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STUDY OF EXISTING TALL BUILDING BY USING PUSHOVER ANALYSIS

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Abstract - *This study deals with the assessment of seismic performance of an existing building using non linear static analysis or Pushover analysis. The selection of G+13 existing building was with an intension to serve for commercial purpose. Analysis was carried out using ETABS 9.7.1 and also analysis of the same existing tall building which has to serve for Industrial purpose is carried out. The structural model with typical storey height of 3.5m is developed and then seismic behavior of commercial as well as Industrial buildings having LL of 4kN/m² and 7kN/m² respectively are studied using Pushover analysis. By comparing the results one can identify whether retrofitting is recommended or not in this study.*

Key Words: Seismic performance, Pushover analysis, Retrofitting.

1. INTRODUCTION

Structural engineering is having tremendous need with advancement of science and technology. One of the simple and noticeable methods is Pushover analysis which considers non linear characteristics of materials but deals with only static load cases. This analysis has become most preferred analysis method for seismic evaluation of buildings and design purposes as it is relatively simple and post elastic behavior is considered.

1.1 PUSHOVER ANALYSIS

It is a static non linear analysis under permanent vertical loads and gradually increasing lateral loads. It is a popular tool for seismic tool for seismic performance evaluation of existing and new structures. The necessity of Pushover analysis is that, as Indian buildings built over decades are seismically deficient due to lack of awareness regarding seismic behaviour of structures, it generates great demand for seismic evaluation and retrofitting of existing buildings.

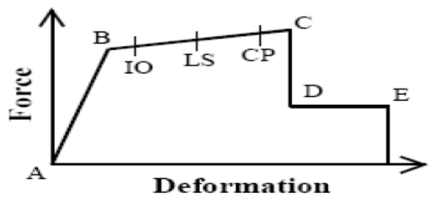


Fig -1: **Force-Deformation Relation in Pushover Analysis**

1.2 OBJECTIVES

1. To determine the effective method to find strength of concrete over Non-Destructive Tests (NDT) on existing commercial building using Static Analysis.
2. The performance and behaviour of the existing commercial building is studied using pushover analysis.
3. To study the performance and behaviour of existing building which has to serve as Industrial building using pushover analysis.
4. To study behaviour of the retrofitted Industrial building by pushover Analysis.

2. STRUCURAL MODEL

Model is done using ETABS 9.7.1. The structural models story height of 3.5m is kept same and live load of 4kN/m² for commercial building and 7kN/m² for Industrial Building. Building plan is shown is figures below.

