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HEALTH MONITORING OF SELF COMPACTING CONCRETE DETERIORATION USING IMAGE PROCESSING

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Abstract: Self-compacting concrete (SCC) is used in places where there can be no access to vibrators for compaction and in complex shapes of formwork, over a period of time concrete structure may cause cracks, spalling, and other potential signs of deterioration. In order to assess the SCC structures at inaccessible locations there is a need for the development of reference charts and baseline images for condition monitoring. In the present study M20grade concrete is cast and cured in water for 28 days then exposed to the chemicals CH_3COOH, NaCl, HCl, and H_2SO_4 for the duration of 7, 14, 28 and 56 days. The color profiles of deteriorated surfaces are analysed in CIE-XYZ color pace, and the respective chromaticity diagrams are investigated. The chemical exposed surfaces are captured using a camera then processed in image processing software to quantify the change in surface colors on the concrete and history of deterioration. Due to the chemical attack, there is a physical change in concrete. A correlation is established between physical changes and vision changes on the concrete surface then the correlation graphs are dawn by the compressive strength and x and y values. This approach contributes to the sustainability of SCC structures for enabling proactive maintenance strategies.

Key words: compaction, formwork, cracks, image processing, deteriorated surfaces, chemical attack, compressive strength, CIE-XYZ color space.

1. INTRODUCTION

Globally, concrete is a commonly utilised building material, and as technology has advanced, so too have its qualities. To improve the many characteristics of concrete, a variety of varieties have been created. There are four phases to this development thus far. Traditionally, concrete with normal strength is the oldest and consists of just four ingredients: cement, water, medium and coarse particles. One of the greatest advancements in modern construction technology worldwide is Self-Compacting Concrete (SCC). One of the biggest advancements in the building business recently is "high performance concrete," which is also known as "self-consolidating concrete." Using home garbage, industrial byproducts, and other treated and untreated resources as raw materials for concrete is a contemporary global trend. They contribute to a cleaner, greener environment in addition to facilitating the reuse of materials. The purpose of this study is to investigate the feasibility of utilising waste materials to prepare creative concrete.

The technique of manipulating a picture to improve it or extract valuable information is called image processing. It involves the manipulation of images to achieve a desired outcome, such as improving visual quality, correcting distortions, or identifying specific features. In The current investigation M20 grade concrete gets exposed to toxic chemicals after it has been cast und treated using water for 28 days. CH_3COOH, NaCl, HCl, and H_2SO_4 for the duration of 7,14,28, and 56 days.

After curing the concrete molds then attack on acids to the concrete to mix the acids on water by every 1 liter of water add on 5% of acids to be added, after adding on chemicals attacking at certain room temperature and lighting also provided then after curing is complete to check the weight, diagonal dimension, and color. after to capture the images on concrete molds to convert the photos into color pigmentation

Health monitoring of self-compacting concrete (SCC) using image processing is a modern and efficient approach to assessing the structural integrity and detecting deterioration in concrete structures. This technique leverages advanced computer vision and machine learning technologies to provide non-destructive evaluation, enabling early detection of issues and ensuring the longevity and safety of SCC structures.

2. LITERATURE REVIEW

Prasanna et al., 2016(1)this is to study the crack detection many studies utilize techniques like canny edge detection or sobel filtering to identify cracks in concrete surfaces. Canny edge detection is widely used for detecting discontinuities or changes in pixel intensity to highlight cracks or surface deformations . Using colorimetry research, Guru Prathap Reddy and colleagues (2022) conducted a recent study on a unique method for assessing concrete deterioration. in this paper I am using chromaticity method and chemicals used for HCl, H_2SO_4, NaCl. In this method to quantify the colors of concrete deteriorated surfaces by damaged surfaces when the color profiles are identified by the deteriorated surfaces are analyzed by CIE-XYZ color space and the respective chromaticity diagrams are investigated. In this case to study the image-based identification of damage, analytical, objective assessment of the degree of deterioration, and analysis of the relationship between the degree of deterioration and concrete strength. feng et al 2017 (3) this is to study the changes in the surface texture can indicate concrete deterioration, studies explore using wavelet transforms for detecting surface anomalies such as scaling or delamination in concrete, these technique are particularly useful for identifying early stage degradation, allowing for protective maintenance. 3D reconstruction advanced image processing integrates photogrammetry and 3D modeling to detect concrete volume changes, providing a clearer understanding of structural deformation or spalling. Komačka *et al*., 2019 (4) It is crucial to standardise the quality of photos captured for digital image processing, which means managing the camera and comprehending the impact of lighting. By means of histogram analysis, these characteristics impact the differentiation between bitumen and aggregate. M K Gokay et al (5) this research explores the impact of chemical exposure on the colour properties of concrete, employing image-based analysis within the CIE-XYZ colour space. The results demonstrate the chemical exposure leads to significant changes in chromaticity of concrete surfaces. The changes can be effectively quantified, offering a non-destructive approach to evaluate concrete durability under different environmental conditions. This study underscores the utility of CIE-XYZ colour space measurements in assessing the effects of chemical exposure of concrete. S Karamanet al (6) this research utilized Image-based analysis to examine the colour changes in concrete surface subjected to various chemical exposures. This study found a strong relationship between the intensity colour alteration and the level of chemical damage. By applying The CIE-XYZ colour space for chromaticity evaluation, significant shifts in the colour properties of concrete in aggressive environments were observed, demonstrating the methods of effectiveness in detecting surface degradation. These findings suggest that colorimetric analysis could serve as a valuable non-destructive approach for assessing concrete quality under challenging chemical conditions.

