EFFECT OF ENVIRONMENT ON THE STRENGTH AND SHRINKAGE OF CONCRETE

Submitted in partial fulfilment of the requirements

for the degree of

BACHELOR OF ENGINEERING

CIVIL ENGINEERING

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CERTIFICATE

This is to certify that the project report entitled '**EFFECT OF ENVIRONMENT ON THE STRENGTH AND SHRINKAGE OF CONCRETE**' submitted partial fulfilment of the requirements for the award of **Bachelors of Engineering** degree in **Civil Engineering** during 2020-2021 session at the Anjuman-I-Islam's Kalsekar Technical Campus, New-Panvel is an authentic work carried out by her under my supervision and guidance.

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PROJECT APPROVAL SHEET

This dissertation report entitled **'EFFECT OF ENVIRONMENT ON THE STRENGTH AND SHRINKAGE OF CONCRETE'** by **QADRI SAYYED ALTAMASH, KAZI QAIS BASHIR, KHAMKAR NAVEED NAUSHAD AND SHAIKH MOHAMMED TAUSEEF** after presenting their thesis work in form of PowerPoint presentation is hereby approved in partial fulfillment for the award of Degree of Bachelors in Civil Engineering of Mumbai University, Mumbai.

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DECLARATION

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ABSTRACT:

The most important constituent of any structure is concrete. It is widely used in every construction project because of its physical and chemical properties. Concrete has a long-life span but everything deteriorate with time and the main reason of deterioration of concrete structure around the world is the weathering effect or we can say the effect of environment. Our environment consists of lot of different constituents. These constituents place a major role in the deterioration and destruction of the structure. The main reason for the destruction of the structure is the decrement in the strength of the concrete because of various different environment agents such as pH, temperature and the shrinkage due to the various conditions.

In this paper we are going to study and analyze the effect of different environmental condition on the strength and shrinkage of concrete. This will help us to understand more about the behavior of concrete even though the exact behavior of concrete cannot be determined accurately. By this data the estimation of strength will be predicted more accurately.

INDEX

Table of Content:

CHAPTER 1: Introduction

Concrete is a non-homogenous material made up of cement, fine aggregate, coarse aggregate and water in a proper proportion which sets into a compact rigid mass and acquire strength over the period of its life.

Fresh Concrete

This versatile material is used in every construction project. As it is used in every project but yet it is a very complicated material. A good quality of concrete can only be manufactured if the material used is of good quality and a good supervision

The most important property of concrete is its strength. To determine the strength of any concrete sample test such as compressive test, flexural test, split tensile strength, etc. are done. We can design concrete so as to achieve its required strength in order to withstand various loads that will be taken by the concrete. IS Code has specified the design procedure on the basis of good experimental results.

There are various factors affecting the strength and shrinkage of concrete.

Shrinkage is process in which change in volume takes place in the concrete as it loses it water due to heat of hydration. In this process micro cracks are generated inside a concrete structure and after a period of time these cracks becomes visible and lead to reduction in the strength of concrete.

Shrinkage Crack.

Therefore, we always try to reduce the shrinkage value. Following are some practice which will can be used in order to reduce the shrinkage value:

- Reduction in water cement ratio can be used to reduce shrinkage.
- Proper curing should be done in order to decrease the shrinkage value.
- Rapid hardening cement caused more shrinkage in concrete.

The strength of the concrete is affected by various environmental agents also such as pH, humidity, salinity, temperature, etc. pH is a scale to measure the acidic or basic property of any substance. Well in this case due to the increase or decrease in pH of soil the strength of the concrete in the footing is affected. Humidity is the amount of moisture present in the atmosphere. This also effect the concrete structure. Salinity can be defined as the amount of salt present in one kilogram of water. Various research papers have shown that the salinity i.e., the sulphate salts or any other salt place a very important part in the deterioration of the concrete structure.

