

# Experimental Investigate of Strength Parameters of Concrete under Acidic Environment

M Tirumala Rao, Dumpy Venkateswarlu



**Abstract:** This paper mainly investigates about the weathering effect of acidic curing environment on the strength parameters and durability concerns of concrete which is cured in different percentages of carbonic acid and nitric acid presence in water supplied for curing and in atmosphere. For this investigation procedures a concrete grade of M40 cubes with sizes 150mmx150mmx150mm, and a beam of size 150mmx150mmx300mm and 150mmx300mm concrete cylinders specimens are considered to check the performance of specimen in matters of compressive, tensile strength, Bending strength (flexure) respectively. By adopting the mix design samples, which are calculated based on locally available materials parameters. These mix design concrete samples are allowed to cured in water with the presence of the chemical concentration of 0,2,5,8 of nitric acid and carbonic acid by volume of water upto the curing duration period of 7,28,60 days. The compressive strength of the specimens which are allowed to cure in the above specified percentage chemical concentration of the acid is observed that there is a decrease with age of curing increases. As far as the possibility in vitality increments with both level of corrosive and restoring age. By observing the overall data it is clear that the rate of deterioration is more at 60 days curing. The tensile and flexural stress at 28 days mentioned as that the vitality diminished with enhance in offer attention to corrosive. For an exact relieving age, both the internal strength and material of the specimen declines with an increase in the attention to corrosive. Likewise for an extraordinary consciousness of corrosive, the weight and strength of material observed as reductions with increase in the age and serviceability. It is clear in all the way that there is a close relationship between loss in weight of aggregate and reduction in compressive strength of the specimen. It can accordingly be reasoned that decay of cement relieved in acidic medium will increment with attention to corrosive and restoring age. The strength diminishes quicker as the solid ages. Along these lines, solid developments can't stand the trial of time in acidic surroundings until exceptional concretes two are utilized.

**Keywords:** Carbonic acid, Nitric acid, Compressive Strength, Split Tensile Strength, Flexural Strength, Durability and Weight loss, Curing.

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## I. INTRODUCTION

Concrete is a highly composite homogenous mixture composed of aggregate, the aggregates of coarse size and fine size made a solid hardened stone like material by means of bonding material called cement when it forms heat of hydration with water. After mixing the all the above discussed ingredients in proper designed proportions it will set and hardened with time. As we know around the globe the most used material ever in the history is concrete. These concrete are classified based on cementing materials like if lime is adopted the port land cement concrete will form like wise others. For the pavement constructions the another most famous concrete we are use from decades are asphalt concrete, bitumen will act as the cementing material i.e., binding material instead of cement. After aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid slurry i.e. easily poured and molded into any shape. In the processes of Heat of hydration the cement responds chemically with water and other ingredients to form a hard matrix that binds the materials together into a strong stone-like material that has several usages. Frequent, additives (for example pozzolans or super plasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Maximum concrete is poured by reinforcing materials (for example rebar) embedded to provide tensile strength, yielding reinforced concrete. Number of researcher's are worked on the fact that the acids will make a strong effect on durability parameters of concrete like strength, which is stated by MOHD.Mutaffa AL.Bakri Abdullah, A.victorsandhu in 2013, Emmanuel,k.attigolle and shami H.rizkallasallem Barbhuiya in 1958, Davin kumala in 2017. Along with these studies some other studies are carried out on effect of  $\text{HNO}_3$  AND  $\text{H}_2\text{CO}_3$  and other chemicals that effect on the concrete durability and life. This project deal with  $\text{H}_2\text{CO}_3$  and  $\text{HNO}_3$  ACIDS attack on concrete durability with different acidic concentrations.

### 1.1 ACID ATTACK ON CONCRETE

Ordinary Portland Cement (OPC) is highly alkaline in nature and having the pH values above 12. So whenever the concrete or matrix paste comes into contact with the acids.



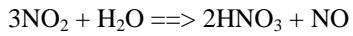
The reaction between the concrete and acid will start and finally leads to disintegration of its components, this phenomenon is known as acid attack.

