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SEISMIC STRENGTHENING OF EXISTING REAL STRUCTURES WITH FUTURE EXPANSION AS CASE STUDIES

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Abstract: In the era of infrastructure, India is having great history for design, construction & life of the structure but many parts of the country have suffered earthquake in last three decades. Seismic protection of buildings is a need-based concept aimed to improve the performance of any structure under future earthquakes. Sometimes the structure which are constructed before Indian standards code or by experienced constructor are not having sufficient strength to survive in earthquake. Many structures are not capable of withstanding seismic action according to current codes and provisions. Furthermore, recent earthquakes have clearly demonstrated an urgency to upgrade and strengthen these seismic deficient structures. Seismic strengthening of heritage buildings has become a concern of greater importance over the world, notably in the developed countries. Heritage structures perform vital role in nation's history, culture and signify the richness of it. To augment life and enhance strength, their restoration is very important for the future generations to have knowledge about how mankind lived in past ages. Seismic strengthening involves investigating, diagnosing and correcting deficiencies and deterioration of any structure. Identification of common defects and problems faced in old structures and devising a systematic approach towards handling these issues is civil engineer's obligation. A case study throws light on the various problems encountered and the methods employed to tackle them. The major defects reported are discussed and a suitable and economical solution for a particular defect is identified by a tradeoff between cost, lifetime and adaptability of the solution to get optimum benefit from structure with the future requirement.

Index Terms : SEISMIC STRENGTHENING, EXISTING REAL STRUCTURES, FUTURE EXPANSION CASE STUDY

I. INTRODUCTION

A higher degree of damage in a building is expected during an earthquake if the seismic resistance of the building is inadequate. The decision to strengthen it before an earthquake occurs depends on the building's seismic resistance. A few components (such as beams, columns, connections, shear walls, diaphragms, etc.) in an existing building may not have adequate strength or deformation capacity, though the building in whole may have substantial strength and stiffness. For such components, local modifications can be performed, while retaining the basic configuration of the building's lateral force resisting system. The local modifications considered are component connectivity, their strength, and/or deformation capacity.

In India, reinforced concrete structures are designed and detailed as per the Indian Code IS 456 (2002). However, structures located in high seismic regions require ductile design and detailing. Provisions for the ductile detailing of monolithic reinforced concrete frame and shear wall structures are specified in IS 13920 (1993). After the 2001 Bhuj earthquake, this code has been made mandatory for all structures in zones III, IV and V. Similar provisions for seismic design and ductile detailing of steel structures are not yet available in the Indian codes IS 13935, 1993 These guidelines cover general principles of seismic strengthening, selection of materials, and techniques for repair/seismic strengthening of masonry and wooden buildings. The code provides a brief coverage for individual reinforced concrete members in such buildings, but does not cover reinforced concrete frame or shear wall buildings as a whole. Some guidelines are also laid down for non-structural and architectural components of buildings.

Importance of Seismic Design Codes Ground vibrations during earthquakes causes forces and deformations in structures. Structures need to be designed to withstand such forces and deformations. Seismic codes help to improve the behavior of structures so that they may withstand the earthquake effects without significant loss of life and property. Countries around the world have procedures outlined in seismic codes to help design engineers in the planning, designing, detailing and constructing of structures. An earthquake-resistant building has four virtues in it, namely: (a) Good Structural Configuration: Its size, shape and structural system carrying loads are such that they ensure a direct and smooth flow of inertia forces to the ground. (b) Lateral Strength: The maximum lateral (horizontal) force that it can resist is such that the damage induced in it does not result in collapse. (c) Adequate Stiffness: Its lateral load resisting system is such that the earthquake-induced deformations in it do not damage its contents under low-to moderate shaking. (d) Good Ductility: Its capacity to undergo large deformations under severe earthquake shaking even after yielding is improved by favorable design and detailing strategies. Seismic codes cover all these aspects. Indian Seismic Codes Seismic codes are unique to a particular region or country. They take into account the local seismology, accepted level of seismic risk, building typologies, and materials and methods used in construction. Further, they are indicative of the level of progress a country has made in the field of earthquake engineering.

II. LITERATURE REVIEWS

M R. ALAM et all(2016) in the 3rd international conference on advances in civil engineering, found out tha the structural failure occurs due to change in live load from residential building to garments factory. it includes failure of columns, beams and foundation. in this paper, a retrofit of beam, column and foundation is introduced. after considering several causes, it is concluded that, with respect to our country, concrete jacketing is the most economic and efficient process of retrofitting of beam, column and foundation. as a member section has to be increased at least 4inch in each face, the rebar requirement is decreased in some cases. in such a situation, minimum reinforcement must be provided in jacketing, a new layer of concrete is applied on the surface. the bond between new and old concrete does not act monolithically. but they are considered monolithic in the analysis. as the building structure is symmetrical by loading pattern, torsion effect is ignored. [1]

M. A. Ismaeil et all(2013)state in International Journal of Engineering Research & Technology (IJERT) that the present study represents the first attempt to investigate the seismic resistance of residual buildings in the Sudan. Due to the lack of knowledge about the seismic activity in this country buildings are designed and constructed without any seismic load consideration. Seismicity of The Sudan may be considered as moderate. Hence, all buildings should be checked against earthquake resistance. The present paper proposes a simple procedure to check the seismic resistance of such buildings. [2]

Chetan chitte (2020)states in International Research Journal of Engineering and Technology (IRJET) that if deficiencies still exist in the members, local retrofit strategies are like column jacketing or steel jacketing to be selected. A retrofit strategy is to be selected after careful considerations of the cost and constructability. Proper design of a retrofit strategy is essential. The failure mode in a member after retrofitting should not become brittle. A global retrofit strategy that involves a shift in either of the centre of mass or centre of rigidity should be checked for torsional irregularity. FRP involves minimum surface preparation, minimum work since no drilling is required. FRP does not increase the dead weight of the structure. [3]

Shabana shaikh et all (2021) states in International Research Journal of Engineering and Technology (IRJET) From the analysis and interpretation of the results it is concluded that provision of bracings is much effective in imparting lateral stiffness as well as ensuring continuity of load path in frames with floating columns. Hence, provision of bracings is an effective tool in frames with floating columns for enhanced and better performance under seismic loads and economy. [4]

Dr. Sunil G. Kirloskar et all(2021) states in International Research Journal of Engineering and Technology (IRJET) that The literature study suggested that there are various other methods of repairs and retrofitting like sand/cement mortar, crack stitching, epoxy injections, etc.; but ferrocement proves to be easy and cost effective providing strength to the damaged masonry before collapse or pre-existing undamaged masonry construction, requiring unskilled labourers. [5]

Arziyeh Mohammadi et all (2021) states in Research Gate publication that the present paper investigated experimental specimens of timber and its mechanical properties. Standard wood tests were used to determine mechanical properties. The modeling results of the timber specimens showed brittle behavior in tension and semi? ductile behavior in pressure. After validating the numerical modeling of the timbers, masonry wall modelling methods were explicated, and out of macro and meso approaches, the meso approach was selected due to its higher accuracy. Then the masonry wall was retrofitted and strengthened by three different timber placement patterns. Timber placement contributes to wall cracking variation and considerable improvement in ductility and shear capacity of wall. Crosswise placement of the timber on the masonry wall exhibited the best seismic performance because it was accompanied by a 211% increase in ductility and 115% increase in ultimate strength, which such increase is very significant.The results showed that masonry wall reinforcement technique using wooden elements is a valid traditional reinforcement method that hasan acceptable ultimate performance despite the low cost and lack of need to expertise or skills of workforce.Note that the walls reinforced by this method are able to withstand more displacement due to their greater ductility than unreinforced walls.[6]

Maria A. PARISI et all (2004) in 13th World Conference on Earthquake Engineering Vancouver,states that Among the many issues related to the seismic strengthening of timber structures, this work focuses on the cyclic behavior of reinforced carpentryjoints, the upgrading of properties of decayed or otherwise insufficient timber elements, and the strengthening of timber slabs.[7]

oannis P. Christovasilis et all (2013) Aether Engineering stats in ReasechGate that Cross Laminated Timber (CLT) systems are structures in which walls and floors are composed of cross laminated timber panels, i.e. panels made of at least three laminations arranged alternatively at right angles and glued together. The laminations shall be made of one or two layers of parallel timber boards. Unlike vertical actions, which affect only a portion of the structure and some of the structural elements, the seismic action is modelled via horizontal forces applied at the floor level that are transferred to the ground involving allthe structural members.[8]

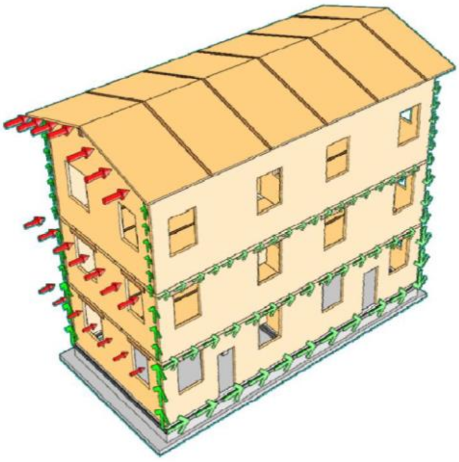


Fig 1 Earthquake force acting on building

Helena CRUZ states in Acedonian Association Of Structural Engineers that Furthermore, the influence of fissures (or delamination) in timber members depends on the type of member and its loading situation. Of particular concern are fissures affecting joints, members with high shear loads or cross sections where tensile perpendicular to the grain is likely to develop. Even in the absence of fissures, one should pay special attention to all situations prone to introduce tensile stresses perpendicular to the grain as the corresponding timber strength is very week and sudden failure may occur. [9]

Marco Corradi et all(2019)staes in MDPI journal in that Timber also exhibits high compressive strength. However, compressive stresses in historic constructions were typically resisted by masonry structural elements. In southern Europe and the Mediterranean basin, buildings often consist of vertical wall elements or pillars, assembled with lime mortar or (rarely) drystone construction, with a frequent use of timber beams for floors and roof structures [34,35]. Although timber is not a heavy material, it wasn't easy or, given its availability, even necessary to transport it in the past from forests. Timber structures were typically made of wood species local to the immediate area.[10]

Kay-Uwe Schober(2010) states in Reaserch Gate publication that Rehabilitation and strengthening of timber structures desires efficient techniques and smart materials with a high load-bearing capacity. To obtain the benefits of these, an efficient connection between the structure and the reinforcing material is necessary. One solution is adhesive mounting to obtain an almost stiff bond line between the different components. Fiber reinforced materials (FRM) and epoxy polymer concrete can be effectively used to improve strength and stiffness of timber beams in different configurations and techniques to utilize the material efficiently and to ensure long service life, especially for timber heritage buildings.[11]

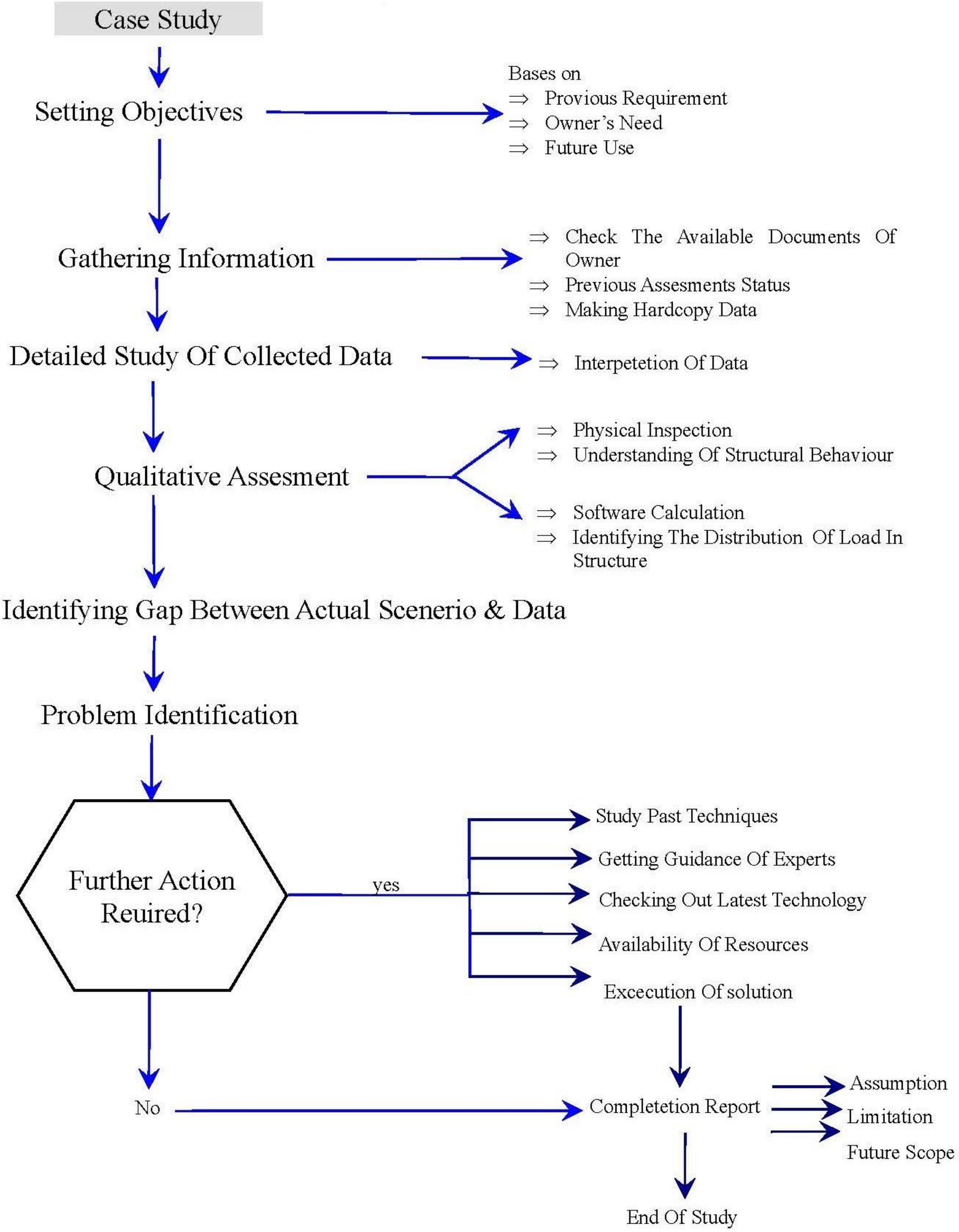
Li sisi et all (2021)states in that Ancient architecture carries Chinese culture, which is helpful to understand the tradition. Timber structure is the main structure of ancient Chinese buildings, and most of the ancient timber structures have been overserved and have been damaged to varying degrees.

