types of cement

1. Ordinary Portland Cement 33 Grade

This type of cement features low compressive strength and low heat hydration which ensures lesser cracking. It is given the Indian Standard code of 269.

2. Ordinary Portland Cement 43 Grade

Similar to the OPC 33-grade cement they are also used for general civil purposes, like plastering, flooring up to M 30 concrete grades. This type of cement attains the minimum compression strengths at 43 Mega-Pascal at 28 days The Ordinary Portland Cement is given the Indian Standard code of 8112.

3. Ordinary Portland Cement 53 Grade

This type of cement is used with a higher concrete grade than M30 for both general purposes and for building bridges, roads, multi-storied building works, etc. They attain the minimum compression strength of 53 Mega-Pascal at 28 days of curing. Application is also observed in cement grouts, instant plugging mortars which generally require higher strength. It is given the Indian Standard code of 12269

4. Portland Slag Cement (PSC)

The Portland Slag is the type of cement which when exposed to rough types of environments like the wastewater treatment or marine applications it does not crack therefore preferred over, Ordinary Portland Cements. This cement is given the Indian Standard code of 455.

5. Coloured Cement: White

Although the coloured type of cement is more expensive in comparison to the Ordinary Portland Cement, it has its benefits and implementations. Made from raw materials such as iron oxide and manganese oxide As the name suggests it is white in colour and the chemical composition and physical properties of this cement is also able to meet the specifications of Ordinary Portland cement. The coloured cement is given the Indian Standard code as 8042.

6. Portland Pozzolana Cement (PPC)

The Portland Pozzolana is known for its fineness, a high degree of impermeability and for being a good corrosion resistor making the concrete dense therefore the structure becomes long-lasting. This cement is given the India Standard code as 1489 P-2.

7. Hydrophobic Portland Cement

The Hydrophobic Portland cement is not that easily available due to the abundance in the availability of different types of cement in the market and is comparatively more expensive than the Ordinary Portland Cement. This cement is given the Indian Standard code as 8043.

In this research, PPC cement is used in making of concrete.

Figure 3 Portland Pozzolona Cement

3.2 Coarse Aggregate

Construction aggregate, or simply aggregate, is a broad category of coarse- to medium-grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates.

3.3 Types of aggregate

- Rounded aggregates
- Irregular or partly rounded aggregates
- Angular aggregates
- Flaky aggregates
- Elongated aggregates

3.4 Sieve Analysis of Coarse Aggregate

Table 2 Sieve Analysis of Coarse Aggregate

IS Sieve Size	Weight Retained 1 (grams)	Weight Retained 2 (grams)	Weight Retained 3 (grams)	Average	% Weight Retained	Cummalative %Weight Retained	% Weight Passing = 100 - CWR
20mm	-	-	-	-	-	-	100
16mm	659	680	682	673	13.46	13.46	86.54
12.5mm	1325	1347	1363	1354	27.08	40.54	59.46
10mm	671	666	674	670	13.4	53.94	46.06
4.75mm	2209	2205	2220	2211	44.22	98.16	1.04
2.36mm	88	76	75	79	1.58	99.74	0.26

Graded Aggregate

3.5 Specific Gravity and Water Absorbtion of Coarse Aggregate

TEST 1:

Weight of aggregate = 5 Kg

Normal size of aggregate is 20mm

It is graded aggregate

Coarse aggregate water absorbtion and specific gravity (IS 2386 PART 3 1963)

- Weight of basket & sample in water after 25 jolting (A1) = 2317 gm
- Weight of empty basket in water after 25 jolts (A2) = 1012 gm
- Saturated aggregate in water A = A1 – A2 = 1305 gm
- Weight of saturated surface dry aggregate (B) = 2082 gm
- Weight of oven dry aggregate (C) = 2078

Specific gravity = C/B-A

= 2078/2082-1305

= 2.674

Water absorbtion = 100(B-C)/C

= 100(2082-2078)/2078

= 0.192 %

TEST 2:

Weight of aggregate = 5 Kg

Normal size of aggregate is 20mm

It is graded aggregate

Coarse aggregate water absorbtion and specific gravity (IS 2386 PART 3 1963)

- Weight of basket & sample in water after 25 jolting (A1) = 2293 gm
- Weight of empty basket in water after 25 jolts (A2) = 1000 gm
- Saturated aggregate in water A = A1 – A2 = 1293 gm
- Weight of saturated surface dry aggregate (B) = 2087 gm
- Weight of oven dry aggregate (C) = 2082

Specific gravity = C/B-A

= 2082/2087-1293

= 2.622

Water absorbtion = 100(B-C)/C

= 100(2087-2082)/2082

= 0.24 %

Average Specific Gravity = 2.648

Average Water Absorbtion = 0.216%

3.6 Fine Aggregate

Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influence the hardened properties of the concrete.

