Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 03, March -2018

PUSHOVER ANALYSIS FOR A MULTISTORIED BUILDING SUBJECTED TO BLAST LOADS USING DIFFERENT BRACING SYSTEMS

K. P. Thejaswi[1]

[1]*Assistant Professor, Civil Engineering Department, KLS Gogte Institute of Technology, Belagavi*

Abstract — *The attack on the Twin Towers of America by the terrorists is an alarming situation and many researchers have focused their attention on the analysis and design of structures subjected to blast loadings.*
In this paper a G+6 storied symmetrical building analysis is done which is subjected to blast loading. A comparative analysis is given when the structure is fitted with X Bracings, Diagonal Bracings, V bracings. The results in the form of Storey Displacement and Storey Drift are compared for all the different cases considered. Push over analysis is carried out for all the different cases.

Keywords*- Blast load, Bracing systems, R C Blast, SAP 2000, Pushover analysis***.**

INTRODUCTION

The design of blast loading has gained its importance when terrorist attacked the twin towers of America on 11th September 2001. Vehicle bombing is considered as one of the most common type of terrorist attack on structures. It is very important to protect some special buildings against the blast loadings. Analysis of structures exposed to blast loading is difficult because it has to take into account the localized nature of the structure, the large variation of pressure over a relatively small area and the fact of the blast pressure not arriving at every point on the structure at the same time, the uniform transient loads produced by the nearby detonation, combined with the localized structural response results in an extremely complex structural analysis problem.

I. ABOUT BLAST LOADING

The warning for a bomb is well-defined by two fundamentals, the stand off distance R among the source of the blast and target, the bomb magnitude (charge weight W). The incident peak overpressure P_{so} are improved by a reflection fact or as the shock wave meets an objective or structure in its track. Reflection aspects depend on intensity of the shock wave. The blast features define a transient pulse of pressure which is discharged from the source of the blast The transient pulse consists of positive phase during which, incident pressure in the environment considerably go beyond the ambient pressure, often followed by a negative phase during which the incident pressure falls underneath the ambient pressure. It is the relation between the transient pulse and an affected structure which governs the dynamic response of a specific structure.

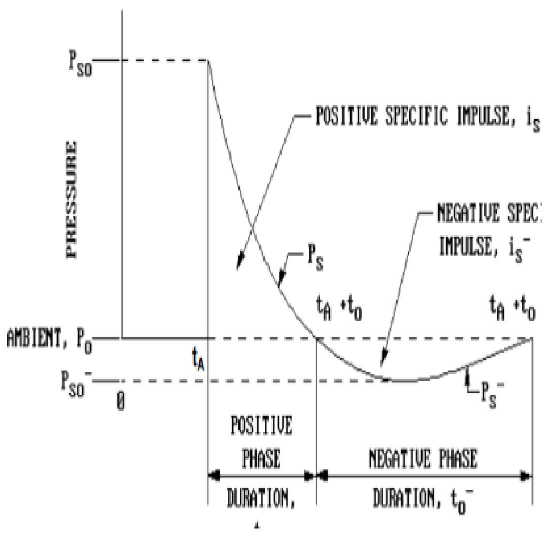
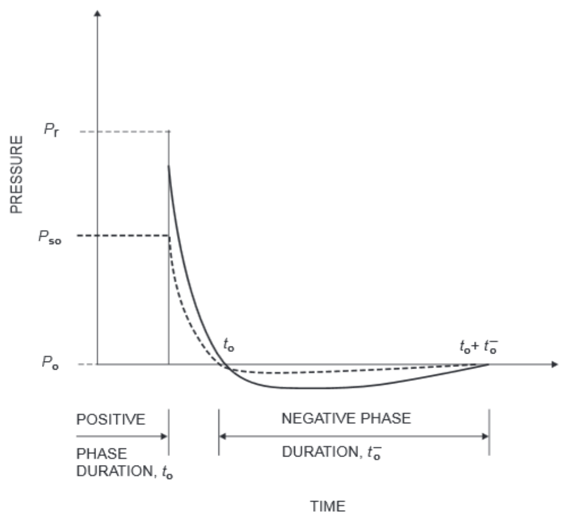


Figure 1: Typical blast pressure with time



Comparison of free field and reflected blast loads

There exists two phases in pressure time profile–

a) Portion beyond the ambient is called positive phase of duration.

b) Portion under ambient is called negative phase of duration.