Objectives:

- To study the effect of acidic curing on concrete strength.
- To study the effect of low pH waste water on concrete strength.
- Effect of climatic temperature of concrete.
- Effect of shrinkage on the strength of concrete.
- Effect of salinity and humidity on the property strength of concrete.

CHAPTER 2 : Literature Review

1. EFFECTS OF SHRINKAGE REDUCING ADMIXTURE IN SHRINKAGE COMPENSATING CONCRETE UNDER NON-WET CURING CONDITIONS.

In this research paper we get to know that there are two types of methods in order to reduce the shrinkage in the concrete. The use of expansive agents is recommended or shrinkage reducing admixtures are added. When there is an inadequate curing of concrete the shrinkage occurs due to the excessive evaporation of moisture. This risk can paradoxically increase in high performance concrete (HPC) structures due to the autogenous shrinkage specially in concretes with w/c in the range of 0.30–0.40.

When the shrinkage reducing admixtures is used in a proper the quantity then the shrinkage is reduced but it requires a good quantity of SRA in order to work and SRA is an expensive chemical.

Because of the expensive nature of SRA, other expansive agents are used. Expansive agents are special products which can increase the volume of concrete due to specific chemical reactions. There are many families of expansive agents. The most important are based on the formation of ettringite (C3A 3CS H32) 1 or calcium hydroxide (CH).

In order to optimize, both SRA as well as CaO-expansive agent is been used. By using both the researcher found synergetic effect in the absence of wet curing.

2. EFFECT OF ACIDIC CURING ON THE STRENGTH AND DURABILITY OF CONCRETE.

This paper has investigated the effect of acidic curing environment on the strength and durability of concrete cured in water containing a various percentage of nitric acid.

In these 80 cubes of M20 grade concrete of size 150mm×150mm×150mm, 18 no. of beams of size 150mm×150mm×450mm and 18 no. of cylinders of size 150mm×300mm were casted for testing of flexural and tensile strength using w/c ratio of 0.69 and mix proportion of 1:3:4 and cured in water containing nitric acid of 0%,5%,10%,15% and 20% respectively by volume of water for 7,14,28 and 60 days.

The results showed that the flexural and tensile strength deceases with increase in the percentage of nitric acid. There is a decrease in flexural strength by 22% and in tensile strength there is a decrease by 41%.

The compressive strength of concrete cured in various percentage of nitric acid at 7,14,28 and 60 days decreases. It was observed that as the concrete ages the deteriorating effect of the acid increases. The drop in percentage of compressive strength increases with increase in both percentage of nitric acid and using age/period. Hence the rate of deterioration of concrete cured in acid medium increases with the increase in concentration of nitric acid and using age.

Thus, concrete structure cannot stand the test of time in acid environment unless special cements are used.

3. PERFORMANCE BASED DESIGN APPROACH FOR REINFORCED CONCRTE PRECAST STRUCTURE.

Nowadays precast concrete structures are becoming the most popular construction procedure in the world. They are also expected to lead the worldwide construction because they are fast, cheap and simple to construct.

More importantly they are sustainable products with high durability. Minimum waste is produced during manufacturing process and precast elements can be completely recycled at the end of their life.

Precast concrete structures have many advantages as compared to that of traditional cast-in-situ.

They are prepared, casted and cured in a well-controlled environment which allow to use material efficiently and to produce high quality precast concrete structural member.

The construction proceeds rapidly once the precast concrete members are manufactured and transported to the site. Only a small amount of formwork and temporary supports are required and the work will not be affected badly due to bad weather conditions.

It was observed that many precast concrete structures perform poorly during earthquake. A review based on the performance of such structures were listed in the international federation for structural concrete. It was found out that the main reason for the poor performance of the precast building were due to poor design and detailing of the structural elements and connections.

4. DAMAGE EFFECT ON CONCRETE PERFORMANCE AND MIRCOSTRUCTURE.

Microcracks exists at cement paste aggregate interface within concrete prior to any load and environmental effects. Such cracks are formed due to drying and thermal shrinkage mismatch of aggregates particle & cement-based matrix.