3.7 Tyes of fine aggregate

- Coarse Sand
- Medium Sand
- Fine Sand
- Silt
- Clay

3.8 Sieve Analysis of Fine Aggregate

Table 3 Sieve Analysis of Fine Aggregate (Sample 1)

Sample 1: Weight of oven dry sample = 1 Kg

IS Sieve Size	Weight Retained (grams)	%Weight Retained	Cummalative %Weight Retained	% Weight Passing = 100 - CWR
10mm	0	0	0	100
4.75mm	68	6.8	6.8	93.2
2.36mm	129	12.9	19.7	80.3
1.18mm	231	23.1	42.8	57.2
600micron	176	17.6	60.4	39.6
300micron	314	31.4	91.8	8.2
150micron	61	6.1	97.9	2.1

Zone II

Table 4 Sieve Analysis of Fine Aggregate (Sample 2)

Sample 2: Weight of oven dry sample = 1 Kg

IS Sieve Size	Weight Retained (grams)	%Weight Retained	Cummalative %Weight Retained	% Weight Passing = 100 - CWR
10mm	0	0	0	100
4.75mm	72	7.2	7.2	92.8
2.36mm	135	13.5	20.7	79.3
1.18mm	181	18.1	38.8	61.2
600micron	194	19.4	58.2	41.8
300micron	325	32.5	90.7	9.3
150micron	55	5.5	96.2	3.8

Zone II

3.9 Specific Gravity and Water Absorbtion of Fine Aggregate

Test 1:

- Weight of saturated surface dry sample in (A) = 518 gm
- Weight of pycnometer filled with distilled water & sample
- (B) = 1819 gm
- Weight of pycnometer filled with distilled water (C) = 1500 gm
- Weight of oven dry sample (D) = 509 gm

Specific gravity = D/A-(B-C)

= 509/518-(1819-1500)

= 2.557

Water Absorbtion = 100(A-D)/D

= 100(518-509)/509

= 1.768%

Test 2:

- Weight of saturated surface dry sample in (A) = 519 gm
- Weight of pycnometer filled with distilled water & sample (B) = 1820 gm
- Weight of pycnometer filled with distilled water (C) = 1500 gm
- Weight of oven dry sample (D) = 511 gm

Specific gravity = D/A-(B-C)

= 511/519-(1820-1500)

= 2.567

Water Absorbtion = 100(A-D)/D

= 100(519-511)/511

= 1.565 %

Average Specific Gravity = 2.562

Average Water Absorbtion = 1.666%

3.10 Saline Water

1) pH (as per IS 3025 Part 11) -

Sample Reading 1 – 7.64

Sample Reading 2 – 7.65

Sample Reading 3 – 7.67

Average value of pH – 7.65

2) Conductivity (as per IS 3025 Part 14 - 1984) –

Sample Reading 1 – 19610 μS/*cm*

(10 ml sample with 20 ml distilled water)

Sample Reading 2 – 14840 μS/*cm*

(10 ml sample with 30 ml distilled water)

Sample Reading 3 – 10650 μS/*cm*

(10 ml sample with 40 ml distilled water)

This shows a high conductivity in the saline water.

3)Total Dissolved Solid (as per IS 3025 Part 16 -1984)

Water sample taken = 100 ml

Empty weight of the beaker = 91.395 g

Weight of beaker after

evaporation 100ml sample

water = 95.642 g

TDS in 100ml water = 95.642 – 91.395

= 4.247g /100ml

3.11 Desalinated Water

1) pH (as per IS 3025 Part 11) -

- Sample Reading 1 – 6.84
- Sample Reading 2 – 6.83
- Sample Reading 3 – 6.84

Average value of pH – 6.83

2) Total Dissolved Solid (as per IS 3025 Part 16 -1984)

