Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 09, September -2018

STRUCTURAL PERFORMANCE ANALYSIS OF NEWLY CONSTRUCTED FRAMED BUILDING

Mahipal Burdak

Structural Consultant Engineer, Dara Construction Company Jodhpur

Abstract- *The issue of upgrading the existing engineering structures has been one of great importance for over a decade. Deterioration of RC elements may be attributed to ageing, environmentally induced degradation, poor initial design and/or construction, lack of maintenance, changes in codel provisions and to accidental events such as earthquakes. Lifetime prediction and damage assessment of engineering structure is a growing part of infrastructure planning. So, the field of condition assessment and Non-Destructive evaluation of engineering structure is an integral part of the Civil Engineering in future.*

Keywords- *Non-destructive testing, Schmidt Rebound Hammer, TICO Ultra sonic Pulse Velocity, water logging*

I. INTRODUCTION

Condition assessment of the structure or structural evaluation is mainly based on visual examination. The purpose of this survey is to know the status of structures under applied load and other environmental condition and to make a preliminary assessment of existing conditions of the structures. During the condition survey we observe the structure through visual inspection and other techniques i.e. hammer, microscope etc. Visual defects directly related to poor workmanship or material deterioration. Lack of structural adequacy often shows up in excessive deflection flexural cracking, while foundation movements may cause distortion of doorframe and cracking of windowpanes. Crushing and spalling normally indicates material deformation during the condition assessment, it is quite important to differentiate between the various types of cracks formed. True examination of crack pattern shows the most probable cause of the problem. Condition assessment is a measurement of the 'state of health' of the building or the structure 'after completion, and also can be checked regularly during its 'life' by further routine tests.

1.1 User Requirement:

Agency approaching Non Destructive assessment will have certain enquiries namely- Quality of constructed structure, Problems in structures with their reasons, Residual strength/ life or the structure, Retrofitting/ remedial measures etc.
Before visiting the site some important data is required: Age of the structure, reasons for its assessment, Geo technical investigation report, Ambient Environment, Design and detailing of the structure, Use of the structure and its repair history etc. This provides certain status to consider appropriate NDT techniques for investigation.

1.2 Techniques for Assessment:

Non Destructive Testing techniques available are:

1. Visual observations to find common defects.
2. Hardness based technique: Schmidt Rebound hammer can be used to find hardness of the concrete structure surface.
3. Ultra sound wave transmission: Ultra sonic Pulse Velocity Equipment can be used to observe wave transmission through Concrete structure.

1.3 Non Destructive Testing of Concrete:

Non-destructive testing (NDT) finds prominence in quality assurance of construction industry. It has great potential in investigation and repairs to various types of structures. Simple NDT techniques can be used to identify weak areas in concrete, which can be suitably repaired. It does not impair the intended performance of the element or member under investigation. NDT may be defined as the technique which is used to determine the strength and durability of critical construction without detrimental effect to them and test can be carried out on site.
NDT is becoming popular now a day as no damage occurs in structures while testing. It gives rapid assessment of existing condition of structure it is used for wide range of objectives as discussed before. NDT includes testing right from visual inspection to the advanced techniques available for the testing of structures. NDT is applied not only in quality control and routine inspection but also in diagnostic investigations.
The need for comprehensive and detailed recording, reporting and interpretation of results is of considerable significance. It is necessary to establish the reason of deterioration before planning the repair programme. Comprehensive photographs are often of particular value for future references.

In view of Limitation of each method of NDT of concrete, it is essential that the results of tests obtained by one method should be complemented by other tests and each method should be adopted very carefully for correct evaluation and diagnosis of structural deficiencies. Some methods appear to be very simple, but all are subject to complex influences and the need of skilled operators and appropriately experienced engineers are vital. There are various NDT methods are available, for which, the scope, applicability and accuracy vary from each other. Some NDT methods are described in this chapter with their basic principles, applications and limitations

