International Journal of
Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: http://dx.doi.org/10.7324/ IJASRE.2017.32479

Vol.3 (7) Aug - 2017

Experimental Investigation of RCC Beam for Analyzing Crack Variation by DIC Method

[1]Lokesh Kumar J, [2] R. Srinivas Raju [2] and Dr. V Ramesh[3]

[1] PG Scholar, [2]PHD Scholar, [3]HOD of Civil Dept.

Civil Engineering Department,

East Point College of Engineering and Technology,

Bangalore, India

India

Abstract

The purpose of this study is to investigate the mode of crack propagation in reinforced concrete using Digital Image Correlation (DIC-MAT LAB). DIC is a robust, non-contact and precise tool for fracture measurements. Digital images are taken at different loading stages and by comparing the images it is possible to infer the deformation of an object subjected to external loads. In this paper, the relationship between the fracture properties and the properties of the concrete is investigated experimentally. Tests were performed on small-scale reinforced concrete specimens in three point bending. By means of the DIC technique the visualization and quantification of the fracture properties of reinforced concrete could be determined. The DIC technique was found to be an effective mean to measure the crack opening displacements.

Key words*: Structural health monitoring,Crack Variation,Crack propagation,DIC,Digital image correlation,Mat lab.*

1. INTRODUCTION

The fracture procedure in strengthened solid structures is complex due to the fact that it is related with the advancement of both micro cracks and major cracks . The fracture conduct is likewise associated with other factors such as the concrete micro-structure,bonding between concrete and steel and properties of fine aggregates,coarse aggregate,cement,reinforcement etc.

As concrete tensile strength is low, to aid tensile stresses concrete is provided with internal reinforcement and the crack propagation and development is affected due to presence of reinforcement in the concrete as the reinforcement bridges crack and toughens the fracture development criteria.

Since reinforced concrete structures must meet both strength and serviceability requirements to be considered safe, serviceability can be monitored by measuring the displacement that occurs during static load testing and checking to ensure the measured deformation is within specified code limits.

1.1Scope of study

In the present paper digital image are utilized to correlate and measure the complete vertical displacement profile of each specimen at various load steps throughout testing and also to Investigate a variety of damage scenarios to determine their effect on the static response of a specimen at a given load

1.2 MATLAB

MATLAB, short for MATrix LABoratory is a programming package specifically designed for quick and easy scientific calculations and I/O. It has literally hundreds of built - in functions for a wide variety of computations and many toolboxes designed for specific research disciplines, including statistics, optimization, solution of partial differential equations, data analysis.

2. PRINCIPLE OF DIGITAL IMAGE CORRELATION

Digital image correlation (DIC) is the process of mapping one digital image to another, either as a single image or by a transformation field that describes the mapping of different parts of the images.DIC is a non-contact optical measurement system that measures surface displacements of an object subjected to a driving force.Given a point and its signature in the undeformed image, search/track in deformed image for the point which has a signature which maximizes a similarity function.

In practice, a single value is not a unique signature of a point, hence neighboring pixels are used.Such a collection of pixel values is called a subset or window.

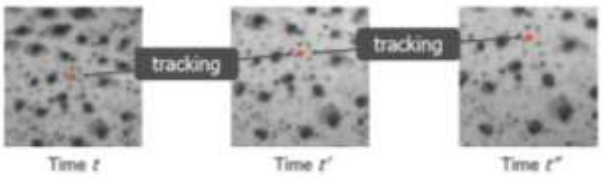

Fig 1 Principle of tracking in DIC

3. METHODOLOGY

3.1 Basic material testing

a. Cement

In this present work Ramco OPC 53g grade has been tested and used as per IS 4031:1988 and confirmed to IS 269-2015; Table 1 represents the physical properties of cement.

Table 1: Physical properties of Cement

1	Normal consistency in (%)	29	-
2	Specific Gravity	3.11	-
3	Intial Setting time (in Minutes)	150	Not less than 30 Min
4	Final Setting time (in Minutes)	250	Not more than 600 Min

b. Fine aggregate

Here manufactured sand has been used as fine aggregate and tested the same as per IS 2386-1963. The results are tabulated in Table 2.