Many techniques have been employed to study the complex and heterogenous microstructure of concrete.

Compression test, flexure impact, fatigue on normal and high strength concrete.

Various damage effects produce different levels and tyle of microcracks propagation in concrete. There seem to be difference in tortuosity and number of microcracks as well as extent of microcracking after different damaging effects.

Post damage properties of concrete also reflect on these normal strength concrete.

High strength concrete exhibit less extension interfacial microcracking in undamaged condition when compared to Normal concrete. This could be due to difference in aggregate texture W/C ratio and interfacial bond strength between types of concrete.

Conclusion: Compression increases the length width and area of fraction of microcracks. Fatigue increases number of microcracks. Microcracks propagating under compression damage seems to reduce the difference in properties of high strength VS normal strength concrete.

5. EFFECT OF SLUDGE WATER FROM READY MIX CONCRETE PLANT ON PROPERTIES AND DURABILITY OF CONCRETE.

Along with the increasing demand of concrete in construction industry also come together is sludge water (SW)as a waste water from concrete mixing plants.

Instead of being disposed of SW that meets the requirement of ASTM specification can be recycled and used as mixing water for concrete production.

Sludge water was replaced by tap water at 0, 20, 40, 60, 80, 100, %.and W/C ratio was 0.5, 0.6, and 0.7.

TEST CARRIED: -

1: -SLUMP TEST: - Increase in percentage of SW reduces the concrete slump because sludge contain large amount of sediment.

2: -COMPRESSION TEST: - As the % of SW increases compressive strength decrease is found that increase in W/C ratio reduces the compressive strength.

3: -DRYING SRRINKAGE: - Concrete mixed with SW replacing tap water yield higher drying shrinkage.

Suggestion for use of SW: -

Due to variation of properties of SW such as solid content chloride surface etc. before using SW basic properties should b investigated periodically. Total solid content should b< 63400 PPM.

CONCLUSION: -

SW has alkalinity of pH 12 which is higher than tap water

Compressive strength, flexural strength, and modulus of elasticity of concrete tends to decrease with increase in proportion of SW as a replacement of Tap water. Overall compressive strength is in range 84 to 95% of concrete which are comparable to ASTM requirement.

Increase in proportion of SW has no effect on unit wt. of fresh concrete.

Increase in SW has negative effect on drying shrinkage and resistance to acid attack.

6. EFFECT OF SALINITY ON CONCRETE PROPERTIES.

In this paper the authors have tested different properties of concrete such as strength (compressive strength, split tensile strength and flexural strength) after the effect of salinity.

The researcher took same grades of concrete and they cured every batch at different concentration of salt content for different time period. They made cubes, cylinders and beams of dimensions 100x100x100, 200x100dia and 100x100x400 respectively. They cured the concrete specimens at 0%, 1%, 2%, 3%, 4% and 5% concentration of salt for 3, 7, 14 and 28 days.

They tested cubes under compression and determined the change in compressive strength in concrete with respect to the change in concentration of salt present as well as the curing period. To find the flexural strength of the concrete beams of dimension 400x100x100 were used and the fluctuation in flexural strength was observed by them with the change in the concentration. The change in split tensile strength with respect to the change in the curing period were determined by the testing the cylinders as specified in the ASTM specification C496-04.

The researchers observed that there was an increase in the compressive, spilt tensile and the flexural strength of the concrete but eventually decreases the strength due to the increase in salinity.

7. EFFECT OF SALT WATER ON COMPRESSIVE STRENGTH OF CONCRETE.

Concrete is mostly used in construction materials it is used in construction of bridge over sea the pillars are under water. Therefore, there is a need of studying this topic

Sea water consist of major salts like NaCl (78%) MgCl2(10.5%), CaSO4(3.9%) and other salts too

Authors have studied that it has total salinity of 3.5% of the dissolved solids of being Nacl and mgcl2

Water containing large quantities of chlorides tends to cause persistent dampness and surface efflorescence

Testing has been done on normal cubes of about 150x150x150mm for about 7 14 and 28 days of curing

There were 2 groups one is in normal water and other is in salt water

In normal water cubes were of mortar cubes and in salt water cubes were of concrete.

