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INNOVATIVE STRATEGIES FOR RESTORATION OF RCC STRUCTURE OF ACID STORAGE TANKS IN PROCESS INDUSTRIES - A CASE STUDY

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Abstract :

Reinforced Cement Concrete when subjected to harsh environmental conditions cause significant damage to the structures which substantially reduces its durability properties. Solutions of acids have very aggressive effect on the cement matrix in concrete. Aggressiveness of the solutions increases with acid concentration. Hence it is essential to design and construct RCC structure highly resistant to acidic environment for mounting sulphuric acid [H_2SO_4] and Hydrochloric Acid [HCL] tanks, since the acid fumes are highly destructive & reactive in nature with Reinforced concrete structure. The hydrochloric acid [HCl] is the fastest-reacting acid for dissolving cement, because HCl is a strong acid that can disintegrate rapidly the calcium silicates and aluminates in the cement, leading to rapid dissolution of binding material. The Sulphuric acid attack on reinforced concrete structure causes gypsum formation close to the surfaces result in disintegration. Spalling and disintegration of the concrete occurs due to the internal stresses developed. The creation of a layer structure is a characteristic of acidic corrosion due to Hydrochloric acid attack.

This case study is an attempt to comprehend how sulfuric acid [H2SO4] and hydrochloric acid [HCL] affect RCC structure supporting Acid Tanks and extent of its deterioration. The data generated will help in understanding the distress mechanism of RCC Structure in the Chemical prone Zone of DM water treatment Plant. It is also discussed about the preventive measures adopted for the restoration of structures to minimise the premature deterioration.

Keywords: Demineralization [DM], Reinforced cement concrete [RCC]

1. Introduction:

A Reinforced concrete (RC) structures in service are often exposed to various types of aggressive environments. The ingress of the reactive ions from external environments can change the hardened Cement paste's microstructure leading to cracking, softening, and disintegration, it is essential to assess concrete performance in the field after long-term exposure. Concrete is not fully resistant to acids. The deterioration of concrete occurs due to acid attack resulting expansion and disruption of concrete.

The effect of Hydrochloric and Nitric acid on concrete is very much high as compared to Sulphuric acid. Complete immersion of the cubes in 10 % HCl for 60 days causes maximum reduction in compressive strength to around 47 %, which is 45 % for Nitric acid and 25 % for Sulphuric acid.

The study was conducted to assess the extent of ageing degradation of concrete structures of Aluminium Process Industries , considering possible acid attacks on supporting RCC framed structure.

A thorough study was conducted to identify the exposure conditions and the concrete's performance under such conditions. The concrete powder samples were collected by drillings holes at a depth 40 mm & 80 mm for laboratory tests to study the effects of exposure conditions on the chemical deterioration to reproduce the field observations.

2. Literature Review :

The following literature survey summarized the study of effect of acid attack on performance of concrete, strength of concrete and durability of concrete.

K.Kawai etal [1], In this paper, Author has proposed a prediction method for the deterioration of concrete due to sulfuric acid. Concrete cylinder specimens were immersed in various concentrations of sulfuric acid. Also, sulfuric acid was circulated over the surface of concrete. It was found that the rate of concrete deterioration caused by sulfuric acid depended on pH value of acid solutions. Also, time of exposure of concrete to acid plays a crucial role in rate of deterioration. Paper also monitors depth of erosion.

Emmanuel K Etal [2], The authors have carried out an experimental study in which four different concrete

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mixes are subjected to same acid attack with different periods of immersion. The deterioration of concrete is studied using Scanning Electron Microscope. The authors concluded that the increase in volume and the decrease in density of concrete due to sulfuric acid-cement paste reaction would be larger the higher the acidity of the acid solution.

Shintaro Miyamoto etal [3], In this study, the authors have tried to establish a relation between deterioration of hardened concrete and sulfuric acid molar fraction and molar fraction of mixed acids. The tests were carried out on cylindrical specimens which were placed in clean acid free plastic containers with enough acid solution to immerse the exposed surfaces completely. The test duration was limited to 120 minutes and the surfaces of the test pieces were scrubbed every 20, 40, 60 and 120 minutes during the test. The tests confirmed that the deterioration rate depends on amount of dissolution of potlandite.