Fig 2 Wooden beams

Although timber structure is made of convenient materials, its low strength and vulnerability to corrosion increase the difficulty of the protection of ancient buildings, so the restoration of ancient buildings is imminent. Through literature research, this paper summarized the repair principles and reinforcement methods, and analyzed the effective methods and research progress of the repair and reinforcement of ancient timber structures from the traditional and modern aspects, and provided reference for the repair work of ancient timber structures.[12]

Guanfeng Qiao et all (2016) states in ELSEVIER that Feiyun Pavilion is located in Shanxi Province, China. It is a classic example of ancient wooden pavilions and one of the primary national cultural assets, which was rebuilt more than 500 years ago. During recent years, the structural deterioration and degeneration of Feiyun Pavilion have accelerated due to inefficiencies in maintenance and management. The main structure is apparently off-plumb and in danger of collapse. With special financial required, the state Administration of Cultural Heritage asked the local Cultural Relic Protection Unit to contact historians, researchers, and engineers to restore this particular ancient structure. This paper presents the necessary assessment data, evaluation method, and the preferred solution for retrofitting and strengthening this historical timber building.[13]

III. METHODOLOGY



IV. CASE STUDY 1

Address: BAPS swaminarayan chatralay, near pramukhswami circle, anand-vidhyanagar road, Gujarat.

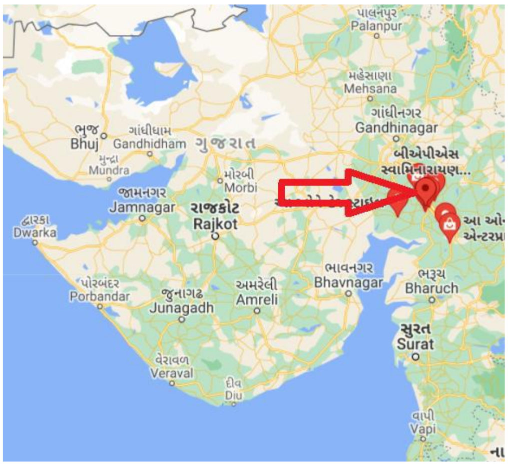


Fig 3 BAPS Swaminarayan Chhatralay.

Baps Swaminarayan chhatralay was constructed in 1992 having mainly 5 blocks the temple, the admin block, the ghanshyam block, the nilkandh block, the sahjanand block & sant ashram. In 2001 bhuj earthquake the book stall & waiting area building got damaged. There was not frequent use of the structure as compared to other structure at the campus. At that time immediate action were taken for the require sustainability of structure. Regarding the information from the authority of baps swaminarayan chatralay no data is found due to the misplacing of working drawings.

Tab. 1 Qualitative Assessment

Element	Damage	Not Damage	Remark
R.C.C. Beam	Yes		Cracks At Support
R.C.C. Column		Yes	
Foundation		Yes	
Plaster	Yes		Debonding Of Surface
Door	Yes		Full Frame Broken Out
Window	Yes		Full Frame Broken Out
Masonary Wall	Yes		Map Cracking
R.C.C. Chajja	Yes		Cover Got Collapsed Reinforcement Exposed To Atmosphere

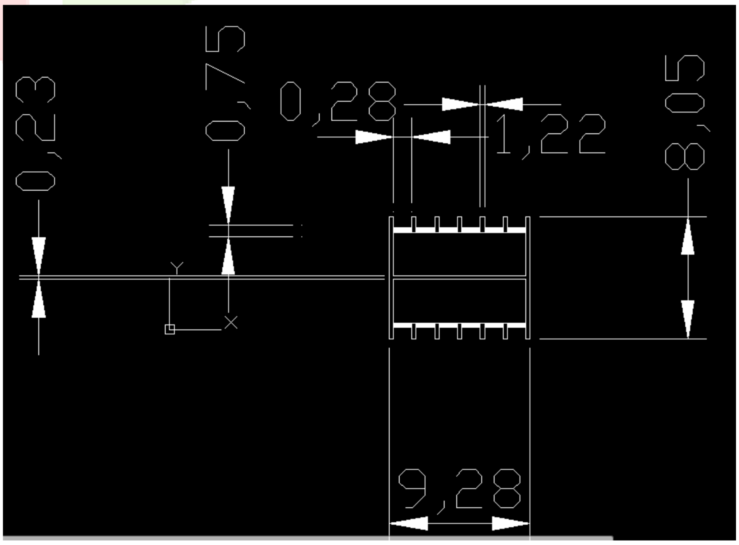


Fig 4 Plan of damage existing structure

Plan Size=9.28m x 8.05m
Frame: R.C.C.
Floor: Only Ground Floor
column Size=0280m x 0.750m
spacing Between Columns=1.22m
Numbers Of Column=
beam Size=0.230X0.450
slab Thickness=1000mm
Type Of Wall Infill=Red Brick
Size of wall=0.30m
Height:4.5m

4.1 Analyzing & design of existing structure at BAPS Chatralay key points for single story analysis.

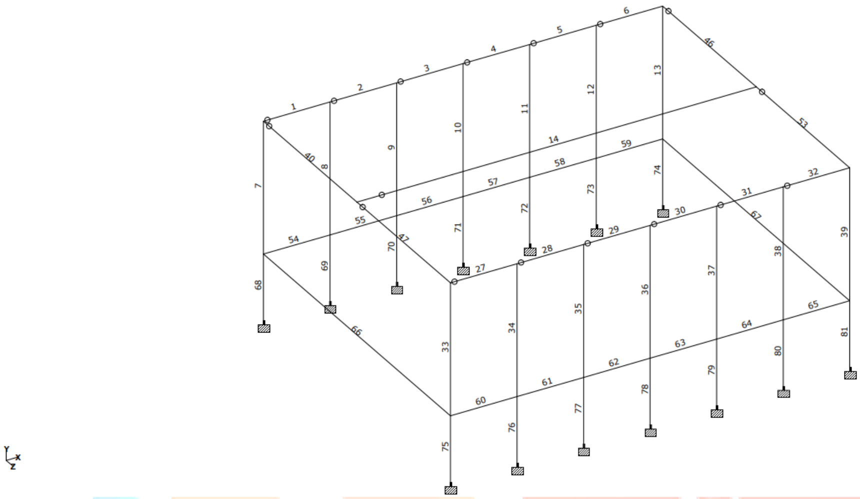


Fig 5 Beam umber for existing structure

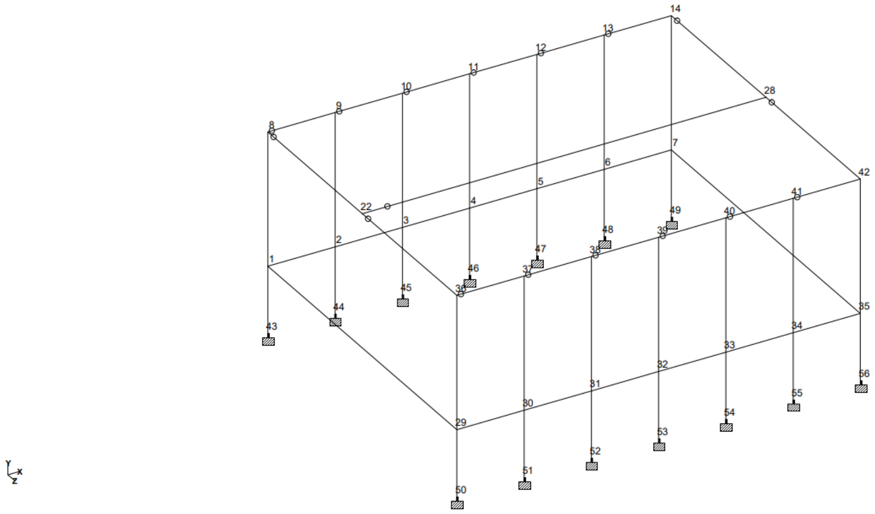


Fig 6 Node numbers for existing structure

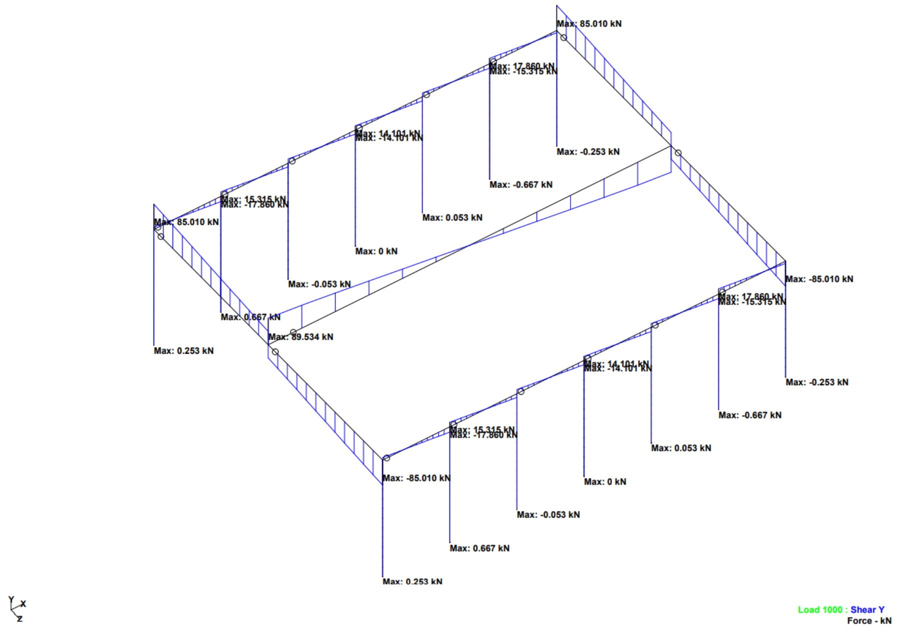


Fig 7 Shear force distributing in existing structure

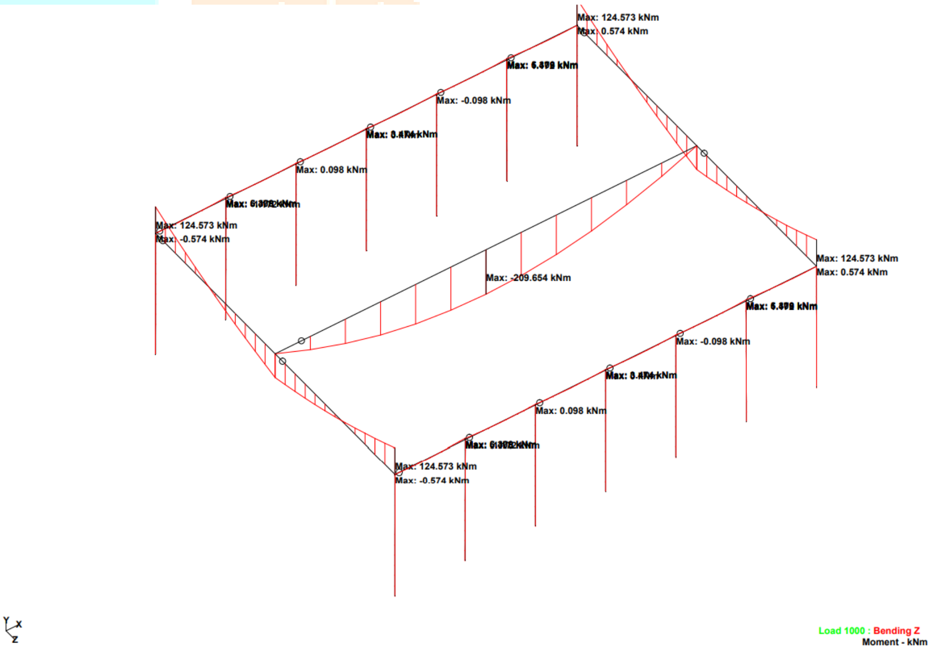


Fig 8 Bending moment diagram of existing Structure

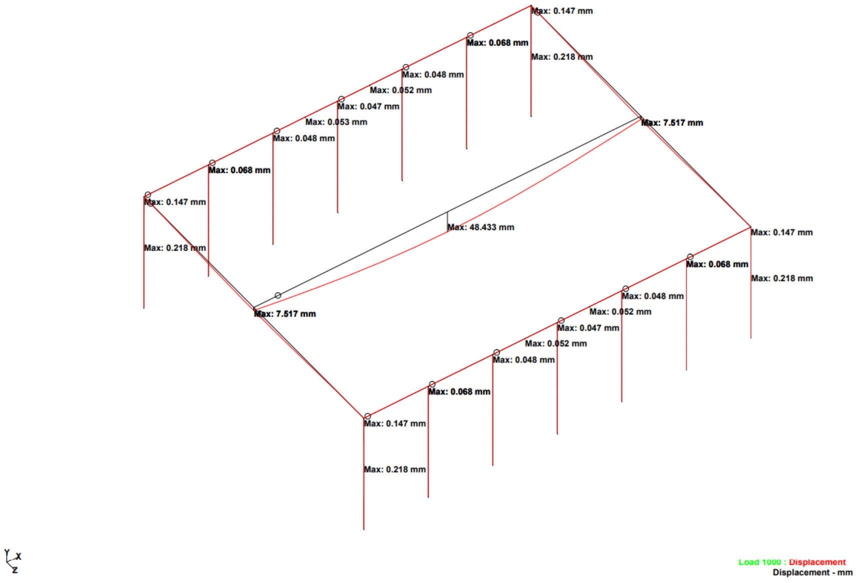
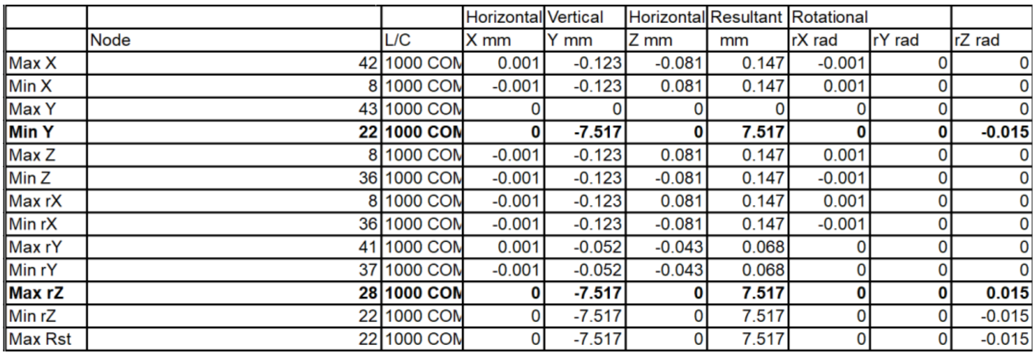