Water sample taken = 100 ml

Empty weight of the beaker = 97.170 g

Weight of beaker after

evaporation 100ml sample

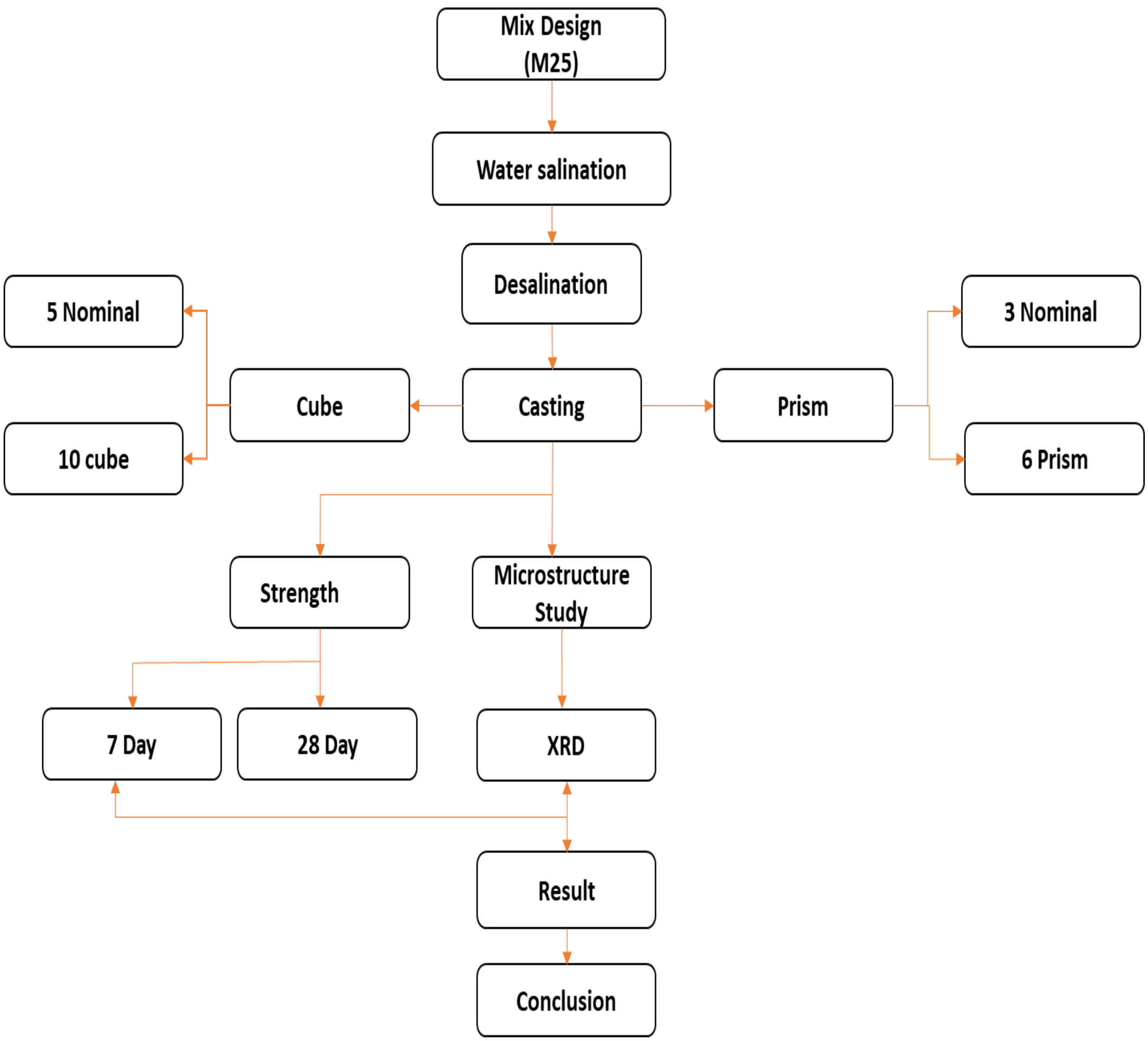
water = 97.317 g

TDS in 100ml water = 97.317 – 97.170

= 0.147g /100ml

CHAPTER 4
METHODOLOGY

4.1 Methodology Flowchart



4.2 Mix Design

For Control Mix (Normal water), Saline water and Desalinated water

A-1 STIPULATIONS FOR PROPORTIONING

a) Grade designation : M25

b) Type of cement : PPC conforming to IS 1489 (Part 1)

c) Maximum nominal size of aggregate : 20 mm

d) Minimum cement content and maximum

water-cement ratio to be adopted and/or : Moderate (RCC) (For reinforced concrete) Exposure conditions as per Table 3 and Table 5 of IS 456

e) Workability : 75 mm (slump)

f) Method of concrete placing : Hand Placing

g) Degree of site control : Good

h) Type of aggregate : Graded aggregate

j) Maximum cement content

not including fly ash : 450 kg/m3

A-2 TEST DATA FOR MATERIALS

Cement used : PPC

Specific gravity of

Specific gravity of cement : 3.15

Coarse aggregate (at saturated surface dry (SSD) Condition) : 2.65

Fine aggregate (Sand) (at saturated surface dry (SSD) Condition) : 2.56

Water absorption

Coarse aggregate : 0.22%

Fine aggregate(Sand) : 1.667%

Moisture content of aggregate [As per IS 2386 (Part 3)]

Coarse aggregate : Nil

Fine aggregate : Nil

Sieve analysis: (As per IS 383:2016)

Coarse aggregate : Graded Aggregate of nominal size 20mm.

Fine aggregate (Sand) : Grading Zone II

A-3 TARGET STRENGTH FOR MIX PROPORTIONING

f'ck = fck+1.65 S

or

f'ck = fck + X

Whichever is higher.

where

f'ck = Target average compressive strength at 28 days,

fck = Characteristic compressive strength at 28 days,

S = Standard deviation

X = Factor based on grade of concrete.