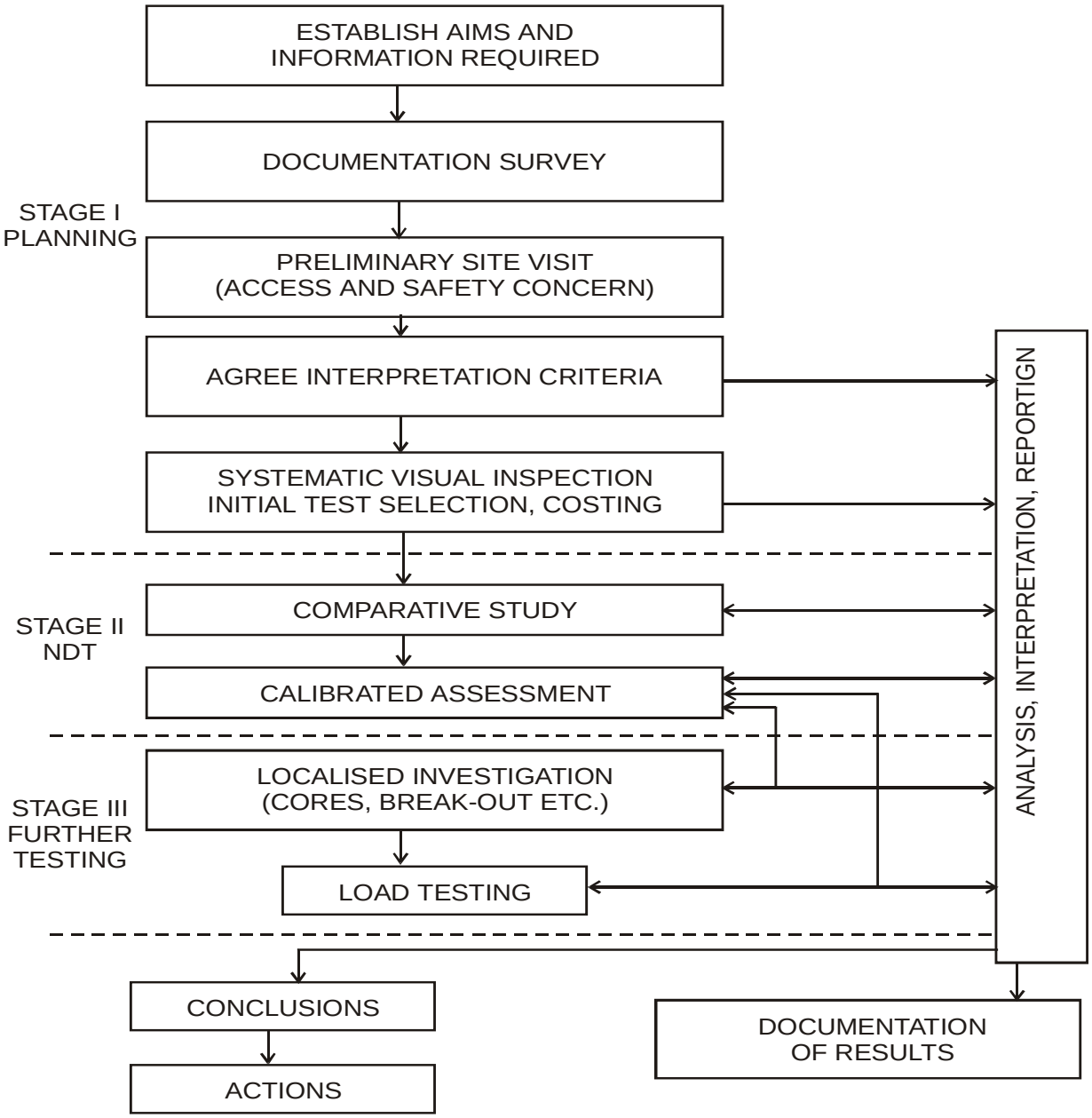

Fig. 1 Typical Assessment Programme Stages

II. FIELD CASE STUDY-

2.1 Problems in structures:

The building under construction is being suspected for low quality material and inferior construction technique. Two drawings i.e. 1. Office Building layout & Details of slab & beam at +1.15 m level (Rev. 25-09-2012), 2. Office Building Foundation plan and sections (Rev. 19-04-2012) in addition to soil testing report executed by M/S Geocon, Mumbai, Tests on Aggregates by M/S Geo Appraisal Private Limited, Jodhpur, Cement compressive strength test results, Compressive strength of Concrete Blocks. Steel test reports by Premier Bars Pvt Ltd, Jodhpur for M/S Giriraj Steel, Jodhpur were also provided. They reported issues related to foundation, Poor design/ detailing, construction techniques, inferior material, and cracks shown at various places. Primarily Visual inspection is essentially required to plan NDT assessment of the framed building. Needless to mention that building has to be checked and identified for good and bad quality of concrete, distressed locations in the structure, basic problems in the structure, nomenclature of structural elements.

