DIGITAL IMAGE PROCESSING IN THE STUDY OF STRUCTURAL BEHAVIOUR OF CEMENT CONCRETE (V/4)

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ABSTRACT:

The range of application of photogrammetric and remote sensing techniques are numerous. These techniques are especially valuable when the change in the subject to be recorded, are rapid and time dependent. The nature of deformation and failure rupture planes under load, are important in studying strength characteristics of engineering materials. The distribution of crack-pattern under deformation can be recorded on a Panchrometic photograph. The time lag photographs may reveal the development of such cracks in the structural material, under various deformations and loading conditions. These data will be useful in predicting the structural behaviour of the material under increasing load. These crack-patterns are visible only when they are sufficiently large in magnitude. The scan line plot of micro-densitometer and the digital processing of the transparency of specimen of the material obtained at various stages of failure, will make it possible to detect the cracks much earlier than it becomes visible to human eye. An attempt has been made in this work to illustrate the application of remote sensing technique in studying the structural behaviour of cement concrete.

INTRODUCTION:

The extreme flexibility of the digital method of image processing makes a wide variety of linear and non-linear processes possible. The digital image processing technique developed at Jet propulsion laboratory California have been applied in analyzing the deep space probe images.(1) Because of the extreme flexibility of the digital approach, it is found that the required operation on the picture can be best performed in a digital computer. This area has experienced utmost growth having been a subject of interdisciplinary study and research in fields such as engineering, information science, medicine, statistics, close range photogrammetry (2) etc. The image processing technique (3) on the data is employed now by interactive digital systems. This research work deals with the feasibility of employing digital technique (using interactive COMTAL Vision one/20 system) and close-range photogrammetry (4) to find the non-destructive test on cement concrete cube. The scan line plot of micro-densitometer with automatic plotter is also used to detect invisible crack in the concrete cube under the dynamic loading condition for the application in non-destructive test.

Non-destructive tests (5) on concrete can be classified broadly into surface hardness methods, sonic and ultrasonic methods. The disadvantages of the standard method of testing the quality of concrete by crushing test cubes are well known and have led to a large number of attempts to test the strength of concrete by a non-destructive means. Exust schmidt devised rebound hammer test or Sclerometer test which has been found of practical application within a limited scope as non-destructive device. Ultrasonic pulse test can be applied to structural members in-situ. The present problem deals with the close-range photogrammetric technique to locate the crack position of the cube under the dynamic condition of loading. The hair pin cracks which are not visible by naked eyes can be located and enhanced by scan line plot of micro-densitometer and digital technique respectively.

EXPERIMENTAL SET-UP:

The experiment under study is to prepare concrete cubes of various types of mixes with water cement ratio and curing the cubes in water for 7, 14, 21 & 28 days. The mix selected for the experiment are cement concrete 1:1.5:3 and 1:2:4 with water cement ratio as 0.45 to 0.5. These cubes are tested for compressive strength by Amsaler Compressive Testing Machine as shown in plate (1). The photographs are taken by YASHICA MAT 124G Camera during the process of testing cubes in the laboratory. The camera is kept at a distance of 2 meters from the cube position which is kept under test. The transparencies are obtained for various samples of cubes under different loading condition as shown in plate (2).

