SEISMIC CALCULATION OF EXISTING REINFORCED CONCRETE BUILDING

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Abstract - In the study of evaluation of any building made up of reinforced concrete is done by using method of inelastic method, capacity curve method etc. Capacity curve which is load deformation plot is output of inelastic method. As this inelastic analysis is nonlinear static analysis, so load deformation curve is obtained from ETABS. ETABS which is based on finite element method is used for performing the non-liner static inelastic analysis and cracking pattern can be analyzed in ETABS. The need of retrofitting of any particular element of any existing building will be obtained by cracking pattern. In this first symmetrical building is analyzed on ETABS for the procedure development as per ATC-40 then symmetric evaluation is done on unsymmetrical building designed for without considering seismic effect and then same building considering the seismic effect according to IS 1893:2002. These results then compared for suggestion.

Keywords: Elastic-Curve, Response Spectrum, ATC Procedure, Cracking Pattern.

I. INTRODUCTION

During earthquakes, buildings that appear to be strong enough, crumble like houses of cards and their deficiencies are (maybe) exposed. Certain past earthquakes for e.g. earthquakes of Bhuj, 2001, show that most of the buildings collapsed were deficient and did not meet the requirements of the present day codes. Thus, due to the ignorance for earthquakes resistant designing of buildings in our country and also wrong construction practices occurring in India, most of the buildings are vulnerable to earthquakes occurring in future.

Seismic designing, in a simplest case is observed to be a two-step process. Firstly, the most important, is the formation of an effective structural system that needs to be sorted out keeping in mind all-important objectives of seismic performance, ranging from the serviceability of the structure, considering life safety and also keeping in mind the collapse prevention. This step mainly involves the art of seismic engineering as no rigid rules can, or should, be obligatory on the creativity of the engineers. By default, the creation process is dependent on judgment, experience and understanding of the seismic behavior rather than tedious and rigorous formulations by using mathematics. For an effective structural system, certain point need to be kept in mind-Rules of thumb for stiffness and strength (desired) targets that is based on the fundaments of ground motion and elastic and inelastic dynamic response characteristics. This would help to configure and roughly size an effective structural system.

Secondly (second step), step of design process which should involve demand /capacity/evaluation at all important performance levels, which also requires and involves the identification of all important capacity parameters and also prescription of demands imposed by the ground motions .Suitable capacity parameters and their acceptable values along with a very well suitable methods for demand prediction will depend on the performance level that is to be evaluated. Thus, the above facts shows that it is imperative to seismically evaluate the past/existing buildings with the present day knowledge, so that major quantity of destruction can be avoided in future earthquakes.

II. PLAN AND SCHEDULES

Table 2.1 Details of Structural drawings

Sr No.	Details of plan	Plan number
1	Typical Beam Layout	1
2	Typical Room Layout	2
3	Typical Column Layout	2
4	Elevation A	3
5	Elevation B	3
6	Beam and Column Schedule	4

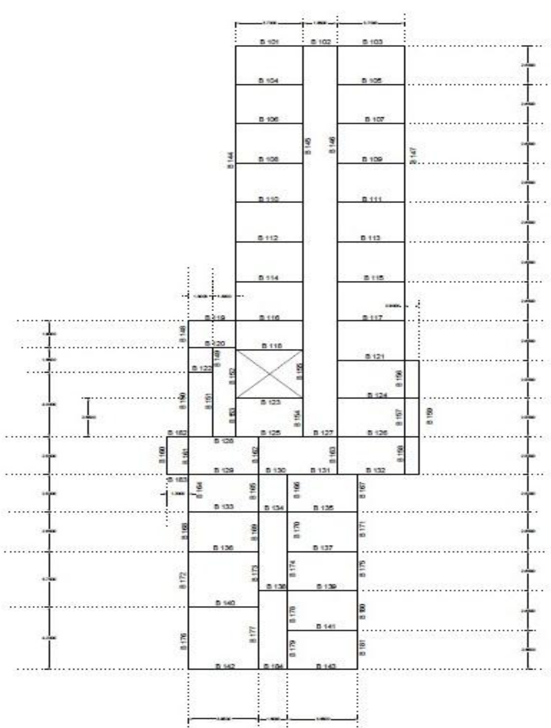
Beam and column schedule of J Block Hostel Building