1. MATERIALS AND METHODOLOGY

In the present work, I am using M20 self compacting concrete for the research purpose. If the materials using cement, The following parameters were chosen and proportioned in accordance with Indian Standards Code: fine particles, coarse aggregate, super plasticiser, and water. IS:2386-4-2016 (BIS, 2016b), IS:383-2016 (BIS, 2016a), IS:10500-2012 (BIS, 2012), IS:12269-2013 (BIS, 2013) and IS:10262-2019 (BIS, 2019) as indicated in this paper's tables 1 and 2. As indicated in table 2, the concrete cubes measuring 150 x 150 x 150 mm were cast and tested in accordance with Indian standard IS:516-2018 (BIS, 2018).

Table-1. Materials used for preparation of concrete

Sl. No.	Materials	Specifications	Standard code
1	Cement	Ordinary Portland cement 53 grade (JSW cement)	IS:12269-2013 (BIS, 2013)
2	Fine aggregate	Zone-II river sand	IS:383-2016 (BIS, 2016b)
3	Coarse aggregate	Machine crushed granite of size 12 mm	IS:2386-4 (BIS, 2016a)
4	Water	potable	IS:10500 (BIS, 2012)
5	Chemical admixture	Conplast sp 430 DIS	ASTM C494

Table 2. M20 concrete mix proportions (obtained as per IS:10262-2019 (BIS, 2019)

Sl.No	Materials	Weight: Kg/M³
1	Cement	355
2	Fine aggregate	1056
3	Coarse aggregate	784
4	water	192
5	Chemical admixture	2.13
6	Water/cement ratio	0.54

Chemicals used

When the concentration of chemicals used in 5% of every 1 litre of water

1. Hydrochloric acid (HCl)
2. Sulfuric acid (H_2SO_4)
3. Acetic acid (CH_3COOH)
4. Sodium chloride (NaCl

Table.3 Tests results on workability of concrete

S.No	Tests	Results
1	Slump flow test	33 mm
2	V-funnel test	7 sec
3	L-box test	0.833sec
4	J-ring test	59mm

Experimental investigation

In this study, The concrete's durability and mechanical properties was evaluated by casting a total of 54 cubes. For four distinct exposure times 7, 14, 28, and 56 days the concrete cubes were subjected to 5% concentrations of hydrochloric acid, sulfuric acid, sodium chloride, and acetic acid. The cubes of concrete underwent a standard 28-day curing regimen.

The concrete cubes were measured after being subjected to a chemical attack in order to record the data and ascertain the specimens' linear variance.

Mechanical performance evaluation

After the concrete has cured for 56 days, it is exposed to the air for 24 hours following the testing of all 54 cubes for compressive strength. The average value obtained is then recorded, and these results are utilized as a guide for additional analysis.

Table 4: compressive strength of concrete at control cube and immersion of acids at their respective solutions at the specified durations

Sl.no	Duration in days	Compressive strength : MPa (Load in N/ Area in mm²)			
		HCl	H_2SO_4	NaCl	CH_3COOH
1	Control sample	29.51	29.51	29.51	29.51
2	7 days	28.88	27.77	29.42	28.75
3	14 days	24.88	27.28	28.97	27.82
4	28 days	21.28	18	27.86	27.11
5	56 days	20.84	17.78	26.75	26.13

Fig. 1. Compressive strength of concrete cubes

Colorimetry analysis

There are Several color models can be used to determine the color profile of samples that degrade after being immersed in reagent solution for 7, 14, 28 and 56 days. According to Hager (2014), the RGB color space is the most widely used color model for examining the color profile of a damaged surface. RGB color Since each of the green, blue, and red values independently defines a pixel's grey scale intensity, which ranges from 0 to 255, space is by convention a three- dimension (3D) coordinate system. The numbers 0 and 255 stand for black and white, respectively. However, because RGB color space is inherently three-dimensional, the equivalent In two dimensions (2D), the RGB distribution of natural sunlight contains negative values. There's still another problem with RGB-based histogram analysis. The color information in the RGB color space varies depending on the device being used to view the image. This phenomenon is known as device dependence. The difficulty of duplicating or using it as a reference for additional study as a result.

(a) (b) (c)

Figure (2), (a) The damage sample is calibrated, the undamaged control sample is calibrated, and the uncalibrated control sample is calibrated.

On the other hand, utilizing the 2D coordinate system, As per Colombo and Felicetti (2007), the CIE-XYZ colour space is not dependent on any particular device. Consequently, chromaticity-based testing on CIE-XYZ values derived from the RGB parameters will be repeated and applied as a baseline. for future projects and image training. Furthermore, CIE-XYZ models closely resemble and reproduce the appearance of human eyesight. To translate RGB pixel values to CIE-XYZ values, one can employ neural networks and polynomial transformations. It has been discovered that polynomial transformations require less effort and time to achieve the same level of precision as the two methods mentioned above. The Z component in mathematics deals with brightness, whereas the X, Y element provides the necessary colour information for the image to be examined. Lighting conditions have been shown to affect a picture's brightness more often than its color information.

Therefore, it can help with the analytical visualization of the color shift trend if a chromaticity-based graph is plotted against the time of immersions for each attack involving acid, salt, and sulfate. By examining and contrasting the trend with the corresponding acid durability factor or reduction in strength loss, one can determine the association between durability performance and image-based visualization. This may open the door for the creation of a degradation detection model based on images.