Beulah M., Prahallada M [4], The authors carried out an experimental investigation to study the effect of replacement of cement by 20 % Metakaolin on high performance concrete with hydrochloric acid attack. Concrete cubes and concrete cylinders were immersed in various concentrations of Hydrochloric acid. The compressive strength of cubes and cylinders decreases with increase in concentration of acid. Also, the study revealed that formation of compound Jennite may be responsible for decrease in strength of concrete.

Shripad Umale & Prof. G.V. Joshi [5],

The Experimental investigation & results carried out by on 150 mm x 150 mm x 150 mm concrete cubes casted for 28 days with immersion with sulphuric acid, HCL and Nitric acid with 5 % & 10 %solution for 30 days & 60 days, the details of experimentation area as follows :

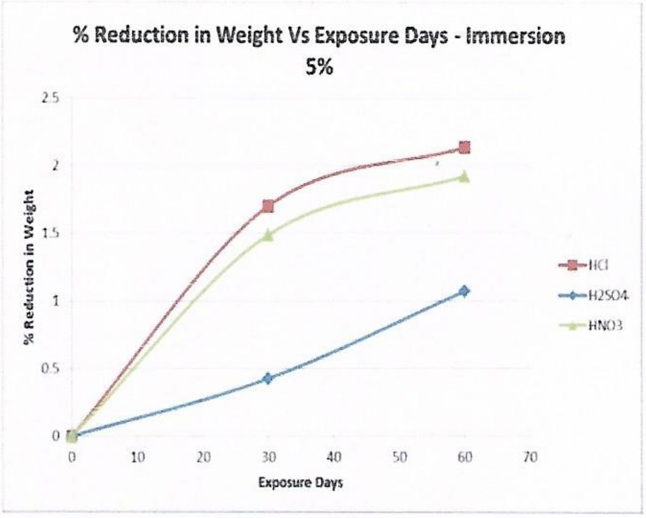

Fig. 1 : Graphical representation of % Reduction in Weight Vs Exposure Time when cubes are immersed in 5 % Acid

The above graph represent the % reduction in weight of concrete cubes for 5 % concentration of different acids when subjected to complete immersion for 30 days and 60 days. At higher exposure period of 60 days, maximum reduction of around 2.1 % is observed. when concrete cubes are immersed in Hydrochloric acid, also at lower exposure period of 30 days, maximum reduction of 1.7 % is observed for Hydrochloric acid.

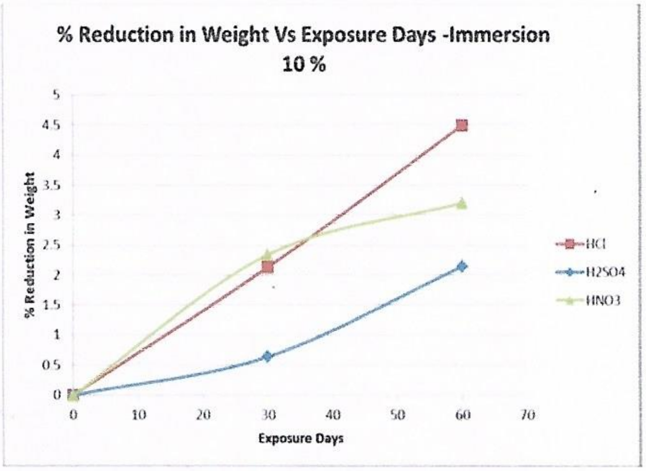

Fig. 2 : Graphical representation of % Reduction in Weight verses Exposure Time when cubes are immersed in 10 % Acid. At higher exposure period, weight reduction for HCl is more, whereas weight reduction is higheest for Nitric acid at lower exposure period.

