Pushover analysis of an existing R.C.C. building with use of software e-tabs

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***Abstract*— This paper deals with the performance based analysis of an existing building. The building taken as a case study was Dharti apartment, Unjha. It is a G+4 residential building without lift core and water tank. The typical storey height is 3m. The year of construction of Dharti apartment was 2011. The selection of existing building was with an intention of finding capacity of building to check its safety against earthquake. Each floor is having four flats almost equal in its construction. Analysis of building was carried out for different position of shear walls.**

***Index Terms*— Pushover; Shear wall; Plastic Hinge; Pushover curve.**

I. INTRODUCTION OF EXISTING BUILDING

Typical slab details, terrace slab details, column and foundation details were the four structural drawings available for Dharti apartment.

The concrete grade was M25 and reinforcement was Fe415. All the beams were 115mm thick and 420 mm depth unless otherwise specified. All the slabs were 115mm thick. Due to symmetry of building in plan the details of beams were same on the either side of the axis of symmetry. Figure 1 shows the column and beam schedule of the building.

Column size of the building was taken as 230x460 mm.

Primary beam size was 230 x 420 mm & secondary beam size was 115 x 420 mm.

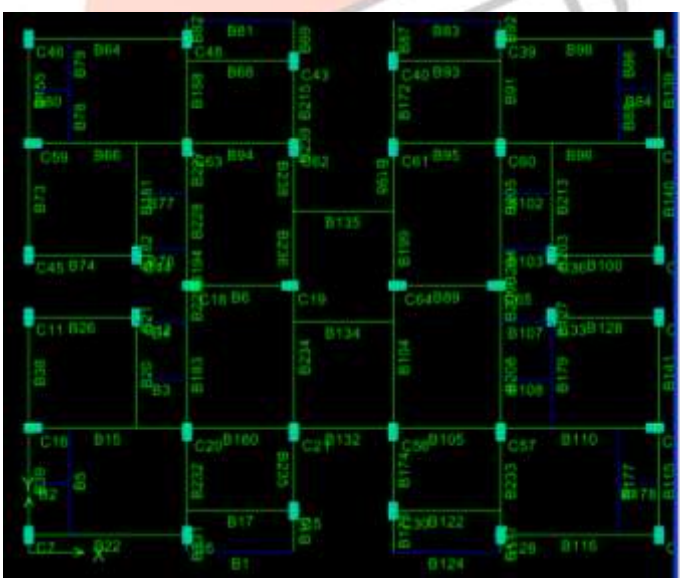


Fig 1 Typical Floor Plan of the Existing Building

II. MODELING OF EXISTING BUILDING

After evaluating the structural details, modeling of an existing building was done in ETABS.

Two different models were created in the software: a bare frame and frame having Shear wall. The material properties and geometrical properties of structural elements were defined in to the software. The orientation of columns was provided and the beam offsets were also given as per the drawings. The Plan and 3D view of building are shown in figure 2. The grid lines were

formed at each location of beams. Typical storey height was taken as 3.0m and base storey height was taken as 3m. The beams were created as per the location in drawing and corresponding properties of beams and columns were assigned. All the slabs were 115mm thick and the slabs were taken as Rigid Floor Diaphragm. Also same building with shear wall is shown in figure.3.

