CAPACITY ESTIMATION OF RCC FRAME STRUCTURED BUILDING FOR SEISMIC VULNERABILITY WITH REFERENCE TO STRUCTURAL ASSESSMENT USING NDT – A CASE STUDY

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Abstract : There is degradation of concrete structures with the passage of time. The degradation may be due to various harmful environmental actions such as carbonation, alkali aggregate reactions, etc. Due to degradation, the load carrying capacity and strength of concrete decreases. On other hand, seismic codes are also frequently revised with the advancement in research and technology and knowledge gained after an earthquake. Hence old structures need to be evaluated from the point of its seismic vulnerability. In current paper, seismic vulnerability assessment of Jamatkhana building, Yavatmal has been presented. This assessment was carried out using E-Tabs software as per IS 1893-2016 using the data obtained by non-destructive test results. Initially, some members failed the design check. Modified sizes of failed members were suggested after reanalyzing the building in the software and retrofitting was suggested.

Keywords - ***Degradation, carbonation, alkali aggregate reaction, seismic vulnerability, retrofitting***.

I. INTRODUCTION

In this era of modern development, the safety and serviceability of structures is an important parameter. Most of the existing structures that are designed as per old codes do not satisfy the requirements of modern code. Hence it is very important to see whether all the buildings satisfy current standards for following purposes:

- Pre earthquake vulnerability check.
- Post-earthquake vulnerability check.
- Additions and alterations in existing buildings.
- Safety and Stability check for buildings.

In India, the seismic risk has been increasing rapidly in the recent years and country has failed in ensuring earthquake-resistant constructions in high seismic regions. Major earthquake events in India are rare but casualties caused in these are very high and each earthquake is characterized by high exposure and their economic and social effects cannot be neglected.

In India, in last few years various old structures have been collapsed. This is because these structures have become too old and due to which the strength of the structure got reduced. This has also led to loss of lives in our country.

Hence, in order to prevent this, it is very essential to assess the structural parameters of existing old structures and reanalyse it and thus check for safety and stability of such structures. Hence prevent the structure from collapsing by using suitable retrofitting measures.

Many studies have been carried out to achieve this aim but still there is much scope in this field. The number of experimental studies have investigated the strength of the building by Rapid Visual screening method. In this paper we have assessed the strength by Non-destructive techniques and then reanalysed the building using E-TABS software.

II. GENERAL DATA OF BUILDING

The building is a commercial community hall building situated at Yavatmal. The building is 32 m long and 15 m wide. The construction of building was completed in 1973.

- The building can be categorized as RCC framed structure public building.
- The building is constructed on fairly level ground with foundation strata having the SBC of 250 – 300 kN/Sq.m.
- The building is a Ground + 2 storied RCC framed structure with 230 mm thick External and 150mm / 115 mm thick brick masonry walls with RCC slab provided at top.
- The roof slab beams are provided inverted and plain soffit can be seen on second floor.

III. NON-DESTRUCTIVE TEST ON BUILDING

The building had become too old and cracks were also noticed in many parts of the building. Hence, NDT was suggested to evaluate the strength of the building and also to evaluate seismic stability of building.

Following conclusions were drawn from the results of Rebound hammer test performed on building.

- Average compressive strength was found to be 15.50 N/mm^2.
- Building was constructed with proper quality control and supervision.
- Steel was non-corroded and its quality was also good.