If pH decreases to values lower than stability limits of cement hydrates, then the corresponding hydrate loses calcium and decomposes to amorphous hydrogel. The final reaction products of acid attack are the corresponding calcium salts of the acid in addition as hydrogels of siliceous, aluminum, and ferric oxides.

When acid attacks the concrete at that time it dissolves both hydrated and un-hydrated cement compounds in addition as calcareous aggregates. In most of the cases the chemical reaction results in water soluble calcium compounds that are leached away. Concrete vulnerability to acid attack rises as the pH of the acid in contact decreases from 6.5. Degree of aggression is Slight for pH: 6.5 to 5.5, Severe for pH: 5.5 to 4.5 and Very Severe for pH less than 4.5. not only the pH values will affect the concrete but also the presence of  $\text{CO}_2$ .

### 1.1.1. Effect of Nitric Acid on Concrete:

Nitric acid ( $\text{HNO}_3$ ), also known as aqua Fortis (Latin for strong water) and spirit of niter, is a highly corrosive mineral acid. The pure form of fresh compound is colorless, but if keep the sample for days it turns into yellow colour, this is mainly due to decomposition into oxides of nitrogen and water. In general mostly available nitric acid has a concentration of 68% in water. When the solution contains more than 86%  $\text{HNO}_3$ , it is referred to as fuming nitric acid. Depending on the amount of nitrogen dioxide present, fuming nitric acid is further characterized as white fuming nitric acid at concentrations above 95%, or red fuming nitric acid at concentrations above 86%. Nitric acid is the primary reagent used for nitration – the addition of a nitro group, typically to an organic molecule. While some resulting nitro compounds are shock- and thermally-sensitive explosives, a few are stable enough to be used in munitions and demolition, while others are still more stable and used as pigments in inks and dyes. Nitric acid is also commonly used as a strong oxidizing agent. Nitric acid usually released from chemical plants during explosives, artificial manure and other similar products. The nitric acid also formed in the form of the radicals of nitrate in the presence of water.



Though  $\text{HNO}_3$  is not as strong as  $\text{H}_2\text{SO}_4$ , its effect on concrete at brief exposure is extra destructive since it transforms CH into highly soluble calcium nitrate salt and low soluble calcium nitro-aluminate hydrate.

Due to nitric acid effect the concrete get corroded along with shrinkage, the shrinkage is mainly due to the leaching of highly soluble calcium nitrate. Such volume contractions of the corroded layer, one can observe the visual cracks across the corroded layer due to the nitric acid attack. In the presence of these cracks the transport rate of acid and corrosion

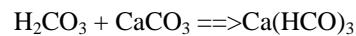
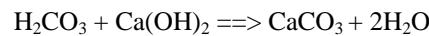
products to and from the corrosion front rises and this accelerates the process of deterioration.

### 1.1.2. Carbonic Acid Attack on Concrete:

Carbonic acid assault typically happens on account of covered concrete material structures noticeable with acidic water quite a while. Air carbon dioxide consumed by downpour penetrates in to ground water as carbonic acid. Components influencing the amount of acid assault are;

- Concrete Quality
- carbon dioxideConcentration
- External conditions

At the point where the concrete is noticeable to carbonic acid, a response creating carbon free radicals happen that is joined by shrinkage. The carbonation that stops the outer face is allowed to seal the face by shaping calcium carbonate, that decreases the penetrability and rises the quality of the carbonated face. Nonetheless, proceeded with carbonation will make a decrease in cementalkinity glue that could be major issue not only just in degradation and consumption of alloys however too in disintegration of binding material moistures. Grube and Rechenberg portrayed that proceeded with carbonation because of carbonic acid assault causes : major change of calcium carbonate as solvent bicarbonate that is expelled by draining into the acidic arrangement and consequently expanding the porosity.



Deterioration of moisture cement items, prompting arrangement of gummy paste at face comprising of silicahydro gels, aluminahydro gels and ferric oxide hydro gels.