From this conclusion we can say that there is no reduction of strength if we can do curing in salt water and we can use it in mass concreting without any loss of strength.

8. EFFECTS OF TEMPERATURE ON CONCRETE

In this paper we studied the effects of different temperature conditions on concrete by exposing concrete to different ranges of temperature. The behavior of the concrete changes with change in strength of concrete, type of cement, aggregate, water cement ratio, density of concrete, reinforcement provided etc. Hence, we should take into account all these factors for better understanding of the behavior of concrete at high temperature.

From this paper we came to know that RCC offers high resistance to fire but when concrete was exposed you high temperature, we came to know that mechanical properties of concrete such as strength, elastic modulus and volumetric stability

get reduced as well as the color of concrete, compressive strength, elasticity and concrete density was also affected.

And experimental study was carried out where concrete was subjected to different temperature such as 60,75,100,200,400 and 600°C for a time period of 4,8,12,72 hours and one month (30 days) on test cylinders of HSC of 100x200mm. The HSC cylinders were made of two strengths such as 80 and 100 MPa. NSC cylinders of strength 40 MPa was also made to compare the performance and it was found that tensile strength, compressive strength and weight loss was also observed in the concrete when exposed to high temperature.

REMEDIES TO REDUCE THE EFFECT IF TEMPERATURE ON CONCRETE:

Mostly in construction industry the most common remedies used to reduce the effect of temperature on concrete is to add admixtures. Or cement and fine aggregates can be partially replaced by silica fumes, copper slag, fly ash, etc.

9. EFFECT OF ELEVATED TEMPERATURE ON PROPERTIES OF CONCRETE.

Concrete material in structure is likely exposed to high temperature during fire.

In this paper authors have shown the effects of elevated temperature on concrete.

Cubes of 70x70x70mm were casted and air dried for 6 days and oven dried at 105°C for 24 Hrs.

Then specimens were tested at elevated temperature ranging between 200°C to 1200°C for 2 Hrs.

Loss of weight and compressive strength were examined. Researcher have found that one of the main effects of high temperature on concrete was reduction of compressive strength of concrete.

Change in color was also observed in the tested specimen

Conclusion,

Surface cracks becomes visible after 600°C and is extremely increased when temperature is 1000°C.Concrete specimen tested at 1200°C is completely decomposed and lost its binding properties. Relative strength reduces when temperature increases.

CHAPTER 3 : Materials

In this chapter we are going to discuss and define what are the materials and chemicals that were used in this project. Materials is an essential thing which is used in any project and it is important to use good quality materials to get the desire strength of the concrete as well as to get the desire conclusions after performing all the tests.

The use of low-quality material will result into wrong conclusions and the whole purpose of the project fails.

Below is the list of materials that were used in the work:

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- Molds of fabrication of testing members

1. **Cement:** Cement is a binding material used for binding aggregate and converts into a rigid mass after addition of water.

Various different types of cement are available here we will be using OPC (Ordinary Portland Cement).

2. **Fine aggregate:** fine aggregates are essentially any natural sand particles won from the land through the mining process. Fine aggregates consist of natural sand or any crushed stone particles that are 4.75mm or smaller.

This product is often referred to as 4.75mm minus as it refers to the size, or grading, of this particular aggregate.

3. **Coarse aggregate:** The Aggregates which will get retained on the 4.75 mm sieve or the aggregates which have size more than 4.75 mm are known as Coarse aggregate.

It is one of the most important and massively used building material in the Construction Industry. It gives volume to the Concrete.

4. **Water:** It is one of the most essential components on site without which no concrete can be produced. Water is used as a hydrating agent to start the process of hydration by which the con concrete gain its rigid structure.

But the water in the concrete should be calculated and used with care if the water cement ratio is not proper the concrete will not reach its desired strength. Here we are designing a M20 concrete and taking the water cement ratio as 0.4.