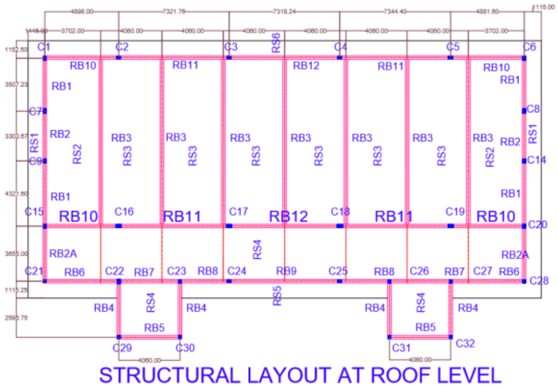

Fig. 1 Existing structural layout of building at roof level

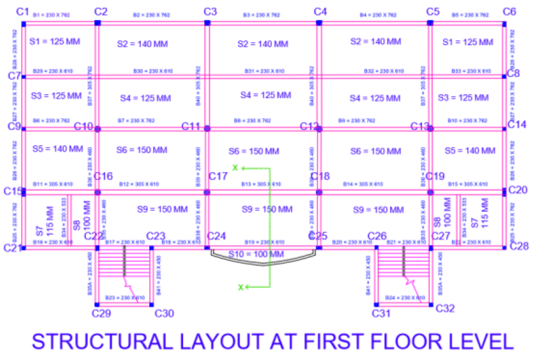

Fig. 2 Existing structural layout of building at first floor level

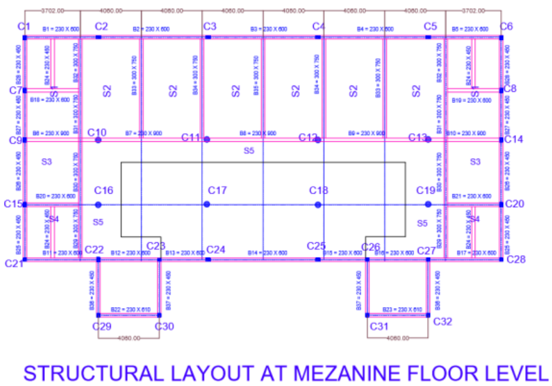

Fig. 3 Existing structural layout of building at Mezanine floor level

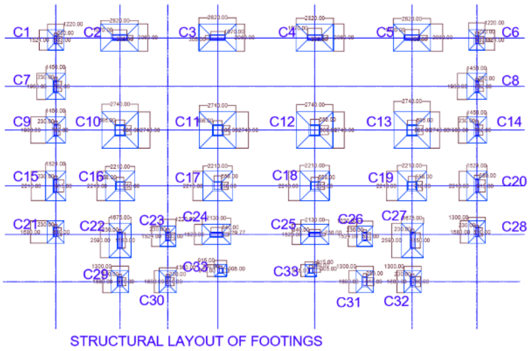

Fig. 4 Existing structural layout of footing

Table 1. Existing schedule Slab at roof level

SLAB NO.	THICKNESS
RS1	75
RS2	115
RS3	115
RS4	115
RS5	88
RS6	100

Table 2. Existing schedule of Slab at First floor level

SLAB NO.	THICKNESS	SLAB NO.	THICKNESS
S1	125	S5	140
S2	140	S6	160
S3	125	S7	115
S4	125	S8	100

Table 3. Existing schedule of Slab at Mezanine floor level

SLAB NO.	THICKNESS
S1	125
S2	115
S3	140
S4	140
S5	100

Table 4. Existing schedule of beams at roof level

BEAM NO.	WIDTH	DEPTH	BEAM NO.	WIDTH	DEPTH
RB1	230	380	RB7	230	380
RB2A	230	380	RB8	230	380
RB2	230	380	RB9	230	610
RB3	230	915	RB10	230	915
RB4	230	305	RB11	230	915
RB5	230	380	RB12	230	915
RB6	230	380			

Table 5. Existing schedule of Footing

COLUMN NO.	FOOTING SIZE	FOOTING DEPTH	COLUMN NO.	FOOTING SIZE	FOOTING DEPTH
C1, C6	1220 X 1524	460	C17, C18	2210 X 2210	680
C2 – C5	2060 X 2820	680	C21, C28	1300 X 1680	460
C7, C8	1450 X 1980	600	C22, C27	1675 X 2590	680
C9, C14	1450 X 1980	600	C23, C26	1220 X 1524	460
C10 – C13	2740 X 2740	900	C24 – C25	1520 X 2130	600
C15, C20	1524 X 2210	600	C29 – C32	1300 X 1680	460
C16, C19	2210 X 2210	760			