Blast wave scaling laws

The blast effects is given by scaling distance relative to $(E/Po)^{1/3}$ and scaling pressure relative to Po, where E is the energy release (kJ) and Po the ambient pressure (typically 100 kN/m2), W is charge weight expressed as an equivalent mass of TNT

$$\text{Scaled didtance}(Z) = \frac{R}{W^{1/3}}$$

Nonlinear hinge properties

Hinge properties are required to carry out nonlinear analysis. They are the measure initial stiffness, ultimate strengths and deformability. These are derived using basic principles of mechanics of materials verified by experimental results. The section below gives the component models used for different structural elements.

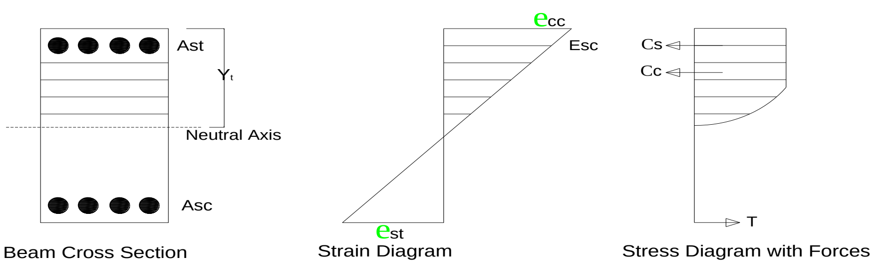


Figure 2: Strip model for beam

The relation between load - deformation is shown in fig.4.6. The parameters “a” and “b” represent the position of the deformation that occurs after yield, i.e., the plastic deformation. Significance of each main point on load deformation curve is explained in ATC-40.

a) Operational (A-B): *The post-earthquake or post-sudden impact damage is the one in which no substantial damage or injury has happened to structural and non-structural components. Structure is reasonable for typical planned inhabitance and usage.*

b) Immediate Occupancy (B-IO): *It is the one in which very minute structural damage has occurred. The perpendicular and lateral-force-resisting structures resist all of their pre-earthquake strength and stiffness. The threat factor of structural damage is very low.*

c) Life Safety (IO-LS): *It is a post-earthquake destruction or post impact destruction level in which structural damage and injuries might happen but the threat of life injuries is not there. Main restoration may require for the structure.*

d) Collapse Prevention (LS-CP): *The structure is ready for entire breakdown. Due of degradation of structure’s strength and stiffness the structure may experience partial or complete collapse.*

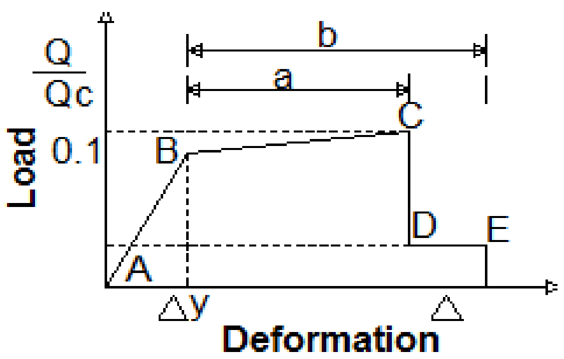
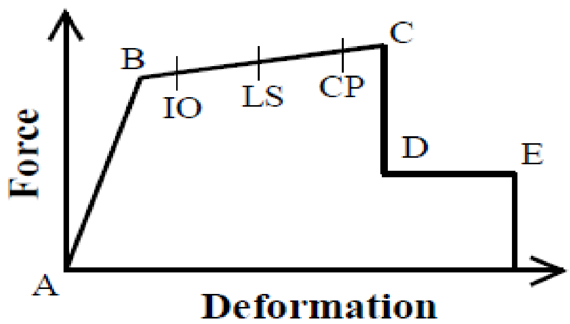


Figure 3: Typical load– deformation curve



Different stages of plastic hinge formation

II. OBJECTIVE OF THE WORK

Analysis of a G+6 storied symmetrical building subjected to blast loading. A comparative analysis of a structure with X bracings, diagonal bracings and V type of bracing systems. For the analysis SAP2000 is used along with RC Blast software. For different cases Push over analysis is carried out. RC Blast software conducts the dynamic inelastic response history analysis of RCC structures exposed to blast loading. The blast loads can be inputted as a sequence of pressure time data and also TNT equivalent explosive mass and stand-off distance so that the software calculates the blast pressure distribution.