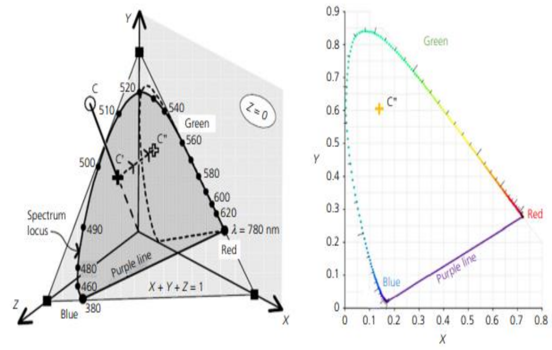
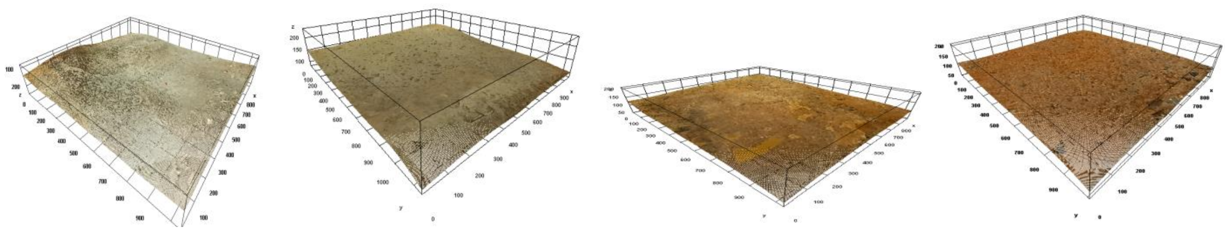


Figure.3 chromaticity diagram (wei et al., 2019)

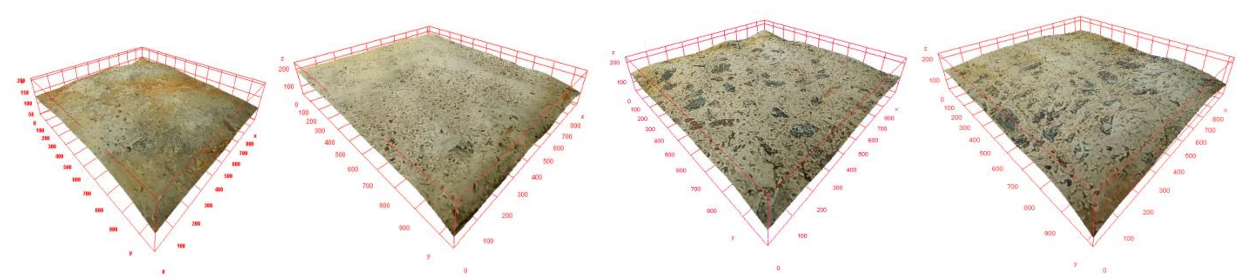
2. RESULTS AND DISCUSSION

The program "ImageJ" has been used to analyze calibrated images. Medical imaging commonly uses this Java-based, open-source image processing application. including radiological image processing and 3D live-cell imaging. It is frequently employed as a digital image processing technique in civil engineering research. When the corresponding calibrated photos are examined and



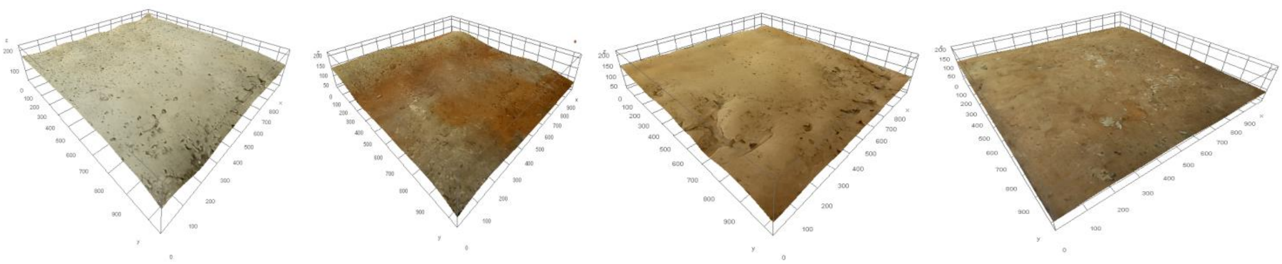
(a) (b) (c) (d)

Fig.4. 3D plots of damaged surface after immersion in 5% of hydrochloric acid for the duration of (a) 7days,(a)14days, (c) 28 days and (d) 56 days



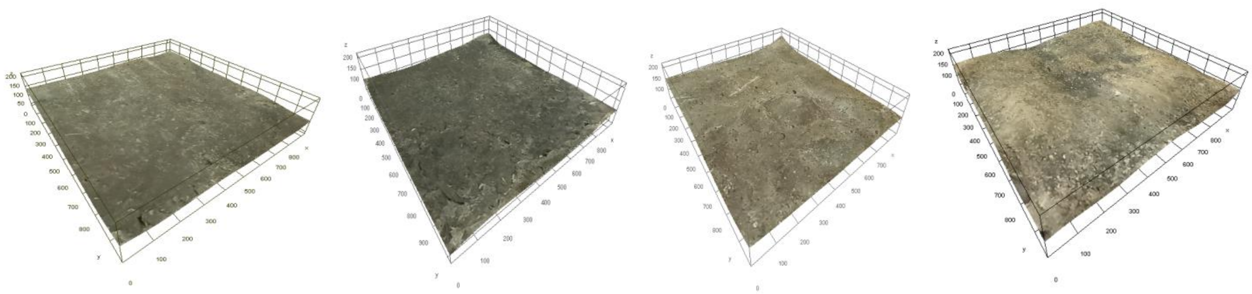
(a) (b) (c) (d)

Figure.5. 3D plots of damaged surfaces after immersion in 5% of sulfuric acid for the duration of (a) 7 days, (b) 14 days, (c) 28 days and (d) 56 days



(a) (b) (c) (d)

Figure.6. 3D plots of damaged surfaces after immersion in 5% of acetic acid for the durations of (a) 7 days, (b) 14 days, (c) 28 days and (d) 56 days



(a) (b) (c) (d)

Figure.7. 3D plots of damaged surfaces after immersion in 5% of sodium chloride for the durations of (a) 7 days, (b) 14 days (c) 28 days and (d) 56 days.

the corresponding 3D surface maps are created, the degree of degradation for each individual immersion after 7, 14, 28, and 56 days can be seen.