Fig 9 Displacement diagram of Exiting Structure

Tab. 2 Nodal displacement for existing structure

Beam	L/C	Length m	Max x mm	Dist m	Max y mm	Dist m	Max z mm	Dist m	Max mm	Dist m	Span/Max
1	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	-0.008	0.5	0.002	0.25	0.008	0.5	>10000
2	1000 COMBINATION LOAD CASE 5	1.5	0	1.375	0.002	0.25	-0.002	0.583	0.002	0.25	>10000
3	1000 COMBINATION LOAD CASE 5	1.5	0	1.25	-0.006	0.75	-0.002	0.5	0.006	0.75	>10000
4	1000 COMBINATION LOAD CASE 5	1.5	0	1	-0.006	0.75	-0.002	0.5	0.006	0.75	>10000
5	1000 COMBINATION LOAD CASE 5	1.5	0	0.875	0.002	1.25	-0.002	0.417	0.002	1.25	>10000
6	1000 COMBINATION LOAD CASE 5	1.5	-0.001	1.375	-0.008	1	0.002	0.75	0.008	1	>10000
7	1000 COMBINATION LOAD CASE 5	3	0	1.75	-0.008	2	-0.227	0.667	0.227	2	>10000
8	1000 COMBINATION LOAD CASE 5	3	0	2.25	-0.01	2.25	-0.004	0.417	0.01	2	>10000
9	1000 COMBINATION LOAD CASE 5	3	0	1.75	0.001	2	-0.001	0.417	0.001	2	>10000
10	1000 COMBINATION LOAD CASE 5	3	0	2	0	0	0	0.417	0	1.25	
11	1000 COMBINATION LOAD CASE 5	3	0	1.75	-0.001	2.5	-0.001	0.417	0.001	2.5	>10000
12	1000 COMBINATION LOAD CASE 5	3	0	2.25	0.01	2.25	-0.004	0.417	0.01	2	>10000
13	1000 COMBINATION LOAD CASE 5	3	0	1.75	0.008	1.75	-0.227	0.667	0.227	2	>10000
14	**1000 COMBINATION LOAD CASE 5**	**9**	**0.001**	**5.25**	**-40.917**	**4.5**	**0**	**0**	**40.917**	**4.5**	**220**
27	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	-0.008	0.5	-0.003	0.417	0.008	0.5	>10000
28	1000 COMBINATION LOAD CASE 5	1.5	0	1.375	0.002	0.25	0.002	0.417	0.002	0.25	>10000
29	1000 COMBINATION LOAD CASE 5	1.5	0	1.25	-0.006	0.75	0.003	0.583	0.007	0.75	>10000
30	1000 COMBINATION LOAD CASE 5	1.5	0	1	-0.006	0.75	0.002	0.417	0.006	0.75	>10000
31	1000 COMBINATION LOAD CASE 5	1.5	0	0.875	0.002	1.25	0.002	0.167	0.003	1.25	>10000
32	1000 COMBINATION LOAD CASE 5	1.5	-0.001	1.375	-0.008	1	-0.003	0.583	0.008	1	>10000
33	1000 COMBINATION LOAD CASE 5	3	0	1.75	-0.008	2	0.228	0.667	0.228	2	>10000
34	1000 COMBINATION LOAD CASE 5	3	0	2.25	-0.01	2.25	0.005	0.417	0.01	2	>10000
35	1000 COMBINATION LOAD CASE 5	3	0	1.75	0.001	2	0.001	0.667	0.002	2	>10000
36	1000 COMBINATION LOAD CASE 5	3	0	2	0	0	0.001	0.333	0.001	1	
37	1000 COMBINATION LOAD CASE 5	3	0	1.75	-0.001	2.5	0.001	0.667	0.002	2	>10000
38	1000 COMBINATION LOAD CASE 5	3	0	2.25	0.01	2.25	0.005	0.417	0.01	2	>10000
39	1000 COMBINATION LOAD CASE 5	3	0	1.75	0.008	1.75	0.228	0.667	0.228	2	>10000
40	1000 COMBINATION LOAD CASE 5	3.65	0	2.129	-0.83	2.738	-0.006	0.333	0.83	2.738	4396
40	1000 COMBINATION LOAD CASE 5	3.65	0	2.129	-0.83	2.738	-0.006	0.333	0.83	2.738	4396
46	1000 COMBINATION LOAD CASE 5	3.65	0	2.129	-0.83	2.738	0.007	0.25	0.83	2.738	4396
47	1000 COMBINATION LOAD CASE 5	3.65	0	2.738	-0.831	0.913	-0.006	0.667	0.831	0.913	4395
53	1000 COMBINATION LOAD CASE 5	3.65	0	2.738	-0.831	0.913	0.006	0.667	0.831	0.913	4395
54	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	-0.007	0.625	0.003	0.75	0.007	0.625	>10000
55	1000 COMBINATION LOAD CASE 5	1.5	0	0.375	-0.003	0.75	0.003	0.417	0.004	0.75	>10000
56	1000 COMBINATION LOAD CASE 5	1.5	0	1.375	-0.004	0.75	-0.001	0.5	0.004	0.75	>10000
57	1000 COMBINATION LOAD CASE 5	1.5	0	0.875	-0.004	0.75	-0.001	0.5	0.004	0.75	>10000
58	1000 COMBINATION LOAD CASE 5	1.5	0.001	0.875	-0.003	0.75	0.003	0.583	0.004	0.75	>10000
59	1000 COMBINATION LOAD CASE 5	1.5	-0.001	1	-0.007	0.875	0.003	0.25	0.007	0.875	>10000
60	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	-0.007	0.625	-0.003	0.667	0.007	0.625	>10000
61	1000 COMBINATION LOAD CASE 5	1.5	0	0.375	-0.003	0.75	-0.004	0.333	0.004	0.75	>10000
62	1000 COMBINATION LOAD CASE 5	1.5	0	1.375	-0.004	0.75	0.001	0.583	0.004	0.75	>10000
63	1000 COMBINATION LOAD CASE 5	1.5	0	0.875	-0.004	0.75	0.001	0.5	0.004	0.75	>10000
64	1000 COMBINATION LOAD CASE 5	1.5	0.001	0.875	-0.003	0.75	-0.003	0.667	0.004	0.75	>10000
65	1000 COMBINATION LOAD CASE 5	1.5	-0.001	1	-0.007	0.875	-0.003	0.333	0.007	0.875	>10000
66	1000 COMBINATION LOAD CASE 5	7.3	0	4.258	-2.437	3.65	0.032	0.5	2.437	3.65	2996
67	1000 COMBINATION LOAD CASE 5	7.3	0	4.258	-2.437	3.65	-0.033	0.5	2.437	3.65	2996
68	1000 COMBINATION LOAD CASE 5	1.5	0	1.375	0.001	1.25	-0.003	0.75	0.003	1.125	>10000
69	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	-0.002	1	-0.001	0.583	0.002	1	>10000
70	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	0	0.75	-0.001	0.5	0.001	0.75	>10000
71	1000 COMBINATION LOAD CASE 5	1.5	0	0.875	0	0	-0.001	0.417	0.001	0.625	
72	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	0	0	-0.001	0.5	0.001	0.625	
73	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	0.002	1	-0.001	0.583	0.002	1	>10000
74	1000 COMBINATION LOAD CASE 5	1.5	0	1.375	-0.001	0.875	-0.003	0.75	0.003	1.125	>10000
75	1000 COMBINATION LOAD CASE 5	1.5	0	1.375	0.001	1.25	0.003	0.667	0.003	1	>10000
76	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	-0.002	1	0.001	0.167	0.002	1	>10000
77	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	0	0.75	0.001	0.333	0.001	0.5	>10000
78	1000 COMBINATION LOAD CASE 5	1.5	0	0.875	0	0	0.001	0.833	0.001	1.25	
79	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	0	0	0.001	0.333	0.001	0.5	
80	1000 COMBINATION LOAD CASE 5	1.5	0	1.125	0.002	1	0.001	0.167	0.002	1	>10000
81	1000 COMBINATION LOAD CASE 5	1.5	0	1.375	-0.001	0.875	0.003	0.667	0.003	1	>10000

Table 3 Beam deflection for existing structure



			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	42	1000 COM	0.001	-0.123	-0.081	0.147	-0.001	0	0
Min X	8	1000 COM	-0.001	-0.123	0.081	0.147	0.001	0	0
Max Y	43	1000 COM	0	0	0	0	0	0	0
Min Y	**22**	**1000 COM**	**0**	**-7.517**	**0**	**7.517**	**0**	**0**	**-0.015**
Max Z	8	1000 COM	-0.001	-0.123	0.081	0.147	0.001	0	0
Min Z	36	1000 COM	-0.001	-0.123	-0.081	0.147	-0.001	0	0
Max rX	8	1000 COM	-0.001	-0.123	0.081	0.147	0.001	0	0
Min rX	36	1000 COM	-0.001	-0.123	-0.081	0.147	-0.001	0	0
Max rY	41	1000 COM	0.001	-0.052	-0.043	0.068	0	0	0
Min rY	37	1000 COM	-0.001	-0.052	-0.043	0.068	0	0	0
Max rZ	**28**	**1000 COM**	**0**	**-7.517**	**0**	**7.517**	**0**	**0**	**0.015**
Min rZ	22	1000 COM	0	-7.517	0	7.517	0	0	-0.015
Max Rst	22	1000 COM	0	-7.517	0	7.517	0	0	-0.015

Referring the analysis the no.14 beam is having deflection of 40.917mm. The span/deflection ratio is 220 which is lesser than permissible ratio of 240.the node points of beam (22 & 28) no. 14 is also having deflection of 7.517mm.So strengthening is required. The cracks which develop at nearer to beam support are warning for seismic strengthening. at this crucial time baps Swaminarayan chatralay is planning of one floor extension on this single story frame building. So that we have to take out the design details of the future story & after completing. It seismic strengthening of beam no.14 will be conduct for safe load transmission of structure.