Description of the problem
Plan dimension: 12x18m
Total height of the building: 21.2m
Type of concrete used: M30
Type of rebar: HYSD500
Column dimension: 600X600mm
Beam dimension: 300X600mm
Thickness of wall: 230mm
Spacing of beams in X-direction: 6m
Spacing of beams in Y-direction: 6m
Type of steel used for bracing: Fe250
Load combinations: Following load combinations are considered according to IS 456 and IS 4991:1968
i) 1.5DL+1.5SDL+1.5WALL
ii) 1.5DL+1.5LL+1.5SDL+1.5WALL
iii) 1.0DL+1.0LL+0.5BL
The wall load is calculated and live load is taken from IS (875-Part II)

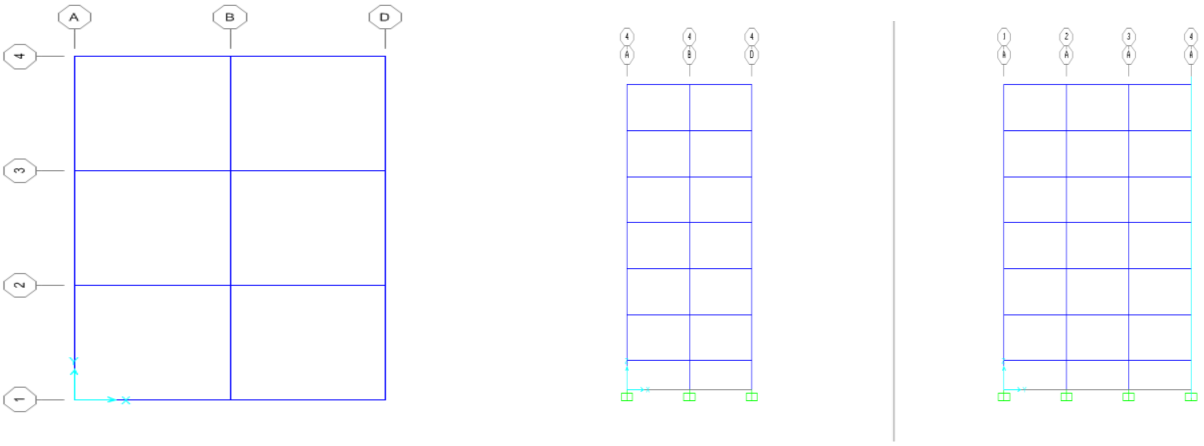


Figure 2: Plan and Elevation on X-Z and Y-Z plane

III. BLAST PRESSURE PARAMETERS

As the height of building rises, scaled distance increases correspondingly and the value of blast pressure reduces by some amount. These blasts reflected positive pressures are applied to the front side of building in the form of blast force. These blast forces can be obtained by multiplying the pressures with the contributing area of each node. A sample calculation for forces acting on the nodes due to blast weight of 100kg at standoff distance of 20m is shown below,