The images on each of the The concrete cube sample underwent calibration and inspection on its six faces. The concrete sample cube's most damaged faces are depicted in Figures (4–7) following a certain length of immersion time for a certain acid exposure. Figure 4 illustrates the damage and variations in extent after being immersed in hydrochloric acid for the designated periods of time. Visual analysis of these calibrated surface plots shows a clear color shift toward red. Ettringite is generated when subjected to sulfuric acid (Figure 5) due to the chemical reaction between the acid and calcium hydroxides, which is recognized to induce deterioration.This is confirmed by the visible shift toward the white shift observed in the photographs of the sample treated to sulfuric acid. As seen in Figures 6 and 7, respectively, exposure to acetic acid and sodium chloride resulted in early saturation-induced discolouration followed by the formation of pale yellow and white patches. The dynamic color changes throughout the ensuing durations, however, are barely perceptible.

Development of chromaticity diagram

In color systems like each colour is denoted by a set of values (x, y, z) in the *CIE 1931 XYZ* colour space. which describe how the color is perceived by the human eye. The chromaticity coordinates x and y are typically used, with z being derived as $z = 1 - x - y$. These coordinates help locate the position of a color on a chromaticity diagram, allowing for easy comparison and understanding of the relationships between different colors.A chromaticity diagram is a two-dimensional plot where the x and y chromaticity coordinates are graphed. It represents the range of all visible colors. The boundary of the diagram corresponds to the “spectrum locus”, where pure spectral colors lie (ranging from violet to red). White light lies at the center of the diagram and represents the equal mixture of red, green, and blue light. Colors inside the diagram represent combinations of these spectral colors, with *hue* being indicated by the position on the curve and *saturation* by the distance from the white point.

Created by the International Committee on Illumination (CIE), the CIE 1931 XYZ Colour Space this model represents color as a combination of three primary components (X, Y, and Z), with chromaticity derived by normalizing the color values.

The steps to create a chromaticity diagram are as follows:

(a) To begin, extract the RGB colour data from the calibrated photograph of the deteriorating concrete surface. The method for achieving this is to take the average RGB value of a subset of pixels that best capture the image's colour profile.

(b) Utilising polynomial transformations developed by (Cowan, 1983), one can convert to XYZ colour space.:

$$X = 0.41245.R + 0.35758.G + 0.18042.B \quad (1)$$

$$Y = 0.21267.R + 0.71516.G + 0.07217.B \quad (2)$$

$$Z = 0.01933.R + 0.11919.G + 0.95023.B \quad (3)$$

where R, G, B represents the corresponding colour coordinates in RGB colour space.

(c) In order to counteract the impact of illumination, that since x+ y+ z =1 if we taken only two coordinates, x and y, are needed for the chromaticity diagram. The z value can be inferred

$$x = X/(X + Y + Z) \quad (4)$$

$$y = Y/(X + Y + Z) \quad (5)$$

The first goal was to identify the pixels that most accurately captured the colour data regarding the surface deterioration.

There are several approaches to choosing the area of interest. It is thought that the pixels there contain the colour data of the zone that is fascinating and can convey the colour information about damage overall. Depending on the needs of the project, a rectangular or randomly chosen pixel-based zone of interest was chosen (Figure 3).Depending on the needs of the project, a rectangular or randomly chosen pixel-based zone of interest was chosen (Figure 3).

Analysis of chromaticity diagrams

Following the creation of the samples dipped in the proper solutions, and analysis was performed to create the chromaticity diagrams.assess how the color profiles of the samples varied for each solution for each of the predetermined immersion times. Additionally, changes in color profiles were assessed for each sample submerged in each solution for each immersion time.

A few inconsistent values that differed significantly from After examining the x, y readings of the data points collected from the specimen faces during immersion in hydrochloric acid, the mode x, y readings of the example faces at that specific immersion length were discovered. These values were disregarded since they only show localized damage caused by the hydrochloric acid attack, rather than offering color information for the entire affected surface.

Figure-8, The graph presents the chromaticity coordinates (x, y) of the control sample and the samples treated with hydrochloric acid (HCl) over different durations: 7, 14, 28, and 56 days. The control sample is positioned lower on the graph, serving as a baseline for comparison against the HCl-treated samples.

A gradual shift in chromaticity is observed in the samples exposed to HCl, with the magnitude of this shift increasing over time. After 7 days of exposure, the sample shows a slight deviation from the control, indicating the onset of acid-induced changes. This trend continues with the 14-day sample, which shows a further increase in both x and y values, suggesting a progressive reaction between the acid and the material.

The most significant changes are observed in the 28-day and 56-day samples, with the 56-day sample showing the red shift in figure 4 on the surface plots. This indicates that prolonged exposure to HCl intensifies the alteration of the material's color properties. The changes in chromaticity are likely the result of surface reactions and material degradation, which become more evident as the exposure duration increases.

Figure-9, The graph illustrates the effect of sulfuric acid (H_2SO_4) exposure on samples over time. The x-axis likely represents a measure such as concentration or exposure level, while the y-axis shows a response, perhaps indicating a change in material properties. Different symbols represent the control sample and samples exposed to sulfuric acid for varying durations: 7, 14, 28, and 56 days.