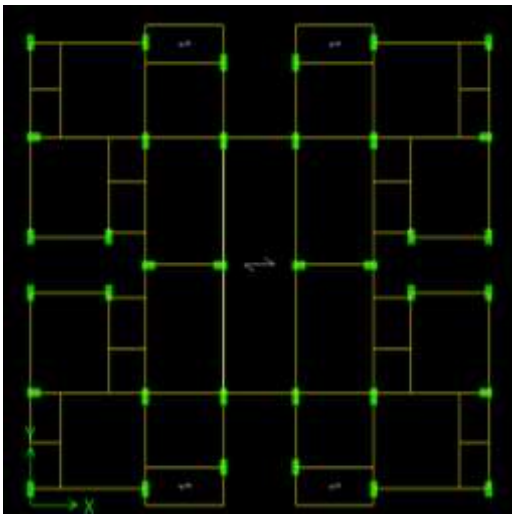


Fig. 2a Plan of existing building

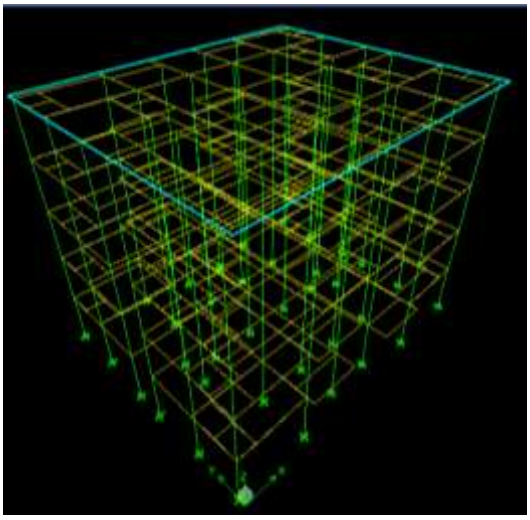
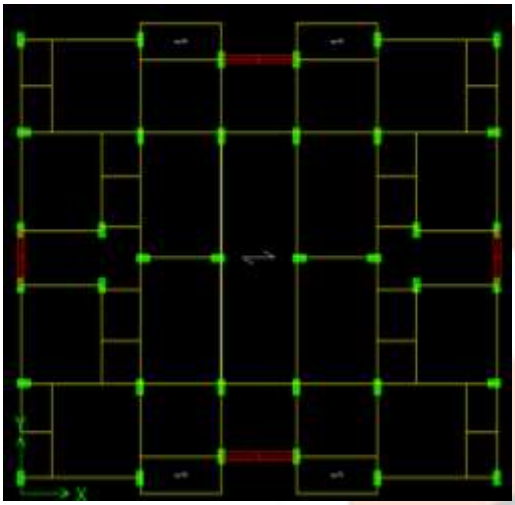


Fig. 2b 3D model of existing building



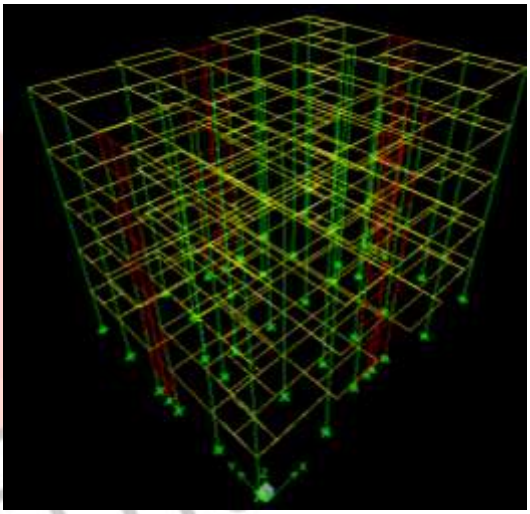


Fig. 3 Model having shear wall

III. Assign Frame Nonlinear Hinge Property

For pushover analysis, nonlinear hinges were to be provided to the frame structural elements. All the beams were provided with default moment (M3) hinge and default shear hinge at both the ends. All the columns were provided with default PMM hinge. The size of beams, columns and the reinforcement provided into the software. Depending upon this data the program will calculate the yield moments and corresponding displacement which is used for nonlinear static analysis.

IV. Nonlinear Static Load Cases & Analysis Of Existing Building

For Before carrying out nonlinear analysis, nonlinear static load cases were to be defined. Three load cases were defined one having gravity load pattern (PUSH1), second having lateral load pattern in X dirn (PUSH2) and third having lateral load pattern in Y dirn (PUSH3). Unloading method used was "Unload Entire Structure" and geometric nonlinearity was also considered. PUSH1 case was load controlled, PUSH2 and PUSH3 case was displacement controlled and was considered started at the end of PUSH1 case.

Static linear and dynamic analysis was performed before performing pushover analysis. Once the pushover analysis is performed, the software creates a LOG file which contains all the details of the iterations and steps involved into the pushover analysis.

V. Results and Discussions

Existing Building without Shear wall

The building was analyzed for lateral loading in both the horizontal directions. Figure 4shows the pushover curve in X direction. The capacity spectrum curves are shown in figure 5.