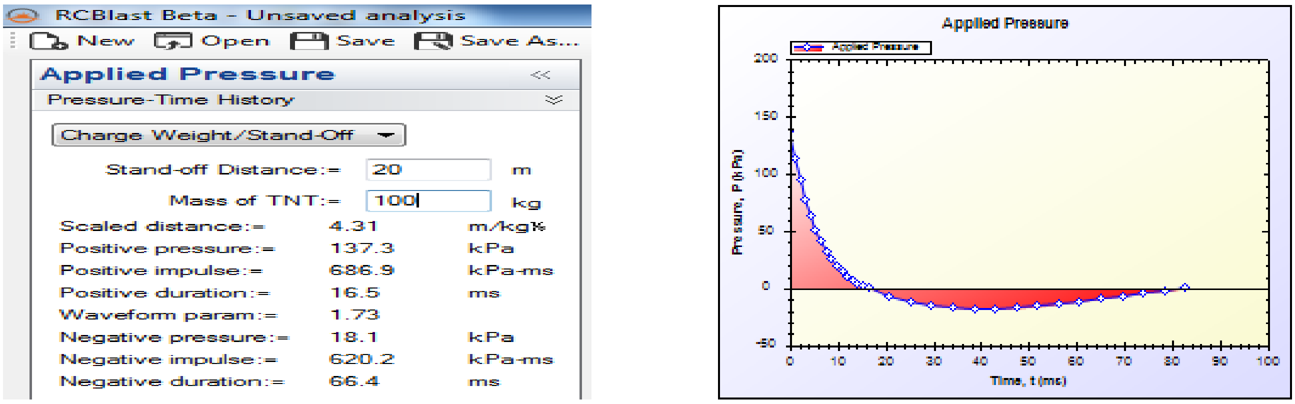


Figure 3: Windows screen of RC Blast software to calculate blast pressure and time

I) For node no 83;
Positive pressure= 137.3 kPa
Blast force P_{83} = 0.1373x0.25x1000 = 34.32 kN
II) For node no 86;
Positive pressure = 80.8 kPa
Blast force P_{86} = 0.0808x0.5x1000 = 40.4 kN
III) For node 89;
Positive pressure = 56.1 kPa
Blast force P_{89} = 0.0561x0.5x1000 = 28.05 kN
IV) For node 80;
Positive pressure = 42.5 kPa
Blast force P_{80} = 0.0425x0.25x1000 = 10.63 Kn

Figure 4: Application of blast load laterally to the nodes

The blast load is applied at each node along front, middle and side face of the structure.

Table 1: Application of blast loads at front side nodes

Node number	Stand off distance, z (m)	Positive pressure (kN/m^2)	Time (ms)	Applied blast load (kN)
83	20.00	1373	16.5	34.32
86	26.00	808	18.3	40.40
89	32.00	561	19.7	28.05
80	38.00	425	20.8	10.63
13	20.09	1360	16.5	68.00
14	26.07	804	18.3	80.40
15	32.06	559	19.7	59.00
6	38.05	424	20.8	21.20
29	20.66	1280	16.7	64.00
24	26.51	780	18.4	70.80
23	32.41	549	19.8	54.90
18	38.35	419	20.9	20.95
37	21.69	1156	17.1	57.80
38	27.32	738	18.6	73.80
39	33.08	531	19.9	53.10
30	38.91	410	21.0	20.50
49	23.12	1015	17.5	50.75
50	28.47	685	18.9	68.50
51	34.03	507	20.1	50.70
42	39.73	397	21.1	19.85
54	24.88	879	18.0	43.95
55	29.91	629	19.2	62.90
56	35.25	479	20.3	47.90
57	40.78	382	21.3	19.10
66	26.90	759	18.5	37.95
67	31.62	572	19.6	57.20
68	36.71	449	20.6	44090
69	42.04	365	21.5	18.25
1	29.14	658	19.1	16.45
2	33.54	519	20.0	25.95