Table 2: Physical properties of manufactured sand

1	Specific gravity	2.56
2	Water absorption (%)	3.8
3	Zone	II

C. Coarse aggregate

In this investigation 20mm downsize of coarse aggregate were used and they were tested as per IS 2386-1963. The results are shown in Table 3.

Table 3: Physical properties of Coarse aggregate

1	Specific gravity	2.62
2	Water absorption (%)	0.7
3	Impact value (%)	18.46
4	Crushing Value (%)	20.73
5	Flakiness index (%)	18.63
6	Elongation index(%)	19.48

D. Cement and admixture compatibility test(Marsh cone test)

Marsh cone test conducted to check the compatibility of Ramco OPC 53g and Super plasticizer Fosroc SP 430; Chart 1 represents Marsh cone test result

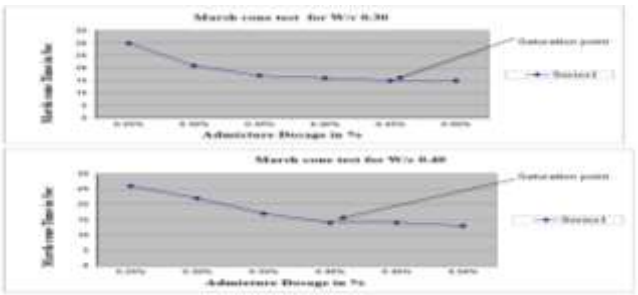

Chart 1: Marsh cone test result

3.2 Preparation of the RCC member

a. Mix design of M40 grade concrete by using IS10262-2009

The concrete mix design is done under the guidelines of IS: 456 - 2000 and IS: 10262 – 2009.

Table 4: Mix design of M40 grade of concrete

Particulars	M40 100%	M40 80%+20%	M40 65%+35%	M40 50%+50%
Cement (kg/m3)	410	360	305	265
GGBS (kg/m3)	-	90	170	265
Water (kg/m3)	164	164	164	164
Fine aggregate (kg/m3)	757	740	729	708
20mm (kg/m3)	642	642	618	600
12.5mm (kg/m3)	428	428	412	400
w/c ratio	0.4	0.4	0.35	0.31
Admixture in %	1	1	1	1

b. Casting and testing of cubes

Concrete cubes of size 150mm x 150mm x 150mm is casted and curried in curing tank for a period of 3 days , 7days and 28 days; compressive strength of concrete has been tested in compression testing machine to check is it passing the permissible limit as per Indian standards and project requirements.

3.3 Design, Casting and testing of RCC beam

a. Reinforcement Details

- Main reinforcement 2 of 12mm dia
- Hanger bars 2of 10mm dia
- Shear reinforcement 8mm dia 200 mm c/c

b. Casting and testing of RCC Beam

- Casting of RCC beam of size 0.2m x 0.3m x 1.25m
- Testing of a RCC beam by three point bend testing machine
- Capturing images of failure of beam by using digital camera
- Recording Flexural strength of RCC beam

3.4 Analysis of strain, displacements using MATLAB - DIC

Following are the set of programs that are coded and are executed in MATLAB pool for image processing and analyzing using DIC

- filelist_generator.m: It generates file name lists with max. 8 letters and „.jpg“ at the end and creates a time_image list needed for merging stress and strain
- grid_generator.m : generates grid raster needed for the correlation code)
- large_displ.m : used when the displacement exceeds the correlation area
- automate_image.m : This function does all the hard correlation work
- displacement.m: This function will helps in analyzing your data
- RTCorrCode.m : “realtime”correlation code

- Multipeak_tracking.m : track multiple peaks along one axis

4. RESULTS

4.1 Compressive strength of M40 grade of concrete

Compressive strength of concrete has been tested in compression testing machine and comparing test results with permissible limit as per Indian standards and project requirements. Table 5 shows the compressive test results and chart 2 indicates comparison of compressive strength of M40 grade concrete for various proportions.