The control sample has the lowest values on both axes, serving as a baseline. After 7 days of exposure, there is a slight increase in both the x and y values, indicating a minor change in the material's properties. The 14-day sample shows behavior very similar to the 7-day sample, with only minor changes from the control. The sample exposed for 28 days shows a white shift on the (figure-5), suggesting some response, though not as significant. After 56 days, the top surface of concrete got worn out then inside surface is visible at materials, then the surface of concrete is visible at white color. When the color increases compared to the shorter exposure times, suggesting a different material response, possibly degradation or a chemical change. The results suggest that short-term exposure (7–14 days) leads to a steady increase in the measured properties. However, after longer exposure (28–56 days), the material's behavior changes. The large white shift on the x-axis after 56 days, combined with the drop on the y-axis, could indicate significant structural degradation or altered chemical properties.

Fihure-10, The graph illustrates the effect of acetic acid (CH_3COOH) exposure on samples over time. The x-axis likely represents exposure duration or concentration, while the y-axis shows the material's response, potentially reflecting changes in physical or chemical properties. The symbols represent the control sample and those exposed for 7, 14, 28, and 56 days. The control sample has the lowest values on the x-axis, establishing the baseline for comparison. After 7 days, there's a slight increase on both axes, indicating that the material begins to show a reaction to the acetic acid. The 14-day sample shows a further increase, suggesting that the material continues to respond to the acid. This sample shows minimal change from the 28-day sample, indicating that the material's response begins to stabilize. After 56 days, there is little to no variation from the 28-day sample, indicating that the material has reached a steady state. In figure-6, when the magnitude of concrete when the colour is shifted at pale yellow at the duration of 56 days of exposure condition. The graph suggests an initial phase of change in the material in response to acetic acid exposure, particularly within the first 14 days. However, beyond this point, the material's response begins to plateau, as indicated by the similarity between the 28- and 56-day samples. This stabilization suggests that the material reaches a point of equilibrium, where prolonged exposure no longer significantly alters its properties.

In figure-11 The graph illustrates the effect of sodium chloride (NaCl) exposure on samples over time. The x-axis likely represents a concentration or exposure-related factor, while the y-axis reflects the material's response. Each symbol represents a different sample: a control and samples exposed to NaCl for 7, 14, 28, and 56 days. The control sample is positioned around 0.32 on the x-axis and 0.35 on the y-axis, serving as the baseline. The 7-day exposure sample shows a very slight change from the control, with only a minor shift in the y-axis value. The sample exposed for 14 days remains virtually the same as the 7-day sample, showing no significant deviation from the control. After 28 days, the sample still exhibits minimal change, maintaining almost the same values as the control and other samples. The 56-day sample also shows no noticeable difference from the control or other exposed samples. In figure-7 the suface of concrete is there is no change in colour shift when the concrete is visible at light white changes on surface. The data suggests that sodium chloride exposure over time has no significant effect on the material. Across all time periods (7, 14, 28, and 56 days), the samples show nearly identical values to the control, indicating that the material is resistant to NaCl and does not undergo significant changes or degradation.

Interpretation of Results

The relationship between the samples' of residual compressive strengths and their corresponding x values of following varying immersion times in their respective solutions and the chromaticity data points wasexamined using an analysis.

In the figure12, The 3D polynomial fits the data perfectly, as shown by the R^2 = 1value. This indicates the data follows a complex pattern. The 2D polynomial provides a reasonable but less accurate fit with an $R^2$of 0.7156, capturing part of the trend but not all of the details. Overall, the cubic model is more accurate, while the quadratic model is a simpler but less precise approximation of the data.

In this case when the figure-13 we discuss the results are, HCl immersion consistently weakens the material, causing a steady decrease in compressive strength. NaCl and H_2SO_4 immersions show more complex, non-linear responses, with compressive strength initially increasing before declining. H_2SO_4 immersion, in particular, leads to a rapid degradation after an initial strength peak.in the acetic acid this suggests that immersion in CH_3COOH initially reduces the materials compressive strength, but after a certain point, the strength begins to recover. This could reflect the material undergoing degradation, followed by a stabilization or adoption process in the acetic acid

These results highlight that different chemical environments have varying impacts on the material's compressive strength, with each chemical causing degradation in unique ways.

The compressive strength of NaCl is to starts around 27 MPa, peaks near 29 MPa, and then decreases, showing some variation across the x-values (0.315–0.33).

Compressive strength values decrease consistently from around 30 MPa to 20 MPa over the x-values (0.3–0.38), suggesting that HCl immersion negatively affects the material's strength.

Compressive strength starts low, rises to approximately 29.51 MPa, then sharply declines beyond 0.4 x-value, suggesting a nonlinear response to H_2SO_4 immersion.

The compressive strength of concrete decreases initially upon immersion in CH_3COOH, followed by a partial recovery after reaching a value of x is 0.352 the value is slightly decreases, then the compressive strength is decrease at liner variation the value is 26.13 when compared to control sample the value is decreased.

Table-5 CIE-XYZ values on samples immersed on chemicals

Sl.on	Immersion chemicals	Duration days	XYZ values			x	y
			X	Y	Z		
1	Control sample		146.033	155.654	152.86	0.321	0.342
2	H_2SO_4	7	137.84	146.799	118.870	0.341	0.363
		14	157.827	168.324	152.47	0.329	0.351
		28	142.079	151.404	137.099	0.329	0.351
		56	215.803	149.886	135.89	0.43	0.29
3	HCL	7	146.10	155.669	139.003	0.331	0.353
		14	119.860	127.446	100.880	0.344	0.366
		28	109.04	112.435	66.240	0.378	0.390
		56	110.111	121.311	67.90	0.367	0.405
4	CH_3COOH	7	167.978	178.942	166.22	0.327	0.348
		14	105.78	109.11	70.95	0.370	0.381
		28	128.69	134.997	94.850	0.358	0.376
		56	116.830	122.43	91.974	0.352	0.369
5	NaCl	7	112.784	120.946	111.552	0.326	0.350
		14	88.853	95.548	90.597	0.323	0.347
		28	126.41	134.429	123.277	0.329	0.349
		56	135.251	146.87	130.28	0.32	0.356