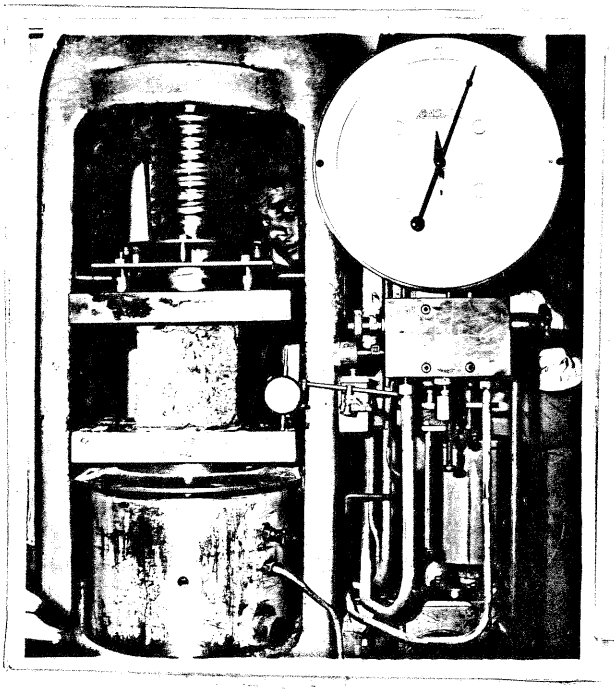


Plate 1. Experimental set-up

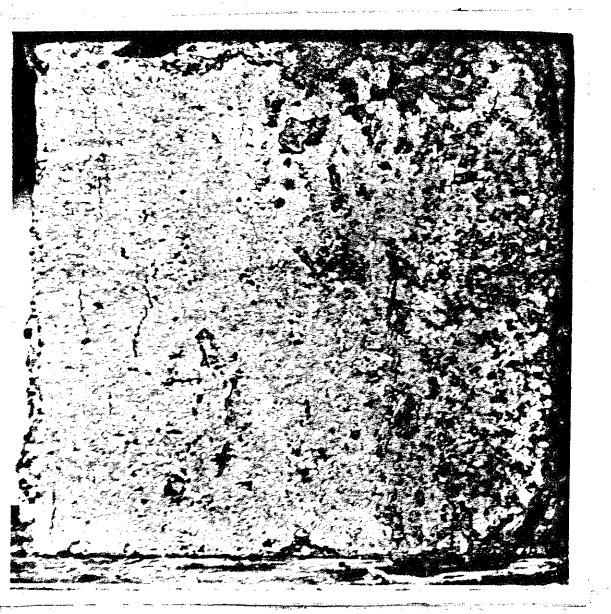


Plate 2. Sample of Concrete cube during testing

DATA PROCESSING:

The transparency is digitized and processed with the help of interactive digital image processing system. The Comtal vision one/20 system is a system with built in interactive processing and control capabilities. The system provides a high spatial resolution video image over a full range of brightness levels in shades of gray, pseudo colour or full colour. Digital data is entered into the system via the system option. The Histogram is prepared by Comtal system showing the frequency distribution of gray levels. The frequency distribution graph shown in plate (3) which shows the gray level variation from 60 to 190. The mean value of gray level is 68. The nature of graph shows gaussion distribution. The enhancement is processed in the system by two techniques which are as follows:

a. Contrast Stretching
b. Equipopulation Technique

(a) **Contrast Stretching:**

A contrast stretching enhancement (6) expands the range of pixel value, so that they are displayed over a fuller range of gray level. Plate (3) illustrates a histogram of brightness of the given speciman of the cement concrete cube. The histogram shows scene values occurring in the limited range of 60 to 190.