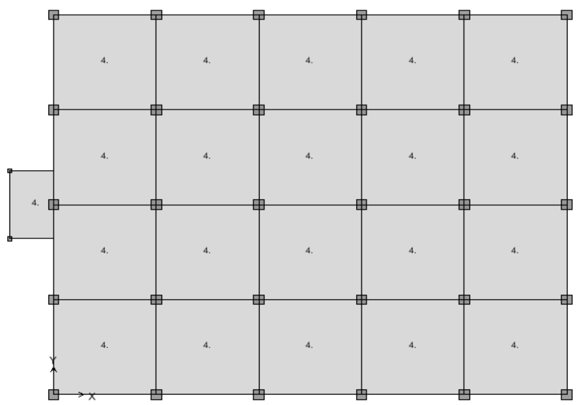


Fig -2: T1 type of commercial Building

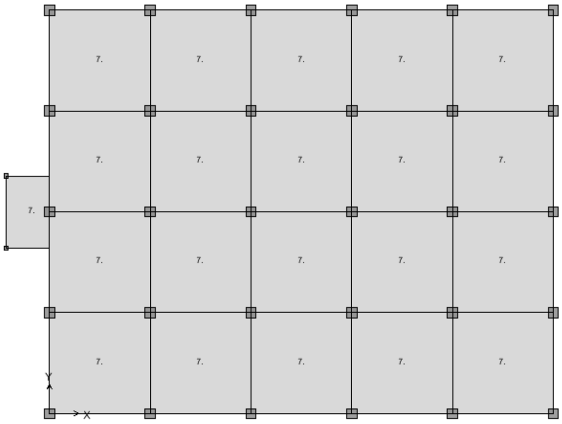


Fig -3: T2 type of Industrial Building

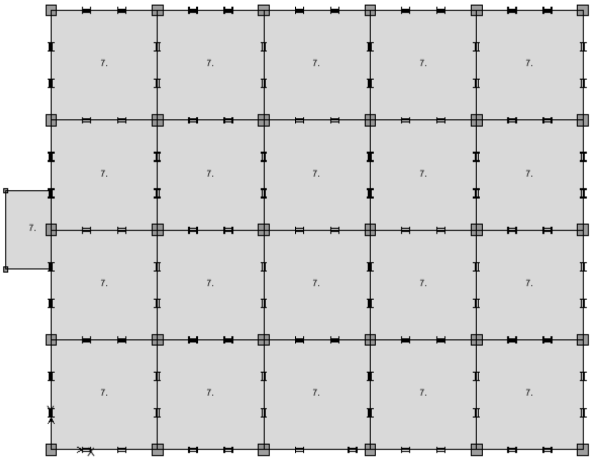


Fig -4: T3 type of Retrofitted Industrial Building

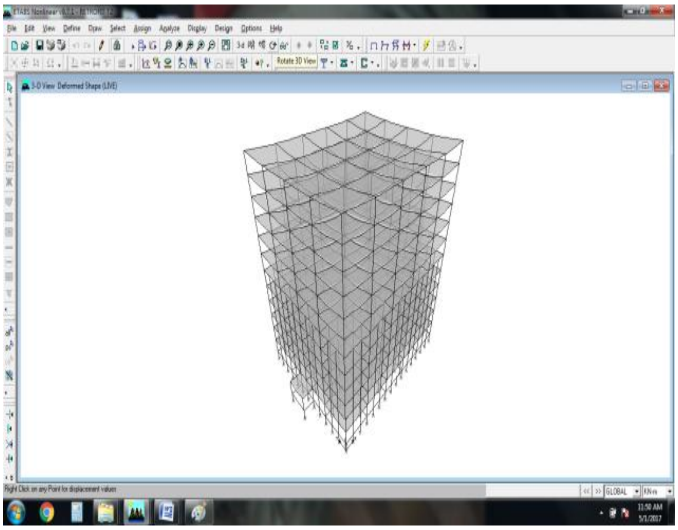


Fig -5: 3D view of T3 model after analysis

2.1 Types of models

There are three types of model
- Commercial building with live load of 4kN/m^2 (TYPE1)
-Industrial building with live load of 7kN/m^2 (TYPE2)
- Retrofitted Industrial building with live load of 7kN/m^2 (TYPE3)

Table -1: Section Details

		COL	BEAM	SLAB
TYPE1	B-14	C 300X300	B 250X500	200
		C 700X700	B 700x700	200
TYPE2	B-14	C 300X300	B 250X500	200
		C 700X700	B 700x700	200
TYPE3	B-14	C 300X300	B 250X500	200
		C 700X700	B 700x700	200
		Dbl.ISMB550		

Table -2: SEISMIC LOADING ZONE AS PER IS:1893 2002

DETAILS	VALUE
R	5
I	1.5
Z	0.24
Sa/G	Type2

Table -3: Material Properties

MODEL TYPE MATERIAL PROPERTIES	All Model
Column	M35
Beam	M25
Slab	M25

Slab thickness: 200mm
Dead Load: Floor finish = 2 kN/m^2
Roof floor finish = 3 kN/m^2
Imposed Load: On roof 1.5 kN/m^2
Hinge Assignment Beams : default M3=0
default M3=1
Columns: default P-M-M =0
default P-M-M =1
Static non linear data for PUSH1
DL=Dead load factor 1
LL=Live load factor 0.5
FF=Floor finish factor 1
EQX= 1