Sakthieswaran N , Dhanaraj R [6],

The authors carried our experimental investigation in which he concluded that compressive strength of concrete with fibers silica fume and copper slag after 28 days immersion in sulphuric acid and hydro chloric acid is 11.03% and 30.50% greater than concrete without acid immersion respectively.

T. Raghunathan [7],

The author elaborately covered various basic test procedures adopted and also acid rain effect process. Remedial measures adopted to prevent acid attack on concrete is enumerated.

Dr. B. KOTAIAH [8],

The author demonstrated that acidic materials attack cement-based products. Hence, while choosing protective measures and assessing the service life of concrete structures in acidic environments, which should be taken into account.

Technical Report on Evaluation of Acid-Alkali Tank foundation [9],

Non Destructive Testing of Concrete Structures was carried out to assess the severity of the RCC structure of the Acid-Alkali Tank, Hypo Storage Tanks and HCL Tank at Process Industries in Lapanga, Odisha. The structure was distressed due to acid attack.

Trisco Systems described carbonation of concrete and mechanism of Acid Attack in Technical report documentation "Carbonation in Concrete"

Shaik Naseeruddin, Dumpa Venkateswarlu, Alamanda Sai Kumar [10],

The authors concluded in their experimental study that Acidic curing environment have a negative effect on the "compressive, flexural and tensile strengths, density of concrete cured in acidic water. The study reveals that the structure exposed to severe acidic environmental conditions did not achieved the desired serviceability.

Joseph MwitiMarangu , Joseph Karanja Thiong' and JacksonMuthengiaWachira [11],

The authors discussed carbonation process, resistance to carbonation, and the consequences of carbonation on hardened concrete.

A.Olowofoyeku,O.Ofuyatan, J.Oluwafemi [12]

The author described in this paper the Non-Destructive Testing on Concrete structures Subjected to Chemical Condition by carrying out experimental investigation in which he concluded that cubes cured with water had better strength throughout the test and deterioration was observed in the cube specimen subjected to acid.

N. Jamaluddin1, S. S Ayop [13],

In this paper the author described method to to determine the depth of carbonation by drilling hole in concrete and spraying phenolphthalein indicator to pre-drilled holes at specific pre-determined locations to obtain real time results in accordance with BS EN 14630:2006

3. Acid attack on Reinforced Cement concrete :

3.1 Effect of Sulphuric Acid [H_2SO_4] on Concrete

The Calcium sulphate salt is produced by the reaction of the sulphuric acid and Calcium hydroxide which increases degradation of concrete due to sulphate attack. The dissolution of Calcium hydroxide caused by acid attack proceeds in two phases. The first phase being the acid reaction with calcium hydroxide in the cement paste . The second phase being the acid reaction with calcium silicate hydrate. The dissolution of calcium silicate hydrate can cause structural damage to concrete. Acid attack leads to loss of binder and strength in concrete and eventually loss of section

Normally, the chemical changes of the cement matrix are restricted to the regions close to the surfaces because of less penetration of the Sulfuric acid in concrete. In certain instances, it is noted that the early decomposition of calcium hydroxide produces a significant amount of gypsum which softened the concrete.

The chemical reactions involved in sulphuric acid attack on cement based materials can be given as follows:

The following are the chemical processes that occur when sulfuric acid attacks hardened cement concrete

$$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + H_2O \quad - (1)$$

Sulphuric Acid + Calcium Hydroxide → Calcium Sulfate + Water

(Calcium sulfate product contributes to sulfate attack)

$$3CaO.2SiO_2.3H_2O + H_2SO_4 \rightarrow CaSO_4.2H_2O + Si(OH)_4 \quad - (2)$$

(Tri-calcium silicate + Sulphuric Acid → Calcium Sulfate + Orthosilicic acid

Orthosilicic acid is an inorganic compound with the formula $Si(OH)_4$. It is the key compound of silica and silicates.

The liberation of $Ca(OH)_2$ from hydration that reacted with H_2SO_4 leads to the development of $CaSO_4$ as presented in Eqn. 1.