## II. MIX DESIGN

Material	Water	Cement	Fine aggregate	Coarse aggregate
Kgs/cum	197.2	493	604	1164
Ratio	0.40	1	1.23	2.36

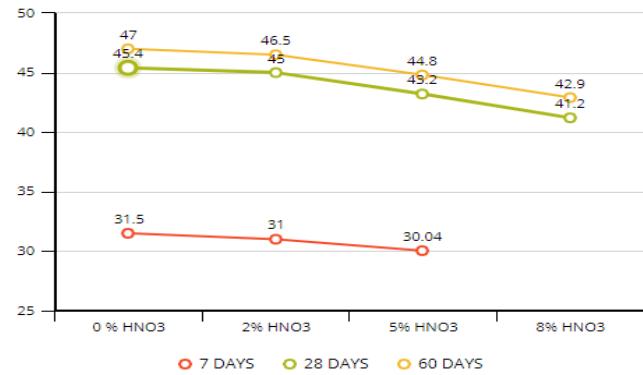
## III. EXPERIMENTAL PROCEDURES



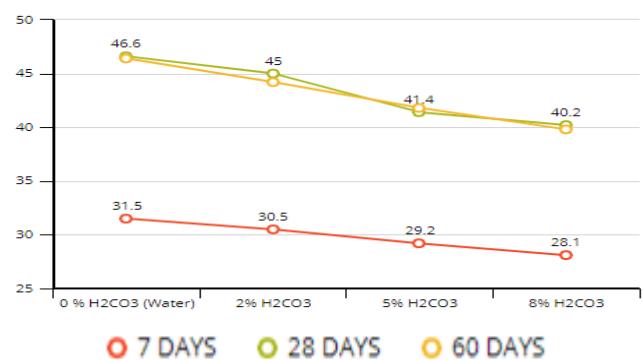
Fig 1.Curing the cube in  $\text{H}_2\text{CO}_3$  solution

**Fig 2. Testing the cube in  $HNO_3$  solution****Fig 3: Cubes of  $HNO_3$  0% Concentration and 2% Concentration.****Fig 4: Cubes of  $HNO_3$  5% Concentration. and 8% Concentration.****Fig 5. Compressive Strength testing****Table 1: Effect of  $HNO_3$  on compressive strength at 7, 28 and 60 days**

Sl. No	Grade of concrete M40	Cured in different % of $HNO_3$ solution	7 days strength (MPa)	28 days strength (MPa)	60 days strength (MPa)
1	M40	Water	31.5	46.4	46.6
2	M40	2% $HNO_3$	31	46	46.2
3	M40	5% $HNO_3$	30.04	44.2	44.6
4	M40	8% $HNO_3$	30	42.2	42.4

**Fig 6. Effect of  $HNO_3$  on compressive strength at 7, 28 and 60 days.****Table 2: Effect of  $H_2CO_3$  on compressive strength at 7, 28 and 60 days .**

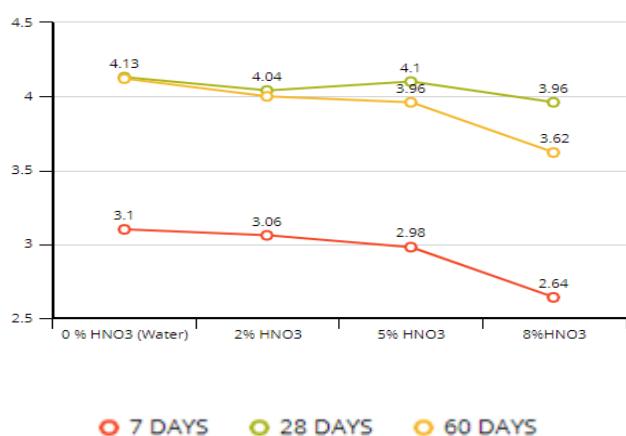
Sl. No	Grade of concrete M40	Cured in different % of $H_2CO_3$ Solution	7 days strength (MPa)	28 days strength (MPa)	90 days strength (MPa)
1	M40	0 % $H_2CO_3$ (Water)	31.5	46.4	46.6
2	M40	2% $H_2CO_3$	30.5	44.2	45.0
3	M40	5% $H_2CO_3$	29.2	41.8	41.4
4	M40	8% $H_2CO_3$	28.1	39.8	40.2