2.2 Work Strategy:

On the basis of preliminary site visit it was decided that NDT will be carried out using suitable technologies accessible in the institution. Boundaries of the study were also discussed. Preliminary site visit was undertaken on 23-10-2012. Thus it was decided that certain NDT tests will be carried out using appropriate technologies available in the institution. Limitations of the study were also discussed. As agreed up on Techniques used are: Schmidt Rebound Hammer Digital model of Proceq (Swiss company), TICO Ultra sonic Pulse Velocity also of Proceq, Core tests, additionally some other instruments were used as deemed fit. These tests were carried out on 26th 27th Oct 2012. Core extracted was provided capping and tested after desired curing.

As agreed up on Techniques used are: Schmidt Rebound Hammer Digital model of Proceq (Swiss company), TICO Ultra sonic Pulse Velocity also of Proceq, Profometer, additionally some other instruments were used as deemed fit.

III. NDT TEST RESULTS

3.1 Schmidt Rebound Hammer Test Results:

S.N.	*Average Rebound no (6 readings)*	*Maximum Reading*	*Minimum Reading*	*Standard Deviation*	*Related Compressive Strength N /sq mm*	*Remarks*
B-2	29.3	32	28	1.5	24	
B-2	28.3	32	24	2.9	22.4	
B-2	31.3	37	29	2.9	27.5	
B-2	31.7	36	28	3.6	27.8	
B-2	30.3	37	27	1.9	26.3	
B-2	29.8	34	27	2.7	24.8	
B-2	27.5	30	26	1.6	21.1	
B-2	34.7	43	30	5.5	32.9	
B-2	29.2	32	25	2.6	23.7	
B-2	29.5	37	26	4.1	24.3	
B-2	26.3	29	24	2.1	19.3	
B-2	31.0	35	28	2.7	26.7	
B-2	27.8	29	226	1.2	21.6	
B-2	29.5	33	25	2.7	24.3	
B-2	28.0	30	26	1.7	21.9	
B-2	26.2	28	25	1.2	19.0	
C-2	26.5	28	25	1.0	19.5	
C-2	26.0	28	24	1.7	18.8	
C-2	24.3	25	23	0.8	16.2	
C-2	27.5	30	25	1.6	21.1	
C-2	29.5	33	27	2.3	24.3	
C-2	29.2	32	26	2.1	23.7	
C-2	32.2	40	28	5.1	28.8	
C-2	30.3	32	29	1.4	28.6	
C-2	30.3	37	27	3.4	25.6	
C-2	29.2	33	24	3.5	23.7	
D-2	24.5	27	22	1.6	16.5	
D-2	26.5	35	23	4.5	19.5	
D-2	25.8	26	25	0.4	18.5	
D-2	25.0	26	24	0.6	17.2	
D-2	25.2	32	22	3.6	17.5	
D-2	25.2	29	23	2.1	17.5	
D-2	26.0	29	24	1.7	18.4	
D-2	32.5	34	30	1.6	29.2	
D-2	31.5	37	29	2.8	27.5	
E-2	29.5	31	27	1.4	24.3	
E-2	30.0	33	27	2.4	25.1	
E-2	31.7	35	28	3.1	27.8	
E-2	27.8	31	26	1.2	21.6	
E-2	30.8	36	26	3.3	26.4	
E-2	26.0	29	20	3.5	18.8	