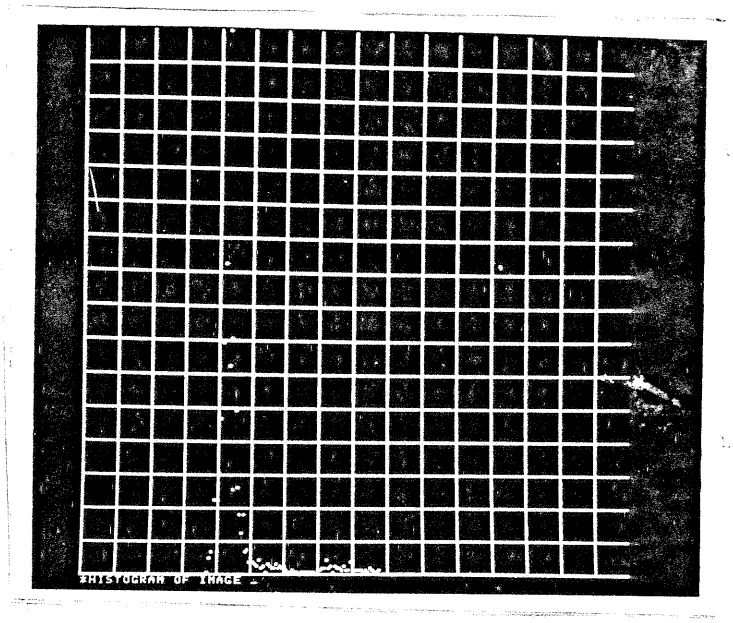


Plate 3. Histogram of Image

The range of image level present in the scene (60 to 190) to fill the range of displayed values (0 to 255). The range of image values has been uniformly expanded to fill the total image. This uniform expansion is referred to linear stretch. The results of enhancement of the given concrete cube is shown plate (4). The hair pin

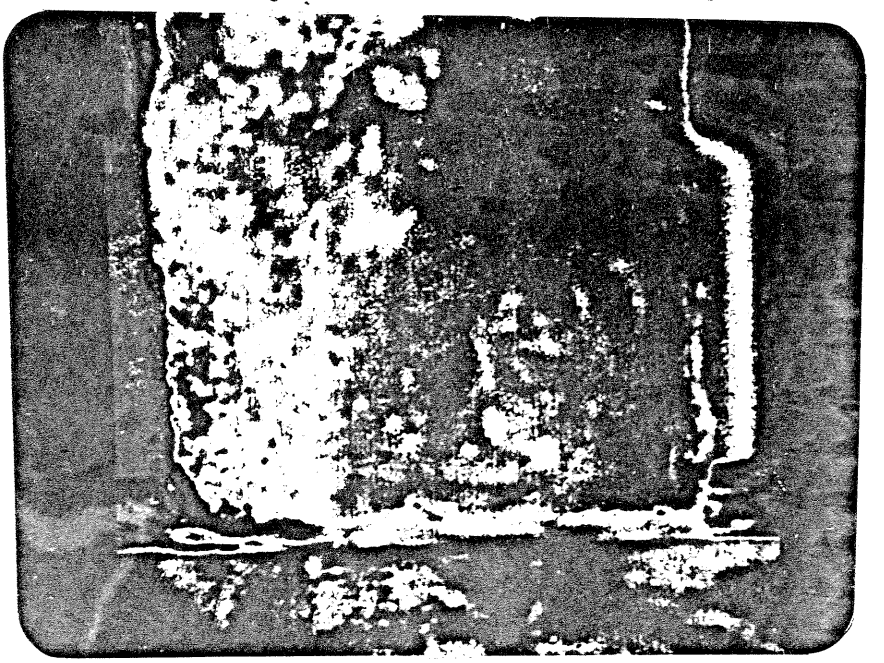


Plate 4. Enhancement by linear stretching showing invisible cracks visible

cracks which were not seen by naked eyes of concrete cube under the dynamic condition of loading has been shown very clearly in the enhanced transparencies obtained by interactive digital system.

(b) ***Equipopulation Technique:***

To improve on the above situation a equipopulation technique is applied in this approach. Image values are assigned to the display levels on the basis of their frequency of their occurrence. The image value range of 60 to 190 is now stretched over a larger portion of displayed levels (60 to 255). Plate (5) shows the output of the scene of concrete cube processed by Comtal interactive system. The hair