Table 6. Existing schedule of Columns

COLUMN NO	BELOW 2nd FLOOR	BELOW 1st FLOOR	BELOW MEZANINE FLOOR	BELOW GROUND FLOOR
C1, C6	230 X 380	230 X 380	230 X 450	230 X 533
C2 – C5	300 X 350	300 X 600	300 X 900	305 X 1070
C7, C8	230 X 230	230 X 480	230 X 600	230 X 762
C9, C14	230 X 230	230 X 480	230 X 600	230 X 762
C10 – C13	380 Ø	530 Ø	680 Ø	686 X 686
C15, C20	230 X 300	230 X 550	230 X 760	230 X 915
C16, C19	380 Ø	530 Ø	550 Ø	558 X 558
C17, C18	380 Ø	530 Ø	530 Ø	558 X 558
C21, C28	230 X 230	230 X 380	230 X 450	230 X 610
C22, C27	230 X 330	230 X 660	230 X 990	230 X 1150
C23, C26	230 X 230	230 X 300	230 X 380	230 X 533
C24 – C25	230 X 330	230 X 600	230 X 760	230 X 840
C29 – C32	230 X 230	230 X 380	230 X 500	230 X 610

Table 7. Existing schedule of beams at first floor level

BEAM NO.	WIDTH	DEPTH	BEAM NO.	WIDTH	DEPTH
B1	230	762	B20	305	610
B2	230	762	B21	305	610
B3	230	762	B22	305	610
B4	230	762	B23	230	610
B5	230	762	B24	230	610
B6	230	762	B25	230	762
B7	230	762	B26	230	762
B8	230	762	B27	230	762
B9	230	762	B28	230	762
B10	230	762	B34	230	533
B11	305	610	B35	230	450
B12	305	610	B35A	230	450
B13	305	610	B36	230	450
B14	305	610	B37	305	760
B15	305	610	B38	230	450
B16	305	610	B39	230	450
B17	305	610	B40	305	760
B18	305	610	B41	230	450
B19	305	610			

Table 8. Existing schedule of beams at mezanine floor level

BEAM NO.	WIDTH	DEPTH	BEAM NO.	WIDTH	DEPTH
B1	230	600	B13	230	600
B2	230	600	B14	230	600
B3	230	600	B15	230	600
B4	230	600	B16	230	600
B5	230	600	B17	230	600
B6	230	900	B18	230	600
B7	230	900	B19	230	600
B8	230	900	B20	230	600
B9	230	900	B21	230	600
B10	230	900	B22	230	610
B11	230	600	B23	230	610
B12	230	600	B24	230	450
B25	230	450	B32	230	750
B26	230	450	B33	300	750
B27	230	450	B34	300	750
B28	230	450	B35	300	750
B29	230	750	B36	230	450
B30	230	750	B37	230	450
B31	230	750			

IV. Observations

After collecting all the information such as existing plans and schedules of building, the building was analysed using ETABS software by using the above mentioned details of building for Earthquake loading.

From the analysis it was found that some of the members were vulnerable for earthquake loading and hence needs to be retrofitted.

As a retrofitting measure, the building was redesigned and modified sizes of members were obtained.

Similarly depth of slab and footing were also compared in order to check for the safety of the same for the earthquake loading.

Table 9. Modified schedule of beams at roof level

BEAM NO.	MODIFIED SIZE	
	WIDTH	DEPTH
RB11	400	915

Table 10. Modified schedule of beams at Mezanine floor level

BEAM NO.	MODIFIED SIZE	
	WIDTH	DEPTH
B1	300	600
B2	300	600
B4	300	600
B6	300	915
B7	300	915
B9	350	900
B10	300	915
B11	300	600
B17	300	600

Table 11. Modified schedule of Columns at roof level

COLUMN NO.	MODIFIED SIZE	
	WIDTH	DEPTH
C1, C6	300	600
C2 – C5	300	600
C7, C8	300	480
C9, C14	300	600
C12	680 Ø	
C15, C20	300	600
C16, C19	600 Ø	
C17, C18	680 Ø	
C22, C27	230	990
C23, C26	300	380

Table 12. Modified schedule of Columns at first floor level

COLUMN NO.	MODIFIED SIZE	
	WIDTH	DEPTH
C1, C6	300	600
C2 – C5	300	600
C7, C8	300	480
C9, C14	300	600
C12	680 Ø	
C15, C20	300	600
C16, C19	600 Ø	
C17, C18	680 Ø	
C22, C27	230	990
C23, C26	300	380