E-2	30.5	33	29	1.6	25.2	
E-2	31.5	37	22	5.2	27.5	
Columns Ground Floor						
A-1	27.5	29	26	1.4	21.1	
A-1	27.0	29	25	1.4	20.3	
A-1	26.2	27	25	1.0	19.0	
A-1	28.3	31	26	2.3	22.4	
B-1	28.3	33	27	2.3	22.4	
B-1	28.2	32	26	2.0	22.1	
B-1	29.3	37	27	3.9	24.0	
B-1	27.3	30	23	2.4	20.8	
C-1	26.2	31	23	2.8	29.0	
C-1	25.5	32	22	3.4	18.0	
C-1	23.7	26	19	2.4	15.2	
C-1	26.5	33	23	3.6	19.5	
D-1	27.5	30	24	2.6	21.1	
D-1	26.8	34	25	3.5	20.0	
D-1	27.8	30	25	1.7	21.6	
D-1	28.3	34	26	2.9	22.4	
E-1	28.5	32	26	2.0	22.7	
E-1	32.8	41	29	4.4	29.8	
E-1	31.0	35	27	3.3	26.7	
C-3	40.5	45	37	3.4	43.4	
C-3	40.8	45	37	3.1	44.0	
C-4	36	41	32	2.9	35.2	
C-4	35.8	39	34	1.8	34.9	
Core Location B 2-1 Ground Floor						
B 2-1	27.7	31	25	2.5	21.3	
B 2-1	30.2	39	22	6.2	25.3	
B 2-1	27.0	35	20	5.4	20.3	
B 2-1	22.8	27	19	3.0	14.0	
Beams						
B-2-1	22.5	37	27	3.6	29.2	
B-2-1	31.7	37	29	2.8	27.8	
B-2-1	25.5	29	24	2.9	18.0	
B-2-1	30.8	35	25	4.0	26.4	
B-2-1	27.3	29	26	1.0	20.8	
C-2-1	28.5	33	24	3.4	22.7	
C-2-1	30.7	36	26	3.7	26.2	
C-2-1	25.3	27	24	1.2	17.7	
C-2-1	32.5	38	28	3.8	29.2	
C-2-1	26.3	28	23	2.1	19.3	
C-2-1	26.5	29	25	1.4	19.5	
D-2-1	29.5	33	27	2.2	24.3	
D-2-1	30.2	33	28	2.0	25.3	
D-2-1	27	33	19	4.6	20.3	
D-2-1	20.6	28	23	1.9	19.0	
D-2-1	24.2	26	23	1.0	16.0	
D-2-1	25.8	28	24	1.7	18.5	
E-2-1	27.3	32	24	2.0	20.8	
E-2-1	29.2	33	25	3.3	23.7	
E-2-1	29.5	33	27	2.2	24.3	
E-2-1	26.3	28	23	2.0	19.3	
A B -2	29.2	32	26	2.2	23.7	

Schmidt Rebound hammer readings SN 1-6 were observed on Schmidt Rebound hammer readings are related to surface hardness of the Concrete and its strength is related using inbuilt calibration curve in the instrument. The strength with rebound hammer number not necessarily is truly indicative of its compressive strength to the extent shown, these have to be corrected for different factors but it does give comparison of surface hardness for quality of concrete, Refer IS 13311 pt II.