3. RESULT AND DISCUSSION

DETERMINATION OF GRADE OF CONCRETE

Table -4: Calculation of Compressive strength of concrete(fck)

Col size(mm)	700X700	
(Characterstic strength of steel) fy	500	N/mm²
Rebar percentage	2.93	%
(Axial load) Pu=	10553	kN
(Area of concrete) Acon=	490000	mm²
(Area of steel) Ast=	14357	mm²
(Area of cement)Ac=	475643	mm²
(Compressive strength of concrete)fck=	32.82871818	N/mm²
Therefore,fck=	35	N/mm²

Fig -7: Base shear Vs Displacement of T2 model

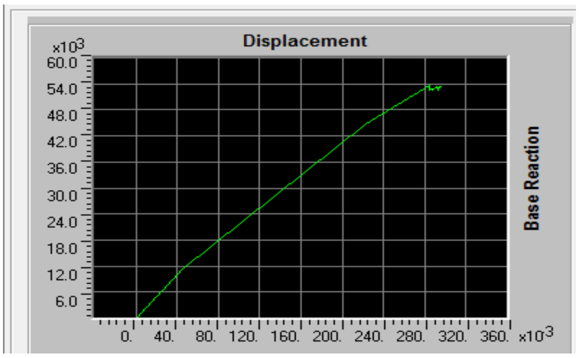


Fig -8: Base shear Vs Displacement of T3 model

3.1 Pushover Curves

Type1 model, the ultimate base shear is around 9307 kN and the corresponding roof displacement is 467mm is shown in Fig 6
Type2 model, the ultimate base shear is around 9078kN and the corresponding roof displacement is 461mm is shown in Fig 7
Type3 model, the ultimate base shear is around 53640kN and the corresponding roof displacement is 297 mm is shown in Fig 8

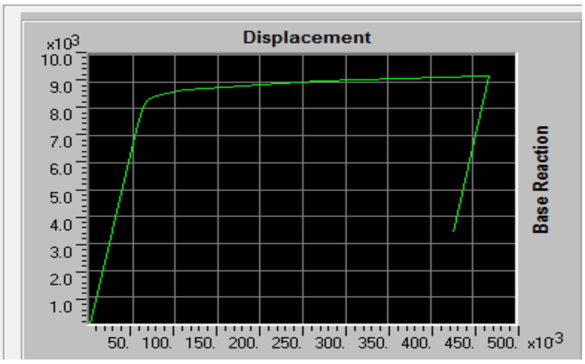


Fig -6: Base shear Vs Displacement of T1 model

3.2 Capacity Spectrum

The base shear at performance point is 8824kN and corresponding displacement is 175mm is shown in Fig 9 overall performance of building is said to be Live safety to Collapse prevention.
The base shear at performance point is 8798kN and corresponding displacement is 175 mm is shown in Fig 11 overall performance of building is said to be Live safety to Collapse prevention.
The base shear at performance point is 28311kN and corresponding displacement is 136mm is shown in Fig 13. overall performance of building is said to be in Immediate occupancy.

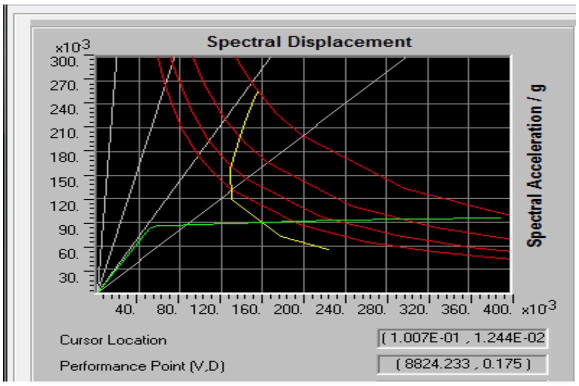
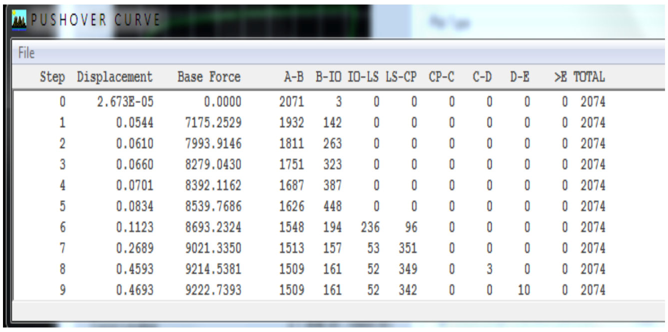