4.2 Future expansion story calculation

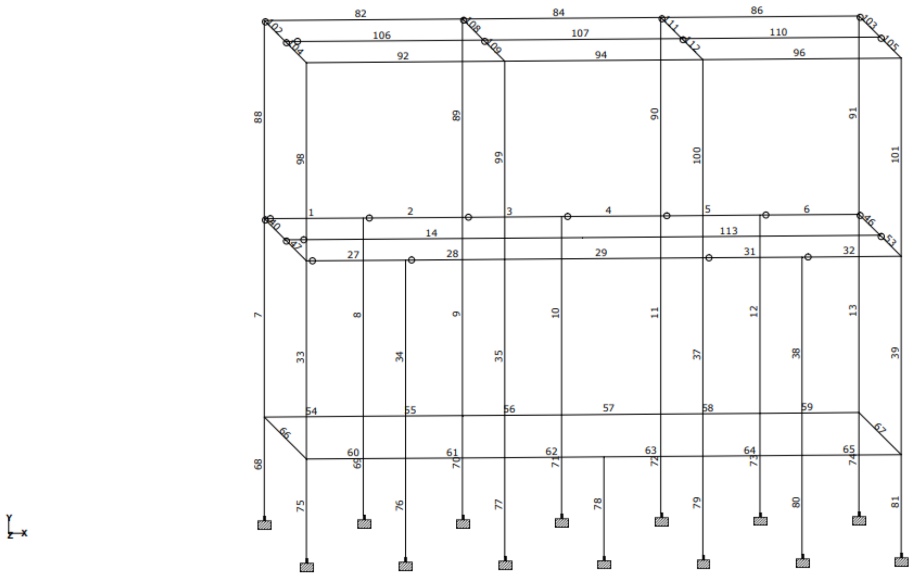


Fig 10 Beam number for future expansion

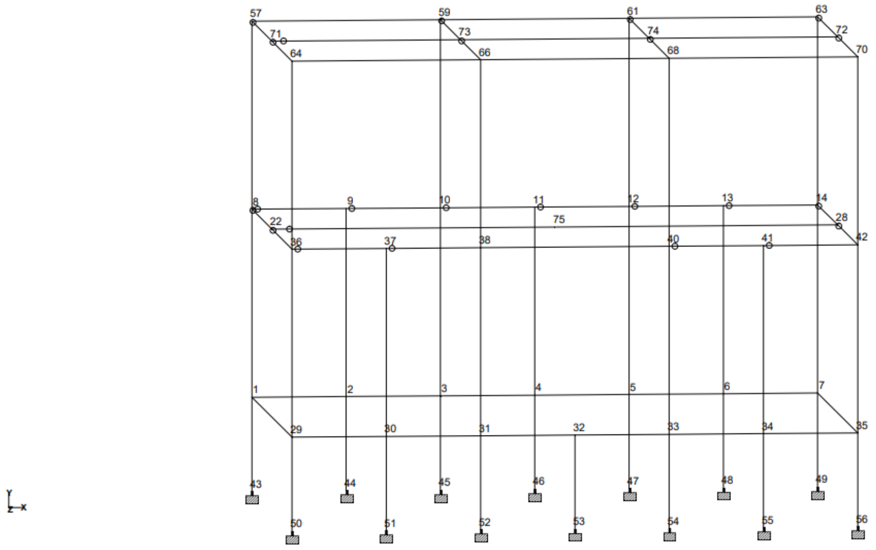


Fig 11 Node number for future expansion

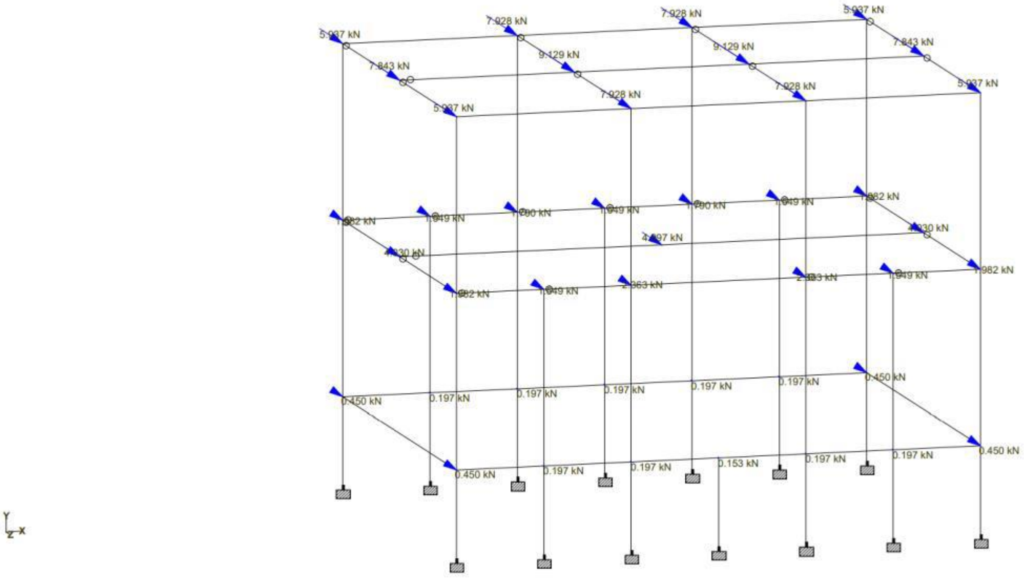


Fig 12 Earthquake force in x-direction

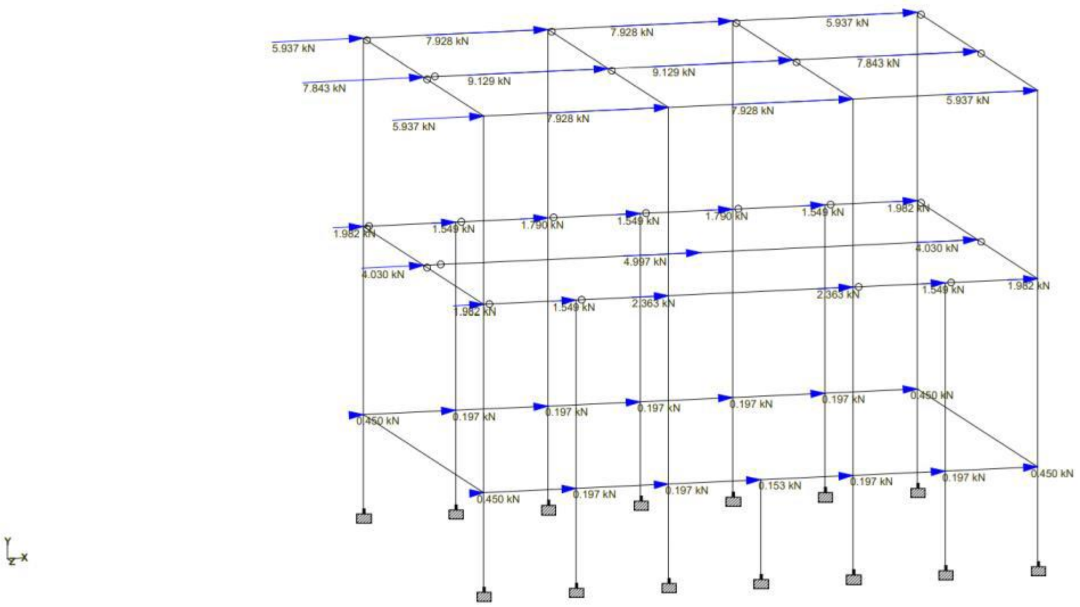


Fig 13 Earthquake force in z-direction

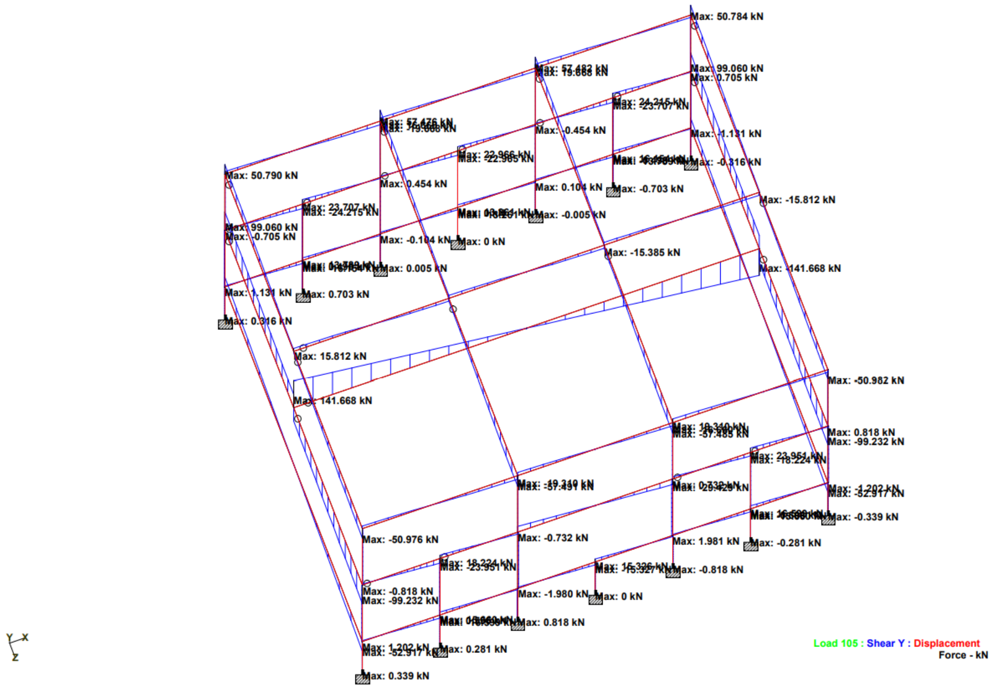


Fig 14 Shear force diagram for future storey

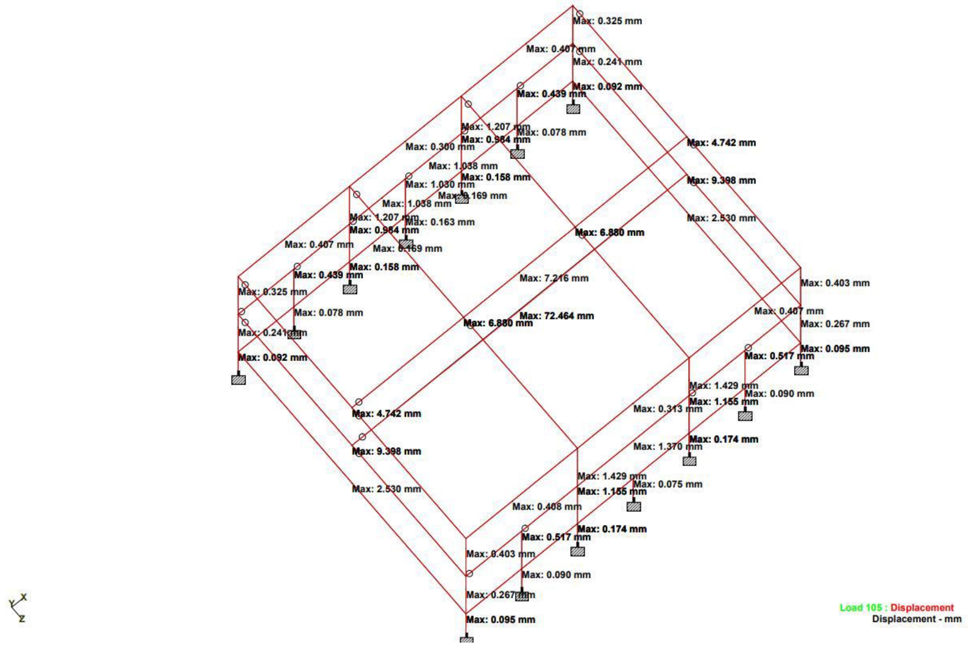


Fig 15 Bending moment diagram for future storey

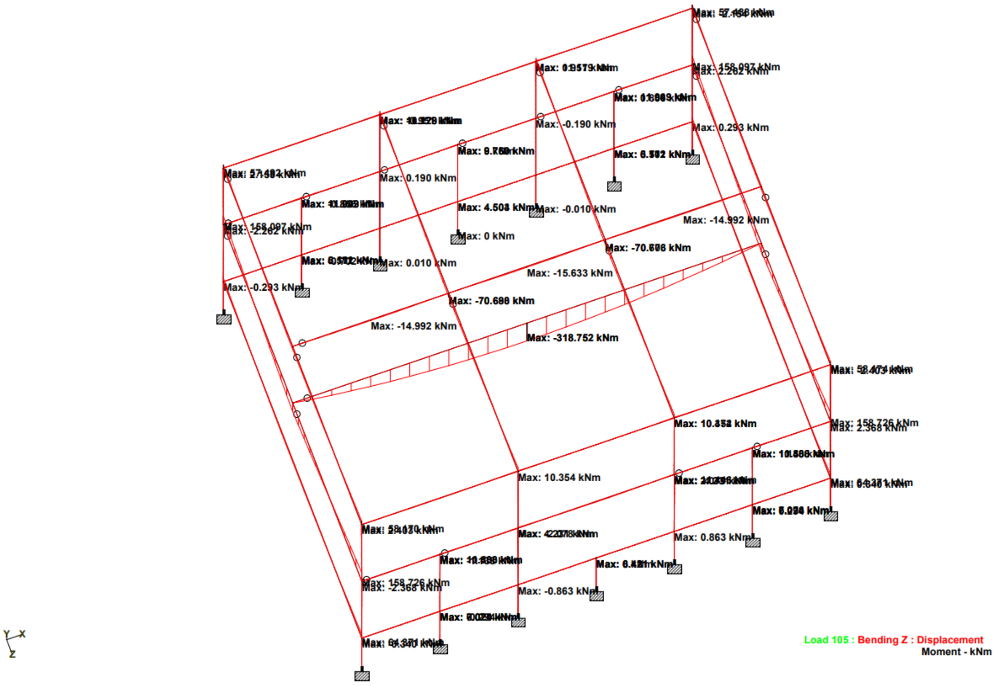


Fig 16 Dispcement in future storey

Table 4 Nodal displacement for future floor

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	42	105 1.0(DL+LL)	0.005	-0.206	0.011	0.207	0	0	0
Min X	36	105 1.0(DL+LL)	-0.005	-0.206	0.011	0.207	0	0	0
Max Y	43	105 1.0(DL+LL)	0	0	0	0	0	0	0
Min Y	**75**	**105 1.0(DL+LL)**	**0**	**-72.464**	**0.022**	**72.464**	**0**	**0**	**0**
Max Z	38	105 1.0(DL+LL)	-0.001	-0.156	1.144	1.155	0	0	0
Min Z	11	105 1.0(DL+LL)	0	-0.065	-1.028	1.03	0	0	0
Max rX	61	105 1.0(DL+LL)	0	-0.237	0.147	0.279	0.002	0	0
Min rX	66	105 1.0(DL+LL)	0.001	-0.264	0.096	0.281	-0.002	0	0
Max rY	41	105 1.0(DL+LL)	0.004	-0.063	0.513	0.517	0	0	0
Min rY	37	105 1.0(DL+LL)	-0.004	-0.063	0.513	0.517	0	0	0
Max rZ	**28**	**105 1.0(DL+LL)**	**-0.003**	**-9.398**	**0.026**	**9.398**	**0**	**0**	**0.022**
Min rZ	**22**	**105 1.0(DL+LL)**	**0.003**	**-9.398**	**0.026**	**9.398**	**0**	**0**	**-0.022**
Max Rst	75	105 1.0(DL+LL)	0	-72.464	0.022	72.464	0	0	0