(From Table 2, standard deviation,(S) = 4 N/mm^2 & From Table 1, X = 5.5)

Therefore, target strength using both equations, that is,

a) $f'ck = fck + 1.65 S$

$f'ck = 25 + 1.65 \times 4 = 31.60 N/mm^2$

b) $f'ck = fck + 5.5$

$f'ck = 25 + 5.5 = 30.5 N/mm^2$

The higher value is to be adopted.

Therefore, the target strength will be 31.60 N/mm^2.

A-4 APPROXIMATE AIR CONTENT

The approximate amount of entrapped air to be expected in normal (non-air-entrained) concrete is 1.0 % for 20 mm nominal maximum size of aggregate.

(From Table 3)

A-5 SELECTION OF WATER-CEMENT RATIO

From Fig. 1, the free water-cement ratio required for the target strength of 31.60 N/mm^2 is 0.36 for OPC 43 grade curve. (For PPC, the strength corresponding to OPC 43 grade curve is assumed for the trial).

This water cement ratio is 0.5 prescribed for 'Moderate' exposure for reinforced concrete as per Table 5 of IS 456.

Hence O.K.

A-6 SELECTION OF WATER CONTENT

From Table 4, water content = 186 kg/ m^3 (for 50 mm slump) for 20 mm aggregate.

Estimated water content for 75 mm slump

= 186 + (3/100)*186

= 191.58 kg/ m^3

A-7 CALCULATION OF CEMENT CONTENT

Water-cement ratio = 0.44

Cement content = 191.58/0.5

= 383.16 kg/m^3

(From Table 5 of IS 456, minimum cement content for 'Moderate' exposure condition = 300 kg/m^3. Here 383.16 kg/m^3> 300 kg/m^3)

Hence O.K.

A-8 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGETE CONTENT

From Table 5, the proportionate volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 = 0.62. In the present case water-cement ratio is 0.5.

Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.06, the proportion of volume of coarse, aggregate is increased by 0.012 (at the rate of ± 0.01 for every ± 0.05 change in water-cement ratio).

Therefore, corrected proportion of volume of-

Coarse aggregate for the water-cement ratio of 0.5 = 0.62

Fine aggregate content = 1 – 0.62= 0.38

A-9 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows:

Total Volume = 1 m^3

Volume of entrapped air in wet concrete = 0.01 m^3

Volume of cement =(Mass of cement/Specific gravity of cement)*(1/1000).

Volume of cement =(383.16/3.15)*(1/1000)=0.1216^3

Volume of water = (Mass of water/Specific gravity of water)*(1/1000).

Volume of water = (191.58/1)*(1/1000) =0.19158 m^3.

Volume of all in aggregate = [(a-b)-(c+d)]

= [(1-0.01) – (0.1216 + 0.19158)]

= 0.6769m^3

Mass of Coarse Aggregate = Volume of all in aggregate × proportion of volume of CA × Specific gravity of CA × 1000

= 0.6769 × 0.62 × 2.65 × 1000

= 1112.14 kg/m^3

Mass of Fine Aggregate = Volume of all in aggregate × proportion of volume of FA × Specific gravity of Sand × 1000

Mass of Sand = 0.6769 × 0.38 × 2.56 × 1000

= 658.48 kg/m^3

A-10 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement = 383.16 kg/m³

Water = 191.58 kg/m³

Fine Aggregate (SSD) = 658.48 kg/m³

Coarse aggregate (SSD) = 1112.14 kg/m³

Free water-cement ratio = 0.5

A-11 ADJUSTMENT ON WATER, FINE AGGREGATE AND COARSE AGGREGATE (IF THE COARSE AND FINE AGGREGATE IS IN DRY CONDITION)

Fine Aggregate (Dry) = Mass of Sand in SSD condition/(1+ Water Absorption of Sand/100)

FA (Dry) = 658.48/(1+ 1.667/100) = 647.68 kg/m³.

Coarse Aggregate (Dry) = Mass of CA in SSD condition/(1+ Water Absorbtion of CA/100)

CA (Dry) = 1112.14 /(1+ 0.22/100) = 1109.69 kg/m³.

The extra water to be added for absorption by coarse and fine aggregate,

1) For coarse aggregate = Mass of CA in SSD condition –mass of CA in dry condition

= 1112.14–1109.69 = 2.45 kg/m³

2) For fine aggregate = Mass of FA in SSD condition – mass of FA in dry condition

= 658.48 – 647.68 = 10.195 kg/m³

The estimated requirement for added water, Therefore, becomes

$$= 191.58 + 2.45 + 10.8 = 204.83 \text{ kg/m}^3$$

A-12 MIX PROPORTIONS AFTER ADUSTMENT FOR DRY AGGREGATES

Cement = 383.16 kg/m^3

Water = 204.83kg/m^3

Fine aggregate (SSD) = 647.68 kg/m^3

Coarse aggregate (SSD) = 1109.69 kg/m^3

Free water-cement ratio = 0.5

Total cube = 5

Total prism = 3

Total volume required for 5 cubes = 0.15 * 0.15* 0.15 * 5 = 0.016875 m^3

Total volume required for 3 prism = 0.1* 0.1* 0.5 * 3 = 0.015 m^3

Total volume = 0.016875 + 0.015 = 0.031875 m^3

Quantity of –

Cement = 383.16 * 0.031875 = 12.213 kg

Water = 204.83 * 0.031875 = 6.528 kg

Fine aggregate = 647.68 * 0.031875 = 20.644 kg

Coarse aggregate = 1109.69 * 0.031875 = 35.371 kg

4.3 Water Salination

Salination is the process of mixing composition of dissolved salts into water.