3.2 UPV Test Results:

S N	*Column/Beam No.*	*Path length mm*	*Travel time µ sec*	*Velocity m/sec*	*Remarks/ Method*
COLUMNS Basement 09/09/12					
1	B-2	200	87.5	2290 (ID)	
2	B-2	200	87.7	2280 (ID)	
3	B-2	200	90.8	2160 (ID)	
4	C-2	200	100.8	1980 (ID)	
5	C-2	200	97.7	2050 (ID)	
6	C-2	200	91.7	2180 (ID)	
7	C-2	200	102.8	1950 (ID)	
8	D-2	200	102.7	1950 (ID)	
9	D-2	200	112.8	1770 (ID)	
10	D-2	200	105.8	1890 (ID)	
11	E-2	200	153.9	1300 (ID)	
12	E-2	200	134.7	1490 (ID)	
13	E-2	200	134.3	1490 (ID)	
Columns Ground Floor					
15	A-1	600	596	1010 (D)	
16	A-1	600	245	2450 (D)	
17	A-1	200	123.7	1620 (ID)	
18	B-1	200	166.5	1200 (ID)	
19	B-1	250	192	1300 (SD)	
20	B-1	600	191.4	3080 (D)	
21	B-1	600	185.8	3180 (D)	
22	C-1	200	166.5	1200 (ID)	
23	C-1	600	194.5	3090 (D)	
24	D-1	200	129.7	1540 (ID)	
25	D-1	600	180	3330 (D)	
26	E-1	600	178.9	3350 (D)	
27	E-1	200	86.8	2330 (ID)	
Core Location B 2-1					
29		200	48.2	4150 (ID)	
30		200	68.8	2910 (ID)	
31		200	71.7	2790(ID)	
New Construction Column					
33	C-3	600	139.3	4310 (D)	32.3
34	C-3	200	78.8	2540 (ID)	
35	C-4	600	251	2390 (D)	
36	C-4	200	81.9	2440 (ID)	
37	C-4	600	139.8	4290 (D)	29.4
Beams					
39	B-2-1	400	117.7	3400 (D)	
40	B-2-1	200	89.9	2500 (ID)	
41	B-2-1	200	125.7	1520(ID)	
42.	B-2-1	200	120.4	1600(ID)	
43	C-2-1	200	119.3	1610(ID)	
44	C-2-1	200	134.4	1490 (ID)	
45	C-2-1	400	122.8	3260 (D)	
46	D-2-1	200	123.4	1620 (ID)	
47	D-2-1	200	118.3	1710(ID)	
48	D-2-1	200	174	1140 (ID)	
49	E-2-1	200	132	1510 (ID)	
50	E-2-1	200	111.7	1790 (ID)	

Ultrasonic pulse velocity test indicate travel time through concrete continuous media. In Indirect method probes are kept on same side of the surface while in semi direct these are kept at right angles to each other. Higher pulse velocity

indicates better quality of concrete. Difference in velocities obtained by different methods should be compared with corrections as given in IS 13311 pt I.

3.3 Crack Depth Measurement

S.N.	*Member*	*B mm*	*T1 µ sec*	*T2 µ sec*	*Crack Depth mm*	*Remarks*
1.	Beam B 2-1	75	116.8	160	117	Bottom Nr Sleeve
2.	Beam B 2-1	75	157.5	170.6	303	Side Above N. A.
3.	Beam B 2-1	75	205	351	56	Side Above N. A.
4.	Beam C 2-1	75	93.4	-	-	Bottom
5.	Beam C 2-1	75	109.5	157.9	100	Side
6.	Beam C 2-1	75	99.6	141.5	105	Bottom

3.4 Other Correlation Results

Core Testing: Core was extracted on 27-10-2012 on Beam B 2-1 top surface approximately 2 m away from column face. It was capped tested after 3 days curing in the lab.
Diameter of core 70 mm, Height of core 115 mm, Load 6.35 British Ton, H/D Ratio
With H/D ratio correction factor is negative, Correction factor for Age and presence of reinforcement bars are compensating, Correction factor for Cylinder to Cube strength is 1.25 positive.

IV. OBSERVATION & DISCUSSION

Summarized observations: Quality of concrete is in general visually appears to be average in general in patches. Workmanship appears to be poor in execution of the work. NDT test indicate in surface hardness. Ultrasonic pulse velocity test show quality in undisturbed part. Rebound readings with standard deviation more than 5.0 show wide range of data and quality as well. Quality of concrete with Compressive strength obtained with Rebound hammer test more than 20.0 N / sq mm can be considered meeting desired level. Point where this is not shown may be checked with other methods to confirm their quality. Ultrasonic Pulse Velocity obtained less than 2000 m/s shows doubtful quality of concrete. It can be considered good if the velocity obtained is more than 3000 m/s and excellent if it is more than 4000 m/s. At some points compressive strength with combined Rebound and Ultra sonic Pulse Velocity are obtained showing more reliable results hence can be considered better.

V. RECOMMENDATIONS/CONCLUSION

In view of the BIS code major relevant code revisions and state of cracks in the middle span beams it not prudent to continue with the building. Rather it would be in the interest of the public at large and Staff in particular to retrofit RCC frame structure and go for repair. Current codal provisions must be implemented.