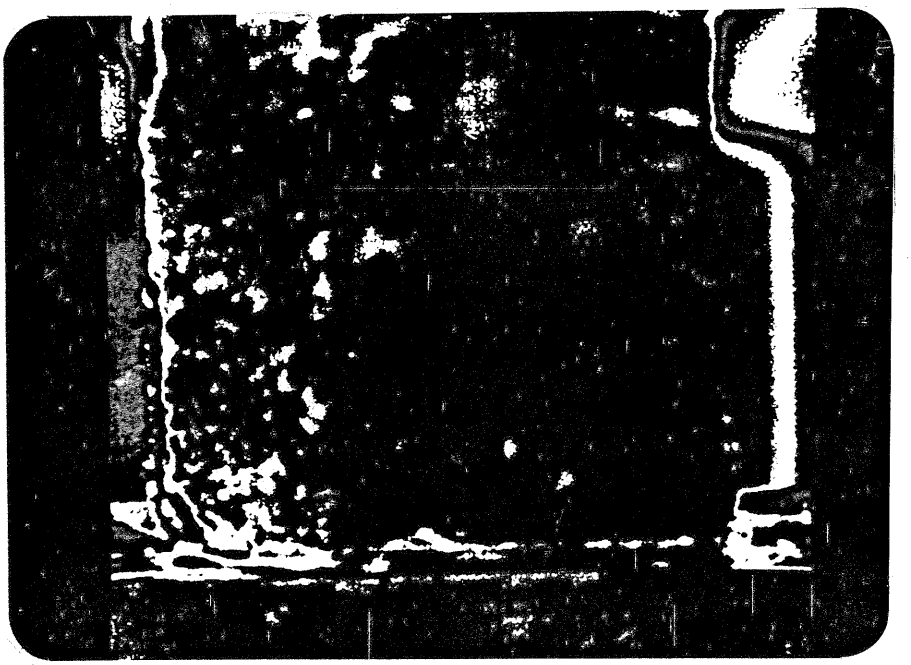


Plate 5. Enhancement by Equipopulation Technique showing invisible cracks more visible

pin cracks are more enhanced and shows that crack has developed under this dynamic condition of loading of 8 tons, which was seen by the naked eye at the load of 12 tons.

The micro-densitometer with automatic plotter is also used for the analysis of the data. The scan line plot of the transparencies is taken at three or four places as shown in figures (1) & (2). It is observed that the scan line plot of the speciman shows kinks and the deep spikes, where the cracks occurred during the loading operation with the help of compressive machine.

ANALYSIS:

The analysis of the transparencies was aimed by the help of data obtained by scan line plot of the micro-densitometer and the digital output of the data in the form of Themater of Comtal interactive digital system. It is observed from both the figures (1) & (2) that the position of the cracks is indicated by deep spikes when joined by the straight line. The crack which has occurred on the speciman under the loading condition appears to be at a load which is nearly one third of the ultimate load which the cement concrete cube can sustain as