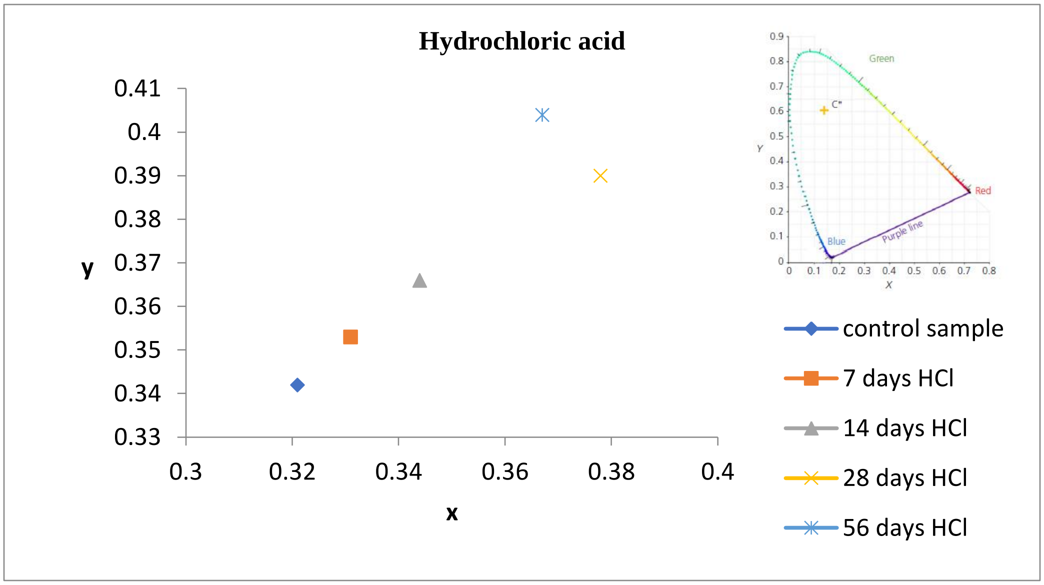


Figure-8: chromaticity diagram of (a) control sample and deteriorated surface owing to hydrochloric acid immersion at 5 % concentration after (b) 7days, (c) 14 days, (d) 28 days and (e) 56 days.

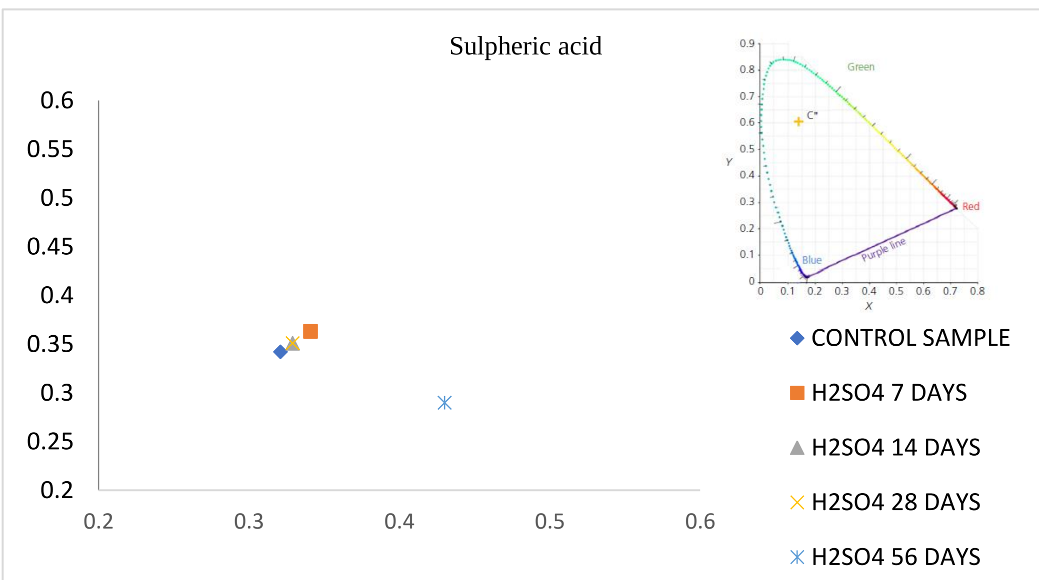


Figure-9: chromaticity diagram of (a) control sample and deteriorated surface owing sulfuric acid immersion at 5 % concentration after (b) 7days, (c) 14 days, (d) 28 days and (e) 56 days.