Fig -9: Capacity spectrum of T1 model.



PUSHOVER CURVE

File

Step	Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
0	2.673E-05	0.0000	2071	3	0	0	0	0	0	0	2074
1	0.0544	7175.2529	1932	142	0	0	0	0	0	0	2074
2	0.0610	7993.9146	1811	263	0	0	0	0	0	0	2074
3	0.0660	8279.0430	1751	323	0	0	0	0	0	0	2074
4	0.0701	8392.1162	1687	387	0	0	0	0	0	0	2074
5	0.0834	8539.7686	1626	448	0	0	0	0	0	0	2074
6	0.1123	8693.2324	1548	194	236	96	0	0	0	0	2074
7	0.2689	9021.3350	1513	157	53	351	0	0	0	0	2074
8	0.4593	9214.5381	1509	161	52	349	0	3	0	0	2074
9	0.4693	9222.7393	1509	161	52	342	0	0	10	0	2074

Fig -10: Hinge distribution table of T1 model

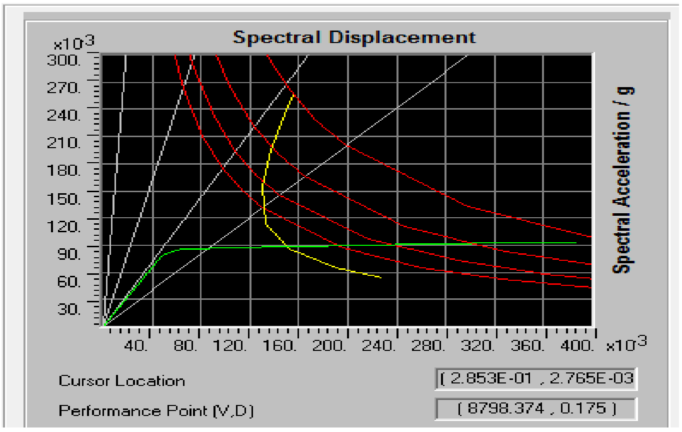
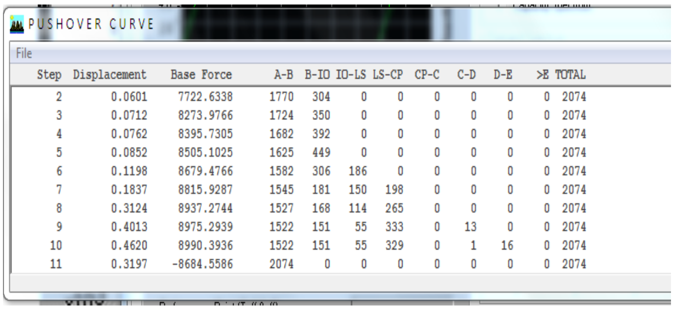


Fig -11: Capacity spectrum of TYPE 2



PUSHOVER CURVE

File

Step	Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
2	0.0601	7722.6338	1770	304	0	0	0	0	0	0	2074
3	0.0712	8273.9766	1724	350	0	0	0	0	0	0	2074
4	0.0762	8395.7305	1682	392	0	0	0	0	0	0	2074
5	0.0852	8505.1025	1625	449	0	0	0	0	0	0	2074
6	0.1198	8679.4766	1582	306	186	0	0	0	0	0	2074
7	0.1837	8815.9287	1545	181	150	198	0	0	0	0	2074
8	0.3124	8937.2744	1527	168	114	265	0	0	0	0	2074
9	0.4013	8975.2939	1522	151	55	333	0	13	0	0	2074
10	0.4620	8990.3936	1522	151	55	329	0	1	16	0	2074
11	0.3197	-8684.5586	2074	0	0	0	0	0	0	0	2074