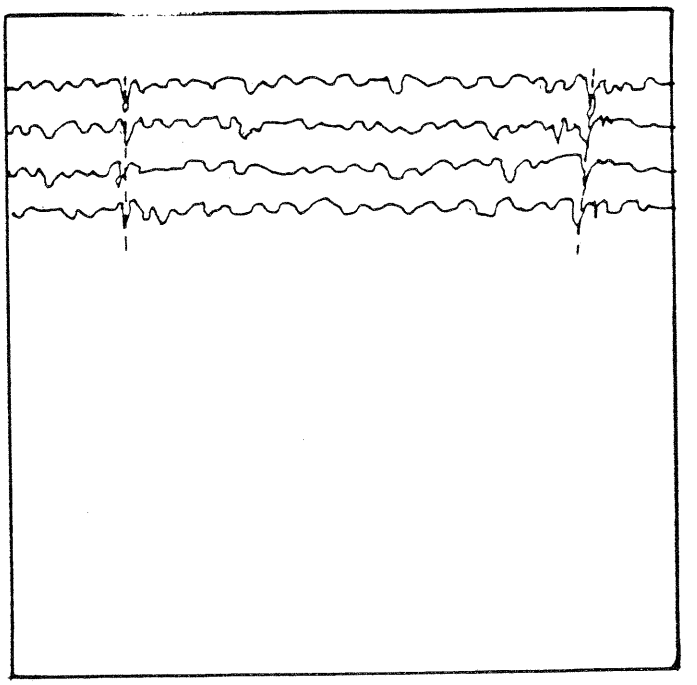


Fig. 1. Scan line plot of speciman (1:2:4) with micro-densitometer

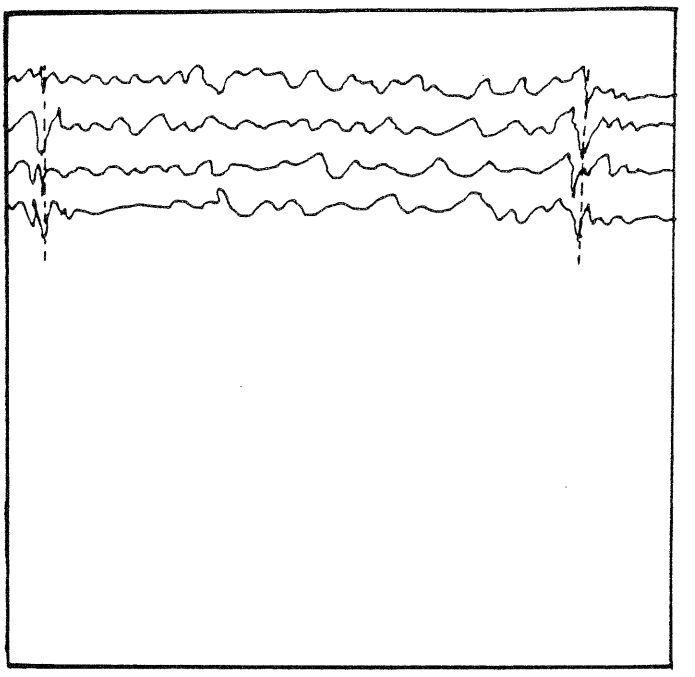
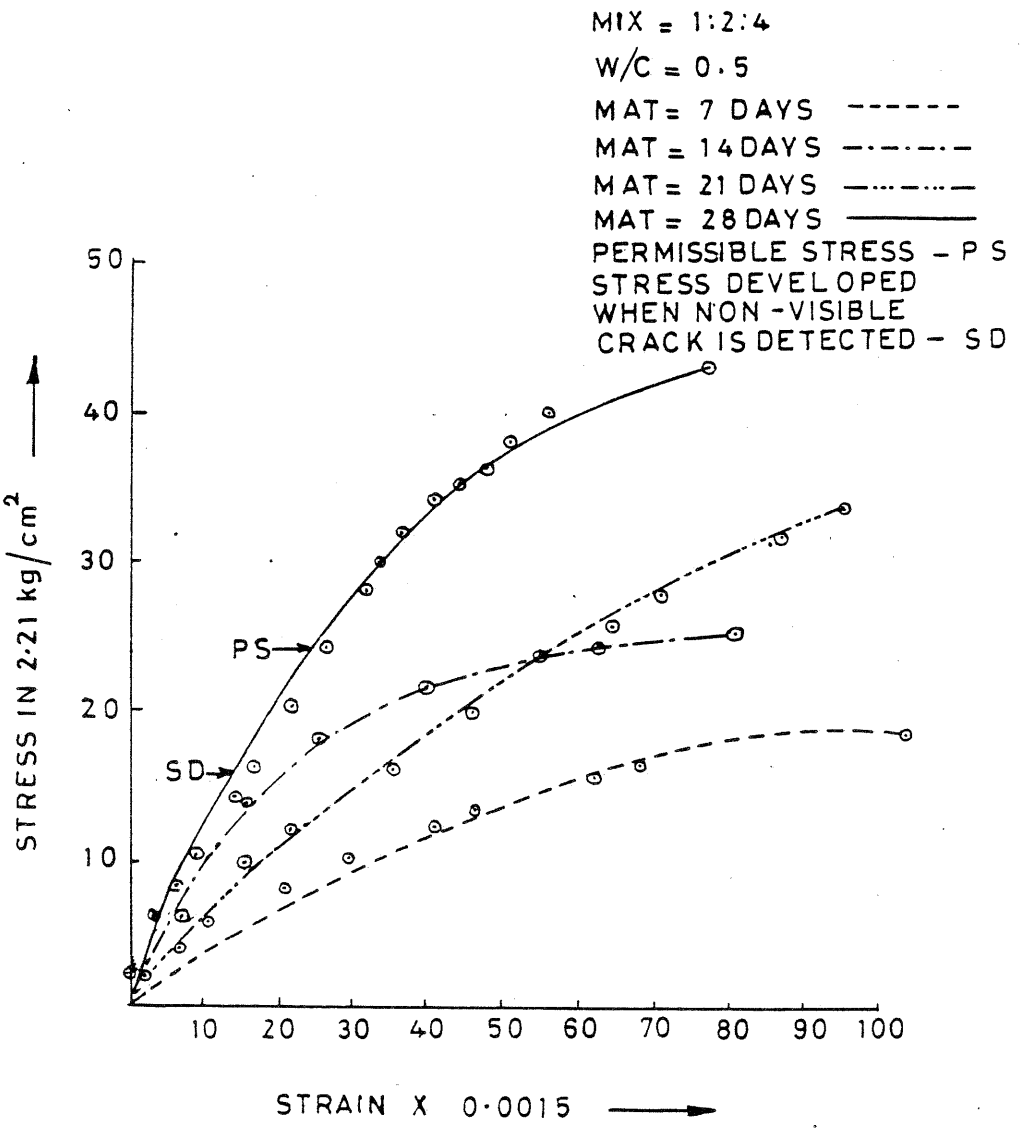


