Study and Analysis of Blast Resistance Structure

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Abstract: A day by day increase in terrorist activity is the most dangerous problem facing the world. Despite of the advancement in technology there is a feeling of insecurity among the people. Despite the fact that the magnitude of the explosion and load causes by it can not be anticipated perfectly, efforts can be made to reduce the consequences of the explosion. In this present work, a G+4 storey RCC building is subjected to 100Kg,150Kg,200Kg and 250Kg Triton Toluene (TNT) blast sources at a distance of 30m,40m and 50m from the building is considered for analysis.IS 4991-1968 is used for the manual calculation of blast load and force time history is performed in STAAD Pro. The parameter like moment on column and shear force and moment on beam are studied.

Keywords: Blast load, standoff distance, Beam-column joint force, time history, STAAD Pro.

I. INTRODUCTION

The rapid expansion of hot gases resulting from the detonation of an explosive charge gives rise to a compression wave called a shock wave, which propagates through the air. The front of the shock wave can be considered infinitely steep, for all practical purposes. That is, the time required for compression of the undisturbed air just ahead of the wave to full pressure just behind the wave is essentially zero.If the explosive source is spherical, the resulting shock wave will be spherical, since its surface is continually increasing, the energy per unit area continually decreases. Generally the buildings are not designed for blast load, so the blast load create very high pressure over a building than the general loading. Blast load last for only short duration of time. B.M. Luccioni et. al.(2004)[1] concluded that for blast analysis, simplifying assumptions is to be made for the structure and materials. S.Ahmad et.al. (2012)[2] said that for accurate analysis of structural response air blast and ground shock pressure must be considered. Aditya Kumar et. al. (2014)[3] concluded that while designing the structure in absence of relevant code is the significant concern behind the ignorance of blast phenomenon. Jiji Madonna et.al.(2016)[4] studied that standoff distance would have an impact on the pressure at various floors. Sarita Singla et. al. (2015)[5] concluded that as the distance increases from the building, blast pressure reduces.

II. BLAST FORCE AS TIME HISTORY

IS 4991-1968 used for the manual calculation of scaled distance and blast and the force for the assumed charge weight. For different time interval, variation of force for each beam-column joint is also manually calculated. By using finite element method in STAAD Pro, a time history load are applied for each beam-column joint along with dead and live load. Load generated due to blast is similar to wind load but as the blast load is impulse load so it last for very short period of time. As blast load have very high intensity initially and then decreases gradually to zero in very short interval of time, a time history function is used.

III. METHODOLOGY

In this present work 3 models of G+4 storey RCC building is considered for base dimensions of 20mx20m, 30mx30m and 40mx40m. Following table shows the material property considered and description of models considered.

Table 1- Property of material considered

| Material        | Description |
|-----------------|-------------|
| Grade of concrete | M25         |
| Grade of steel  | Fe415       |
| Density of concrete | 25kN/m³   |
| Density of steel | 78.5kN/m³  |

Table 2- Description of models

| Models | 1 | 2 | 3 |
|--------|---|---|---|
| Number of bays in X-direction | 4 | 6 | 8 |
| Number of bays in Y-direction | 4 | 6 | 8 |
| Width of bays in X-direction | 5 | 5 | 5 |
| Width of bays in Y-direction | 5 | 5 | 5 |
| Height of each storey | 3 | 3 | 3 |
| Column | 0.3mx0.5m | 0.4mx0.5m | 0.4mx0.5m |
| Beam  | 0.3mx0.4m | 0.3mx0.4m | 0.3mx0.4m |
| Slab  | 0.12m    | 0.12m    | 0.12m    |
| Wall  | 0.23m    | 0.23m    | 0.23m    |
IV. COMPUTATION OF BLAST WAVE PARAMETERS

A TNT explosive of 100Kg, 150Kg, 200Kg and 250Kg weights are considered for the study. The source of blast is considered at a distance of 30m, 40m and 50m interval individually. The various parameter of blast are obtained by using following formula.

\[
\text{Scaled distance } x = \frac{\text{Actual distance}}{W^{\frac{1}{3}}} \\
\text{Scaled time } t_o = \frac{\text{Actual time}}{W^{\frac{1}{5}}}
\]

Where,
\( W \) = yield of explosion in equivalent weight of the reference explosive measured in tonnes,
\( x \) = scaled distance for entering the Table 1 in IS: 4991-1968 for reading peak values, and
\( t_o \) = scaled time read from Table 1 in IS: 4991-1968 against scaled distance.

### Table 3 - Final peak reflected over pressure on front face of building

| Charge weight | Distance | Scaled distance | Scaled distance | Pro (KN/m²) | t_q (millisecond) |
|---------------|----------|----------------|----------------|-------------|------------------|
| 100 Kg        | 30       | 64.655         | 34.656         | 79.012      | 18.857           |
|               | 40       | 86.206         | 22.810         | 49.807      | 19.48            |
|               | 50       | 107.75         | NO EFFECT      |             |                  |
| 150 Kg        | 30       | 56.603         | 42.815         | 100.714     | 17.695           |
|               | 40       | 75.471         | 27.144         | 60.183      | 20.195           |
|               | 50       | 94.339         | 19.172         | 41.285      | 22.42            |
| 200 Kg        | 30       | 50.847         | 52.269         | 52.269      | 16.725           |
|               | 40       | 67.796         | 32.162         | 72.569      | 19.251           |
|               | 50       | 84.745         | 84.745         | 51.239      | 21.232           |
| 250 Kg        | 30       | 47.619         | 58.643         | 145.658     | 16.061           |
|               | 40       | 63.492         | 35.804         | 82.062      | 18.711           |
|               | 50       | 79.365         | 25.046         | 55.535      | 20.582           |

The peak side-on over pressure \( P_{so} \) is obtained from Table 1 of IS:4991-1968 and the corresponding force lasting for about 20 milli-seconds which is calculated manually is applied on sides of the building which are applied using force time history in STAAD Pro for every beam column joint.
V. RESULTS

After analyzing each model for blast load, the column forces (bending moment) and beam forces (shear force, bending moment, torsion) are noted down for a distance of 30m, 40m, and 50m. Then, the decrease in member forces is calculated for each model.