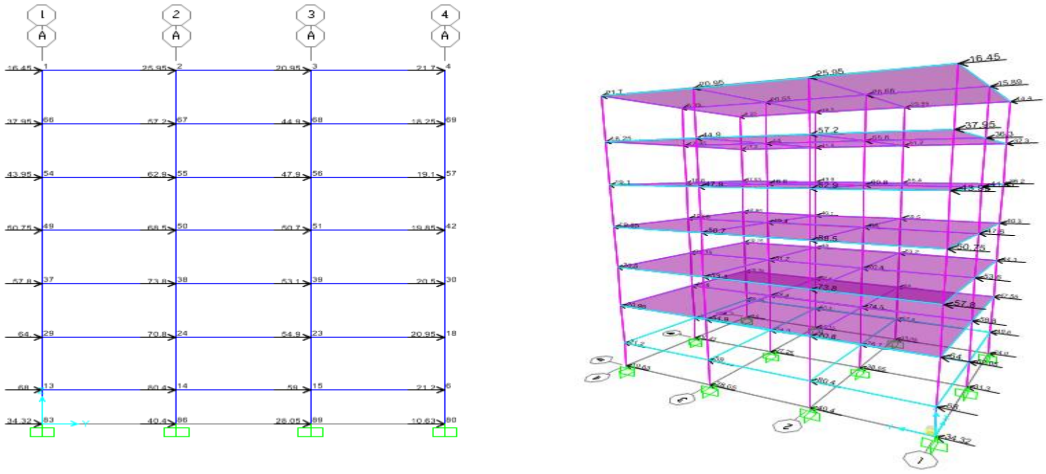


Figure 5: Blast load application on the front side of the structure and three dimensional view of the building with the application of blast load at the node

Displacements of structure at different floors

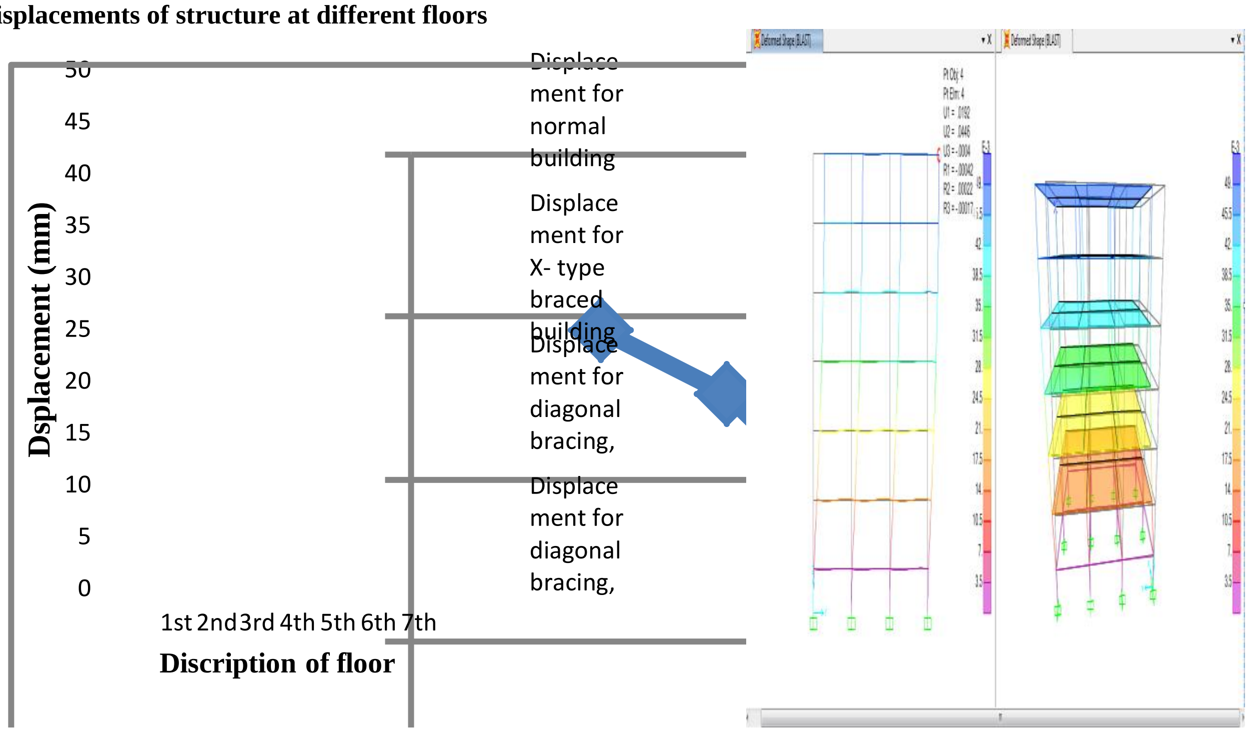


Figure 7: Graph of no of stories v/s displacements and lateral displacement of G+6 storey building without bracing