Fig -12: Hinge distribution table of T2 model

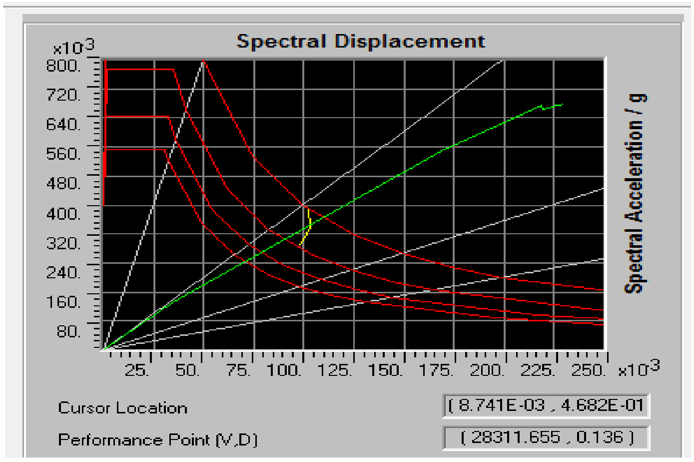
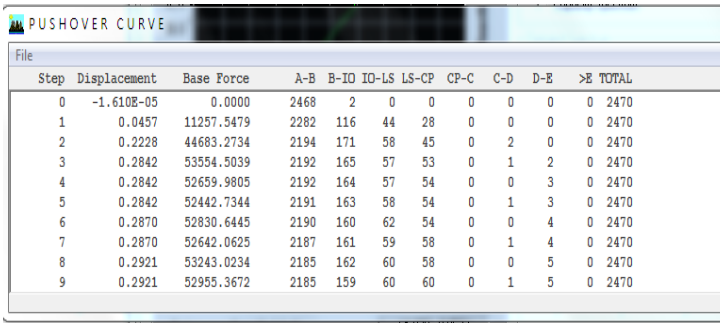


Fig -13: Capacity spectrum of TYPE 3



PUSHOVER CURVE

File

Step	Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
0	-1.610E-05	0.0000	2468	2	0	0	0	0	0	0	2470
1	0.0457	11257.5479	2282	116	44	28	0	0	0	0	2470
2	0.2228	44683.2734	2194	171	58	45	0	2	0	0	2470
3	0.2842	53554.5039	2192	165	57	53	0	1	2	0	2470
4	0.2842	52659.9805	2192	164	57	54	0	0	3	0	2470
5	0.2842	52442.7344	2191	163	58	54	0	1	3	0	2470
6	0.2870	52830.6445	2190	160	62	54	0	0	4	0	2470
7	0.2870	52642.0625	2187	161	59	58	0	1	4	0	2470
8	0.2921	53243.0234	2185	162	60	58	0	0	5	0	2470
9	0.2921	52955.3672	2185	159	60	60	0	1	5	0	2470

Fig -14: Hinge distribution table of T3 model

3.2 Output

Table -5: Time period of T1 and T2 models

TIME PERIOD		
	Period T1	**Period T2**
1	1.495984	1.495983
2	1.464757	1.464757
3	1.314588	1.314585
4	0.488513	0.488512
5	0.479319	0.479319
6	0.431555	0.431554
7	0.280868	0.280868
8	0.276684	0.276684
9	0.251331	0.251331
10	0.192763	0.192763
11	0.190254	0.190254
12	0.173095	0.173095

