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## Influence Of Acid On The Strength Of Concrete

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**Abstract:** Concrete is widely used in infrastructure due to its high compressive strength, durability, and cost-effectiveness. However, exposure to acidic environments significantly affects its mechanical and durability properties. Acid attack primarily occurs when concrete structures are exposed to industrial effluents, acid rain, sewage systems, or aggressive soils containing acids such as sulfuric acid, hydrochloric acid, and nitric acid. These acids react with the alkaline components of hydrated cement paste, particularly calcium hydroxide ( $\text{Ca}(\text{OH})_2$ ) and calcium silicate hydrate (C-S-H), leading to chemical degradation.

The interaction between acids and cement hydration products results in the formation of soluble salts and expansive compounds such as gypsum and ettringite, which weaken the internal structure of concrete. This process reduces compressive strength, increases porosity, and accelerates surface deterioration through scaling, cracking, and mass loss. Sulfuric acid is particularly aggressive due to both chemical reaction and sulfate attack mechanisms, causing severe structural damage compared to other acids.

The rate and extent of strength reduction depend on several factors, including acid concentration, exposure duration, type of cement, water-cement ratio, permeability, and use of supplementary cementitious materials such as fly ash, silica fume, and slag. Concrete with lower permeability and higher density generally exhibits better resistance to acid attack.

Understanding the influence of acid on concrete strength is essential for designing durable structures in aggressive environments. Preventive measures such as proper mix design, protective coatings, and the use of acid-resistant materials can significantly enhance service life and structural performance under acidic exposure conditions.

**Key Word:** Acid attack, Concrete degradation, Strength loss, Durability, Chemical corrosion (or chemical attack), pH value, Cement matrix (or cement paste), Microstructure, Pore structure (or porosity, permeability), Material properties (mechanical properties, physical properties).

### INTRODUCTION

Water is an important in gradient of concrete, which is not only actively participates in the hydration of cement but also contributes to the workability of fresh concrete. Cement is a mixture of complex compounds, the reaction of cement with water leads to setting and hardening. All the compounds present in the cement are a hydrous, but when brought in contact with water, they get hydrolyzed, forming hydrated compounds. Since water helps to form the strength giving cement gel, the quality of water is to be critically monitored and controlled during the process of concrete making as the water universally the most abundant and naturally available solvent, can be contain large no of impurities ranging from less to very high concentration of them. In practice, very often, great control on properties of cement and aggregate is exercised but the control on the quality of water is often neglected. A popular yardstick to the suitability of water for mixing concrete is that, if it is fit for drinking, it is fit for making concrete. This doesn't appear to be a true statement for all condition. Sometimes, water contain a small amount of sugar would be suitable for drinking, but not for making concrete and conversely water suitable for making concrete may not be necessarily be fit for drinking, especially if the water contains pathogenic microbial contaminants. In connection research work has been carried out on effect of polluted/chemical water on hardened concrete strength and durability. The damage impact of various deicing chemicals and exposure conditions on concrete materials was studied and results indicated that the various deicing chemicals penetrated at different rates in to a given paste and concrete

resulting in different degree of damages (Kejin et al 2006). One study had presented an assessment of the chemical resistance of eight different compositions of polymeric mortars (Gorninsi et al 2007). In one of the studies, the effects of environmental factors on the addition and durability characters, was reported, of epoxy bonded concrete prisms (Adnan et al 2009). Some researchers had investigated the resistance of mortars to magnesium sulphate attack and reported that there is assign if I can't change in compressive.