The Tri-calcium silicate generated from hydrated concrete was reacted and caused to generation of CaSO4 with Si(OH)4 and the final products were shown in Eqn. 2

It indicates loss of compressive strength of concrete when reacted with H_2SO_4.

3.2 Hydrochloric Acid(HCl) Attack on Concrete:

A mixture of soluble and insoluble salts are the byproducts of the reaction between the hydrated cement phases and hydrochloric acid.

The soluble salts mostly those containing calcium leach out, while insoluble salts and amorphous hydrogels stay in the corroded layer. In addition to dissolving, some Fe-Si, Al-Si, and Ca-Al-Si complexes that seem stable in the pH range above 3.5 may also develop as a result of the interaction between hydrogels.

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

$Ca(OH)_2$ is basically leached from the hardened cement by the reaction

The formation of a layer structure is a characteristic of acidic corrosion due hydrochloric acid attack.

3.3 Effect of Nitric Acid (HNO_3) on Concrete ;

A common acidic corrosion that causes the corroded layer to shrink is nitrate attack, which is caused by the leaching of highly soluble calcium nitrate. Visually noticeable cracks may occur across the corroded layer as a result of such volume contractions, particularly in the case of nitric acid.

The transit rate of acid and corrosion products rises in the presence of these cracks, hastening the deterioration process..

Despite being weaker than H_2SO_4, HNO_3 has a greater detrimental effect on concrete when exposed for a short period of time because it transforms the soluble calcium hydroxide $Ca(OH_2)$ present in hardened concrete into the highly soluble calcium nitrate salt and a low soluble calcium nitroaluminate hydrate.

The process can be represented by the equations below :

$$2HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)2 \bullet 2H_2O \text{ (Calcium nitrate)} \quad - (3)$$

$$Ca(NO_3)2 \bullet 2H_2O + 3CaO\bullet Al_2O_3 \bullet 8H_2O \rightarrow 3CaO\bullet Al_2O_3\bullet Ca(NO_3)2\bullet 10H_2O \quad - (4)$$

(Calcium nitroaluminate hydrate)

3.4 Effect of Carbonic acid (H_2CO_3) on the degradation of Cement Concrete :

Carbonic acid attack will cause the cement to carbonate and then cause the carbonate to dissolve, leaving a more porous silica gel where the calcium hydroxide and calcium silica hydrate (C-S-H)

Normal concrete has a highly alkaline environment (pH level of 12-13). This high alkalinity protects the reinforcing steel from corrosion due to a passive oxide layer that forms on the surface of the steel. This protective layer remains stable in the highly alkaline environment, but not at lower pH levels.

When carbonation occurs, the pH level of the concrete is lowered, and consequently, the protective layer over the steel is lost. When the steel is depassivated and the concrete has a low pH level, then corrosion will begin when moisture is introduced into the concrete.

The carbon dioxide in the air diffuses into the concrete pores and reacts with water, it creates carbonic acid, which reacts with calcium hydroxide in the concrete to form the calcium carbonate in the presence of moisture . As a result of this reaction, the alkalinity of the concrete is reduced in the affected area. It typically begins at the exterior and moves inward at a typical rate of about 1mm per year. Reinforced Concrete structures buried in the ground and exposed to acidic groundwater over an extended period of time are subjected carbonic acid attack.

Carbonates are the product of a reaction between cement concrete and carbonic acid.

calcium carbonate is changed into soluble bicarbonate, which is eliminated by evaporating into the acidic solution and thereby expanding the porosity.

The first reaction is in the pores where carbon dioxide (CO_2) and water (H_2O) react to form carbonic acid (H_2CO_3) Eqn. 5

$$CO_2 + H_2O \rightarrow H_2CO_3 \quad -(5)$$
$$H_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2H_2O \quad -(6)$$
$$H_2CO_3 + CaCO_3 \rightarrow Ca(HCO_3)_2 \quad -(7)$$

Eqn. 6 shows that when Calcium hydroxide $Ca(OH)_2$ reacts with carbonic acid (H_2CO_3) to give calcium carbonate ($CaCO_3$) and water.