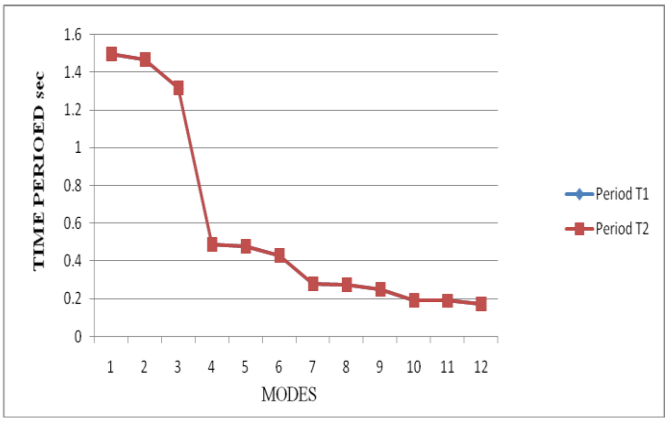


Chart -1: Graph of Time period showing T1 and T2 models

Table -6: Time period of T1 and T2 models

DISPLACEMENTS		
	UX T1	**UX T2**
13	422.2494	411.0996
12	420.9112	409.7873
11	417.273	406.6111
10	407.789	398.7492
9	388.4553	382.1157
8	356.8933	353.5165
7	312.7363	311.9642
6	257.6478	258.7104
5	194.5703	196.6772
4	130.3103	132.5415
3	72.8918	74.4512
2	28.631	29.3591
1	3.8301	3.9467
BASE	0	0

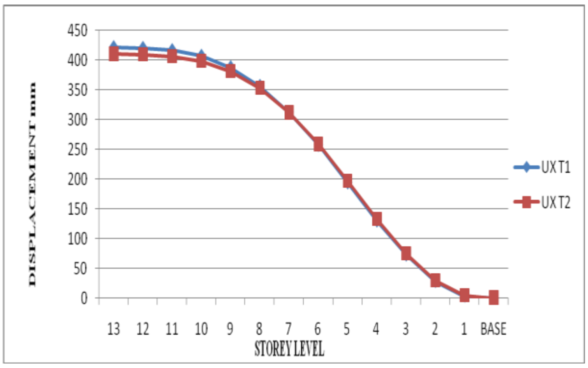


Chart -2: Graph of Displacement (mm) showing T1 and T2 models

Table -7: Storey Drift ratio of T1 and T2 models

STOREY DRIFTS		
	DriftX T1	**DriftX T2**
13	0.000729	0.000695
12	0.001606	0.00143
11	0.003482	0.002963
10	0.006471	0.005635
9	0.010106	0.009187
8	0.013804	0.012982
7	0.016947	0.01635
6	0.018951	0.018638
5	0.019324	0.019271
4	0.017715	0.01783
3	0.013982	0.014136
2	0.00822	0.008321
1	0.002367	0.002385

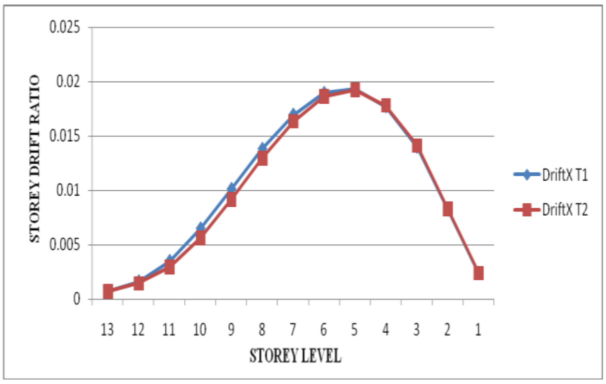


Chart -3: Graph of Storey Drift ratio showing T1 and T2 models

Table -8: Storey Shear of T1 and T2 models

STOREY SHEAR		
	VX T1	**VX T2**
13	-664.41	-714.63
12	-1266.15	-1361.86
11	-1768.38	-1902.05
10	-2180.08	-2344.88
9	-2510.26	-2700.02
8	-2767.88	-2977.12
7	-2961.95	-3185.86
6	-3101.45	-3335.9
5	-3195.36	-3436.91
4	-3252.63	-3498.49
3	-3281.94	-3529.93
2	-3292.47	-3541.09
1	-3293.88	-3542.78