The base shear at performance point for loading in X-dirn was 3061.624 kN and corresponding displacement was 57mm. Table 1shows the hinge development of structure under lateral loading in X-dirn.There were 11 steps of analysis in X-direction Table 1shows the hinge formation of Existing building without shear wall in X. Initially the hinges started forming in beams and subsequently hinges were formed into columns. Figure 6 shows the pushover curve results. For loading in X-direction, at performance point, out of 2224 assigned hinges, 2039 hinges were in linear range, 163 were in B-IO range and 22 were in IO-LS range. Thus the overall building was considered to be in Life Safety level in case of predicted earthquake in X-direction. The graphical representation of hinge formation at performance point of existing building without strut in X-direction is shown in figure 7.

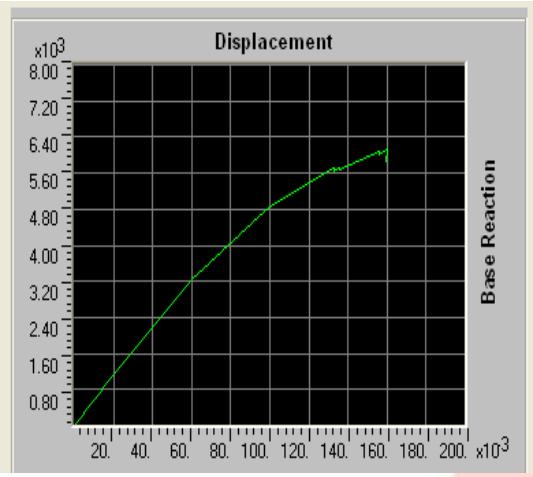


Fig.4 Pushover Curve

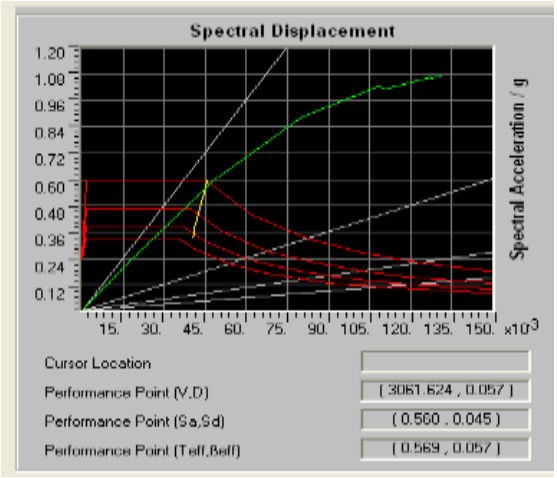


Fig.5 Capacity Spectrum

Step	Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
0	0.0000	0.0000	2216	8	0	0	0	0	0	0	2224
1	0.0190	1074.4996	2135	89	0	0	0	0	0	0	2224
2	0.0599	3235.5374	2039	163	22	0	0	0	0	0	2224
3	0.1000	4869.0835	1956	175	75	16	1	1	0	0	2224
4	0.1331	5721.3188	1956	173	77	16	1	0	0	1	2224
5	0.1331	5654.8271	1951	175	80	16	0	1	0	1	2224
6	0.1359	5721.5176	1948	175	83	16	0	0	0	2	2224
7	0.1359	5682.2065	1928	185	57	44	6	2	0	2	2224
8	0.1557	6064.8677	1928	185	56	45	6	0	2	2	2224
9	0.1557	6022.9268	1924	186	57	46	4	3	2	2	2224
10	0.1604	6110.5127	1924	184	57	46	4	1	5	3	2224
11	0.1596	5830.1499	2224	0	0	0	0	0	0	0	2224

Fig. 6 Tabular format of pushover curve for Existing Building without shear wall in X-dirn.