Table 5: Compressive strength of M40 grade concrete

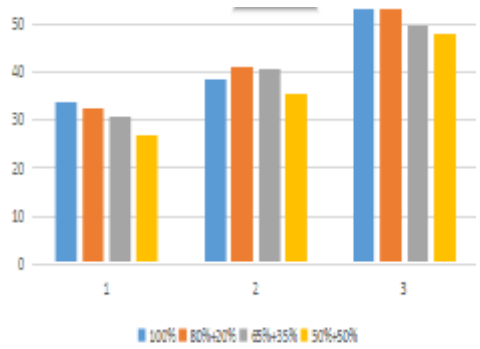

Chart 2: Comparison of compressive strength

4.2 Flexural strength of RCC beam under three point bending test

After 28days curing of RCC beams ; beams has been tested under three point testing machine (loading frame) and flexural strength calculated by using $\frac{3\ x\ P\ x\ L}{2\ x\ b\ x\ h2}$ formual.

Table 6 represents flexural strength of RCC beams and Chart 3 shows flexural strength comparison.

Table 6: Flexural strength of RCC beam

Flexural Strength Results				
Sl. No.	Grade of concrete	Proportion	Load at 1st Crack(KN)	Flexural strength in Mpa
1	M50	100%	118	9.81
2		80%+20%	98	8.18
3		65%+35%	137	11.45
4		50%+50%	128	10.63

As per IS 456 -2000 limit for flexural strength of concrete is **Error! Reference source not found.Error! Reference source not found.** = 4.43 Mpa therefore all our M40 grade proportion are passing the requirements

Compressive strength M40 grade concrete in N/mm2					
Sl No	Age of curing	100%	80%+20%	65%+35%	50%+50%
1	3	33.62	32.37	30.53	26.85
2	7	38.26	40.84	40.66	35.61
3	28	53.08	53.14	49.73	48.10

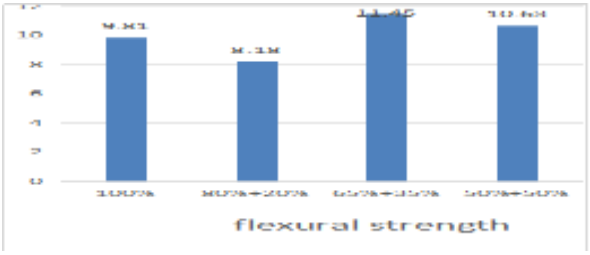

Chart 3: Comparison of flexural strength

4.3 Horizontal and vertical displacement

Horizontal and vertical displacements for each beam are found by processing the images in MATLAB-DIC by using displacement command.

Fig 2 and Fig 3 represents horizontal and vertical displacement respectively.

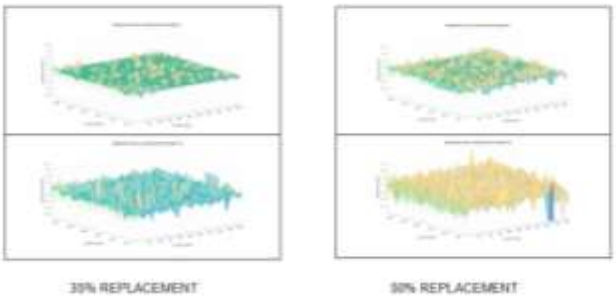

Fig2: Horizontal displacement

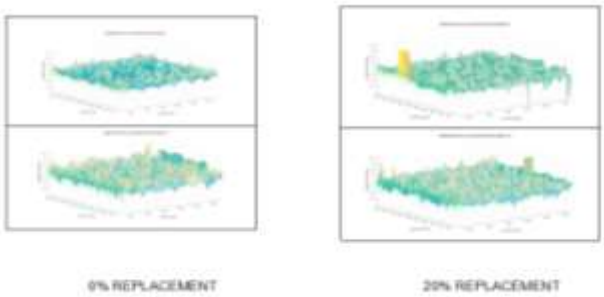

Fig 3: vertical displacement

In the above horizontal and vertical displacement results Red indicates higher scale displacements and Blue indicates lower scale displacements. By comparing the displacement results it's found that horizontal displacements are greater than vertical distance due to bending.