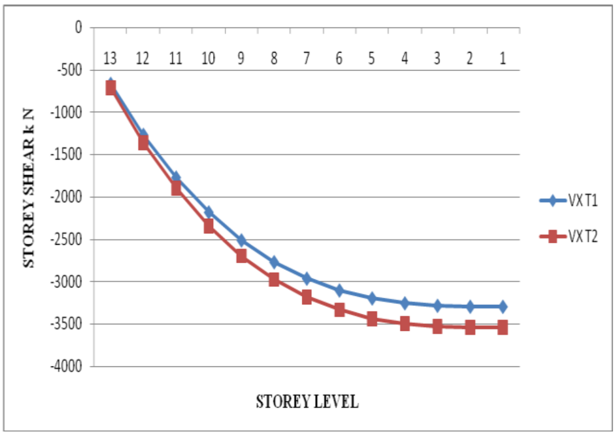


Chart -4: Graph of Storey Shear showing T1 and T2 models

Table -9: Time period of T1 and T3 models

TIME PERIOD		
	Period T1	**Period T3**
1	1.495984	1.011881
2	1.464757	0.987741
3	1.314588	0.88493
4	0.488513	0.390852
5	0.479319	0.38381
6	0.431555	0.349565
7	0.280868	0.223521
8	0.276684	0.220176
9	0.251331	0.200681
10	0.192763	0.150304
11	0.190254	0.147977
12	0.173095	0.135206

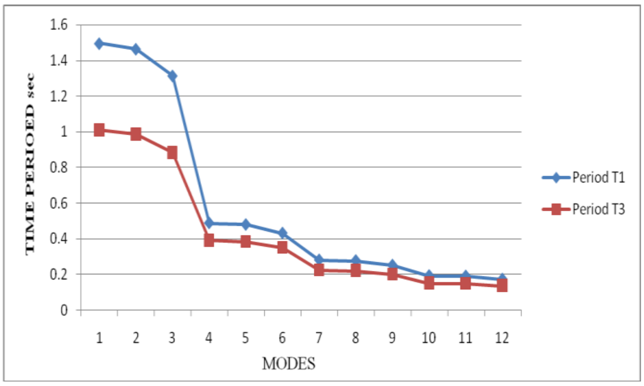


Chart -5: Time period graph showing T1 and T3 models

Table -10: Displacement (mm) of T1 and T3 models

DISPLACEMENTS		
	UX T1	**UX T3**
13	422.2494	268.5618
12	420.9112	256.3862
11	417.273	235.7482
10	407.789	205.9964
9	388.4553	165.4345
8	356.8933	114.6061
7	312.7363	68.7771
6	257.6478	56.4504
5	194.5703	45.579
4	130.3103	34.5091
3	72.8918	23.3829
2	28.631	12.3594
1	3.8301	2.3702
BASE	0	0