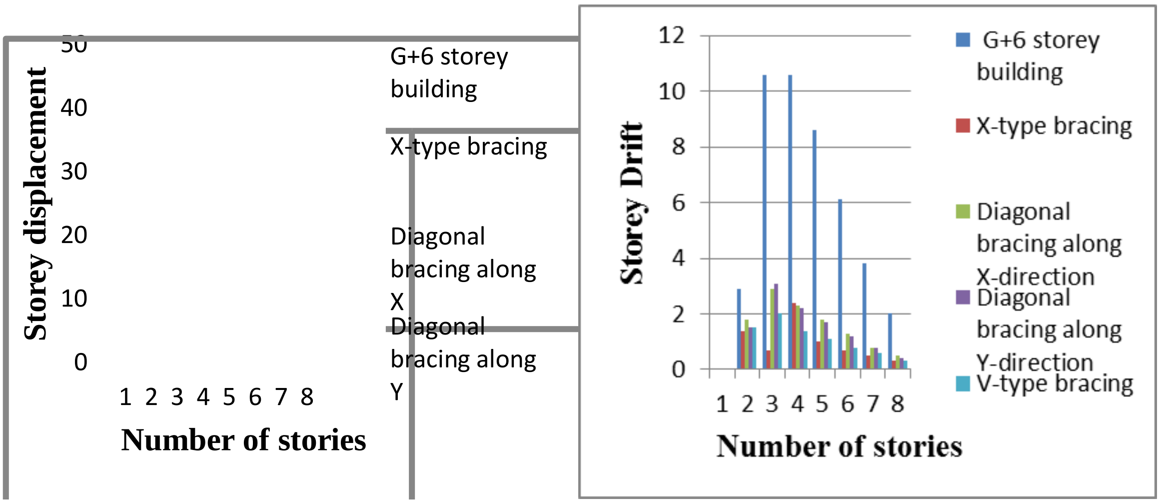


Figure 9: Graph showing No. of Stories V/S Storey displacement and storey drift

Hinge status at performance point

Performance point is all around characterized as a situation for which the seismic or impact limit of the structure is equivalent to the seismic or impact request forced on the structure by the predefined ground movement. The convergence of the demand spectrum with the nonlinear pushover response is called "Performance Point". Depending on position and state of the performance point, it is possible to decide how much safe or weak the structure is. It also tells where strengthening of the structure is required. When the performance point is obtained, the formation of plastic hinge at on the structure at different location can be studied.

Table 5.7 Hinge status at performance point for the G+6 storey building

Model	Displacement (m)	Base Force (kN)	AtoB	BtoIO	IOtoLS	LStoCP	CPtoC	CtoD	DtoE	< E	Total
I	0.076952	12915.606	618	79	48	0	0	69	0	0	814
II	0.34308	3799.301	396	36	93	0	0	85	0	0	610
III	0.163603	14383.697	470	49	91	0	0	0	0	0	610
IV	0.304805	14034.513	574	49	75	13	0	102	0	1	814