Table 2.2 Schedule of beams

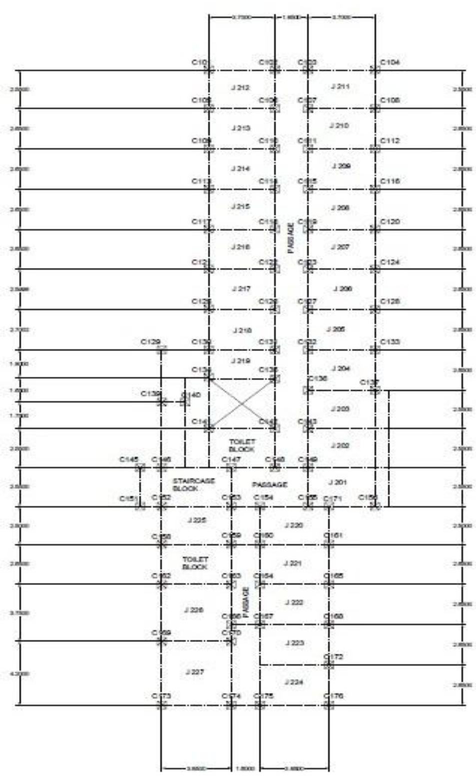
Sr no	Beam designation	Width (mm)	Depth (mm)
1	B101 , B102 , B103	230	500
2	B104 – 117	230	470
3	B144 , B147	230	450
4	B145 , B 146	230	400
5	B121 , B124 , B126 , B132	230	470
6	B156 , B157 , B158	230	850

7	B154 , B155	230	400
8	B152 , B153 , B127	230	350
9	B151	230	550
10	B149	230	320
11	B122	230	320
12	B119 , B120	230	400
13	B167 , B180 , B176 , B171 , B167	230	550
14	B176 , B172 , B168 , B164	230	550
15	B130 , B131	230	750
16	B134	230	400
17	B138	230	450
18	B177 , B179 , B173 , B178	230	950
19	B169 , B166	230	400
20	B135 , B137 , B139 , B141 , B143	230	470
21	B142	230	700
22	B133 , B136 , B140 , B151	230	550
23	B129	230	500
24	B 102	230	450
25	B128	230	600
26	B148	230	440
27	B159	230	450
28	B162	230	650
29	B119 , B161 , B160 , B182 , B183	230	350
30	B 184	230	450

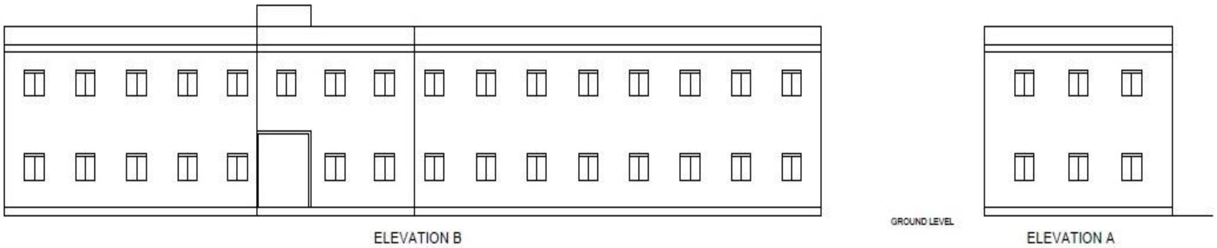
Size of Column :- 250 mm x 250 mm



TYPICAL BEAM LAYOUT



COLUMN LAYOUT



III. SEISMIC EVALUATION OF G+1 HOSTEL BUILDING

3.1 Preliminary Investigation

General details of the structure:-

3.1 Preliminary information of the structure

Sr no.	Parameter	Details
1	Name of the structure	J Block Building (Kondana)
	Address	COEP Hostel
	Age	Approx. 35 years (verbal sources)
2	Type of structure	Reinforced Concrete framed structure
		G+1
3	Base area(Ground floor)	411.14 m^2
	Base area(First floor)	
	Height	8.10 m
4	No of staircases	1
	Lift	Absent
5	Roofing	Concrete slab with water proofing
6	Type of flooring	Marbonate Tiles
7	Details of waterproofing on roof slab	Brick bat coba covered with mortar and tar
8	Exterior paint	Cement Paint
	Interior paint	Distemper
9	Exposure environment	Mild to Moderate
10	Availability of plans/data	Unavailable