Table 5 Beam deflectionfor strengthenstructure

		Horizontal	Vertical	Horizontal	Resultant	Rotational			
Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad	rZ rad
1	105 1.0(DL+LL)	0.001	-0.084	-0.037	0.092	0	0	0	
2	105 1.0(DL+LL)	0.001	-0.032	-0.071	0.078	0	0	0	
3	105 1.0(DL+LL)	0	-0.049	-0.151	0.158	0	0	0	
4	105 1.0(DL+LL)	0	-0.03	-0.161	0.163	0	0	0	
5	105 1.0(DL+LL)	0	-0.049	-0.151	0.158	0	0	0	
6	105 1.0(DL+LL)	-0.001	-0.032	-0.071	0.078	0	0	0	
7	105 1.0(DL+LL)	-0.001	-0.084	-0.037	0.092	0	0	0	
8	105 1.0(DL+LL)	-0.005	-0.205	0.041	0.21	0	0	0	
9	105 1.0(DL+LL)	-0.004	-0.068	-0.433	0.439	0	0	0	
10	105 1.0(DL+LL)	-0.002	-0.13	-0.975	0.984	0	0	0	
11	105 1.0(DL+LL)	0	-0.065	-1.028	1.03	0	0	0	
12	105 1.0(DL+LL)	0.002	-0.13	-0.975	0.984	0	0	0	
13	105 1.0(DL+LL)	0.004	-0.068	-0.433	0.439	0	0	0	
14	105 1.0(DL+LL)	0.005	-0.205	0.041	0.21	0	0	0	
22	**105 1.0(DL+LL)**	**0.003**	**-9.398**	**0.026**	**9.398**	**0**	**0**	**-0.022**	
28	**105 1.0(DL+LL)**	**-0.003**	**-9.398**	**0.026**	**9.398**	**0**	**0**	**0.022**	
29	105 1.0(DL+LL)	0	-0.084	0.044	0.095	0	0	0	
30	105 1.0(DL+LL)	0	-0.031	0.085	0.09	0	0	0	
31	105 1.0(DL+LL)	-0.001	-0.057	0.165	0.174	0	0	0	
32	105 1.0(DL+LL)	0	-0.011	0.073	0.074	0	0	0	
33	105 1.0(DL+LL)	0.001	-0.057	0.165	0.174	0	0	0	
34	105 1.0(DL+LL)	0	-0.031	0.085	0.09	0	0	0	
35	105 1.0(DL+LL)	0	-0.084	0.044	0.095	0	0	0	
36	105 1.0(DL+LL)	-0.005	-0.206	0.011	0.207	0	0	0	
37	105 1.0(DL+LL)	-0.004	-0.063	0.513	0.517	0	0	0	
38	105 1.0(DL+LL)	-0.001	-0.156	1.144	1.155	0	0	0	
40	105 1.0(DL+LL)	0.001	-0.156	1.144	1.155	0	0	0	
40	105 1.0(DL+LL)	0.001	-0.156	1.144	1.155	0	0	0	
41	105 1.0(DL+LL)	0.004	-0.063	0.513	0.517	0	0	0	
42	105 1.0(DL+LL)	0.005	-0.206	0.011	0.207	0	0	0	
43	105 1.0(DL+LL)	0	0	0	0	0	0	0	
44	105 1.0(DL+LL)	0	0	0	0	0	0	0	
45	105 1.0(DL+LL)	0	0	0	0	0	0	0	
46	105 1.0(DL+LL)	0	0	0	0	0	0	0	
47	105 1.0(DL+LL)	0	0	0	0	0	0	0	
48	105 1.0(DL+LL)	0	0	0	0	0	0	0	
49	105 1.0(DL+LL)	0	0	0	0	0	0	0	
50	105 1.0(DL+LL)	0	0	0	0	0	0	0	
51	105 1.0(DL+LL)	0	0	0	0	0	0	0	
52	105 1.0(DL+LL)	0	0	0	0	0	0	0	
53	105 1.0(DL+LL)	0	0	0	0	0	0	0	
54	105 1.0(DL+LL)	0	0	0	0	0	0	0	
55	105 1.0(DL+LL)	0	0	0	0	0	0	0	
56	105 1.0(DL+LL)	0	0	0	0	0	0	0	
57	105 1.0(DL+LL)	0.001	-0.281	0.121	0.306	0.001	0	0	
59	105 1.0(DL+LL)	0	-0.237	0.147	0.279	0.002	0	0	
61	105 1.0(DL+LL)	0	-0.237	0.147	0.279	0.002	0	0	
63	105 1.0(DL+LL)	-0.001	-0.281	0.121	0.306	0.001	0	0	
64	105 1.0(DL+LL)	0.001	-0.282	0.014	0.283	-0.001	0	0	
66	105 1.0(DL+LL)	0.001	-0.264	0.096	0.281	-0.002	0	0	
68	105 1.0(DL+LL)	-0.001	-0.264	0.096	0.281	-0.002	0	0	
70	105 1.0(DL+LL)	-0.001	-0.282	0.013	0.283	-0.001	0	0	
71	105 1.0(DL+LL)	0.001	-4.741	0.068	4.742	0	0	-0.001	
72	105 1.0(DL+LL)	-0.001	-4.741	0.068	4.742	0	0	0.001	
73	105 1.0(DL+LL)	0	-6.879	0.121	6.88	0	0	0	
74	105 1.0(DL+LL)	0	-6.879	0.121	6.88	0	0	0	
75	105 1.0(DL+LL)	0	-72.464	0.022	72.464	0	0	0	

As the analysis of ground existing story with future floor expansion referring the analysis the no.14 beam was having deflection of 40.917mm with no upper story. The span/deflection ratio is 220 which is lesser than permissible ratio of 240.the node points of beam (22 & 28) no.14 is also having deflection of 7.517mm. At this crucial time baps Swaminarayan chatralay is planning of one floor extension on this single-story frame building. Which leads to the beam is having deflection of 72mm with node no.22 & 28 having deflection of 9.398mm. So, the strengthening of beam no 14 is must. For strengthening of this beam, we are using steel strengthening method with 2 numbers of ismb250.

4.3. seismic strengthening with 2 numbers of ismb250

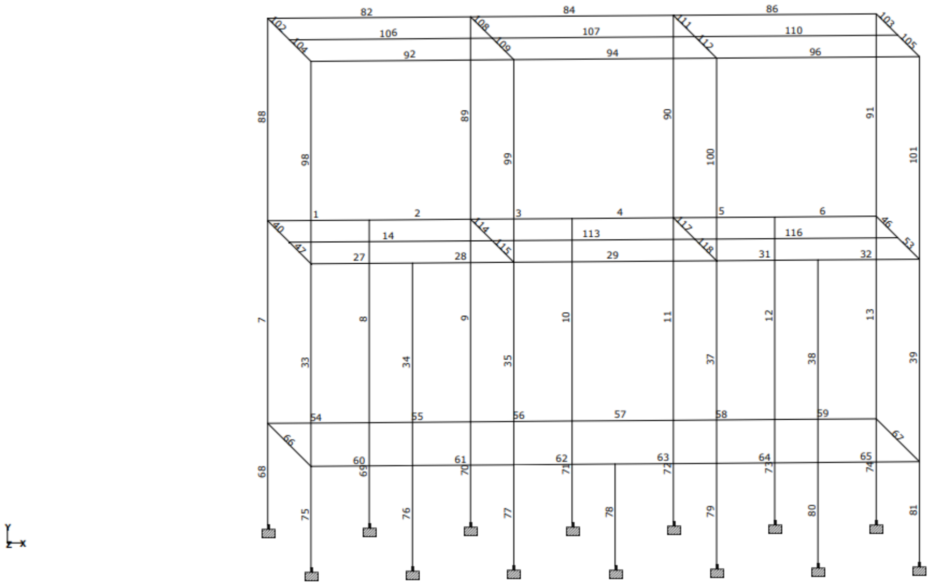


Fig 17 Beam numbers for seismic strengthening

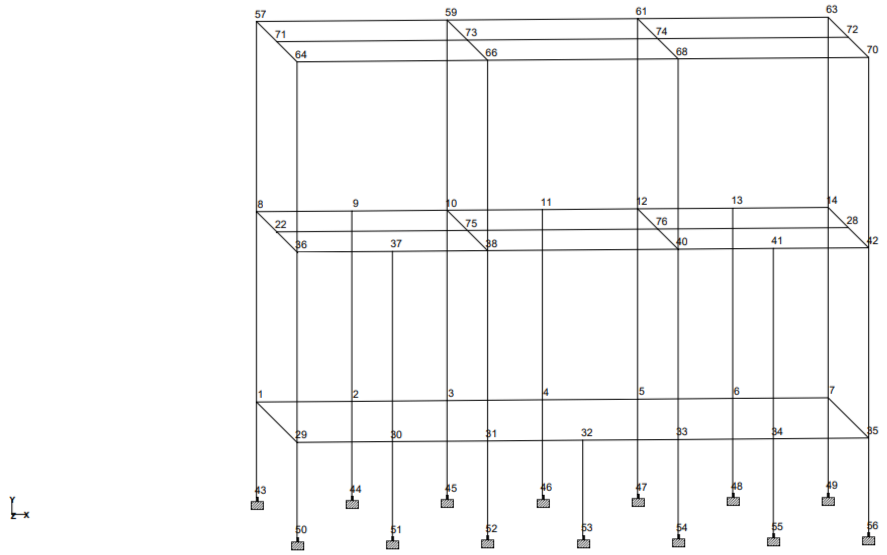


Fig 18 Node numbers for seismic strengthening

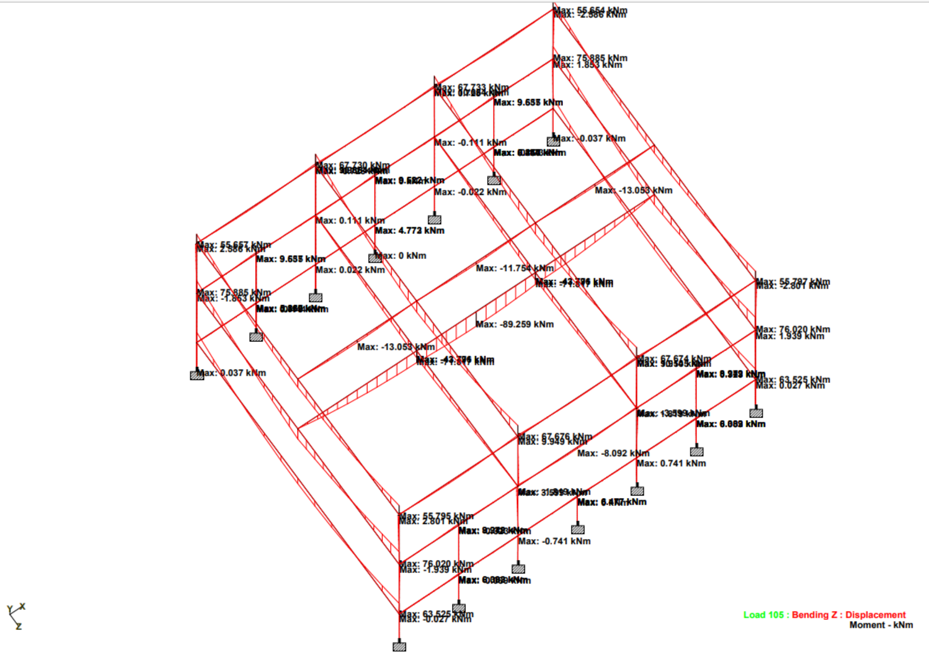


Fig 19 Whole structure displacement at time of seismic strengthening

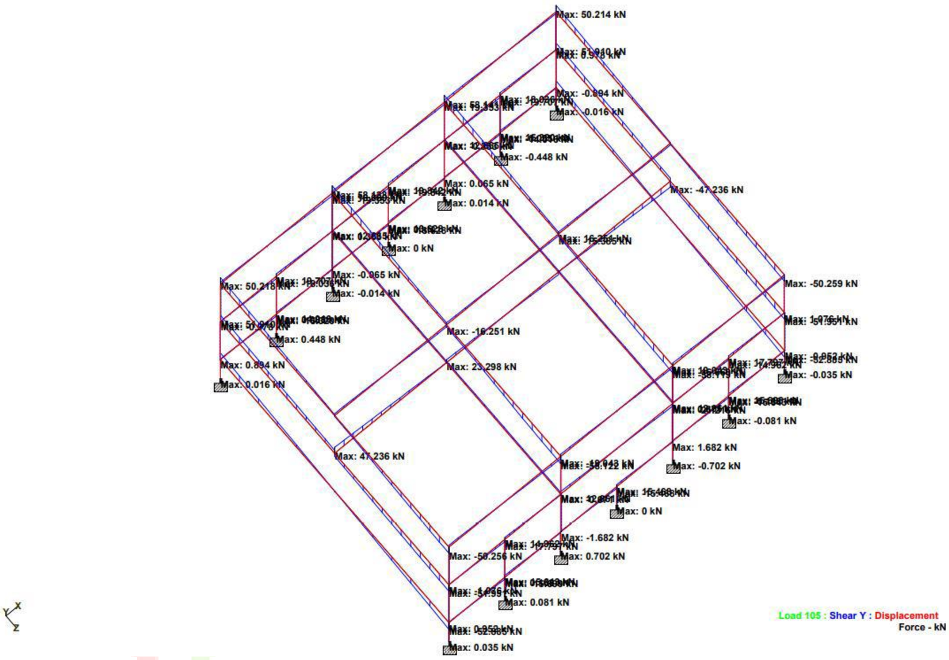


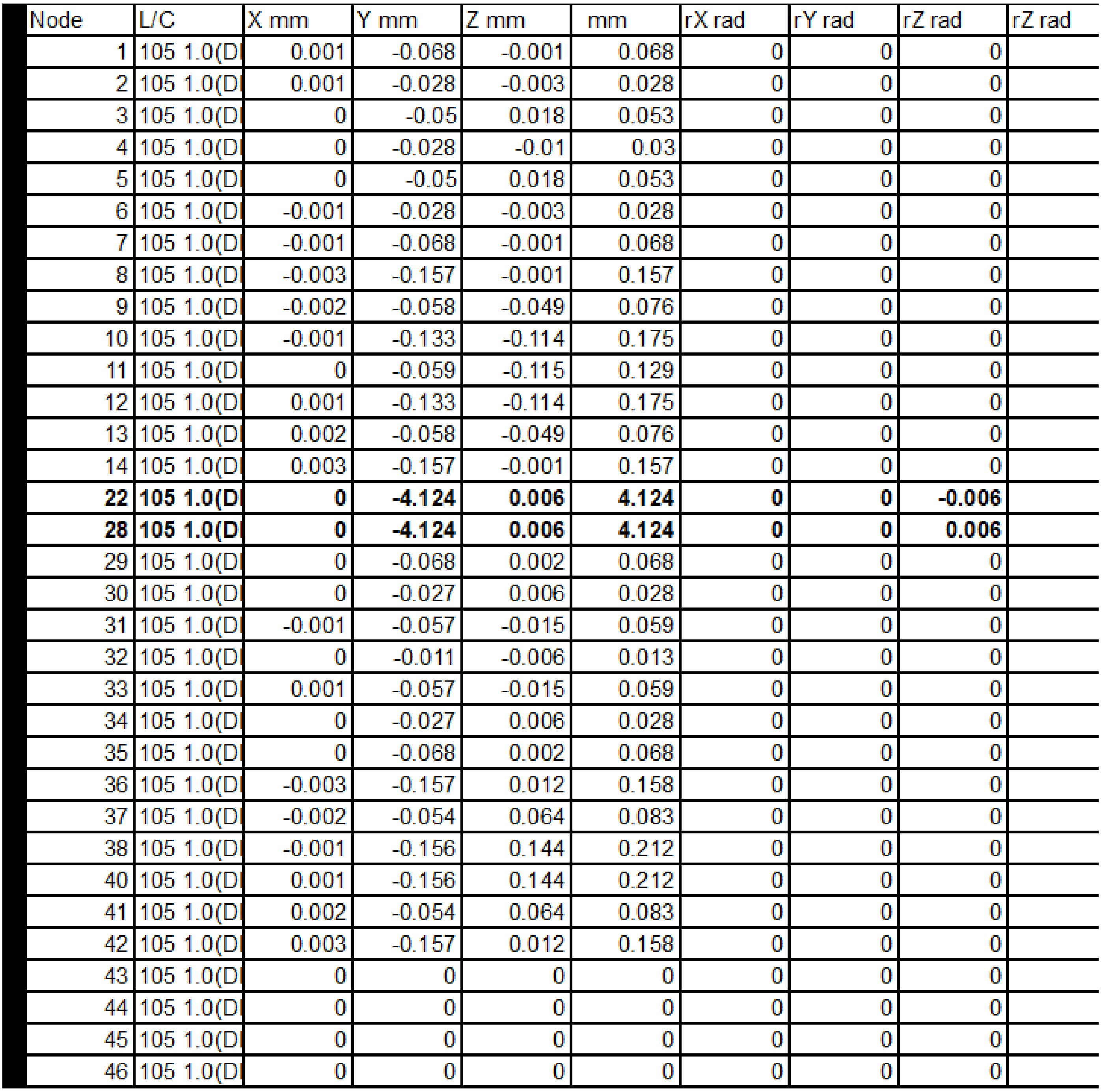
Fig 20 Shear force diagram at a time of seismic strengthening