**Fig 7. Effect of  $H_2CO_3$  on compressive strength at 7, 28 and 60 days.****Fig 8. Split tensile testing**

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**Table 3. Effect of HNO<sub>3</sub> on split tensile strength of concrete at 7, 28 and 60 days**

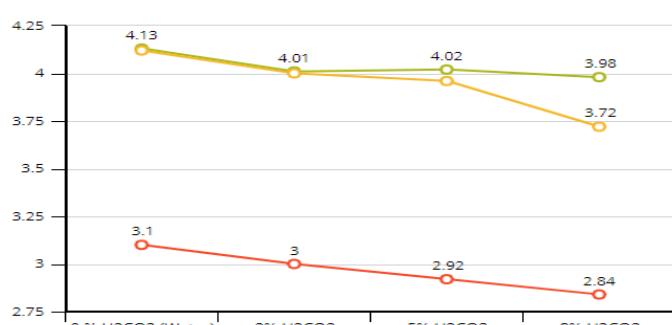
Sl. No	Grade of concrete M40	Cured in different % of HNO <sub>3</sub> solution	7days Split tensile strength(Mpa )	28 days split tensile strength(Mpa )	60 days split tensile strength(Mpa )
1	M40	Water	3.1	4.12	4.13
2	M40	2% HNO <sub>3</sub>	3.06	4.00	4.04
3	M40	5% HNO <sub>3</sub>	2.98	3.96	4.1
4	M40	8%HNO <sub>3</sub>	2.64	3.62	3.96



**Fig 8.Effect of HNO<sub>3</sub> on split tensile strength of concrete at 7, 28 and 60 days**

**Table 4.Effect of H<sub>2</sub>CO<sub>3</sub> on split tensile strength of concrete at 7, 28 and 60 days**

Sl. No	Grade of concrete M40	Cured in different % of H <sub>2</sub> CO <sub>3</sub> Solution	Split tensile strength at 7days (Mpa)	Split tensile strength at 28 days (Mpa)	Split tensile strength at 60 days (Mpa)
1	M40	0 % H <sub>2</sub> CO <sub>3</sub> (Water)	3.1	4.12	4.13
2	M40	2% H <sub>2</sub> CO <sub>3</sub>	3.00	4.00	4.01
3	M40	5% H <sub>2</sub> CO <sub>3</sub>	2.92	3.96	4.02
4	M40	8% H <sub>2</sub> CO <sub>3</sub>	2.84	3.72	3.98



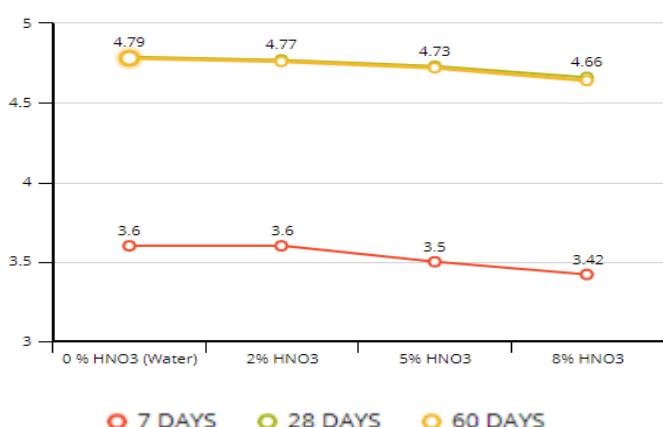
**Fig 9.Effect of H<sub>2</sub>CO<sub>3</sub> on split tensile strength of concrete at 7 days, 28 days and 60 days**