3.2 Utility of Floors

Utility of floors

Sr no.	Floor	Details
1	Ground floor	18 Residential rooms + 1 Toilet block + 1 Communication Centre
2	First floor	28 Residential rooms + 2 Toilet blocks
3	Terrace	3 Syntex water tanks (2- 2000 litres + 1 -500 litres)

3.3 Structural Details

Structural details

Sr no.	Parameter	Details
1	Floor to Floor clear height	3.2 m
2	Thickness of floor slab	0.2 m
	Thickness of roof slab	0.2 m
3	Thickness of flooring on floor slab	5 cm
	Thickness of water proofing on roof slab	12 cm
	Thickness of water proofing in Toilet Block	10 cm
4	Thickness of external wall	230 mm
	Thickness of internal wall	150 mm
5	Thickness of plaster (including paint)	15 mm
6	Concrete cover to beam	25 mm
	Concrete cover to column	30 mm
	Concrete cover to slab	20 mm

3.4 Elevation Levels

Elevation levels of structure

Sr. No.	Level Designation	Level (m)
1	Ground level	0.00
2	Plinth level	0.35
3	1st Landing	1.93
4	Ceiling of Ground Floor	3.55
5	Floor level of 1st Floor	3.80
6	2nd Landing	5.40
7	Ceiling of First Floor	7.00
8	Floor Level of Terrace	7.30
9	Top of Terrace Parapet	8.10

3.5 Foundation Data

From the excavation pit in the adjacent area , the following data has been obtained :-
Depth of excavation pit – 113 cm
Depth of brickwork (footpath) below ground level – 68 cm
Depth of soil below brickwork – 68 cm to 113 cm
Hence , it can be assumed that the hard rock is available at 1.5 m

IV. ANALYTICAL ASSESSMENT OF STRUCTURE

Software used: - ETABS

Case	Type of loading	Details
1	Gravity Loading	Live load:- 2 kN/sq.m fck of beams:- 15 MPa fck of columns:-17 Mpa Steel – Mild steel (Fe 250)
2	Earthquake Loading	Seismic Coefficient Method Region :- Pune (Zone 3) Type of soil:- Medium soil Steel – Mild steel (Fe 250)
3	Pushover Loading	D=0.2 m , fck of beams = 18 MPa , fck of columns = 15 Mpa

4.1 Case 1:- Gravity Loading

In this case, the stability of structure is checked under live load and dead load. The real sizes of the beams, columns and slabs are given as inputs.

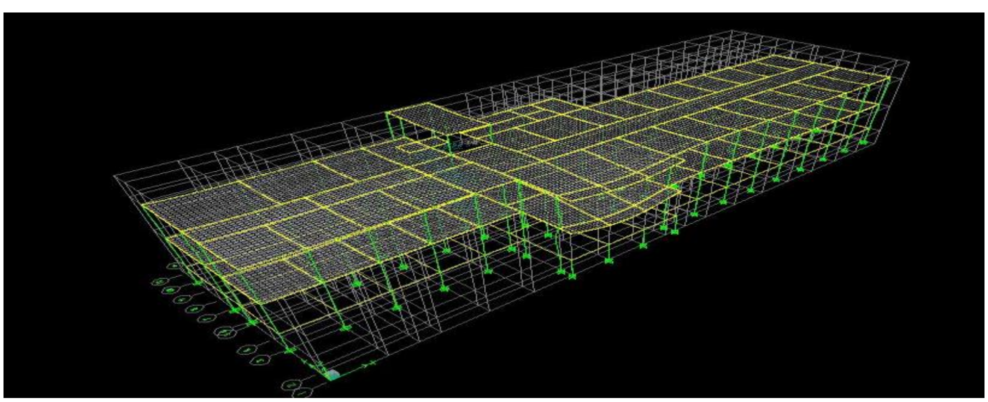


Fig.4.1 Deformed shape of the structure under gravity loading

Summary: - The structure is safe under gravity loading with deflection and stresses under limit.