150 Litre of normal tap water was taken taken in a drum for salination process.

Compositon of dissolved salts is taken given in the Table above.

Table 5 Quantity of salts for 150 Litres of water

Dissolved salts	**Quantity (Grams)**
Chloride	2865
Sodium	1593
Magnesium	192
Sulfate	399

So actually compound which were taken for salination process was sodium chloride and magnesium sulfate. Sodium chloride was 4458 grams and magnesium sulfate was 591 grams. Both of these compound were mixed in 150litres of normal tap water resulting in salinated water.

4.4 Desalination

Desalination is process of removing dissolved salts from salinated water to obtain fresh water.

Desalination was done by using solar energy as a resource by which water is condensed to extract the fresh water.

Step 1 - Bluish transparent water container was taken with the top surface open.

Step 2 - The fibre plate was placed inside the bottom of the container on which the hollow fibre bowl can be placed.

Step 3 - Now the fibre bowl was placed inside the container above the fibre plate.

Step 4 – Two litres of saline water was poured inside the container.

Step 5 – The container was tightly packed up with the Mseal.

Step 6 – After 24 hours of the process water was collected and again the process was repeated till then the required amount of water is not collected.

Result

On an average 90 – 100 mililiters of water was desalinated.

Figure 4 Desalination Technique

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Concrete cast and cured with normal water

Table 6 Compressive Strength of cube cast with normal water

Cube no.	**Wt. of cube(kg)**	**C/S Area of Cube(mm²)**	**Age**	**Failure Load(N)**	**Compressive Strength(Mpa)**
1	7.82	150*150	28	665200	29.6
2	8.113	150*150	28	704200	31.2
3	7.98	150*150	28	564500	25
4	8.204	150*150	28	665400	29.5
5	8.117	150*150	28	601000	26.7
Avg. Compressive Strength(Mpa)					**28.4**

The average compressive strength is 28.4MPa. In this compressive test casting was done with normal water and curing also with normal water.

Table 7 Flexure Strength of cube cast with normal water

Prism no.	Wt. of Prism(kg)	C/S Area of Prism(mm²)	Age	Failure Load(N)	Flexral Strength(Mpa)
1	11.68	100*100*500	28	11680	4.67
2	11.73	100*100*500	28	11730	4.69
3	13.33	100*100*500	28	13330	5.33
Avg. Flexural Strength(Mpa)					**4.897**

The average flexure strength is 4.897MPa. In this compressive test casting was done with normal water and curing also with normal water.

5.2 Concrete cast and cured with saline water

Table 8 Compressive Strength of cube cast with Saline water

Cube no.	Wt. of cube(kg)	C/S Area of Cube(mm²)	Age	Failure Load(N)	Compressive Strength(Mpa)
1	8.168	152*152	28	689300	29.83
2	8.216	152*152	28	771200	33.37
3	8.317	152*152	28	854200	36.97
4	8.244	152*152	28	807400	34.94
5	8.367	152*152	28	608000	22.9
Avg. Compressive Strength(Mpa)					**31.6**

The average compressive strength is 31.6 MPa. In this compressive test casting was done with saline water and curing also with saline water.

Table 9 Flexure Strength of cube cast with saline water

Prism no.	Wt. of Prism(kg)	C/S Area of Prism(mm^2)	Age	Failure Load(N)	Flexral Strength(Mpa)
1	12.206	100*100*500	28	15210	6.09
2	12.101	100*100*500	28	13000	5.20
3	12.231	100*100*500	28	13980	5.59
Avg. Flexural Strength(Mpa)					**5.62**

The average flexure strength is 5.62 MPa. In this compressive test casting was done with saline water and curing with saline water.

5.3 Concrete cast with desalinated water and cured with normal water

Table 10 Compressive Strength of cube cast with desalinated water

Cube no.	Wt. of cube(kg)	C/S Area of Cube(mm^2)	Age	Failure Load(N)	Compressive Strength(Mpa)
1	8.197	150*150	28	651400	28.9
2	8.287	150*150	28	701600	31.1
3	8.184	150*150	28	602300	26.7
4	8.329	150*150	28	686800	30.5
5	8.231	150*150	28	722400	32.1
Avg. Compressive Strength(Mpa)					**29.86**

The average compressive strength is 29.86 MPa. In this compressive test casting was done with desalinated water and curing also with normal water.