Fig 21 Bending moment diagram at a time of seismic strengthening

Tab 6 Nodal displacement for seismic strengthening structure

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	42	105 1.0(D	0.003	-0.157	0.012	0.158	0	0	0
Min X	36	105 1.0(D	-0.003	-0.157	0.012	0.158	0	0	0
Max Y	43	105 1.0(D	0	0	0	0	0	0	0
Min Y	**75**	**105 1.0(D**	**0**	**-19.205**	**0.015**	**19.205**	**0**	**0**	**-0.003**
Max Z	38	105 1.0(D	-0.001	-0.156	0.144	0.212	0	0	0
Min Z	11	105 1.0(D	0	-0.059	-0.115	0.129	0	0	0
Max rX	61	105 1.0(D	0	-0.241	0.066	0.25	0.001	0	0
Min rX	66	105 1.0(D	0.001	-0.264	-0.018	0.264	-0.001	0	0
Max rY	41	105 1.0(D	0.002	-0.054	0.064	0.083	0	0	0
Min rY	37	105 1.0(D	-0.002	-0.054	0.064	0.083	0	0	0
Max rZ	**28**	**105 1.0(D**	**0**	**-4.124**	**0.006**	**4.124**	**0**	**0**	**0.006**
Min rZ	**22**	**105 1.0(D**	**0**	**-4.124**	**0.006**	**4.124**	**0**	**0**	**-0.006**
Max Rst	**75**	**105 1.0(D**	**0**	**-19.205**	**0.015**	**19.205**	**0**	**0**	**-0.003**

Tab 7 Beam deflectionfor strengthen structure



Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad	rZ rad
1	105 1.0(DI	0.001	-0.068	-0.001	0.068	0	0	0	
2	105 1.0(DI	0.001	-0.028	-0.003	0.028	0	0	0	
3	105 1.0(DI	0	-0.05	0.018	0.053	0	0	0	
4	105 1.0(DI	0	-0.028	-0.01	0.03	0	0	0	
5	105 1.0(DI	0	-0.05	0.018	0.053	0	0	0	
6	105 1.0(DI	-0.001	-0.028	-0.003	0.028	0	0	0	
7	105 1.0(DI	-0.001	-0.068	-0.001	0.068	0	0	0	
8	105 1.0(DI	-0.003	-0.157	-0.001	0.157	0	0	0	
9	105 1.0(DI	-0.002	-0.058	-0.049	0.076	0	0	0	
10	105 1.0(DI	-0.001	-0.133	-0.114	0.175	0	0	0	
11	105 1.0(DI	0	-0.059	-0.115	0.129	0	0	0	
12	105 1.0(DI	0.001	-0.133	-0.114	0.175	0	0	0	
13	105 1.0(DI	0.002	-0.058	-0.049	0.076	0	0	0	
14	105 1.0(DI	0.003	-0.157	-0.001	0.157	0	0	0	
22	**105 1.0(DI**	**0**	**-4.124**	**0.006**	**4.124**	**0**	**0**	**-0.006**	
28	**105 1.0(DI**	**0**	**-4.124**	**0.006**	**4.124**	**0**	**0**	**0.006**	
29	105 1.0(DI	0	-0.068	0.002	0.068	0	0	0	
30	105 1.0(DI	0	-0.027	0.006	0.028	0	0	0	
31	105 1.0(DI	-0.001	-0.057	-0.015	0.059	0	0	0	
32	105 1.0(DI	0	-0.011	-0.006	0.013	0	0	0	
33	105 1.0(DI	0.001	-0.057	-0.015	0.059	0	0	0	
34	105 1.0(DI	0	-0.027	0.006	0.028	0	0	0	
35	105 1.0(DI	0	-0.068	0.002	0.068	0	0	0	
36	105 1.0(DI	-0.003	-0.157	0.012	0.158	0	0	0	
37	105 1.0(DI	-0.002	-0.054	0.064	0.083	0	0	0	
38	105 1.0(DI	-0.001	-0.156	0.144	0.212	0	0	0	
40	105 1.0(DI	0.001	-0.156	0.144	0.212	0	0	0	
41	105 1.0(DI	0.002	-0.054	0.064	0.083	0	0	0	
42	105 1.0(DI	0.003	-0.157	0.012	0.158	0	0	0	
43	105 1.0(DI	0	0	0	0	0	0	0	
44	105 1.0(DI	0	0	0	0	0	0	0	
45	105 1.0(DI	0	0	0	0	0	0	0	
46	105 1.0(DI	0	0	0	0	0	0	0	

Tab 8 Beam deflectionfor strengthenstructure

46	105 1.0(D	0	0	0	0	0	0	0	
47	105 1.0(D	0	0	0	0	0	0	0	
48	105 1.0(D	0	0	0	0	0	0	0	
49	105 1.0(D	0	0	0	0	0	0	0	
50	105 1.0(D	0	0	0	0	0	0	0	
51	105 1.0(D	0	0	0	0	0	0	0	
52	105 1.0(D	0	0	0	0	0	0	0	
53	105 1.0(D	0	0	0	0	0	0	0	
54	105 1.0(D	0	0	0	0	0	0	0	
55	105 1.0(D	0	0	0	0	0	0	0	
56	105 1.0(D	0	0	0	0	0	0	0	
57	105 1.0(D	0.002	-0.232	0.057	0.239	0.001	0	0	
59	105 1.0(D	0	-0.241	0.066	0.25	0.001	0	0	
61	105 1.0(D	0	-0.241	0.066	0.25	0.001	0	0	
63	105 1.0(D	-0.002	-0.232	0.057	0.239	0.001	0	0	
64	105 1.0(D	0.002	-0.233	-0.029	0.235	-0.001	0	0	
66	105 1.0(D	0.001	-0.264	-0.018	0.264	-0.001	0	0	
68	105 1.0(D	-0.001	-0.264	-0.018	0.264	-0.001	0	0	
70	105 1.0(D	-0.002	-0.233	-0.029	0.235	-0.001	0	0	
71	**105 1.0(D**	**0**	**-4.772**	**0.014**	**4.772**	**0**	**0**	**-0.001**	
72	**105 1.0(D**	**0**	**-4.772**	**0.014**	**4.772**	**0**	**0**	**0.001**	
73	**105 1.0(D**	**0**	**-6.227**	**0.024**	**6.227**	**0**	**0**	**0**	
74	**105 1.0(D**	**0**	**-6.227**	**0.024**	**6.227**	**0**	**0**	**0**	
75	**105 1.0(D**	**0**	**-19.205**	**0.015**	**19.205**	**0**	**0**	**-0.003**	
76	**105 1.0(D**	**0**	**-19.205**	**0.015**	**19.205**	**0**	**0**	**0.003**	

As we are aware of that the exiting building of baps swaminarayan chatralay’s beam no 14 is having deflection of 40.917 mm. As they are planning for one floor extension the new deflection developed at beam is 72.464mm.So the seismic strengthening is executed at that beam with the 2 numbers of ismb250which resulted into permissible deflection. The cost benefit ratio of seismic steel strengthening to reinforced cement concrete is high, to be in short in this case the cost of the seismic strengthening with reinforced cement concrete & seismic strengthening with steel is nearby same but the life of steel seismic strengthening is approximately twice to thrice to reinforced cement concrete seismic strengthening.

Fig 22 Two numbers of ISMB250 at APC

Fig 23 Connection of old R.C.C. Beam to Steel Beam

Tab 9 Reinforced cement concrete required at APC

APC no.	subject	numbers	length	width	height	cost
material						
1.	column	2	0.6	0.6	3	16200
2.	steel	2412mm2				1641
3.	foundation	2	0.6	2.0	0.6	36000
4.	steel	3390mm2				923
						54764rs

Steel strengthening required at APC :
ISMB250
Weight=37.3kg/m
Total length for ISMB250 beam = 7.3m
Steel rate = 37.3 x 7.30 x 75 x 2 = 40844rs
Labour rate = 37.3 x 7.30 x 30 x 2 = 16338rs
Total cost=40844rs+16338rs = 57182rs
Going with steel strengthening.

4.4 Case study 2

Meera Maheshwarprasad Dave, Dave Pole, Behind Vejnath Mahadev, Near Gayatri Temple, Taluka: Mahudha District: Kheda, Gujarat

Fig 24 Timber Lime Structure

Fig 25 Timber Lime Structure

This timber lime structure was constructed 250 to 300 years ago with the locally available material like lime & imported 'Malbari saag' which is popular for sustainability serviceability & lifelong Ness. This timber lime haveli is having wooden art work same as old heritage structure at the beam column joint as well as the door & window frame. This healthy structure got minorly damaged in Bhuj earthquake 2001but it gave birth to many difficulties. In2019 one of the timber lime column got separated from the wall. The kitchen cum bed room beam got deflected & the open space smaller side secondary beam got cracked decayed. So to stand with structure after 2 years of lack it is compulsory to take the action. Regarding the information from the owner of the house no drawing is found.

Tab. 10 Qualitative Assessment

Element	Damage	Not Damage	Remark
Timber Beam	Yes		Cracks & deflection
Timber Column	Yes		Separated From Wall
Foundation		Yes	
Plaster	Yes		Debonding Of Surface
Door		Yes	
Window		Yes	
Lime Masonry Wall			Map Cracking

Plan size=6.9m m x 17.5m
Frame: timber
Floor: two floor + roof
Column size=0.20m x 0.20
Slab thickness=1000mm
Type of wall infill=red brick ('patla eant': rectangular in shape & 1.5time greater than standard modular brick)
Size of wall=0.45m