4.2 Case 2:- Earthquake Loading

Seismic Coefficient Method
Region: - Pune (Zone 3)
Type of soil: - Medium soil
Steel – Mild steel (Fe 250)

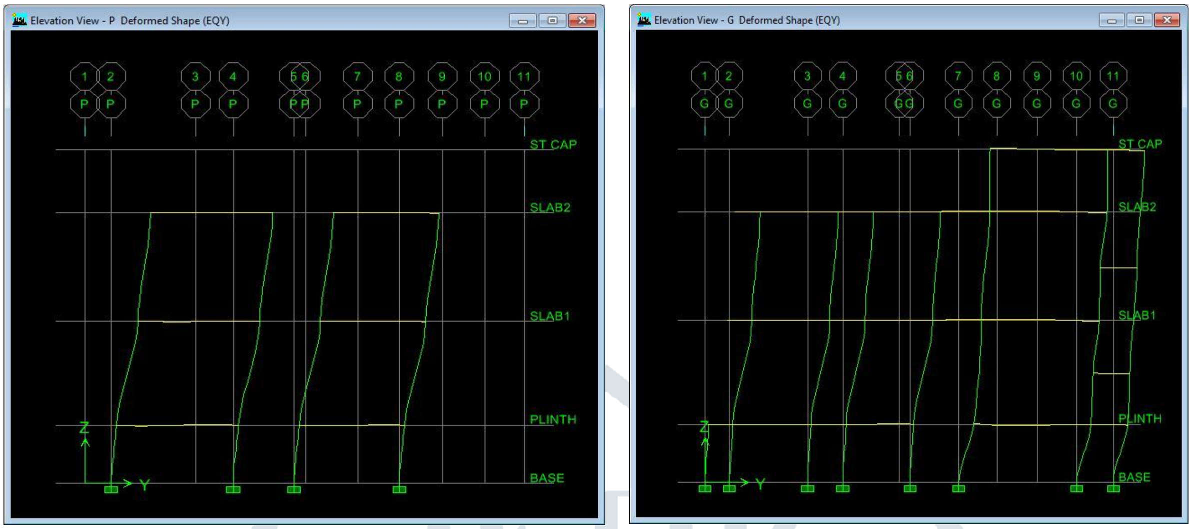


Fig.4.2.1 Deformed shape of structure under Gravity+Earthquake Loading

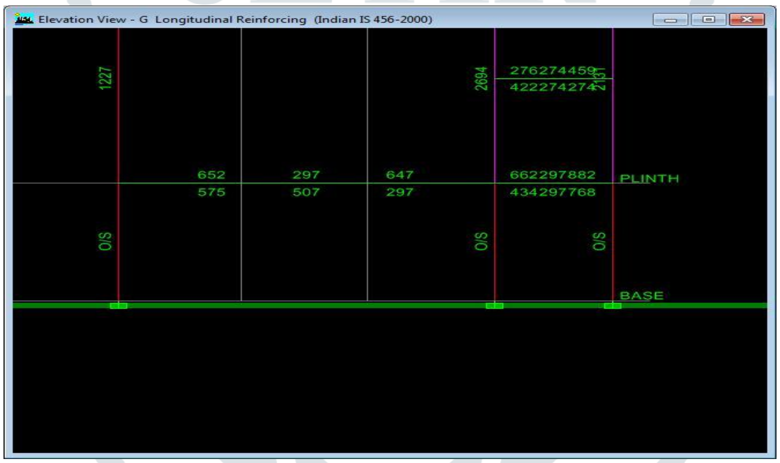


Fig.4.2.2 Figure depicting failed columns under gravity and earthquake loading

List of columns critical in shear under Earthquake and gravity loading

Sr No.	Column Designation	Level	Axial Load **Pu (kN)**	Shear force along X direction **Vu2 (kN)**	Shear force along Y direction **Vu3 (kN)**	Shear strength of concrete **Vc (kN)**	Shear strength of stirrups **Vs (kN)**	Shear strength of section **Vn (kN)**	Vu2/Vn	Vu3/Vn	Degree of risk
1	C156	FF	106.36	372.00	501.28	49.64	35.19	84.83	4.39	5.91	**600%**
2	C156	GF	314.86	190.36	262.94	60.33	35.19	95.51	1.99	2.75	**300%**
3	C137	FF	141.02	412.13	120.32	51.42	35.19	86.60	4.76	1.39	**500%**
4	C137	GF	415.00	240.33	80.23	65.46	35.19	100.65	2.39	SAFE	**200%**