Table 7: Horizontal and vertical displacement

Sl. No.	Proportion	Horizontal displacement in mm	Vertical displacement in mm
1	100%	2.27	1.59
2	80%+20%	2.38	1.19
3	65%+35%	3.12	1.96
4	50%+50%	2.45	2.48

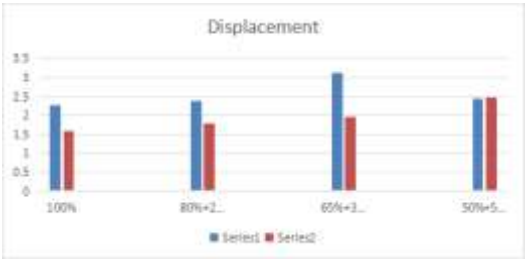

Chart 4: Compassion of horizontal and vertical displacement

4.4 Horizontal and Vertical strain plots

Horizontal and vertical strain plots are represents strain at different points in each images; Fig 4 and Fig 5 are horizontal and vertical strain plots of each mix respectively.

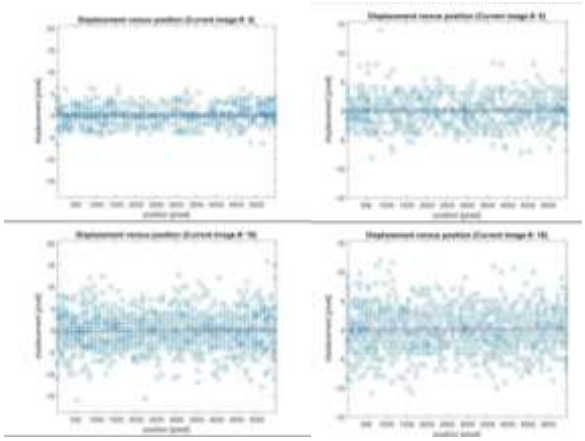

Fig 4: Horizontal strain plots

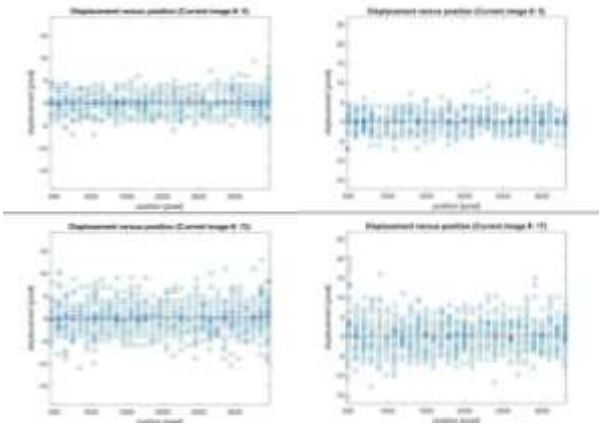

Fig 5: Vertical strain plots

4.5 RT corr results

In the fig 7 A signifies Raster points. Raster points are the heart of correlation since the results depend on them and crack propagation are explained and crack density are depicted using them. The other figures pertaining to RT corr depicts the relation between H and V displacements and strains**.**

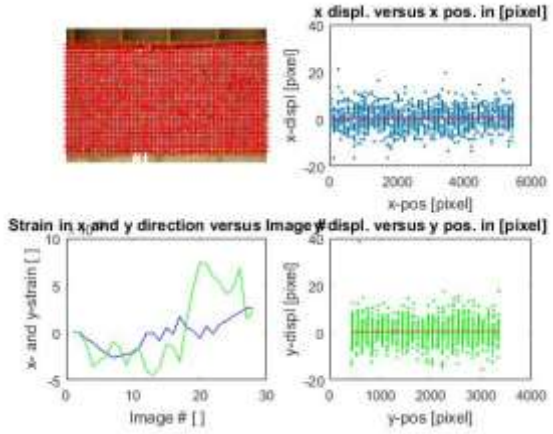

Fig 6: RT corr results

4.5 Peak displacement

The displacements along any axis can be depicted by this programme helpful in analyzing and designing. The peak displacement are listed below for the set of images processed