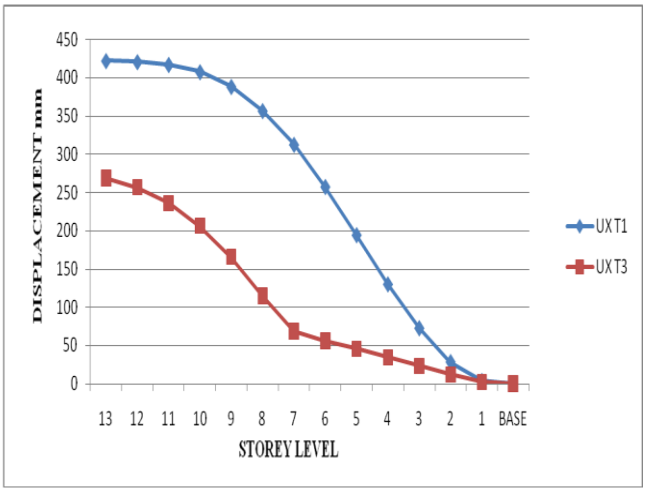


Chart -6: Displacement graph showing T1 and T3 models

Table -11: Storey Drift of T1 and T3 models

STOREY DRIFTS		
	DriftX T1	**DriftX T3**
13	0.000729	0.004456
12	0.001606	0.007525
11	0.003482	0.010759
10	0.006471	0.014522
9	0.010106	0.018144
8	0.013804	0.016801
7	0.016947	0.004782
6	0.018951	0.004269
5	0.019324	0.004342
4	0.017715	0.004362
3	0.013982	0.004325
2	0.00822	0.003925
1	0.002367	0.001636

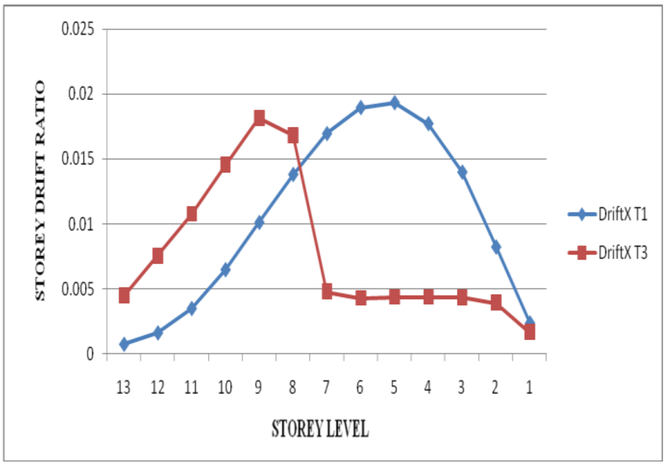


Chart -7: Storey Drift graph showing T1 and T3 models

Table -12: Storey Drift of T1 and T3 models

STOREY SHEAR		
	VX T1	VX T3
13	-664.41	-8232.8
12	-1266.15	-15689
11	-1768.38	-21912.2
10	-2180.08	-27013.7
9	-2510.26	-31104.9
8	-2767.88	-34297.1
7	-2961.95	-36780.9
6	-3101.45	-38626.7
5	-3195.36	-39869.3
4	-3252.63	-40627.7
3	-3281.94	-41019.4
2	-3292.47	-41166.2
1	-3293.88	-41175.9

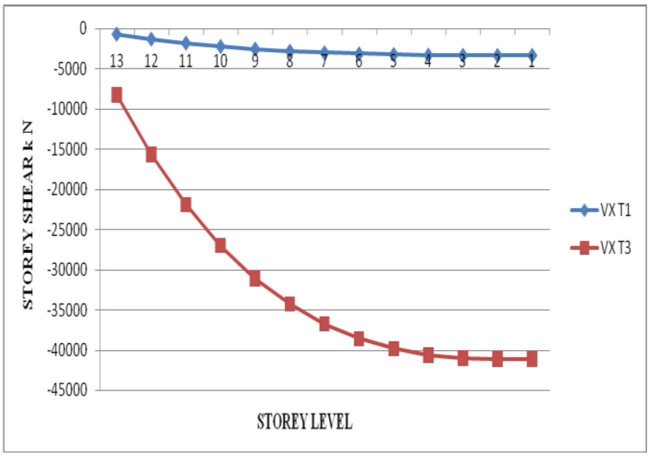


Chart -8: Storey Shear graph showing T1 and T3 models

4. CONCLUSIONS

PUSHOVER ANALYSIS

1) By comparison of T1 and T2 models, as expected we got the results with failure of columns.
2) By using steel sections, in between failed columns, one can reduce the earthquake responses like displacements and storey drifts.
3) This work has showed the method to determine the strength of columns without using any Non Destructive Tests(NDT's)
4) By comparing T1 and T3 models, we seen that as T1 model results shown in the region of Live Safety to Collapse Prevention we decided to make retrofitting and hence results obtained of T3 model fell in region of Immediate Occupancy.

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