5. **Molds for fabrication of testing members:** This is as important as every other component in this project. By this we will get the desired dimensions of the specimens that will be used for testing.

The molds that we are going to use in this project are of good quality and have smooth interior surface for smooth and even specimen surface which is essential for the experiments.

6. **Mix design:** Here we have decided to use M20 grade of concrete and since for the production of M20 grade of concrete no mix design is needed. We are here using a nominal mix design. The Concrete mix ratio for M20 grade of concrete is **1:1.5:3** that mean 1 part of cement, 1.5 part of sand (fine aggregate) and 3 parts of aggregate (crushed stone) in volume and then batched for mixing. And by previous experiences we are here using the water-cement ratio to be 0.4. Which means here for 1 part of cement we will be using **0.4** part of water.

CHAPTER 4 : Methodology.

In order to get the desired results and to complete the project we have to perform some experiments in order to fulfil the desired objectives mentioned above.

Below are some of the complete experiments with the procedure and the material required for the experiments.

1. Effect of acid curing on the compressive and flexural strength of concrete:

Material: Cement, coarse aggregate, fine aggregate, water, nitric acid of 47.8% concentration.

Apparatus: Curing tank, molds of different sizes, compressive testing machine.

Procedure:

- In this experiment to determine the effect of acid curing on the compressive strength of concrete we will mold 18 cubes of concrete of grade M20.
- By using a nominal mix design (1:1.5:3) and the water cement ratio of 0.4 the concrete cube will be casted.
- 3 curing conditions will be made by using nitric acid to increase the acid concentration in the water. (0%, 10% and 20%).
- We will demold all the 18 cubes after 24hrs and prepare 3 batches of them to be cured in different acid concentrated water respectively.
- We will test 2 cubes on 7 days of curing and other cubes similarly on 14days and 28 days.
- We will then test it under compressive load and observe the increment or decrement of compressive strength.

Expected conclusions: As we have studied in a previous research paper the increase in the concentration of the nitric acid decreases the strength by deteriorating the concrete. The duration of curing in an acidic environment as well as the concentration of the acid present both plays a significant role in the deterioration of concrete specimens.

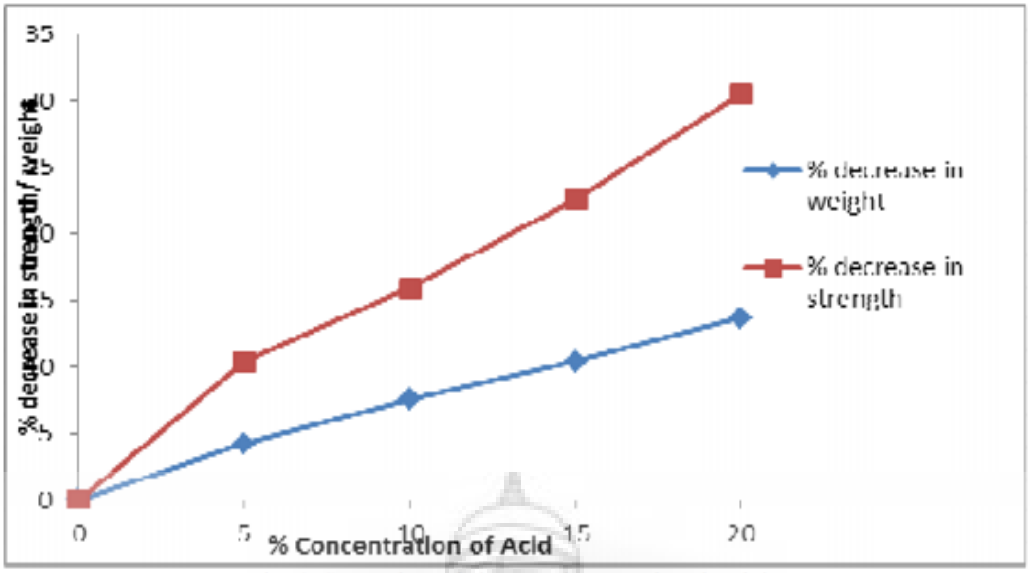

Fig. 6: Comparism of decrease in strength and weight

2. Effect of Salinity on Concrete Properties:

Material: Cement, coarse aggregate, fine aggregate, water, salt.