Eqn. 7 shows that significant penetration of CO_2 results in the conversion of insoluble $CaCO_3$ to soluble Calcium bicarbonate $Ca(HCO_3)_2$ which is easily leached out.

Because of the leaching of calcium compounds, the pH of concrete decreases and minerals which are durable under high pH conditions are dissolved. This causes the deterioration of the mechanical properties of the concrete

Reduction in the alkalinity of the pore solution is deleterious since it results in carbonation-induced corrosion of rebars through dissolution of its passive surface layer

4.0 A Case Study of Health Assessment of RCC structure Acid Storage Tanks is discussed;

The RCC structure of H_2SO4 Tank , HCL Tank were assessed for the Condition Assessment with Non Destructive testing :

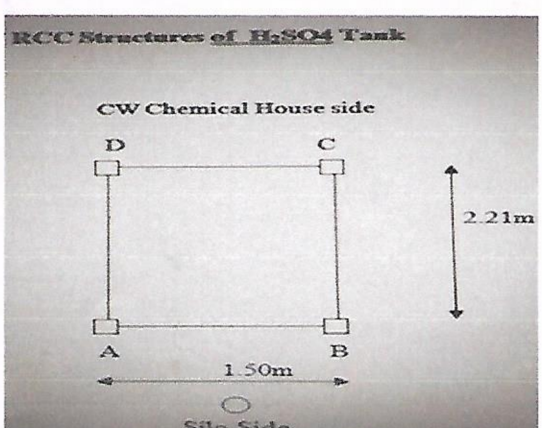

Fig. 3 : Top view of RCC Structure of Sulphuric Acid (H_2SO_4) Tank

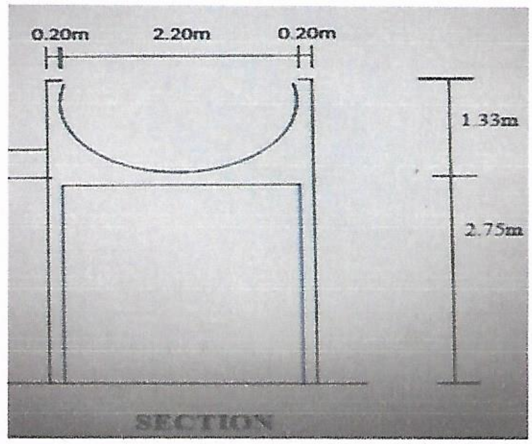

Fig. 4 : Sectional view of RCC Structure of Sulphuric Acid (H_2SO_4) Tank

5. Probing Tests :

The following probing tests were carried out :

5.1 Visual examination:

The visual examination gives important details about the structure's physical state as well as the degree and scope of the distress that has occurred there.

Fig. 5: Cracks & Porosity found in TG deck Pedestal

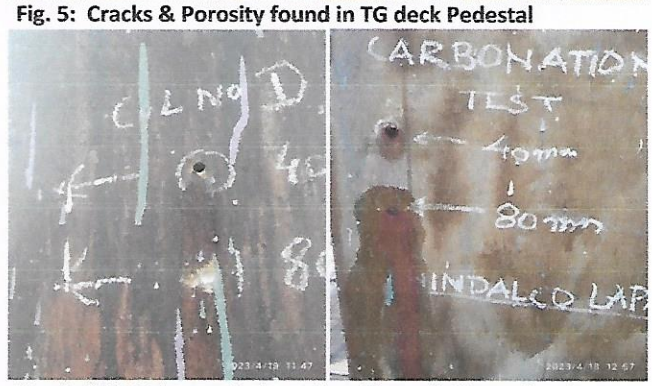

Fig. 6: RCC Columns Carbonation 40mm & 80mm Depth

5.2 Ultrasonic Pulse Velocity Test (USPV) :

The concrete's pulse velocity is determined by measuring the path's length and transit time. The ultrasonic probe's, transducer and receiver of frequency 54KHZ were employed in the investigation. To calculate the pulse velocity, two methods are used: direct and semi-direct.