Table 4: Comparative decrease in member forces with increase in distance between blast and building.

| Decrease in | Area(20m x20m) | Area(30m x30m) | Area(40 x40m) |
|-------------|----------------|----------------|---------------|
|             | Distance (40m) | Distance (50m) | Distance (40m) | Distance (50m) |
| Column (M_y)| 25 %           | 41 %           | 25 %           | 40 %           |
| Column (M_z)| 40 %           | 61 %           | 40 %           | 60 %           |
| Beam (F_y)  | 30 %           | 45 %           | 30 %           | 45 %           |
| Beam (M_z)  | 21 %           | 34 %           | 43 %           | 62 %           |
| Beam (torsion) | 25 %      | 34 %           | 43 %           | 62 %           |

VI. CONCLUSION

A. The significant effect on the building will happen when the charge weight (W) increases and the ground distance decreases.
B. The location and area of building have major effect on minimizing blast pressure on building.
C. Column forces (bending moment) are more when standoff distance is less and vice versa.
D. Beam forces (shear force and bending moment) decreases as the standoff distance increases.
E. The reduction in the effect of moment on the building structure due to blast remains same (i.e., along Y direction in column) approx equal to 25% at 40m distance and 40% at 50m distance.
F. The reduction in the effect of moment on the building structure due to blast remains same (i.e., along Z direction in column) approx equal to 40% at 40m distance and 60% at 50m distance.
G. The reduction in the effect of shear force on the building structure due to blast remains same (i.e., along Y direction in beam) for approx equal to 30% at 40m distance and 45% at 50m distance.
H. The reduction in the effect of moment on the building structure due to blast remains same (i.e., along Y direction in beam) approx equal to 23% at 40m distance and 35% at 50m distance for A(20mX20m) and A(40mX40m) and 43% at 40m distance and 62% at 50m distance for A(30mX30m).
I. The reduction in the effect of moment on the building structure due to blast remains same (i.e., along Z direction in beam) approx equal to 25% at 40m distance and 40% at 50m distance.
J. The reduction in the effect of torsion in the beam on the building structure due to blast remains same approx equal to 25 % at 40m distance and 40% at 50m distance.

REFERENCES

[1] Aditya Kumar Singh, Md. Asif Akbari and P. Saha, “Behavior of Reinforced Concrete Beams under Different Kinds of Blast Loading” International Journal of Civil Engineering Research. ISSN: 2278 – 3652, Vol. 5, No. 1 (2014), pp. 13 – 20.

[2] A.Ghani Razaqpur, Ahmed Tolba and Ettore Constestabile, “Blast loading response of reinforced concrete panels reinforced with externally bonded GFRP laminates”. Science direct, Composites: Part B 38 (2007) 535-546.

[3] B.M. Luccioni, R.D. Ambrosini and R.F. Danesi, “Analysis of Building Collapse under Blast Loads” ELSEVIER Engineering Structures”, 2004, pp. 63 – 71doi:10.1016/j.engstruct.2003.08.011.

[4] Jiji Madonna, Mrs. Vijaya G S, Er. Kirankumar K L (2016) “Analysis of high rise building subjected to blast load”, International Research Journal of Engineering and Technology (IRJET) Volume: 03 Issue: 08.

[5] Mohamed S. Al-Ansari, “Building Response to Blast and Earthquake loading” International Journal of Civil Engineering and Technology (IJCIET), Vol. 3, Issue 2, July - December (2012), pp. 327 – 346, ISSN : 0976 – 6316.

[6] Sarita Singla, Pankaj Singla and Anmol Singla, “Computation of Blast Loading for a Multi-Storeyed Framed Building” International Journal of Research in Engineering and Technology,2015, e-ISSN: 2319 – 1163, p-ISSN: 2321 – 7308.

[7] Saeed Ahmad, Mehwish Taseer, Huma Pervaiz, “Effects of Impulsive Loading on Reinforced Concrete Structures”, UET, Taxila, 2012

[8] T. Ngo, P. Mendis, A. Gupta & J. Ramsay, “Blast Loading and Blast Effects on Structures – An Overview”, The University of Melbourne, Australia, EIJE Special Issue: Loading on Structures (2007)

[9] T.D. Ngo, P.A. Mendis, & G. Kusuma, “Behavior of high-strength concrete columns subjected to blast loading”, The University of Melbourne, Australia (2002).

[10] IS 4991-1968 (1993) “Indian Standard Criteria for Blast Resistance Design of Structures for Explosion Above Ground”,Bureau of Indian Standard,New Delhi, India

[11] TM 5-1300/ NAVFACP-397/AFR 88-22. (1990): Structures to Resist the Effects of Accidental Explosions, published by US Department of Army, Navy and Air Force, 06 Volumes.