## LITERATURE REVIEW

**Venkata Ram babu V and Amit B Mahindra kar (2013)**, studied the impact of aggressive environment on concrete. They stated that the present-day construction industry needs an environmentally friendly material which should with stand its material properties throughout sits estimated lifespan. The material should be a esthetically pleasing, maintain balance in ecology of environment in order to take health care of it and wastages should be minimized. Concrete is one such material which full fill all the needs and lots of research has been going on for predicting its behavior in various environmental conditions. Concrete may be affected by the presence of pollutants in the environment such as carbon di-oxide, NO<sub>x</sub>, oxides of Sulphur and suspended particulate matter. At present concrete is gaining special importance due to its ability to resist severe environmental conditions such as marine environment, harsh environment (high & elevated temperature), high humid regions, sulphate rich environment, acidic environment, alkaline environment, sewer environment, freeze & thaw Cycles, and et. These environments lead to deterioration of concrete by effecting plastic shrinkage, strength loss at later ages, decrease in compressive strength, pore structure, corrosion of steel, and decrease in service life i.e., life expectancy and durability. To overcome these problems concrete made with different types of admixtures in ordinary Portland cement like Fly-ash, Granulated Blast furnace Slag, Rice husk ash and Silica fume, or Pozzolana cements, slag cements, pumice stone concrete and low calcium fly ash-based concrete will serve.

**B. Madhu sudhana Reddy, H Sudarsana Rao and M.P George (2012)**, studied the effect of Hydrochloric Acid (HCl) on Blended Cement (Fly Ash based) and Silica Fume Blended Cement and their concretes. They conducted an experiment

on BC (Blended Cement) and SFBC (Silica Fume Blended Cement) and their concretes BCC and SFBCC produced with HCl dosage of 100, 150, 300, 500 and 900 mg/l added in deionized water. In addition to this control specimens were prepared with de ionized water (without HCl) for comparison. The setting times and compressive strength were evaluated for 28 and 90days apart from studying Rapid chloride ion permeability. The results show that, as HCl concentration increases, there is retardation in initial and final setting of cements (BC and SFBC). The compressive strength of both BCC and SFBCC has come down with an increase in the concentration of HCl at both 28 and 90 days. Compressive strengths of BCC and SFBCC have decreased in the range of 2 to 19%, at 28and 90day age respectively, with an increase in HCl concentration, when compared with the control specimens. It was also observed that Chloride ion permeability has increased with an increase in the concentration of the acid. X-ray diffraction analysis has been carried out for both BCC and SFBCC specimens at HCl concentration of 500mg/l in deionized water.

**Aiswarya Sreehari and Kavitha P E (2017)** studied the Influence of Exposure to Acid Environment on the Bond Strength of Basalt Fiber Reinforced Polymer Bars and Steel Bars Embedded Concrete Blocks. They stated that the concrete is reinforced with steel bars to take care of the tensile stresses. Thus, sufficient bond is required for the combined action of steel and concrete. But in certain aggressive environments, the bond will be eliminated due to the corrosion of steel bar. This led to the usage of non-corrosive FRP bars instead of steel bars. Amongst all the FRP's, basalt fiber reinforced bars (BFRP) is a latest innovation in which limited research is conducted based on the practicability of reinforcing concrete structures. This paper hence studies the applicability of using BFRP bars in an acid environment for 28 days exposure duration to assess whether the bond strength satisfies the limits recommended in the IS 456:2000, in comparison with steel bars. The bond failure modes were also studied by performing a series of pull-out test on concrete blocks with variations in grade of concrete such as M25, M30 and M35 and diameter of bars such as 10 mm, 12 mm and 20 mm. They concluded that the bond stress is higher for higher concrete grades and the bond stress decreased with an increase in the surface area

of bar.

### Emmanuel K Attiogbe and Sami H. Rizkalla (1988)

studied the Response of Concrete to Sulfuric Acid Attack. They examined the response of four different concrete mixes to sulfuric acid attack in an accelerated laboratory test program. Small test specimens cut from standard concrete cylinder sand a 1 percent sulfuric acid solution with a Ph of J were used in the test program. Changes in weight and thickness of the test specimens were used as physical indicators of the degree of deterioration, while increase in sulfur content of the test specimens was used as a chemical indicator of the degree of deterioration. They observed that all three indicators of deterioration are effective measures of concrete response to the acid attack. They concluded that the increase in thickness (expansion) of small specimens (with large surface area-to-volume ratios) maybe a more consistent measure than the weight loss of larger specimens when comparing the effects of different sulfuric acid concentrations on concrete.