Table 13. Modified schedule of Columns at Mezanine floor level

COLUMN NO.	MODIFIED SIZE	
	WIDTH	DEPTH
C1, C6	300	600
C7, C8	300	600
C9, C14	300	600
C15, C20	300	760
C16, C19	600 Ø	
C17, C18	680 Ø	
C23, C26	300	380

Table 14. Modified schedule of Columns at ground floor level

COLUMN NO.	MODIFIED SIZE	
	WIDTH	DEPTH
C1, C6	300	600
C7, C8	300	762
C9, C14	300	762
C23, C26	300	533

Table15. Comparison for footing depth

COLUMN NO.	DEPTH REQUIRED	REMARKS
C1	415	PASS
C2	991	FAIL
C3	1089	FAIL
C4	946	FAIL
C5	975	FAIL
C6	413	PASS
C7	454	PASS
C8	454	PASS
C9	298	PASS
C10	748	PASS
C11	748	PASS
C12	748	PASS
C13	748	PASS
C14	321	PASS
C15	672	FAIL
C16	616	PASS
C17	616	PASS
C18	616	PASS
C19	616	PASS
C20	365	PASS
C21	434	PASS
C22	719	FAIL
C23	300	PASS
C24	639	FAIL
C25	639	FAIL
C26	394	PASS
C27	716	FAIL
C28	433	PASS
C29	433	PASS
C30	433	PASS
C31	433	PASS
C32	433	PASS

Table 16. Comparison for Slab depth at roof level

SLAB NO.	THICKNESS REQUIRED	REMARKS
RS1	67	PASS
RS2	100	PASS
RS3	105	PASS
RS4	111	PASS
RS5	67	PASS
RS6	69	PASS

Table 17. Comparison for Slab depth at first floor level

SLAB NO.	THICKNESS REQUIRED	REMARKS
S1	100	PASS
S2	96	PASS
S3	100	PASS
S4	96	PASS
S5	115	PASS
S6	116	PASS
S7	90	PASS
S8	66	PASS
S9	120	PASS
S10	78	PASS

Table 18. Comparison for Slab depth at mezzanine floor level

SLAB NO.	THICKNESS REQUIRED	REMARKS
S1	124	PASS
S2	115	PASS
S3	104	PASS
S4	103	PASS
S5	98	PASS

V. CONCLUSIONS

From the above observations it is clear that some of the sections of the existing building are unsafe. All such sections should be retrofitted by using proper retrofitting techniques to the required section size so as to make the building safe for earthquake.

VI. Acknowledgment

We feel great pleasure and immense pride to present the project work titled **"CAPACITY ESTIMATION OF RCC FRAME STRUCTURED BUILDINGS WITH REFERENCE TO STRUCTURAL ASSESSMENT USING NON DESTRUCTIVE TESTING".** The sense of achievement, satisfaction, the reward and the appreciation as regards to the completion of our project work cannot be comprehended without the earnest support provided by the various people associated with me.

We would like to thank Principal **Dr. U. P. WAGHE,** Head of department of Civil Engineering **Dr. S. R. KHANDESHWAR**, and our P.G. Coordinator, **Dr. V. G. MESHRAM**, **JAFAR SHARIF GILANI** sir, for their encouragement, support and insightful comments. Their constant queries mingled with constructive criticism shook us out of any sense of complacency, bringing the best of us, to complete the project in stipulated time. It gives us pleasure in acknowledging their sustained dedication, steadfast motivation and indispensable support in the gradual building of this project.

REFERENCES

[1] Hari Darshan Shrestha, Ryuichi Yatabe, Netra Prakash Bhandary and Jishnu Subedi, "*Vulnerability assessment and retrofitting of existing school buildings: a case study of Aceh*", International Journal of Disaster Resilience in the Built Environment, Vol. 3 No. 1, 2012, pp. 52-65.

[2] Luisa Berto, Renato Vitaliani, Anna Saetta and Paola Simioni, "*Seismic assessment of existing RC structures affected by degradation phenomena*", Structural Safety 31 (2009) 284–297, 2008.

[3] Hua-Peng Chen and Nenad Bicanic, "*Identification of structural damage in buildings using iterative procedure and regularisation method*", International Journal for Computer-Aided Engineering and Software, Vol. 27 No. 8, 2010, pp. 930-950.