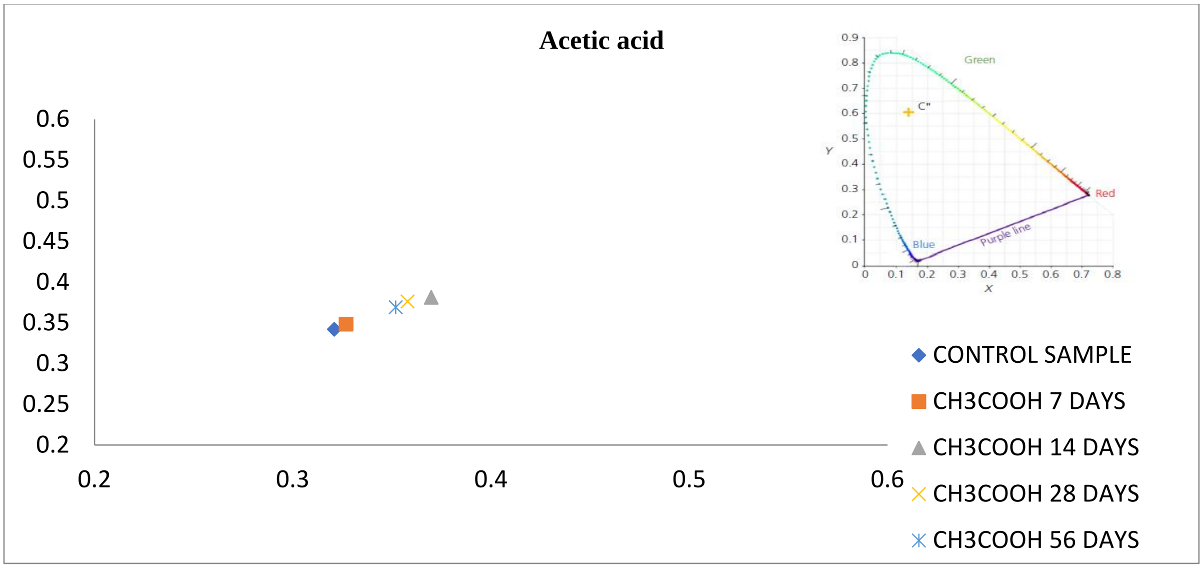


Figure -10: chromaticity diagram of (a) control sample and deteriorated surface owing acetic acid immersion at 5 % concentration after (b) 7days, (c) 14 days, (d) 28 days and (e) 56 days.

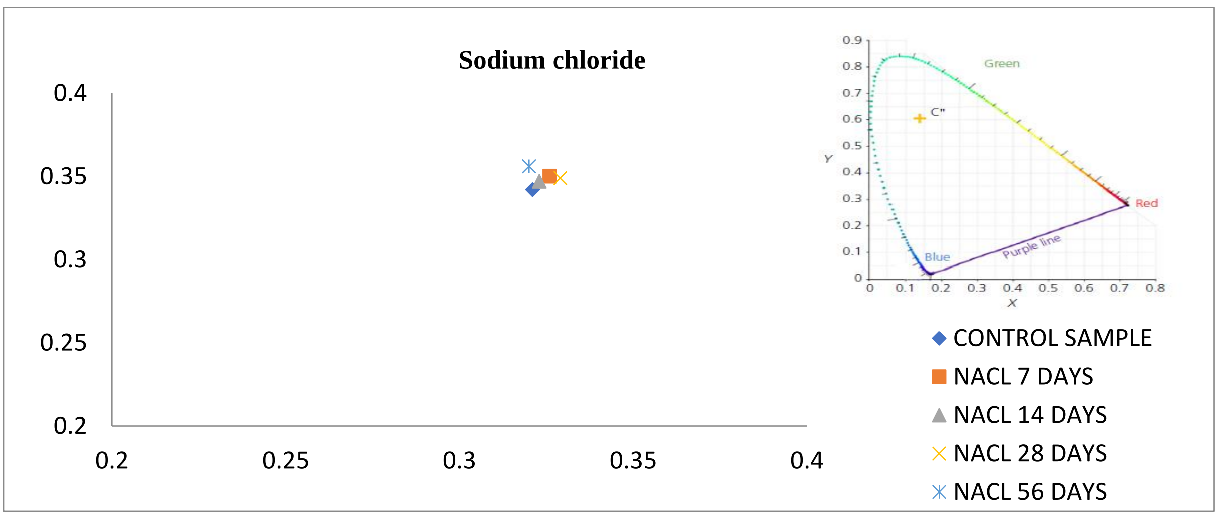


Figure -11: chromaticity diagram of (a) control sample and deteriorated surface owing sodium chloride immersion at 5 % concentration after (b) 7days, (c) 14 days, (d) 28 days and (e) 56 days.

Table. 6 Polynomial curves of second –and third degree relations correlating the x, y co-ordinates with respective solutions on concrete with r-squared values

Polynomial equation	$a.x^2 + b.x + c$				$a.x^3 + b.x^2 + c.x + d$					
Sample immersion (reagent)	a	b	c	R^2	a	b	c	d	R^2	Range of x
NaCl	-422.8	275.4	-44.50	0.715	13472	-13173	42933	-4663	1	(0.326,0.32)
H_2SO_4	-17.31	12.53	-1.898	0.999	-145.7	141.8	-44.94	4.970	1	(0.341,0.43)
HCl	-12.73	9.931	-1.537	0.905	-1282	1329	-457.7	52.65	0.983	(0.331,0.367)
CH_3COOH	-5.870	4.864	-0.614	0.997	-156.3	157.0	-51.64	5.907	0.997	(0.327,0.352)