Apparatus: Curing tank, molds of different sizes, compressive testing machine.

Procedure:

- In this experiment we are going to use concrete of grade M20.
- Total 18 cubes will be casted of standard dimensions and curing will be done for 7,14 and 28 days.
- Two separate curing conditions will be made one with the normal water and the other with the additional salt.
- The salinity of the water is to be maintained at 35 grams per liter of water.
- After the specified time of 7,14 and 28 days take out 3 cubes from both the curing water and test it under compressive force in the UTM (Universal Testing Machine).
- Compare the results obtained from both the curing condition.

Expected conclusion: as we have learnt and analyzed by some previous research paper, increase in the compressive strength is observed in the cubes which were placed in the salt water.

Below are some of the results that were observed.

Table 1 – Compressive strength of mortar cubes cast and cured with fresh water .

Cube Size (mm)	Age of cube (days)	Average Test loads (tonnes)	Average compressive strength (N/mm^2)
150X150X150	7	61	27.12
150X150X150	14	72	32
150X150X150	*28*	*88*	*39.12*

Table 2 – Compressive strength of concrete cubes cast and cured with salt water.

Cube Size (mm)	Age of cube (days)	Average Test loads (tonnes)	Average compressive strength (N/mm^2)
150X150X150	7	64	28.45
150X150X150	14	78	34.67
150X150X150	28	93	41.34

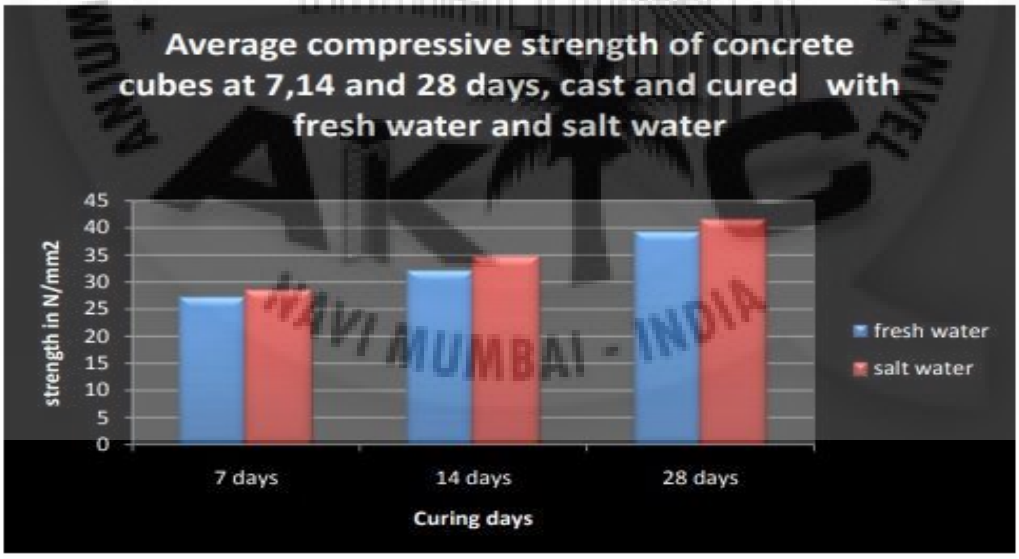

Fig.1- Average compressive strength of concrete cubes.