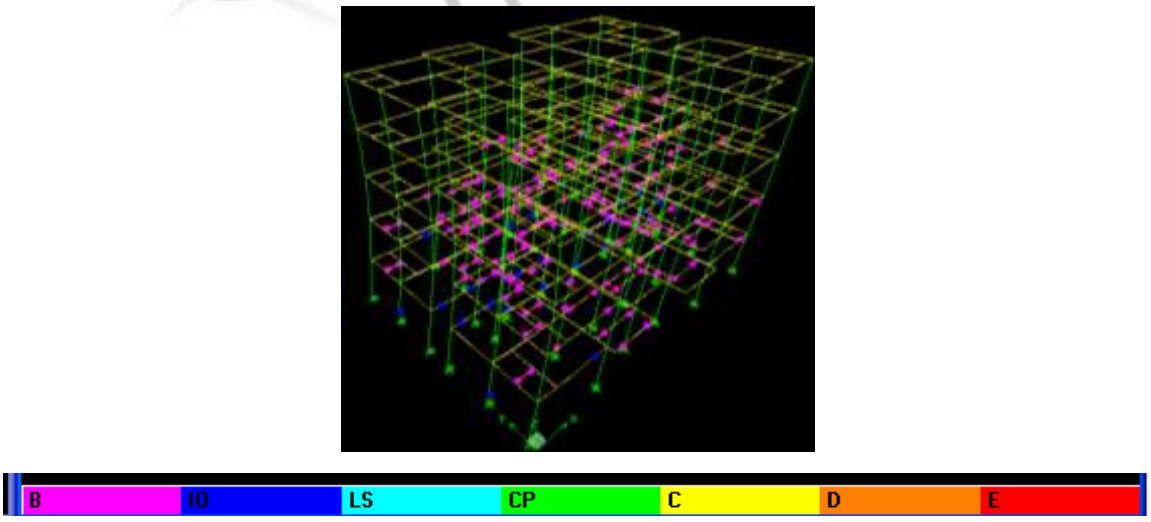


Fig.7 Hinge formation Existing building without strut X-direction at performance point

Existing Building with shear wall

Figure 8 and figure 9 shows the Pushover curve and Capacity Spectrum Curve.

The base shear at performance point for loading in X-direction was 3027.191kN and corresponding displacement 16mm.There were 13 steps of analysis in X-direction. Table 2shows the hinge formation of Existing building with shear wall in X direction. From Table 2, for loading in X-dirn, at performance point, outof 2224 assigned hinges, 2028 hinges were in linear range, 196 were in B-IO range. Thus the overall building was considered to be in immediate occupancy level in case of predicted earthquake in X-dirn.

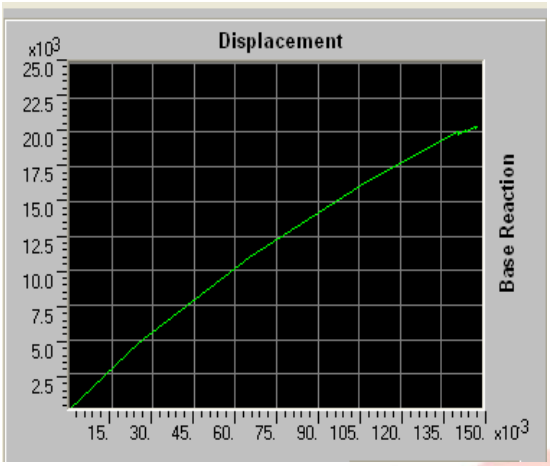


Fig.8 Pushover Curve

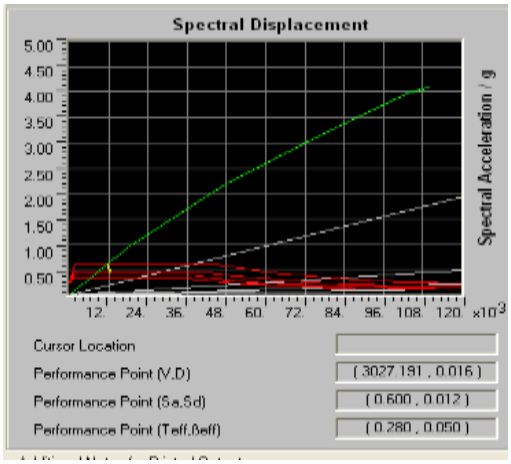


Fig.9 Capacity Spectrum

Step	Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
0	0.0000	0.0000	2222	2	0	0	0	0	0	0	2224
1	0.0246	4708.5225	2028	196	0	0	0	0	0	0	2224
2	0.0648	10962.9961	1904	270	49	1	0	0	0	0	2224
3	0.1056	16080.5801	1820	275	93	12	22	2	0	0	2224
4	0.1409	20062.8281	1817	276	91	16	22	0	2	0	2224
5	0.1409	19844.2168	1813	274	97	16	20	2	2	0	2224
6	0.1438	20171.4668	1813	273	96	16	20	1	5	0	2224
7	0.1438	20082.7285	1812	273	97	16	20	0	6	0	2224
8	0.1438	20046.9785	1812	273	97	16	18	2	6	0	2224
9	0.1441	20086.9063	1812	271	97	17	18	0	9	0	2224
10	0.1441	20028.0566	1806	270	104	17	14	4	9	0	2224
11	0.1471	20384.2324	1806	270	102	19	14	0	13	0	2224
12	0.1471	20284.5020	1806	269	103	19	12	2	13	0	2224
13	0.1484	20419.1953	2224	0	0	0	0	0	0	0	2224