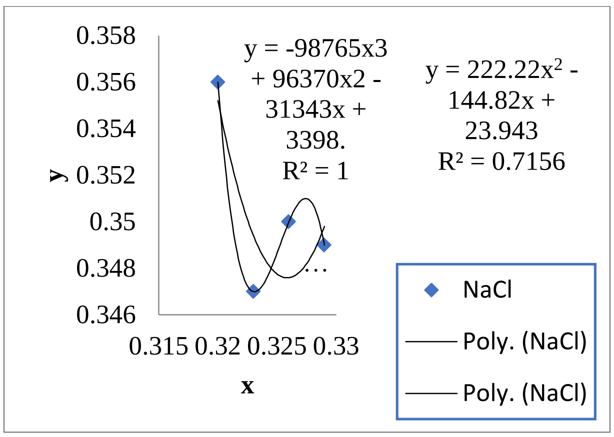
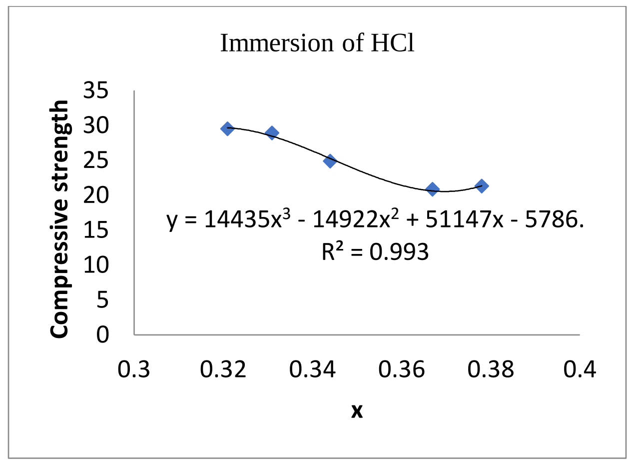
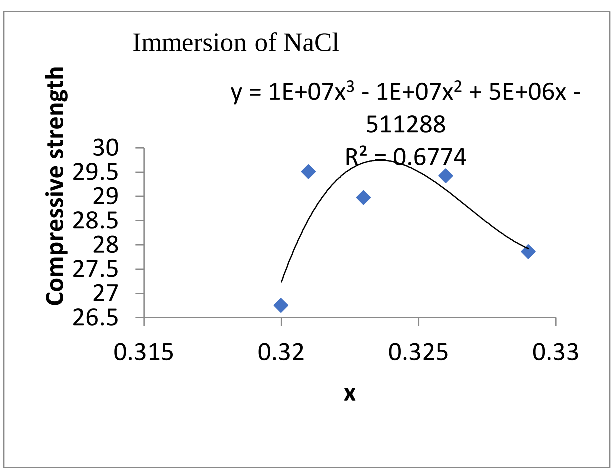


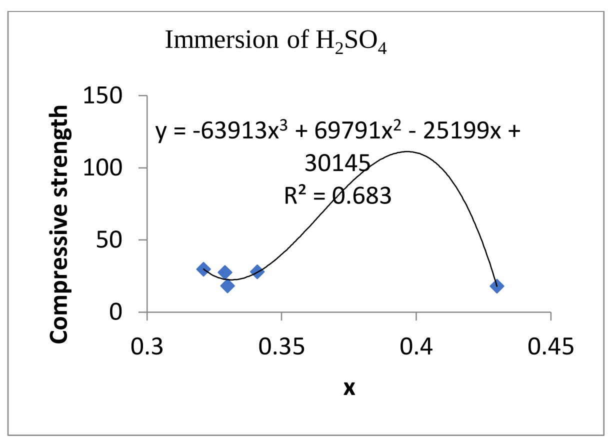
Figure 12. polynomial curves corresponding to the x, y chromaticity coordinates of samples soaked in 5% of sodium chloride 7, 14 ,28 and 56days.



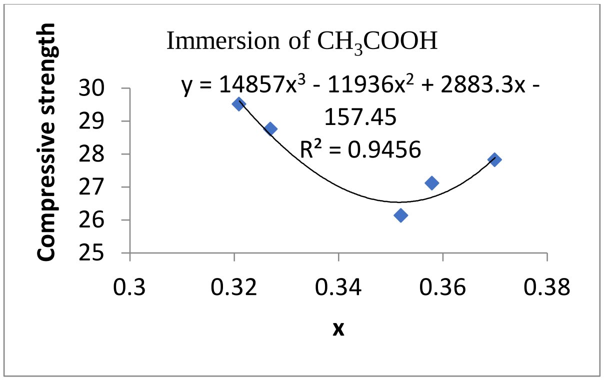
(b)



(a)



(c)



(d)

Figure-13. The polynomial curves relating colour (x) to the corresponding to compressive strength values for samples of immersed in the corresponding reagents at 5% concentration for 7, 14, 28 and 56 days.

CONCLUSION

Drawing on the colorimetric technique experimental study of concrete deterioration, thefollowing conclusions can be drawn.

- When the immersion of concrete cubes on the chemicals, the strength will be loss, when compare to control cube HCl-29.38%, H_2SO_4 - 39.8%,CH_3COOH-11.5 and NaCl-9.35 will be reduced the strength after 56 days of immersion.
- HCl immersion leads to the most consistent and steady reduction in compressive strength, highlighting its corrosive nature. NaCl and H_2SO_4 show more complex behaviour's, with NaCl leading to moderate degradation, while H_2SO_4 causes a sharp and severe decrease after an initial strengthening phase.
- These results suggest that materials exposed to these chemical environments will degrade differently, with HCl being the most predictably damaging, and H_2SO_4 potentially causing more sudden and severe damage after prolonged exposure.A comparative analysis chromaticity diagrams and three-dimensional surface plots of the surfaces that were corroded from immersion in sulphuric and hydrochloric acids, acetic acid and sodium chloride for durations of 7, 14, 28 and 56 days were made. It can be concluded that the qualitative description of It is appropriate to translate the colour information from the damaged surface into quantifiable values so that a mathematical analysis of the colour shift may be performed.
- For the immersion of HCl to change the colour in red shift after 56 days of duration and the top surface of concrete is visible for sandy type, then immersion of H_2SO_4 the top surface became worn down and is exposed. in white colour and light grey the the inside surface is visible. Then immersion of CH_3COOH the top surface of concrete in colour visible for pale yellow there is no loss in strength. Then immersion of NaCl there is no change in strength then compare to normal cube it is little bit of change in colour as white the the top surface is visible as normal cube.
- The characteristics of colour profile alterations in samples submerged in sodium chloride and hydrochloric acid or acetic acid and sodium chloride are similar in nature, but the amount to which each degradation contributes to the alteration in colour profile relies on the rate at which the reagent is absorbed by the sample.concentrations to initiate chemical reactions and the corresponding rates of their reactivity.
- The correlation between the samples' chromaticity 'x' values with their residual strengths for samples immersed in hydrochloric acid and acetic acid were similar.
- The type of correlation that exists in the instance ofimmersion in sulfuric acid and sodium chloride, though similar, differs in their respective degrees of correlation and can be attributed to the rate of degradation.

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