3. Check of low pH waste water on concrete.

For this experiment M20 grade has been used and it is been kept under waste water to know the strength of concrete

Following are the impurities which are present in the waste water: -

Table I: Recommendedlimitsand possible hazardous effectsof dissolved chemical impurities in water [3]

Impurities	Limit	Remarks
$NaNO_3$ and KNO_3	No limit available	Sodium and potassium nitrates give strength little inferior to those obtained with sodium chloride.
$CaSO_4$	No limit available	Water saturated with calcium sulfate is satisfactory for the liquid phase in cement paste which is normally saturated or even super-saturated with this compound.
$Ca(NO_3)_2$	1.7% weight of cement	Calcium nitrate added 1.7% weightof cement accelerates setting time and strength reduction.
Na_2SO_4, $MgCl_2$, $MgSO_4$	10,000 ppm	1% concentration of these common ions, exclusive of carbonate and bicarbonate, could be present without much effect on strength.
$(FeSO_4)$	No limit available	In mix water, if 0.5, 1, 2, and 4 % weight by water shows 28 days and 3 years tensile strengths which is exceeding 10 and 15% of control specimens.
Zinc oxide	0.01% weight of cement	No significant effect but 0.1% strongly retarded setting time and lowered strength.
Ammonium ion	No limit available	Ammonium chloride increased strength. 0.4, 0.8 and higher percentage by weight of water of ammonium nitrate give same strength as with similar percentage of NaCl in water for making concrete.
Tannic acid	0.5% weight of water	No effect on strength but may have a considerable effect on setting time of concrete.

Also, pH according to IS 456:2000: -

Parameter	Standards	Limits	Provision / Remarks
pH value	IS456-2000[6]	≥6.0	- Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.
	AS 1379[7]	>5.0	-Water recycled from ready mix concrete mixer, from washout operations may be used as mixing water if it is first stored in accordance with Clause 3.2.3 and the water drawn from the storage outlet is of acceptable quality. -Testing method is accordance with AS/NZS 1580.505.1
	ACI 318M-08[9]	-	Any natural water that is potable and has no pronounced taste or odour is satisfactory as mixing water for making concrete.
	EN 1008[11]	≥4.0	-Water for use in concrete shall conform to the requirements of clause no. 4.2, 4.3.1, 4.3.2 and 4.3.3. The water shall also conform to the chemical requirements as per clause no. 4.3.4

After studying this experiment, we got to know that degree and rate of attack of corrosion of steel is increases as pH value of water decreases. It was found that, the rate of corrosion is more below 3.0 pH value of water. There is reduction of

compressive strength and split tensile strength of concrete with reduction in pH value of water.

4. Effects of elevated temperatures on properties of concrete.

Concrete is fire proof to some extent, but how their strength gets effected due to increase in temperature. In this reference paper they have introduce concrete to some extreme temperature.

For this experiment concrete have been introduce to 200 ºC, 400 ºC, 600ºC, 800ºC, 1000 ºC and 1200 ºC.