Fig. 10 Tabular format of pushover curve for Existing Building without shear wall in X-dirn.

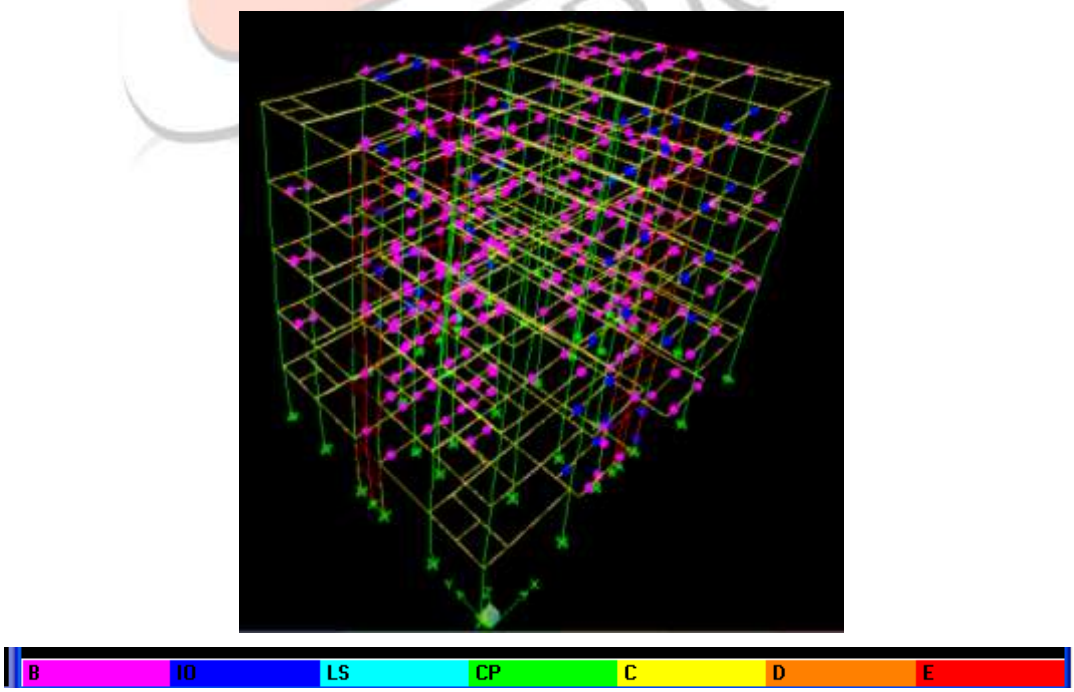


Fig.11 Hinge formation Existing building with shear wall in X-dirn. at performance point

Table 1 Results for Existing buildings for Push X

No.	Name	Perfor-mance Point in X (KN)	Displace-ment in X (M)	Perfor-mance Level	Perfor-mance Point in X (KN)	Displace-ment in X (M)	Perfor-mance Level
1	**Existing Building (Without Shearwall)**	3061.62	0.057	IO-LS	3041.94	0.041	LS-CP
2	**Existing Building (With Shearwall)**	3027.19	0.016	B-IO	3173.06	0.024	IO-LS

VI. CONCLUSION

The pushover analysis was carried out effectively to restrengthing the existing building and from the analysis we conclude following,

- An existing building made without considering shear wall shows its performance in IO-LS in push X i.e. building is called safe against predicted earthquake.
- Even though an existing building is safe for predicted earthquake, some of the members which yielded extensively need an immediate attention - either retrofit or restrengthing.
- An existing building made with considering shear wall shows its performance in IO range in Push X i.e. building is called safe against predicted earthquake.
- Results and behaviour of existing building observed were nearly same as new building.

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