I- X-TYPE BRACED STRUCTURE
II- TYPE BRACED STRUCTURE
III- TYPE BRACED STRUCTURE
IV- V-TYPE BRACED STRUCTURE

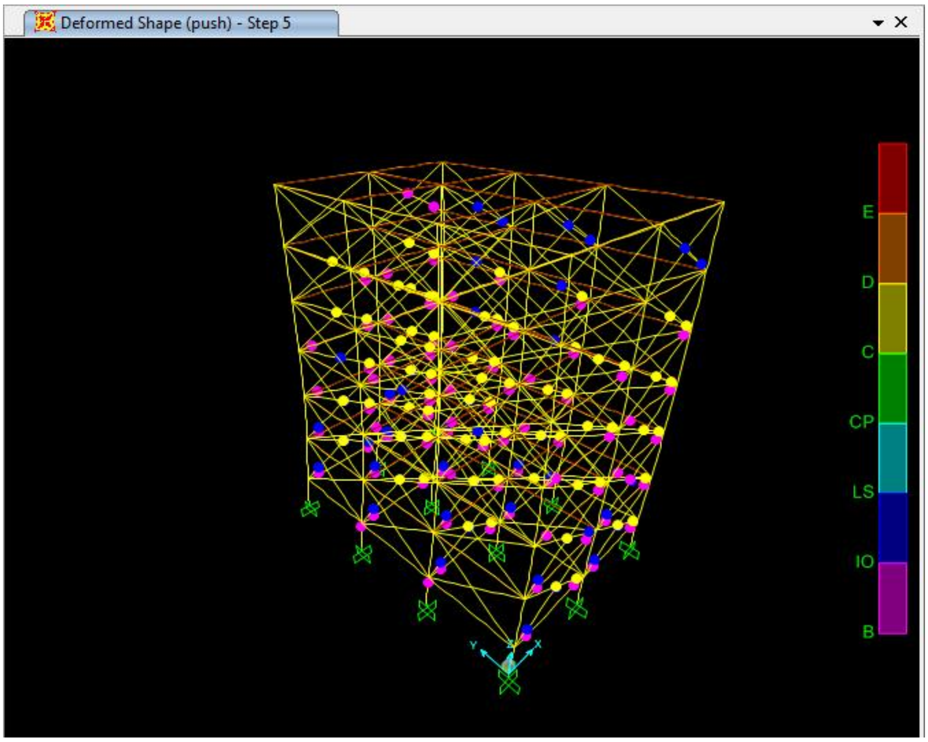


Figure 10: Formation of hinges for X-Type braced structure

For different type of bracing systems it shows that, the hinges formed in the elastic range is found to be more and the plastic hinges formed are lesser in number in model. The plastic hinges found to be in the range of B-IO (Immediate Occupancy) and IO-LS (Life Safety). Hence, the structure performs satisfactory and there is no need of retrofitting of any members.

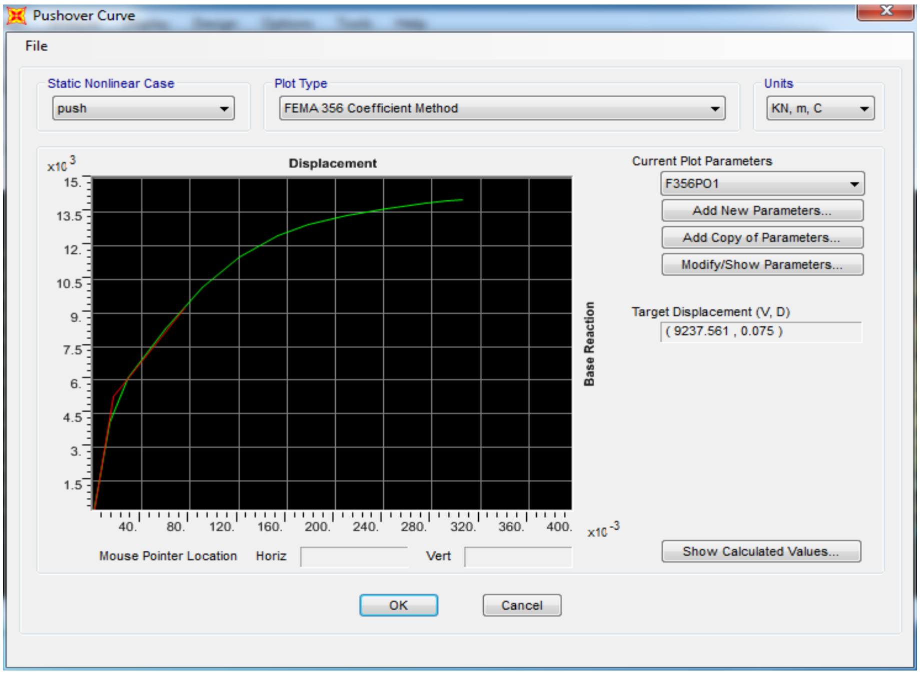


Figure 11: Pushover curve for V-type braced structure

a) The first hinge formation for the G+6 storey structure occurred at 8th stage for which the target displacement(V,D) is (2111.507 kN, 0.162m).

b) For X-type braced structure the first hinge formation occurred at 5th stage for which the target displacement is (12915.606 kN, 0.09m).

c) For diagonal bracing structure the first hinge formation occurred at 8th stage for which the target displacement is (3522.398 kN, 0.13m).

d) For diagonal bracing structure the first hinge formation occurred at 8th stage for which the target displacement is (12666.991 kN, 0.096m).

e) For V-type braced structure the first hinge formation occurred at 5th stage for which the target displacement is (9237.561 kN, 0.075m).