The following formula determines the pulse velocity:

$$\text{Pulse Velocity} = \frac{\text{Path Length}}{\text{Transit Time}}$$

Table -1 : RCC Columns, H_2SO4 RCC Tank Structure

S.N	Particulars	Path Length mm	Transit Time µs	Velocity m/s
1.	RCC Column A	300	87.0	3568
2.	RCC Column B	300	86.0	3624
3.	RCC Column C	300	88.0	3518
4.	RCC Column D	300	89.0	3508
13.	Av. Value			3554

Table-2: RCC Beams

S.N	Particulars	Path Length mm	Transit Time µs	Velocity m/s
1.	Beam AB	300	94	3310
2.	Beam BC	300	94	3243
3.	Beam CD	300	91	3400
4.	Beam AD	300	92	3370
	Average Value			3330

Table-3 : HCL Tank ; RCC Columns

S.N	Particulars	Path Length mm	Transit Time µs	Velocity m/s
1.	RCC Column A	375	99	3800
		300	86	3618
2.	RCC Column B	375	100	3717
		300	103	3640
3.	Column C	375	117	3230
		300	103	3028
4.	Column D	375	84	3700
		300	83	3755
5.	Av. Value			3561

Table-4: RCC Beams

S.N	Particulars	Path Length mm	Transit Time µs	Velocity m/s
1.	AB	300	84	3700
2.	BC	300	83	3755
5.	Av. Value			3727

Table -5 :
The reference Concrete quality grading at different velocities is derived from IS: 13311 (Part-1)1992, Table 2.

S.N	Pulse Velocity (km/sec)	Concrete Quality Grading
1.	Under 3.0	Doubting
2.	3.1 - 3.5	Moderate
3.	3.6 - 4.5	Okay
4.	Beyond 4.5	Excellent

5.1 Schmidt Rebound Hammer Test :
By measuring the average rebound number, the surface hardness of the concrete is determined.

Table-6: RCC Columns, H_2SO4 RCC Tank Structure

S.N	Particular	Rebound Value	Impact Direction	fck N/mm²
1.	Column A	28.0	Horizontal	23.6
		29.0	Horizontal	25.3
2.	Column B	29.0	Horizontal	25.3
		32.3	Horizontal	31.1
3.	Column C	30.3	Horizontal	27.6
		30.0	Horizontal	27.0
4.	RCC Column D	34.0	Horizontal	34.1
		29.3	Horizontal	25.9
5.	Av. Value	30.0	Horizontal	27.4

Table-7: RCC Columns , HCL RCC Tank Structure

S.N	Particular	Rebound Value	Impact Direction	fck N/mm 2
1.	RCC Column A	30.0	Horizontal	27.0
		27.0	Horizontal	21.9
2.	RCC Column B	29.3	Horizontal	25.9
		28.0	Horizontal	23.6
3.	Column C	33.0	Horizontal	32.3
		32.3	Horizontal	31.1
4.	Column D	32.0	Horizontal	30.5
		32.7	Horizontal	31.7
5.	Av. Value	30.5	Horizontal	28.00

The concrete's compressive strength curves as determined by ultrasonic pulse velocity testing in conjunction with rebound hammer testing.

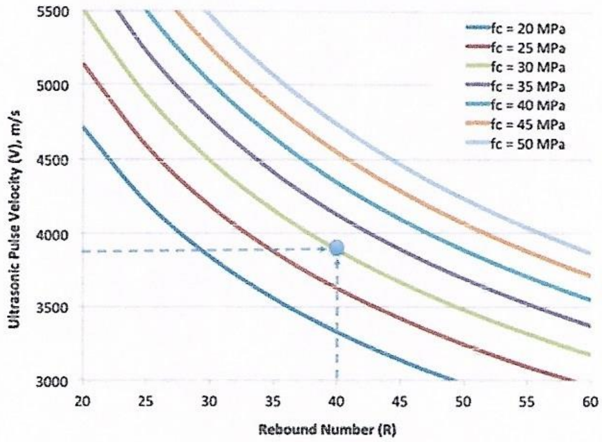

Fig. 7 : Graphical representation of SonReb model for evaluating Strength :

From this figure, the compressive strength Corresponding to any values of Velocity and Rebound Number can be evaluated.