Table 11 Flexure Strength of cube cast with desalinated water

Prism no.	**Wt. of Prism(kg)**	**C/S Area of Prism(mm²)**	**Age**	**Failure Load(N)**	**Flexral Strength(Mpa)**
1	12.193	100*100*500	28	16410	5.05
2	12.232	100*100*500	28	13380	6.01
3	12.315	100*100*500	28	13010	5.17
Avg. Flexural Strength(Mpa)					**5.41**

The average flexure strength is 5.41 MPa. In this compressive test casting was done with saline water and curing with saline water.

5.4 Comparative compressive strength

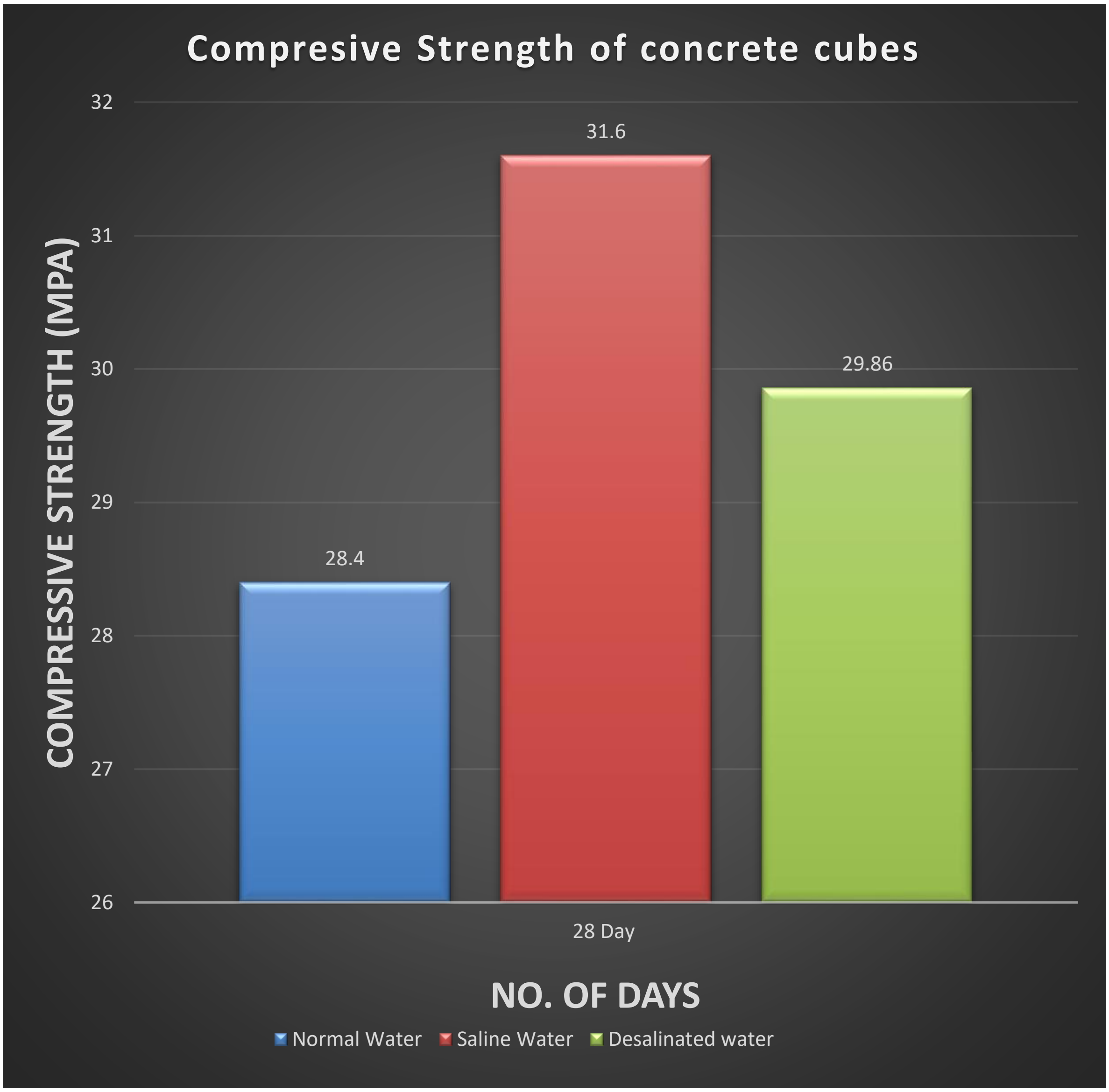


Figure 5 Graph of comparative compressive Strength of cubes

5.5 Comparative flexure strength

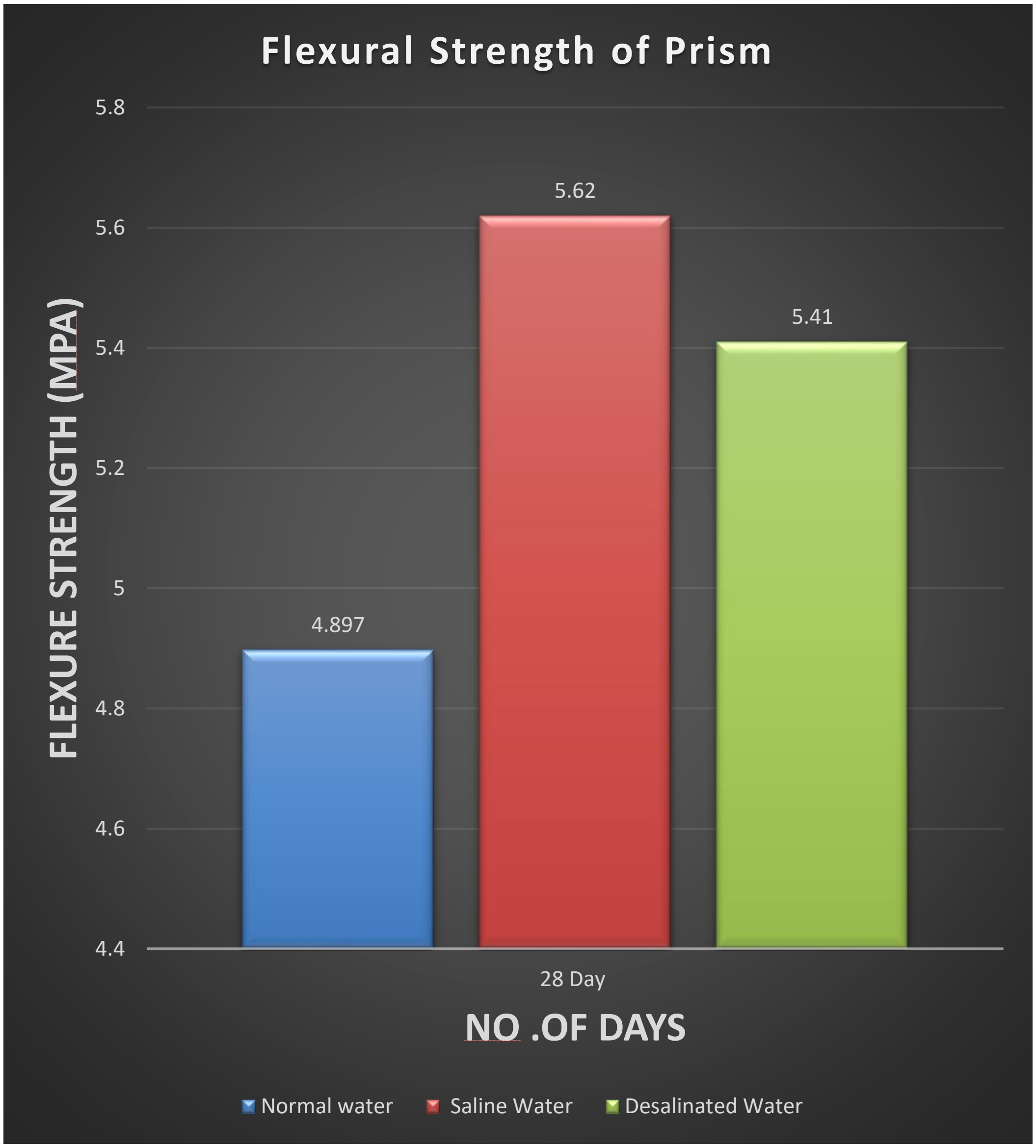


Figure 6 Comparative flexure strength of cubes

5.6 XRD

XRD of Normal water

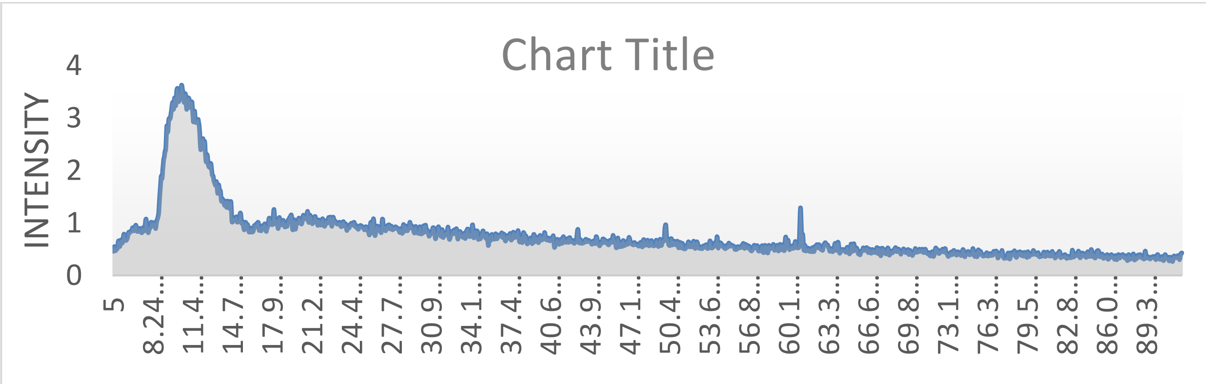


Figure 7 XRD of Normal water

C-S-H gel is properly formed and mix design is ok.