5	C172	FF	52.46	150.70	85.28	46.88	35.19	82.06	1.84	SAFE	**200%**
6	C171	GF	120.76	52.29	289.07	50.38	35.19	85.56	SAFE	3.38	**300%**
7	C155	FF	52.04	41.89	565.00	46.86	35.19	82.04	SAFE	6.89	**700%**
8	C155	GF	107.16	21.41	289.07	49.68	35.19	84.87	SAFE	3.41	**350%**
9	C153	GF	262.38	78.45	258.64	57.64	35.19	92.82	SAFE	2.79	**300%**

List of columns critical in combined axial and bending under Earthquake and gravity loading

Sr no	Column Designation	Level	Axial Load **Pu (kN)**	Major Bending Moment **Mu2 (kNm)**	Minor Bending Moment **Mu3 (kNm)**	Axial Load Capacity **Puz (kN)**	Moment capacity of section **Mur (kNm)**	Pu/Puz	Mu2/Mur	Degree of risk
1	C153	PL	468.01	73.71	9.65	532.56	28.12	SAFE	2.62	**250%**
2	C147	PL	575.29	53.92	11.51	532.56	19.68	1.08	2.74	**250%**
3	C151	PL	123.00	71.06	6.57	532.56	36.56	SAFE	1.94	**200%**
4	C152	PL	288.08	75.63	5.76	532.56	37.96	SAFE	1.99	**200%**

As seen some of the columns are not safe under Load combination – 1.2(DL+LL+EQY) , it seems the structure has not been designed taking ductile detailing into consideration.