References-

1. IS: 13311 (Part 2): 1992 Non-destructive Testing of Concrete –Methods of Test, Part 2 Rebound Hammer, BIS, New Delhi.
2. IS: 13311 (Part 1): 1992 Non-destructive Testing of Concrete – Methods of Test, Part 1 Ultrasonic Pulse Velocity, BIS, New Delhi.
3. National Seminars on “Potential of NDT for Quality Assurance and Diagnosis” 24th February 2004 at Hotel Le Meridien, Andheri (E), Mumbai and ‘Diagnosis & Evaluation of Concrete Structures using Non-Destructive Techniques’ 25th & 26th February, 2004, P.I.E.T. Campus, Pune organized by India Chapter of ACI.
4. V.M. Malhotra, Testing Hardened Concrete: Nondestructive Methods, Published jointly by The Lowa State University Press, Lowa and ACI, Michigan, 1976.
5. "Workshop on Non-Destructive Testing of Concrete Structures" : 22nd Sep. 2000 : Organized by The Institution of Engineers (India), Pune Local Centre
6. Dr. A.K. Gupta and Dr. Ravi Kumar Sharma, “Short term course on Non-destructive Assessment of Structure (NONDAS)”. Department of Structural Engineering, M.B.M. Engineering College, Jodhpur
7. E.A. Whitehurst, Evaluation of Concrete Properties from Sonic Tests, Published jointly by The Lowa State University Press, Lowa and ACI, Michigan, 1967.
8. ACI 228.1R-95, In-Place Test Methods for Determination of Strength of Concrete.
9. ACI 364.1R-94, Guide for the Evaluation of Concrete Structures Prior to Rehabilitation.
10. ACI Manual, December 2007, Inspection Instruments Inc.
11. Gambhir, M.L. (2000), —Concrete Technology‖, Tata McGraw Hill, N. Delhi.
12. IS: 10262:2000, Recommended guide line for concrete mix design", Bureau of Indian Standards, New Delhi.
13. IS: 456-2000, "Code of Practice for Plain and Reinforced Concrete", Bureau of Indian Standards, New Delhi.

14. IS: 516-1959, "Method of Test for Strength of Concrete", Bureau of Indian Standards, New Delhi.
15. Kaushik, S.K. (1996), ―Non-destructive testing in Civil Engineering‖, Dec., Indo-US workshop on N.D.T., I.C.I., U.P., Roorkee.
16. Malhotra V.M. and NaikTarun, "The Ultrasonic Pulse Velocity Method". CRC Handbook on NDT of concrete, CRC Press
17. Neville A.M. and Brooks J.J., "Concrete Technology", Third edition reprint, Pearson Education P. Ltd., Indian branch, New Delhi.
18. Neville A.M., "Properties of Concrete", Fourth Edition, Pearson Education, 2008.
19. Smart NDT System, Investigation of a Fire Damaged Structure: A Report (1999), 203, Signature- 1, Productivity Road, Vadodara.
20. Smart NDT System, NDT of Earth quake Affected Structure, @ Cement Plant, Kutch. : A Report, June 2001, 203, Signature- 1, Productivity Road, Vadodara.
21. Deshpande V.B, Hawlader Suman (2004) Structure Laboratory Manual.
22. Himanshu Jaggerwal, Yogesh Bajpai (2014), Assessment of Characteristic Compressive Strength in Concrete Bridge Girders Using Rebound Hammer Test, International Journal of Computational Engineering Research (IJCER) Vol, 04 || Issue, 4 || April – 2014.
23. Guidebook on non-destructive testing of concrete structure, International Atomic Energy Agency, Vienna, 2002.
24. Himanshu Jaggerwal , Yogesh Bajpai (2014), Estimating the Quality of Concrete Bridge Girder Using Ultrasonic Pulse Velocity Test, International Journal of Computational Engineering Research (IJCER) Vol, 04 || Issue, 4 || April – 2014.
25. Master. Shivendra Tiwari, Miss. Shweta Katrekar, Master.Mustafa Girilwala, Master. Abdul Kader Shahpurwala on Structural Health Monitoring by Non Destructive Techniques On Concrete for UG degree project.