Fig. 2. Scan line plot of speciman (1:1.5:3) with micro-densitometer

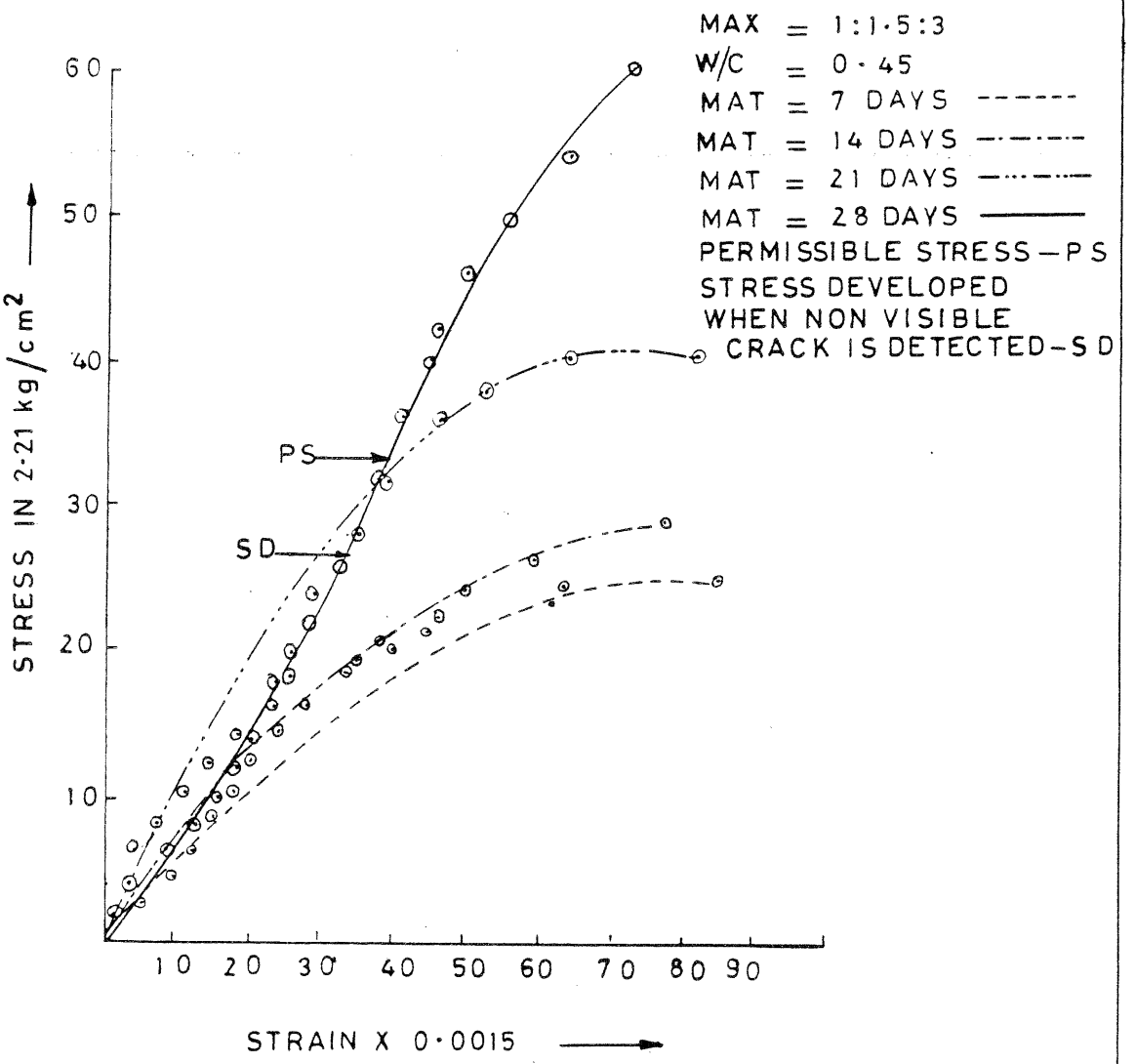
shown in observation table (1). Graphs (1) & (2), show the various conditions of stress and strain for 7, 14, 21 & 28 days maturity periods for cement concrete. This technique can be used as non-destructive test for estimating ultimate stress of the cement concrete cube or varifying whether the stress developed in the structure is within the permissible limit.