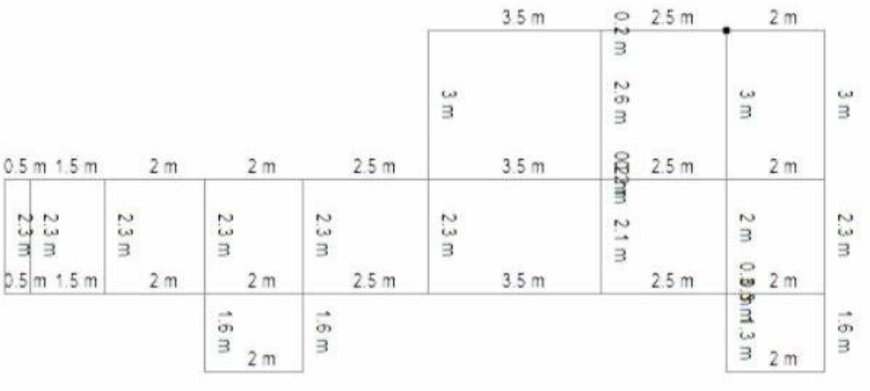


Fig 26 Plan Of Existing Old Heritage Cum Timber Lime Structure

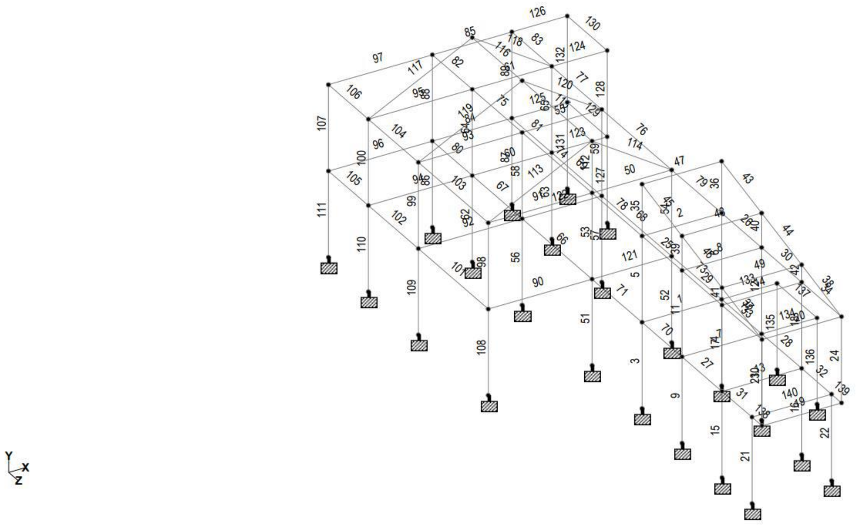


Fig 27 Beam number for timber structure at mahudha

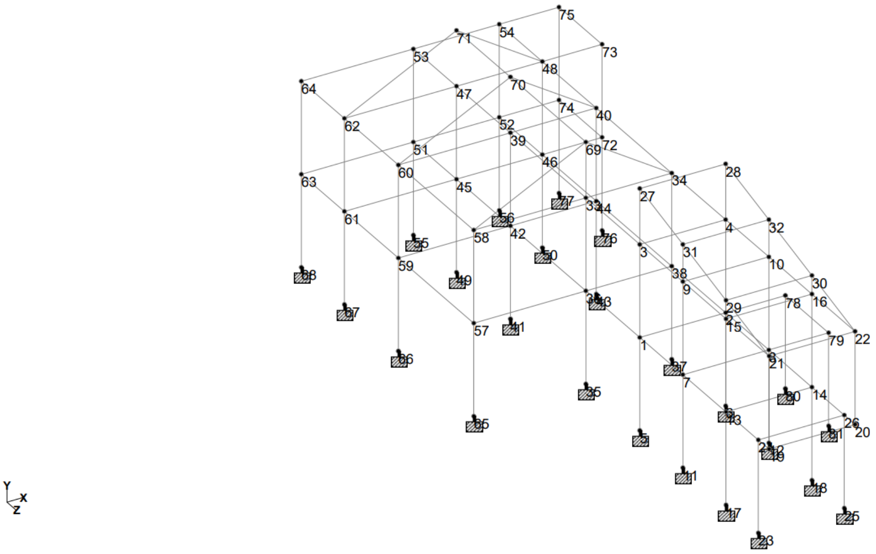


Fig 28 Node number for mahudha timber lime structure

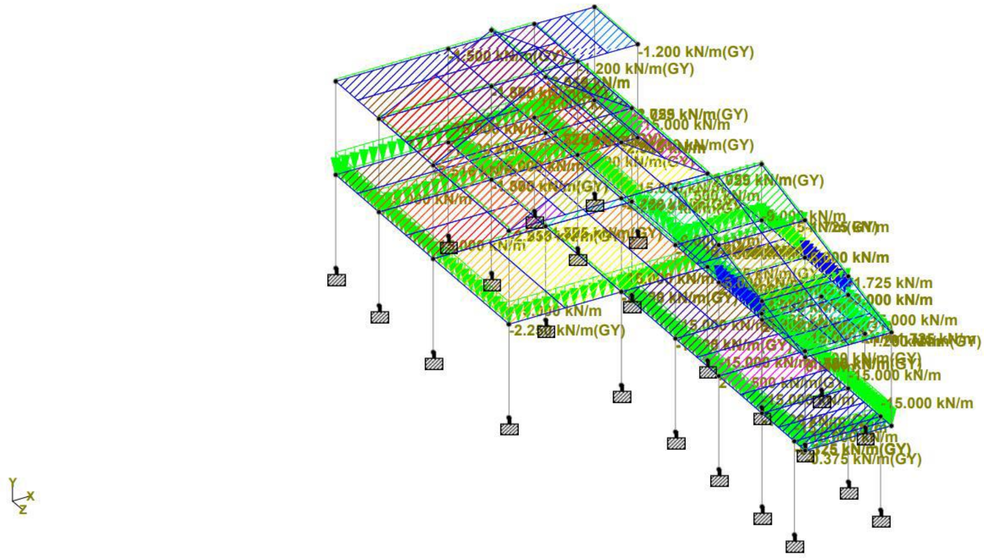


Fig 29 Dead Load on whole structure

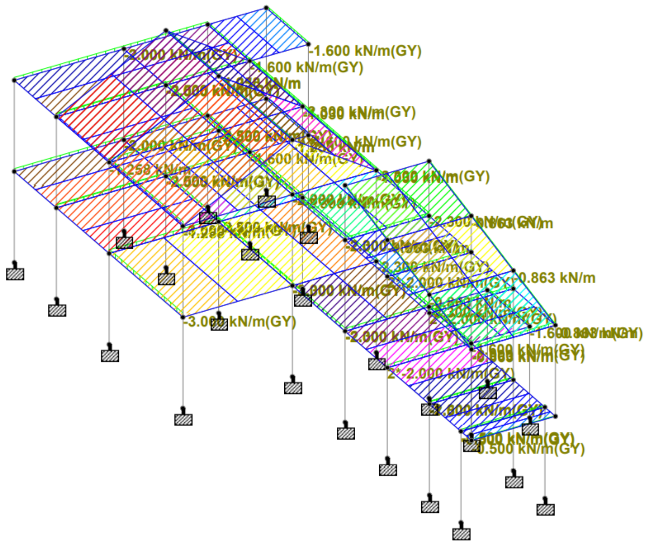


Fig 30 Live Load on whole structure

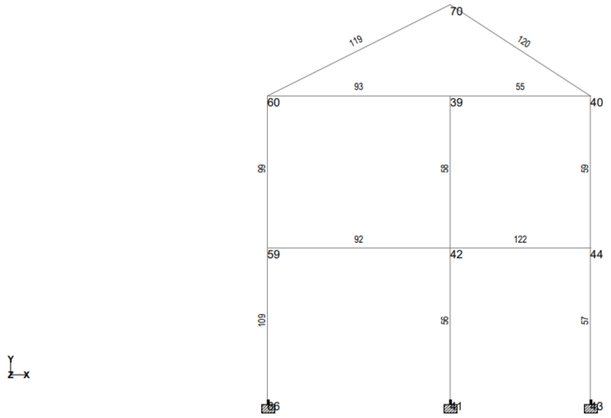


Fig 31 Weaker entrance at mahudha timber lime structure

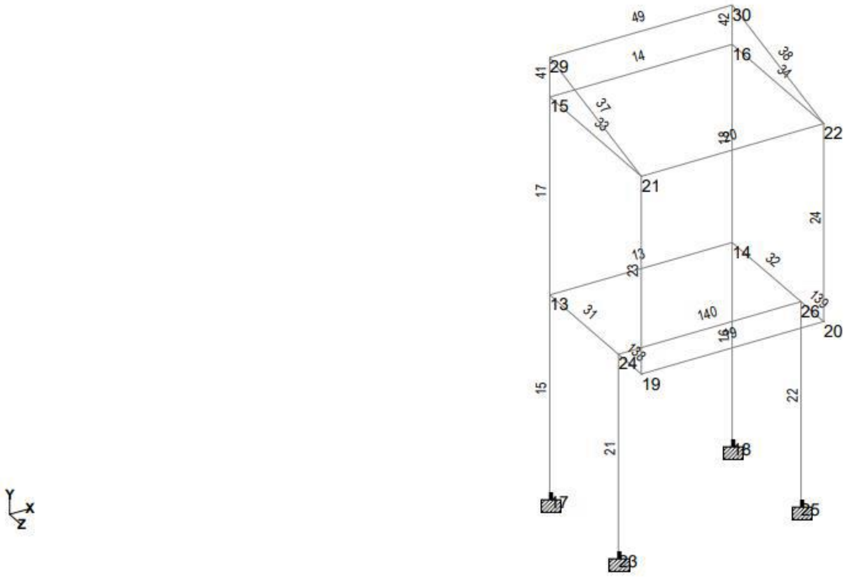


Fig 32 Weaker bathroom joint at mahudha timber lime structure

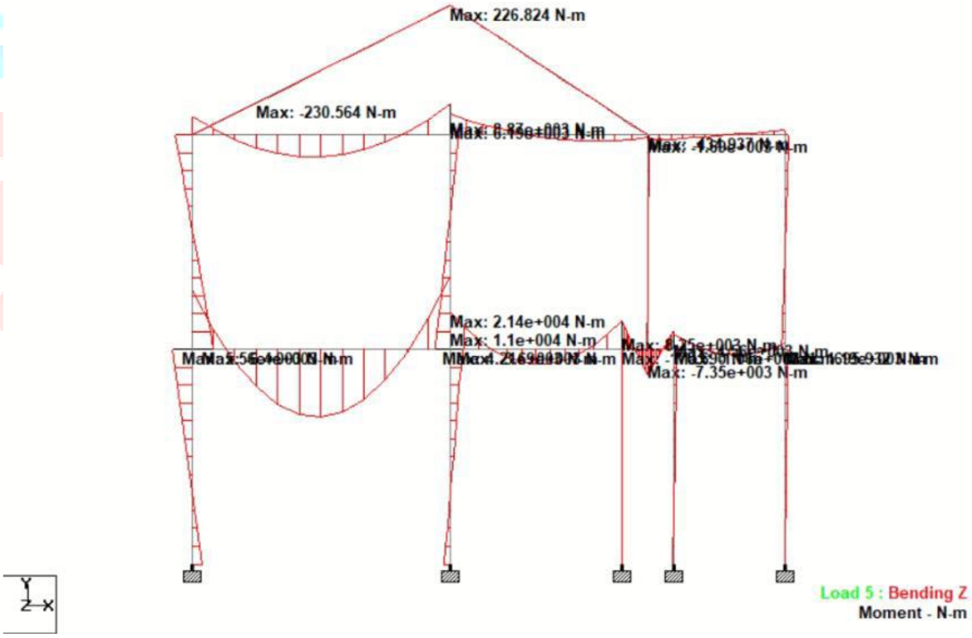


Fig 33 Weaker kitchen beam at mahudha timber lime structure

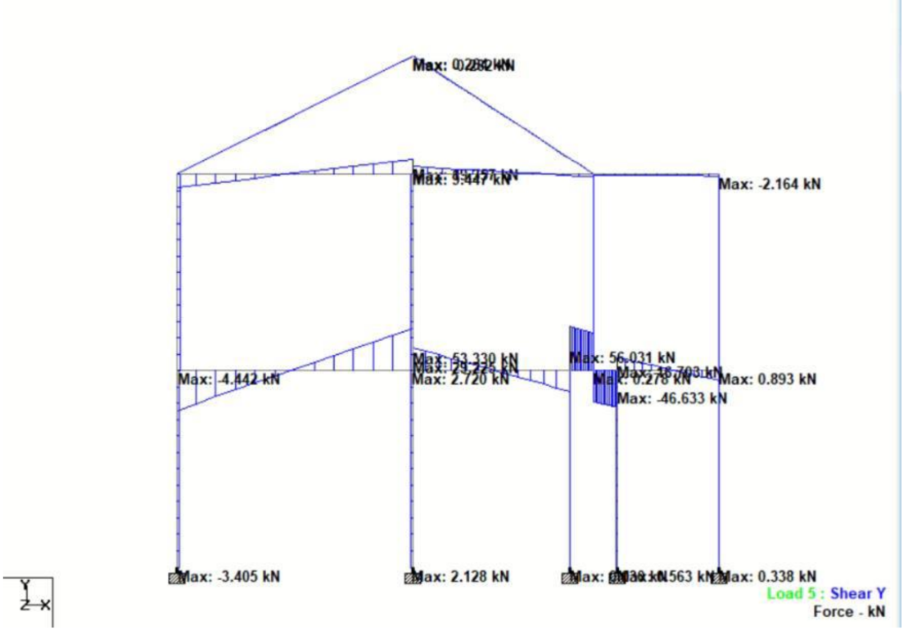


Fig 34 Bending moment

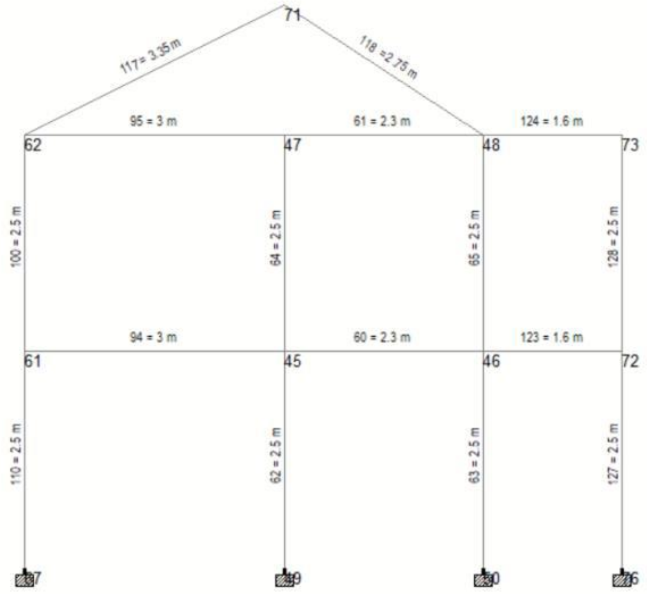


Fig 35 Diagram shear force diagram

As per the analysis of mahudha timber lime structure we had found that the bathroom column no.63 got failure which is locate between beam no.60 & beam no. 123 at node no.46, entrance joint no.190& 20 is weak to transfer the upper storey to the bottom level & got deformed at the last the kitchen wooden beam no. 92 & beam no. 122got deflected having column no.109, 56, 57 respectively.