XRD of Salinated water

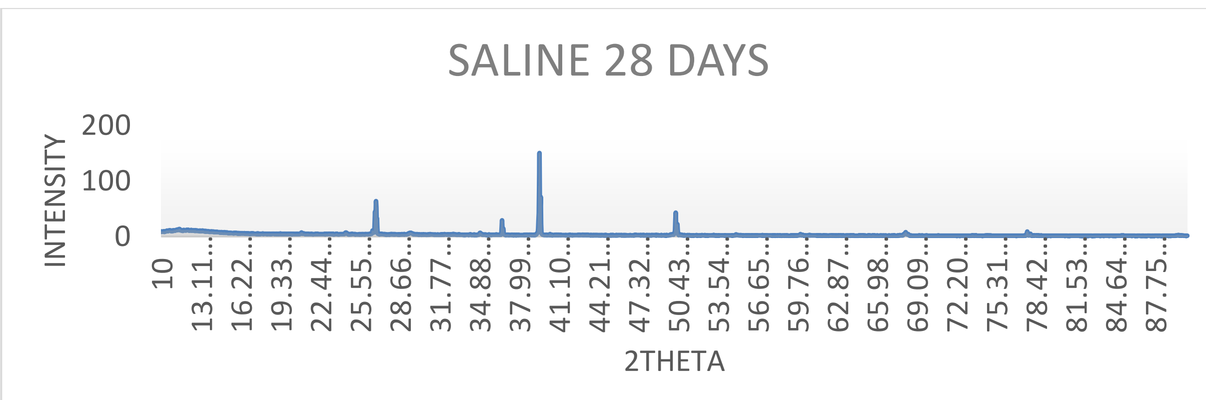


Figure 8 XRD of Saline water

C-S-H gel is properly formed and mix design is ok but the different peaks showing salt concentration.

XRD of Desalinated water

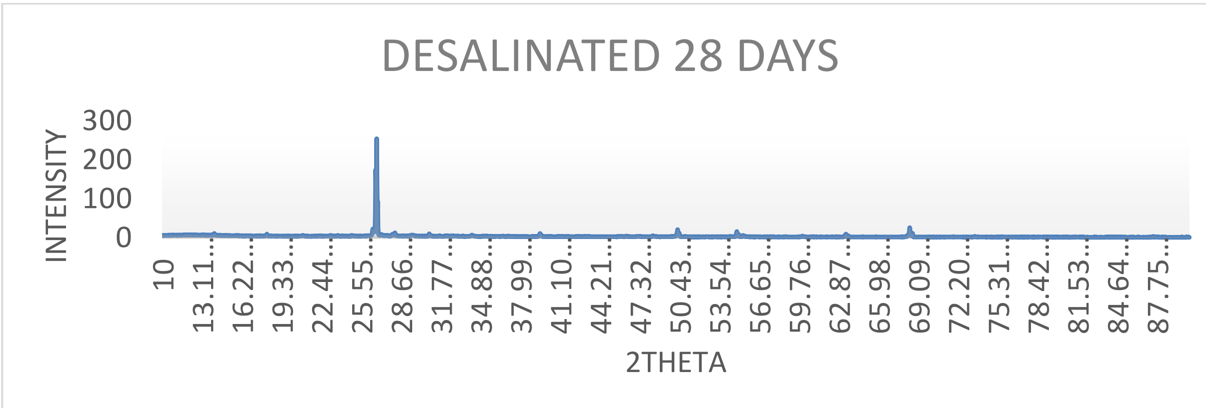


Figure 9 XRD of Desalinated water

C-S-H gel is properly formed and mix design is ok.

CHAPTER 6
CONCLUSION

6.1 Conclusions

On the basis of the results drawn from the comparative analysis of normal water concrete, salinated concrete and desalinated concrete, some important conclusions can be drawn which can prove helpful in establishing research. . A few of the important points are mentioned below:-

1) The average compressive strength of cubes and flexure strength of prism casted with saline water and cured with saline water is 31.6 MPa and 5.62 MPa

2) The average compressive strength of cubes and flexure strength of prism casted with desalinated water and cured with desalinated water is 29.86 MPa and 5.41MPa

3) 28-day compressive strength of saline water is greater than the 28-day compressive strength of desalinated water.

4) Flexural strength of saline water at 28 day is greater than the flexural strength of desalinated water at 28 day.

5) XRD analysis shows that the C-S-H gel is properly formed in salinated water concrete, normal water concrete and desalinated water concrete

6) In saline water concrete XRD shows peaks which denotes the presence of salts.

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