IV: CONCLUSIONS

1. As the stand off distance increases the positive pressure decreases it can be noted that stand off distance is inversely proportional to pressure.
2. Contribution factor of 0.25 is considered for outer nodes but for inner nodes it is taken as 0.5 at the ground level and at the top floor, whereas the contribution factor of 0.5 is considered for outer nodes and for inner nodes it is taken as 1 for all other floors. Therefore at the outer nodes the application of blast load is lesser compared to that of the inner nodes.
3. As the positive pressure decreases the time taken for the blast load to reach the structure also decreases.
4. The displacement for the G+6 storey normal building was found to be more as compared to that of the other type of braced structure.
5. The X-type bracing is found to be efficient when the blast load was applied laterally.
6. The storey displacement is found to be more at the top floor, where as the storey drift is found to more at the middle floors as compared to top floors.
7. Under the influence of blast waves, in X-type braced structure the yielding of beam elements is predominant. In X and V-type bracing the formation of hinges is more. In X, diagonal and V-type bracing the hinges are formed in the range of C to D, therefore the structure is readily to collapse in those type of structures.
8. The diagonal braced structure falls below the collapse prevention level, since the hinges are formed which are within the collapse prevention.
9. It is noted that the displacement for X-braced building is small as compared to other bracings. But 69 plastic hinges are formed in C to D range which indicates that retrofitting is not possible. But in case of diagonal bracing , even though the displacement is little high as compared to X-bracing, the plastic hinges formed are zero in C to D range. This indicates that retrofitting for diagonal braced building.

REFERENCES

[1] API WSD 2000, Recommended Practice for Planning, Designing and Construction Fixed offshore Platforms-Working Stress Design, December (2002)
[2] Donald O. Dusenberry, Handbook for Blast-Resistant Design of Buildings, (2010)
[3] G.C.Mays and P.D.Smith, Blast Effects on Buildngs, G.C.Mays, P.D.Smith, Thomas Telford, Londan, 2003
[4] Homami.P, Kharazmi and M.N.Chimeh, Efficiency of Bracing Systems for Seismic Rehabilitation of Stell Structures, Proceedings of the Fifthteenth World Conference on Earthquake Engineering Lisbon, Portugal, 2012
[5] IS: 4991-1968, Criteria for Blast Resistant Design of Structures for Explosions above Ground, Reaffirmed (2003)
[6] Jon A. Schmidt, Blast Design-Equivalent Static Methods, Structural Engineers Association of Kanas and Missouri, Kanas City, Mo.,2007
[7] Logaraja.R, Blast Resistant Structure, International Journal of advanced technology in engineering and science, volume:02,October(2014), pp 261-264
[8] Madhekar.S.N and Qureshi.Z.A.L, Response of 45 Storey High Rise RCC Building Under Blast Load, Advances in Structural Engineering, Springer India 2015V. Matsagar (ed.), pp 435-448
[9] Mendis .P, Gupta.A , Ngo.T and Rmasay.J, Blast Loading and Blast Effects on Structures–An Overview. EJSCE International journal Loading on Structures (2007), pp 76-91
[10] Pankaj Singla, Sarita Singla, Anmol Singla, Computation of Blast Loading for a Multistoreyed Framed Building, International Journal of Research in Engineering and Technology, volume:04, pp 759-766
[11] PIP STC01018, BLAST Resistant Building Criteria, Process Industry Practices (PIP), Construction Industry Institute, The University of Texas at Austin, Texas, 2006
[12] TM 5-1300, Structures to Resist the Effects of Accidental Explosions, TechnicalManual TM 5-1300, Department of the Army,Navy, and Air Force, Washington, DC, 1990
[13] Vladimir Sigmund, Hrvoje Draganic, Blast Loading on Structures, Technicki vjesnik, volume: 19,3(2012), pp 643-652
[14] Z.A.Siddiqi, Rashid Hameed, Usman Akmal, Comparison of Different Bracing Systems for tall Buildings, Pak J.Engg & Appl.Sci. Volume:14, Jan (2014), pp 17-26