[4] D. Coronelli and P. Gambarova, "*Structural Assessment of Corroded Reinforced Concrete Beams: Modeling Guidelines*", J. Struct. Eng. 2004, 130:1214-1224.

[5] Terala Srikanth, Ramancharla Pradeep Kumar, Ajay Pratap Singh, Bal Krishna Rastogi and Santosh Kumar, "*Earthquake Vulnerability Assessment of Existing Buildings in Gandhidham and Adipur Cities Kachchh, Gujarat (India)*", European Journal of Scientific Research, ISSN 1450-216X Vol.41 No.3 (2010), pp.336-353.

[6] Clotaire Michel, Philippe Gue´guena and Pierre-Yves Bard, "*Dynamic parameters of structures extracted from ambient vibration measurements: An aid for the seismic vulnerability assessment of existing buildings in moderate seismic hazard regions*", Soil Dynamics and Earthquake Engineering 28 (2008), 593–604.

[7] Subhamoy Bhattacharya, "*Safety assessment of existing piled foundations in liquefiable soils against buckling instability*", ISET Journal of Earthquake Technology, Technical Note, Vol. 43, No. 4, December 2006, pp. 133-147.

[8] Atik Sarraz, Md. Khorshed Ali and Debesh Chandra Das, "*Seismic Vulnerability Assessment of Existing Building Stocks at Chandgaon in Chittagong city, Bangladesh*", American Journal of Civil Engineering 2015; 3(1): 1-8.

[9] Brian J. Pashina't Paul E. Gaudettc, "*Strength Evaluation of Existing Concrete Buildings*", Reported by ACI Committee 437.

[10] Chandra Bhakuni, "*Seismic vulnerability assessment of school buildings*", Proceedings of the SECED Young Engineers Conference 21-22 March 2005.

[11] S.J. Welsh-Huggins, J. Rodgers, W. Holmes, A.B. Liel, "*Seismic vulnerability of reinforced concrete hillside buildings in northeast India*", 16th World Conference on Earthquake, 16WCEE 2017 Santiago Chile, January 9th to 13th 2017.

[12] Kerstin Langa and Hugo Bachmann, M.EERI, "*On the Seismic Vulnerability of Existing Buildings: A Case Study of the City of Basel*", Earthquake Spectra, Volume 20, No. 1, pages 43–66, February 2004.

[13] Jerry E. Stephens, M. ASCE and James T. P. Yao, "*Damage Assessment Using Response Measurements*", J. Struct. Eng. 1987.113:787-801.

[14] Miguel Branco and Luís Manuel Guerreiro, "*Seismic rehabilitation of historical masonry buildings*", Engineering Structures 33 (2011) 1626–1634.

[15] VV Sakhare, SP Raut, SA Mandavgane and RV Ralegaonkar, "*Development of sustainable retrofitting material for energy conservation of existing buildings*", International Journal of Civil Engineering 13 (4), pp 411-418.

[16] SB Trupti K. Talwekar, Ms. V.N. Mendhe, "*Analytical Study on Seismic Response of Retrofitting Multistoried RC building through using steel wrapping*", International Journal of Research Eissn : 2348-6848 & Plssn: 2348-795X.

[17] V.V. Sakhare, S.P. Raut, S.A. Mandavgane, R.V. Ralegaonkar, "*Development of sustainable retrofitting material for energy conservation of existing buildings*", International Journal of Civil Engineering, Vol. 13, No. 4A, Transaction A: Civil Engineering, December 2015.

[18] A.V. Patil, Arjun Mudkondwar, "*Performance analysis and behavior of steel framed building with reference to variation in bracing type*", International Journal of Modern Trends in Engineering Research (IJMTER), ISSN 2349-9745, vol. 2, issue 4, 2015.

[19] A.V. Patil, S.M. Hardwani, "*Low cost Earthquake resistant house using Cold formed Steel (CFS) member A case study*", International Journal of Engineering Research & Technology (IJERT), ISSN 2278-0181, vol. 2, issue 9, 2013.

[20] A.V.PATIL & S.P. RAUT, "*Pre-Engineered Reinforcement-Studies in use of Expanded Metal Mesh as Reinforcement in RCC Slabs*", 3rd International Conference on Technology & Innovation for Sustainable Development (TISD2010), 2010.