**Salim Barbhuiya and Davin Kumala (2017)** studied the Behavior of a Sustainable Concrete in Acidic Environment. They conducted an experimental investigation to study the behavior of sustainable concrete in 3% sulphuric acid and 1.5% nitric acid environment in which cement was replaced by a combination of fly ash and ultra fine fly ash. They found that the compressive strength loss of concrete in these acid environments was the minimum in which cement was replaced by 30% fly ash and 10% ultra fine fly ash.

**K. Bhanu Prakash Reddy, K. Tanuja and N. Vasu Deva Naidu (2016)** studied the Use of copper slag in concrete and cement mortar as replacement of sand. They stated that, it is potential to use copper scum as a concrete combination, as a result of copper scum has similar particle size characteristics seemingly to it of sand. Fine grained powder of copper scum is used as a supplementary cementing material to concrete and in cement clinker production. though their area unit several studies that are reported by investigators from alternative countries on the employment of copper scum in cement concrete, not abundant analysis has been meted out in India regarding the incorporation of copper scum in concrete. Concrete cubes were solid and tested in laboratories. The optimum proportion of

replacement was found by conducting Compressive and split lastingness. Similarly, the second a part of the thesis, assessment of corrosion and sturdiness studies were incorporated. Since copper scum contains quite fifty fifth of Fe<sub>2</sub>O<sub>3</sub> content, conclusion and sturdiness factors area unit necessary to seek out. So, seven concrete mixtures were legitimate with replacement of third to 100% of copper scum with sand in concrete. Acid and resistance check, inaudible pulse rate (UPV) check, Initial surface absorption check, Capillary suction check was conducted to assess corrosion and sturdiness characteriorrostics.

## EXPERIMENTATION & RESULTS

**Table.1:** Results obtained for the cubes (OPC) tested at 1% acid solution

S. No	Age of Acidm- mersion (in days)	Strength of Cubes Attained (in MPa)			
		Water	Type of Acid		
			HCL	H <sub>2</sub> SO <sub>4</sub>	HNO <sub>3</sub>
1	14	24.70	23.91	21.90	22.28
2	21	25.89	22.58	20.21	21.56
3	28	27.70	21.17	18.95	19.43

**Table.2:** Results obtained for the cubes (PPC) tested at 1% acid solution

S. No	Age of Acidm- mersion (in days)	Strength of Cubes Attained (in MPa)			
		Water	Type of Acid		
			HCL	H <sub>2</sub> SO <sub>4</sub>	HNO <sub>3</sub>
1	14	25.91	24.62	23.60	24.08
2	21	27.98	23.89	21.43	22.76
3	28	28.23	21.87	19.20	20.03



**Fig.1.** Cubes cured in 1% acid solution.



**Fig 2 Specimens**



**Fig 3 Qube immersed in 1% nitric acid 28 days**

## CONCLUSIONS

The following conclusions are made based on the laboratory experiments carried out in this investigation:

1. Copper slag concrete mixes resisted acid attack in a better way as compared to conventional concrete at all stages of exposure to HCl, HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>.
2. It is observed that the percentage loss of compressive strength of copper slag concrete mixes are considerably lower than that of conventional concrete mixes at all ages of acid exposure.
3. It is also observed that maximum loss of compressive

strength and weight occurs in case of H<sub>2</sub>SO<sub>4</sub> acid immersion as compared to HCl and HNO<sub>3</sub>

4. The loss of compressive strength of conventional concrete is almost double the loss of compressive strength of copper slag concrete in H<sub>2</sub>SO<sub>4</sub> acid immersion at all ages.
5. The percentage weight loss of Conventional concrete is more when compared to copper slag concrete. This is true for all the acids tried in this investigation.
6. The weight loss of Copper Slag concrete is very low when compared to Conventional concrete mixes are exposed to 1% acid attack.

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