5.2 Carbonation Test (CT) :

A carbonation test is conducted to ascertain the level of carbonation in the RCC members. Using this technique, the depth of carbonation is determined by spraying phenolphthalein indicator into small drilled holes.

Table-8: RCC Columns, H_2SO_4 RCC Tank Structure

Sl. No	Particulars	The Carbonation Depth	
		40 mm or more	80mm or more
1.0	Column A	Carbonation Not occured	Carbonation Not occured
2.0	Column B	Carbonation Not occured	Carbonation Not occured
3.0	Column C	Carbonation	Carbonation Not occured
4.0	Column D	Carbonation	Carbonation

Table-9: RCC Beams, H_2SO4 RCC Tank Structure

Sl. No	Description	Depth of Carbonation	
		up to 40 mm	up to 80 mm
1.0	Beam AB	Carbonation	Carbonation
2.0	Beam BC	Carbonation	Carbonation
3.0	Beam AD	Carbonation	Carbonation
4.0	Beam CD	Carbonation	Carbonation

Table-10: RCC Columns , HCL RCC Tank Structure

S.N	Description	Depth of Carbonation	
		up to 40 mm	up to 80 mm
1.0	Column A	Carbonation Not occured	Carbonation Not occured
2.0	Column B	Carbonation Not occured	Carbonation Not occured
3.0	Column C	Carbonation	Carbonation Not occured
4.0	Column D	Carbonation	Carbonation

Table-11: HCL RCC Tank Structure – RCC Beams

S.N	Description	Depth of Carbonation	
		up to 40 mm	up to 80 mm
1.0	Beam AB	Carbonation Not occured	Carbonation Not occured
2.0	Beam CD	Carbonation Not occured	Carbonation Not occured
3.0	Beam BC	Carbonation	Carbonation
4.0	Beam AD	Carbonation	Carbonation

5.5 Stipulation of Carbonation Test :

British standard BS EN 14630:2006 for determining thcarbonation depth in hardened concrete using the phenolphthalein indicator.
Carbonation Depth (D)
$D = Kt^{0.5}$ Where, K = Carbonation coefficient in mm per year, 3-4mm/year, t = time of exposure in years.

5.6 pH & Potential tests :

Ordinary Portland cement typically has a pH of 12.5 to 13. It may decrease as a result of degradation mechanisms such acid attack, carbonation or chloride intrusion to determine whether the nature of concrete is acidic or alkaline.

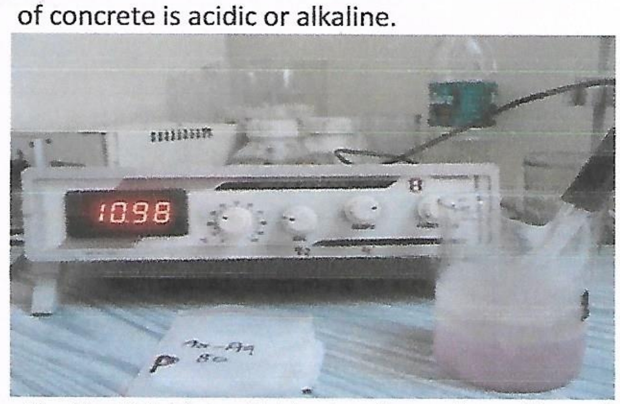

Fig. 8: pH & Potential tests of samples collected

5.6.1 pH and Potential Test:

Table-12 : RCC Column, H_2SO_4 RCC Tank Structure

Test Object : Acid storage Tanks					
Method : Direct measurement					
Instrument : El Digital pH meter					
S.N	Particular	pH	Potential (mV)	pH	Potential [mV]
		Depth -40mm		Depth- 80mm	
1.0	Column A	10.53	-212	0.41	-205
2.0	Column B	10.27	-197	10.05	-183
		10.27	-197	10.26	-196
3.0	Column C	10.43	-206	10.60	-217
		10.02	-181	10.29	-198
4.0	Column D	9.53	-152	10.6 2	-218
		10.27	-197	9.94	-177
		9.61	-157	9.53	-152
		10.53	-212	10.60	-217
5.0	Beam AB	9.20	-132	9.2 8	-137
6.0	Beam BC	9.16	-130	9.85	-171
7.0	Beam AD	9.48	-149	9.59	-155
				9.58	-155
8.0	Beam CD	8.90	-113	9.43	-146

Table-13 : RCC Columns

Test Object : HCL RCC Tank Structure					
Method : Direct measurement					
Instrument : El Digital pH meter					
S.N	Particular	pH	Potential (mV)	pH	Potential (mV)
		Depth-40mm		Depth-80mm	
1.	Column A	10.85	-231	10.51	-211
		9.98	-178	10.69	-222
2.	Column B	10.72	-223	10.77	-227
		10.11	-186	9.63	-157
3.	Column C	10.61	-216	10.75	-225
		10.73	-224	10.43	-206
4.	Column D	10.16	-190	10.72	-223
		10.57	-214	10.77	-226
5.	Beam AB	10.37	-202	10.29	-197
		10.31	-198	10.53	-211
6.	Beam CD	10.27	-196	10.41	-204
		10.11	-186	10.30	-198

The pH of the newly mixed concrete should be in the range of 12 to 13. If the pH value is much lower than 10, which denotes concrete carbonation, the concrete will be affected by carbonation.

5.0 Results and Discussion:

Given the correlation between the observed data and the hardened concrete parameters in the reference, the following observations were made.

The concrete has a medium quality grading, according to ultrasonic pulse velocity (USPV) statistics.

The concrete is carbonated upto and beyond the level of reinforcement, according to the pH and potential data values.

Restoring the structure with unique high-strength material and the appropriate strengthening technique is required, taking into account long-term durability and the surrounding operational condition.

6.0 Recommendations :

It is necessary to restore the RCC structure of the hydrochloric acid (HCL) tank and sulfuric acid (H_2SO_4) tank using modern methods and high-strength materials.

The following approach was used to strengthen the structure.

6.1 Repair of RCC Beams and Columns

6.1.1 Providing and injecting Super Low viscosity Epoxy injection grouting through 12mm dia NRV Nozzle inserted in to the concrete by at operating pressure of 4.5 to 5.5 Kg/cm^2 using pressure pump for strethening of core concrete and making concrete alkaline.

6.1.2 Providing, mixing and applying chemically modified Polymer Plaster on concrete surface average depth of 10mm.

6.1.3 Acid resistant Tiles fixing on concrete surface
Providing acid resistant treatment on horizontal & vertical surfaces by laying acids resistant bricks of 230 x 115 x 38 mm with min 6 mm thick under bed of potassium silicate based mortar, raking of joints & filling the gaps/joints with acid resistant epoxy mortar

7.0 Conclusions:

The Case Study conducted on site for making Innovative strategies for restoration of RCC structure of acid storage tanks in industrial process industries in the DM Plant region has been thoroughly addressed in this paper.

This has also addressed the various non-destructive tests performed on the structural elements and the degree of structural degradation from a durability perspective.

To prevent the disastrous outcome of the structure, the preemtive measures to strengthen the existing structure is also discussed.

The conclusion of the case study is that "higher safety factors should be adopted and special attention should be given while designing the structures that are exposed to severe acidic environments."

Special material that offers the highest level of protection against various chemicals and acids should be used to make the structure strong, resilient, and acid-resistant.

8.0 Acknowledgement :

The management's support and permission for submission of this technical paper and also to complete the diagnostic case study at the work site in process industry are greatly appreciated by the authors.

The author expects that the case study will be helpful to the researchers, executors, plant engineers and others, since it will provide crucial information to make Innovative strategies for restoration of RCC structure of acid storage tanks in industrial process industries in the DM Plant region.

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