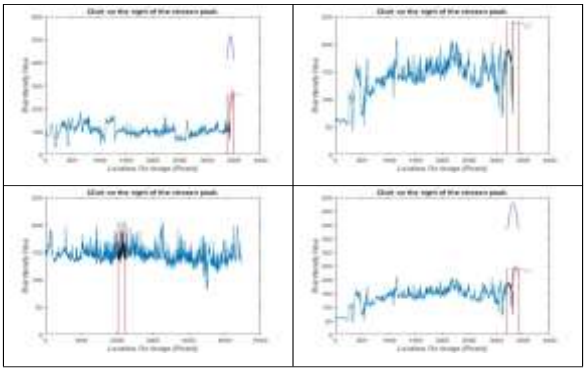

Fig 7: Peak displacement

Sl no.	Image No.	Horizontal Displacement mm	Vertical Displacement mm
1	Image 1	2.2749	2.2876
2	Image 2	2.281	1.9645
3	Image 3	2.2722	1.8839
4	Image 4	2.2743	1.8771
5	Image 5	2.2791	1.8734
6	Image 6	3.3165	1.8449
7	Image 7	2.283	1.8766
8	Image 8	2.2891	1.8751
9	Image 9	2.2976	1.8794
10	Image 10	2.3101	1.7453
11	Image 11	2.287	1.8253
12	Image 12	2.3021	1.7714
13	Image 13	2.2759	1.8992
14	Image 14	2.2834	1.8685
15	Image 15	2.2911	1.8367
16	Image 16	2.2798	1.9144
17	Image 17	3.282	1.8978
18	Image 18	2.2899	1.8649
19	Image 19	2.281	1.9062
20	Image 20	2.3087	1.7977

Table 8: Compressive strain and tensile strain

5. CONCLUSION

In this paper work RCC beams were casted and tested in loading frame by three point bending method. While testing failure of beam is capture by using digital camera and both strain and displacement of RCC beam are analyzed by using MATLAB – DIC.

1. In this paper work cement is partially replaced by GGBS i.e; 20%, 35% and 50% and all the mixes are achieving target strength.
2. By partial replacement of cement by GGBS reduce the demand of cement and reduces the cost of concrete mixes.
3. Environmental green product can manufacture by using by-product GGBS in concrete mix.
4. The DIC technique enabled the visualization and quantification of the fracture properties in reinforced concrete. The DIC technique is found to be very effective in monitoring the crack profile in small-scale reinforced concrete beams.
5. It was found that concrete strength has a limited influence on crack opening, however, the bond stresses between reinforcement and concrete seemed to play a role in the observed crack propagation and crack bridging.
6. This could potentially be utilized for applications of structural health monitoring for civil infrastructure.

6.REFERENCE

1. Rajath M H, Dr. V Ramesh "Propagation of Crack in Cement Concrete Beam by Using Digital Image Correlation"(2015)
2. Michel Küntz, Marc Jolin, JoséeBastien, Fabien Perez, and François Hild "Digital image correlation analysis of crack behavior in a reinforced concrete beam during a load test"(2011)
3. MING-HSIANG SHIH1 and WEN-PEI SUNG " Application of digital imagecorrelation method for analyzing crack variation of reinforced concrete beams" (2013)
4. M. Pavan Kumar, Y.Mahesh " The Behaviors of Concrete by Partial Replacement of Cement with GGBS" (2015)
5. IS 456-2000 Indian Standard Plain and reinforced concrete.

First Author Lokesh kumar J – Mtech researcher, Civil Engineering Department, East Point College of Engineering and Technology, Bangalore, India

Second Author Srinivas Raju, Phd researcher, Bangalore

Third Author Dr.V.Ramesh, HOD of Civil Engineering Department, East Point College of Engineering and Technology, Bangalore, India