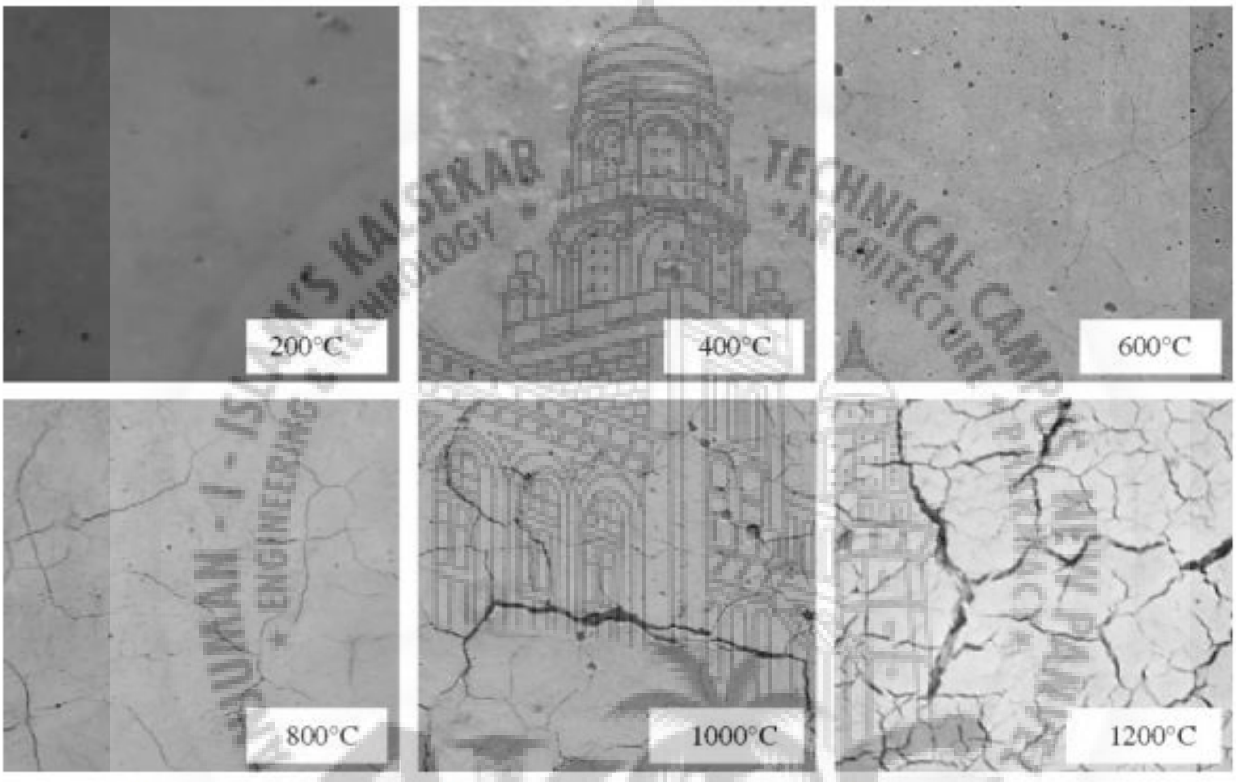

Fig. 2. Surface texture of the concrete samples exposed to elevated temperatures.

Results:

It was noticed that the surface cracks became visible when the temperature reached 600 ºC. The cracks were very pronounced at 800 ºC and increased extremely when the temperature increased to 1000ºC

Concrete specimens subjected to a temperature of 1200 ºC were completely decomposed.

The weight of the concrete specimens reduced significantly as the temperature increased. This reduction was gradual up to 800 ºC. A sharp reduction in weight was observed beyond 800 ºC.

The effects of w/c ratio and aggregate type on the weight losses were not significant.

The relative strength of concrete reduced with increase in exposure temperature.

CHAPTER 5 : Conclusion:

1. Check of Acidic curing on flexural and compressive test of concrete: As we have studied in a previous research paper the increase in the concentration of the nitric acid decreases the strength by deteriorating the concrete. The duration of curing in an acidic environment as well as the concentration of the acid present both plays a significant role in the deterioration of concrete specimens.
2. Check of extreme temperature on concrete: It was noticed that the surface cracks became visible when the temperature reached 600 ^{o}C. The cracks were very pronounced at 800 degree C and increased extremely when the temperature increased to 1000^{o}C. Concrete decomposed after 1200 ^{o}C.
3. Check of salinity and its behavior on concrete: - There is marginal increase in the strength of cubes cast and cured in salt water as compared to those of cast and cured in fresh water at all ages of curing.
4. Changes in concrete strength after addition of fly ash: - Since fly ash ties up free lime which leads to less bleed voids, it leads a considerable reduction of permeability to water and sulfate as aggressive chemical. Moreover, in case of sulfate attacks the experimental results show that uses of %20 FA (fly ash) as replacement of Portland cement cause a slight difference in strength properties of concrete samples.
5. Check of low pH waste water on concrete: - Degree and rate of attack of corrosion of steel is increases as pH value of water decreases. It was found that, the rate of corrosion is more below 3.0 pH value of water. There is reduction of compressive strength and split tensile strength of concrete with reduction in pH value of water.

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