**Fig 10.Flexural Testing**

**Table 5.Effect of HNO<sub>3</sub> on flexural strength of concrete at 7, 28and 60 days.**

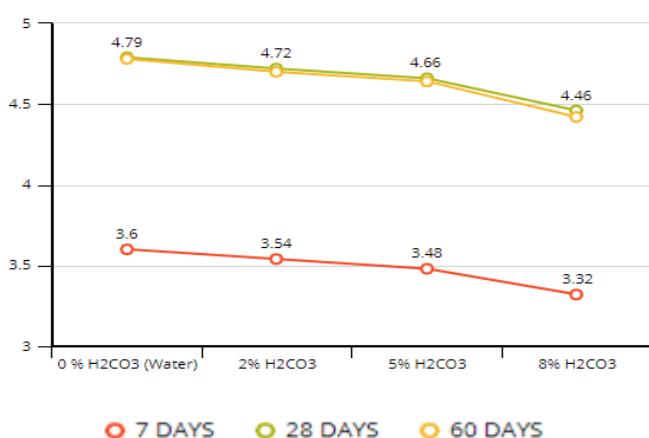
Sl. No	Grade of concrete M40	Cured in different % of HNO <sub>3</sub> solution	7days Flexural strength (Mpa)	28days Flexural strength (Mpa)	60days Flexural strength (Mpa)
1	M40	Water	3.60	4.78	4.79
2	M40	2% HNO <sub>3</sub>	3.60	4.76	4.77
3	M40	5% HNO <sub>3</sub>	3.50	4.72	4.73
4	M40	8% HNO <sub>3</sub>	3.42	4.64	4.66



**Fig 11. Effect of HNO<sub>3</sub> on flexural strength of concrete at 7, 28and 60 days.**

**Table 6. Effect of H<sub>2</sub>CO<sub>3</sub> on flexural strength of concrete at 7, 28 and 60 days .**

Sl.No	Grade of concrete M40	Cured in different % of H <sub>2</sub> CO <sub>3</sub> Solution	Flexural strength (Mpa) at 7days	Flexural strength (Mpa) at 28days	Flexural strength (Mpa) 60days
1	M40	0 % H <sub>2</sub> CO <sub>3</sub> (Water)	3.6	4.78	4.79
2	M40	2% H <sub>2</sub> CO <sub>3</sub>	3.54	4.70	4.72
3	M40	5% H <sub>2</sub> CO <sub>3</sub>	3.48	4.64	4.66
4	M40	8% H <sub>2</sub> CO <sub>3</sub>	3.32	4.42	4.46



**Fig 12. Effect of H<sub>2</sub>CO<sub>3</sub>on flexural strength of concrete at 7 , 28 and 60 days .**

#### Durability Test Resistance Against Acid Attack

For corrosive attack check concrete solid structure of measurement 150 ' 150 ' 150 mm are set up for one of a kind statements of silica rage extension. The model are tossed and re-established fit as a fiddle for 24 hours, following 24 hours, all the precedent are demoulded and placed in easing chamber for seven days. Following seven days all models are put away in atmosphere for two days for standard weight, along these lines, the precedents are checked and immersed in five percentNitric corrosive (HNO<sub>3</sub>) answer for 60-days. The acidic medium of the ph value was at 0.3. The acidic medium having phchecked and set aside at 0.3. adopted 60 days of immersed in aggressivve course of action, the precedents could taken out side and have been cleaned as strolling water and put away in air for two days for consistent weight. Along these lines the models are checked and disaster in weight and hereafter the charge weight loss used to be resolved

#### IV. CONCLUSIONS

The accompanying conclusions are drawn

1. The acidic nature water or environment curing had a adversely negative effect on the strength parameters like compressivestrength, flexural parameter and mass density of the specimen made with concrete in high concentrated amd low concenrtated acidic environment.
2. As we all know serviciblty is very important while designing the structure, but concrete elements strength gets

decreases with increase in concentration of acid in the surrounding environment and at the same time in the curing water

3. A close straight relation exists between misfortune in weight and quality as the level of acid increments
4. For Concrete structures that exposed to acidic condition, exact thought ought to be given to the arrangement, a more noteworthy component of security for high caliber used and if possible, radiant bonds used to manage the affect of the breaking down because of the reality of the acidic condition.
5. To over come the acid assaults on concrete,Acid safe Novolac Epoxy floor coatings gives the most elevated amount of security against several unique synthetic compounds and acids. Novolac epoxies are a class of epoxy coatings that are exceptionally made to oppose harsh acid and concoction spills.

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