Fig 36 Entrance weaker portion

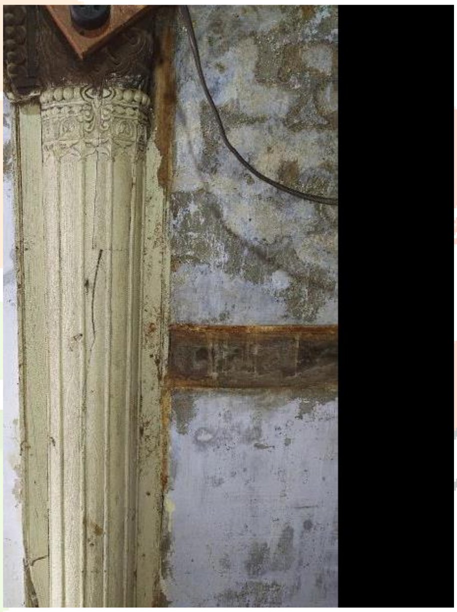


Fig 37 Entrance weaker portion

Fig 38 Failed bathroom column

Fig 39 Failed bathroom column

Fig 40 Crack in wooden art

Fig 41 Crack in wooden art

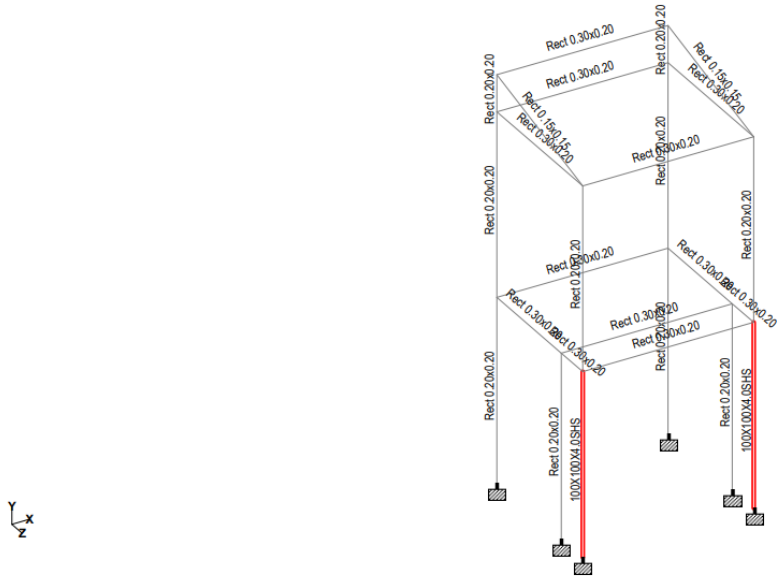


Fig 42 Steel strengthening entrance atmahudha timberlime structure

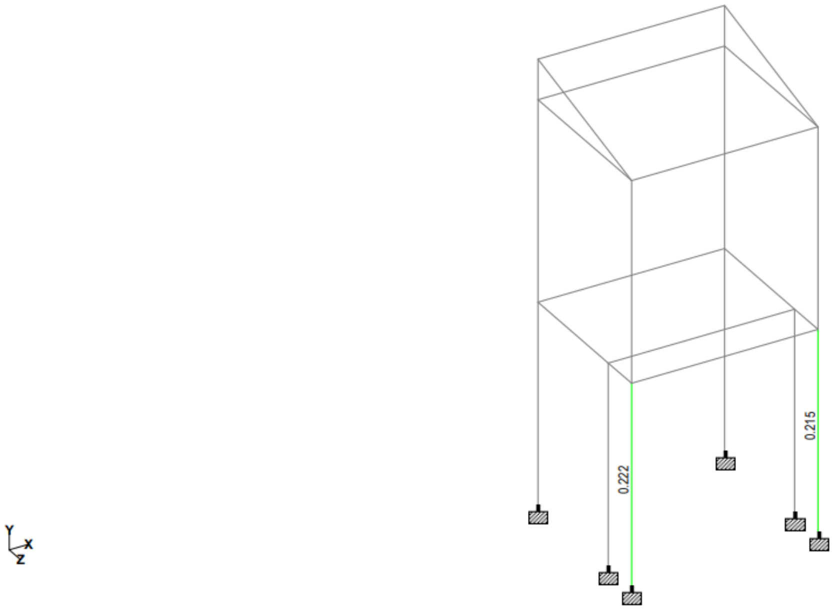


Fig 43 Steel strengthening entrance stress ratio at mahudha timber lime structure

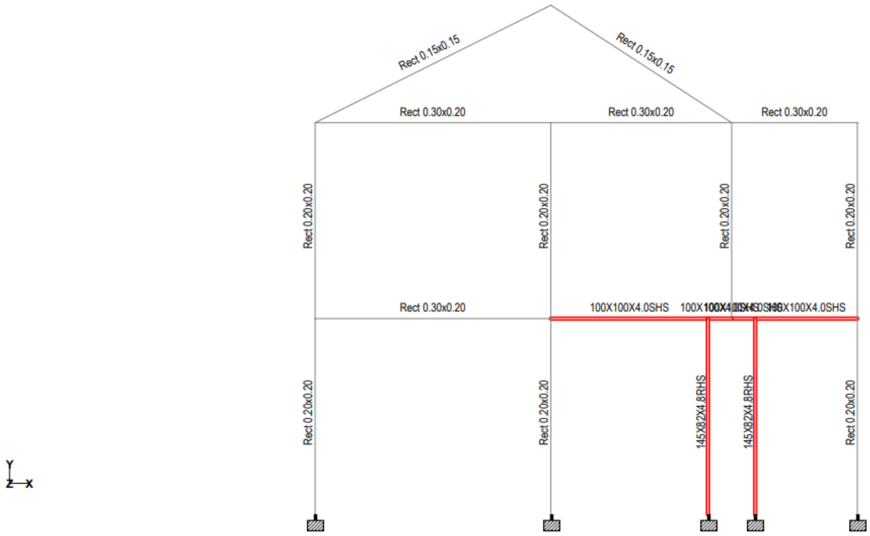


Fig 44 Strengthening bathroom joint at mahudha timber lime structure

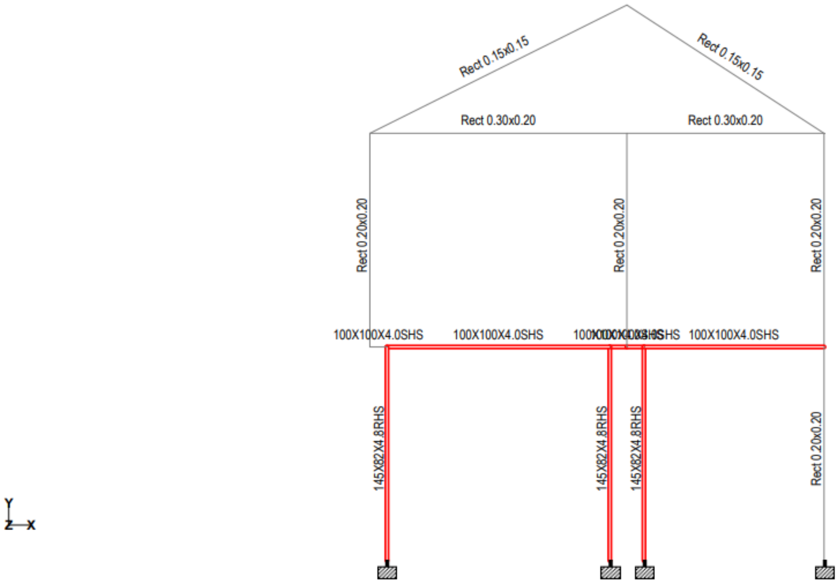


Fig 45 Steel strengthening bathroom joint stress ratio at mahudha timber lime structure

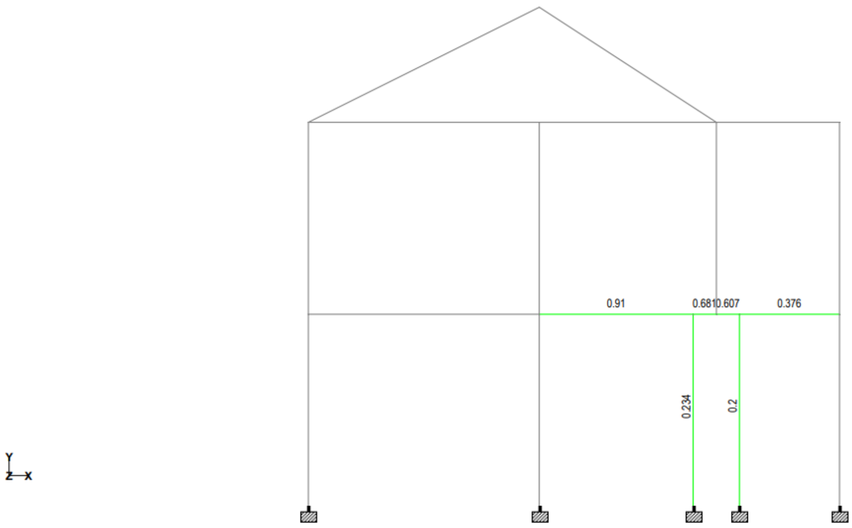


Fig 46 Strengthening kitchen joint at mahudha timber lime structure

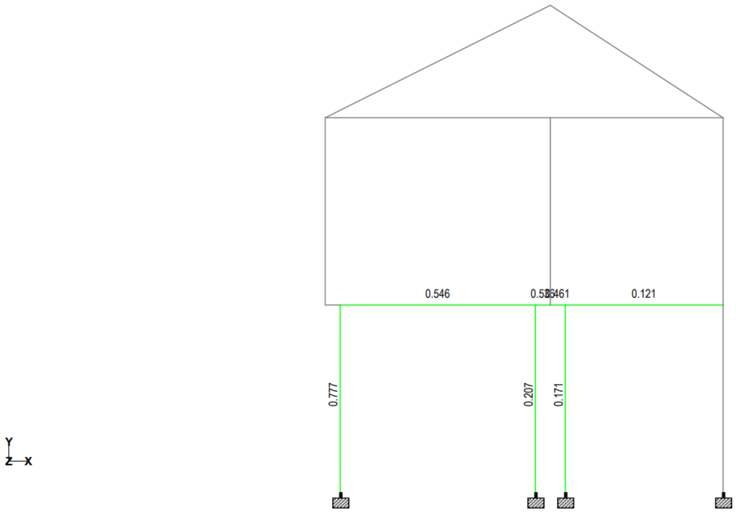


Fig 47 Steel strengthening kitchen stress ratio at mahudha timber lime structure

Fig 48 Kitchen cum bed room steel strengthening column

Fig 49 Bathroom steel strengthening column

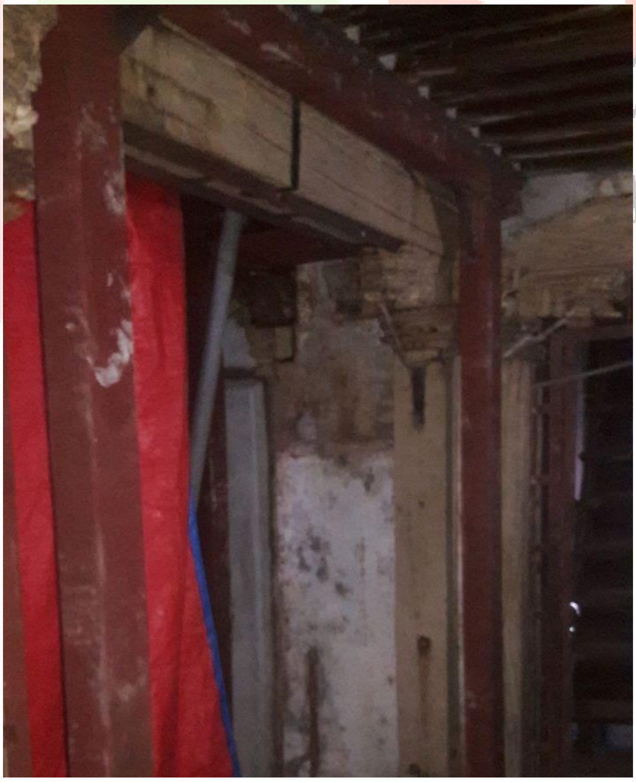


Fig 50 Entrance column seismic strengthening

Fig 51 Measurement and site visit

Fig 52 Measurement and site visit

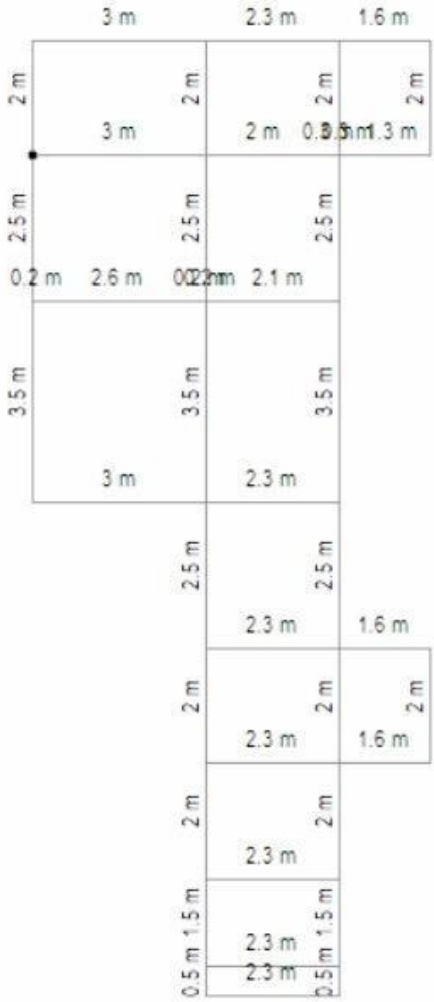


Fig 53 Steel strengthening plan of mahudha timber lime structure

Steel strengthening in mahudha
Total Length Required For 100mm X 100mm X 4mm Beam= 0.2+3+0.2+2.3+0.2(kitchen) +0.2+3+0.2(bath) +0.2+2.3+0.2 (entrance) =10m
Total Length Required For 145mm X 82mm X 4.8mm Column =3+3(bathroom) +3+3+3(kitchen) +3+3(entrance) =21m
Tata Steel Rate 75/kg For 145mm X 82mm X 4.8mm Weight Is 15.92kg/m =15.92 X 10 X 75 =11940rs
For 100mm X 100mm X 4mm Beam Weight Is 14.95kg/m =14.95 X 21 X 75 =23546rs
Labour Charges =30rs X{(10 X 15.92)+(21 X 14.95)} =14195 rs

V. CONCLUSION

The evaluation of seismic performance of existing buildings has received a great attention in the last two decades because all types of buildings are not earthquake-resistant. The objective of this research paper to assess the seismic performance of existing buildings in the all condition whether its is constructed with refences to Indian standard or by laymen’s method. One case study has been chosen for this purpose. The evaluation has proved that the beam of buildings are not seismically safe. A study has been done to choose a suitable seismic strengthening material with consideration of future expansion. Heritage structures perform vital role in nation’s history, culture and signify the richness of it. To augment life and enhance strength, their restoration is very important for the future generations to have knowledge about how mankind lived in past ages. Restoration involves investigating, diagnosing and correcting deficiencies and deterioration of any structure. Identification of common defects and problems faced in old structures and devising a systematic approach towards handling these issues is civil engineer’s obligation. A case study throws light on the various problems encountered and the methods employed to tackle them. In the old heritage structure as the owner of the house is attach to his house at that level she is not happy to use concrete in structure. The malbari saag which is used at that time is not available .Only on client demand for longer serviceability we prefer steel over the other material used in construction.

VI. FUTURE WORK

Currently the problem of both structures is regarding deflection in beam & column settlement which has been cured with the analysis, design & proper execution. In future the rein-forced cement concrete structure may not require any precaution regarding its structural connections with future expansion as the load combinations considered. The old heritage timber structure is in good condition but after the time engineers shall be prepare to the decay, deformation & continuously assessment of structure.

VII. ACKNOWLEDGMENT

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