Hence, the structural safety is endangered under earthquake loading

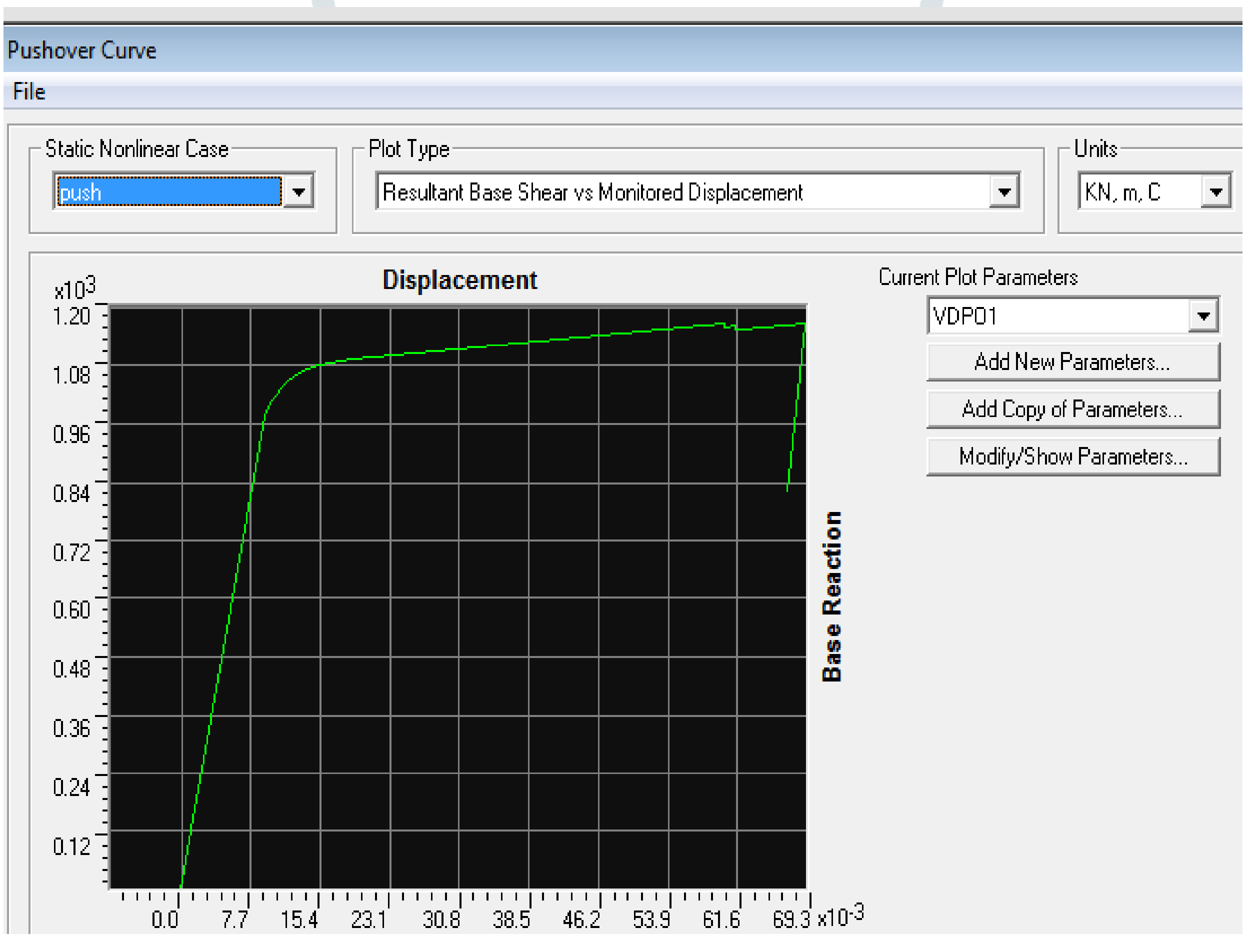
4.3 Case 3:- Pushover Analysis

D=0.2 m (At corner of top slab)