SCALE
ON X AXIS = 1 DIV = 0·0015 STRAIN
ON Y AXIS = 1 SMALL DIV = 2·21 kg/cm²

TYPICAL STRESS V/S STRAIN GRAPH

GRAPH 1



SCALE

ON X AXIS = 1 DIV = 0·0015 STRAIN

ON Y AXIS = 1 SMALL DIV = 2·21 kg/cm^2

TYPICAL STRESS V/S STRAIN GRAPH

GRAPH 2

OBSERVATION TABLE (1)

Date of Casting:	3.10.83	Maturity	- 28 days
Date of Testing:	1.11.83	Cement concrete Proportion	- 1:2:4
Sample No.:	IV	W/C ratio	- 0.50

S.No.	Load in tons (Dial gauge reading)	Stress Kg/cm^2	Linear deflection (Dial gauge reading) 1 Div.=0.01 mm.	Strain
1	2.0	8.85	1	0.0006
2	4.0	17.71	2	0.0013
3	6.0	26.50	9	0.0059
4	8.0	35.40 *	16	0.010
5	10.0	44.30	24	0.016
6	12.0	53.10 **	28	0.018
7	14.0	62.00	35	0.023
8	16.0	70.86	41	0.027
9	18.0	79.70	48	0.032
10	20.0	88.50	54	0.036
11	22.0	97.40	58	0.038
12	24.0	106.20	65	0.043
13	26.0	115.10	70	0.046
14	28.0	124.00	78	0.052
15	30.0	132.80	82	0.055
16	32.0	141.70	89	0.059
17	34.0	150.50 §	100	0.060

NOTE:

(*) Non-visible crack detected by digital technique.

(**) Crack visible by naked eye.

(§) Ultimate load.

For M150 Mix, with 28 days curing period as shown in table (1):

US	:	*Ultimate Stress*	---	*150.5 Kg/cm^2*
PS	:	*Permissible Stress*	---	*53.1 Kg/cm^2*
FS	:	*Factor of Safety*	---	*3*
SD	:	*The Stress developed when the non-visible first crack is detected*	---	*35.4 Kg/cm^2*

Thus the stress developed when the non-visible first crack detected (SD) is less than the permissible working stress. Therefore it can be categorised as non-destructive test.

CONCLUSION:

The following conclusions have been drawn by this research work:

(i) *it is possible to apply close range photogrammetric technique in the non-destructive test of cement concrete;*

(ii) *the data obtained at laboratory level should be digitally analysed for enhancement to locate the invisible cracks in cement concrete;*

(iii) *the long spikes of scan line plot obtained from micro-densitometer (with plotter) shows the position of hair pin invisible cracks.*

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