Damping=5%

Results:-

Pushover curve:- Base shear Vs Displacement curve



4.3.1 Graph .Pushover curve:- Base shear Vs Displacement curve

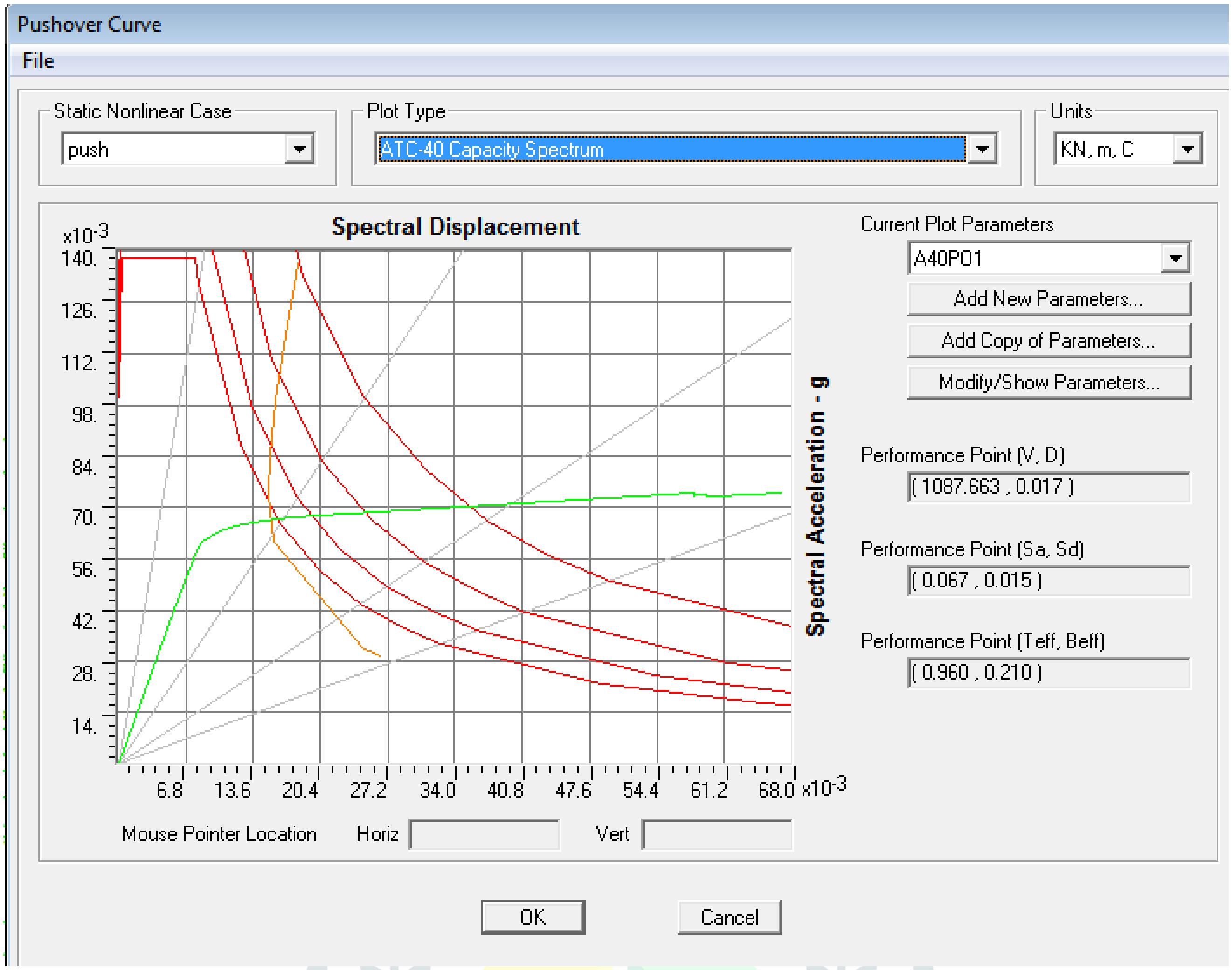
Maximum nodal displacement = 70 mm

Seismic wt of building = 19660 kN

Base Shear capacity = 1171 kN = 5.95 %

Design Base Shear = 1966 kN

Capacity Curve, Demand Curve and Performance Point



4.3.2 Graph. Capacity Curve, Demand Curve and Performance Point

Status of Performance point

Quantity	Value	Quantity	Value
Base Shear (kN)	1087.66	Roof displacement (m)	0.017
Spectral acceleration, Sa (m/s^2)	0.067	Spectral displacement, Sd (m)	0.015

4.3.1 Description of Capacity-Demand curve

1. The red lines indicate the family of demand curves for different degrees of damping starting with 5%, 10%, 15% and 20% respectively. Demand curves are plot of spectral acceleration against spectral displacement. Normally, for RCC structures 5% damping is assumed, hence, First demand is considered for this building.
2. The green line indicates the capacity curve which is the plot of base acceleration against displacement. Capacity curve is derived from the Base shear – displacement curve.
3. The grey lines represent the constant period lines- 0.5 s, 1.0 s, 1.5 s and 2.0 s respectively.

V. CONCLUSION

The building is capable of taking lateral force up to 6 % of its seismic weight. The performance point lies between the zone of Immediate occupancy and Life safety. Hence, when a lateral force equal to around 1087 kN is acted upon the building, there will be light to moderate damage. Cracking may be observed with permanent drifts. The gravity elements will function with no collapse of structure, however, the building may go beyond economical repair. As capacity curve is the output of Pushover analysis, Load Deformation Plot (capacity curve plot) can be obtained from ETABS. Seismic Evaluation of pre-existing R.C buildings is carried out. Firstly, analysis was done on symmetrical building for procedure development as given in ATC 40 guidelines. Then, analysis is done on the asymmetrical building. In first case, evaluation is carried out on the building designed non-seismically and its results (outcomes) have been compared with the analysis of seismically designed building (as per IS 1893:2002). And the affected members have been recommended for strengthening.

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