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The Effects of Blast Loading on RCC Structures

MRS. STHITIPRAGYAN SATPATHY
Assistant Professor, Dept. of Civil Engineering, Aryan Institute of Engineering & Technology, Bhubaneswar
ANAND MANDAL
Assistant Professor, Department of Civil Engineering, Raajdhani Engineering College, Bhubaneswar, Odisha
ANJAN KUMAR M. U.
Department of Civil Engineering, NM Institute of Engineering and Technology,Bhubaneswar , Odisha

Abstract

The problem identified by research is the effects of blast loading on RCC structures. A comprehensive parametric study was conducted on RCC structure using the 3-D element model. In the analysis and design methodologies structures are subjected to blast loads with the understanding of blast phenomena and the dynamic response of various structural elements. This gives an parametric overview of the effects of blast effects on structures. Here in this paper, we are dealing with the blast force and its impact on the RCC structures. The blast pressures i.e. reflected blast pressure and overpressure have been evaluated. From this values blast forces have been evaluated. The values coming after displacement shows that as the floor height increases, deflection caused due to blast effect decreases. The result also shows relevant bending moment, shear force, axial forces. Deflection, axial force values of blast forces for charge 1500 kg at standoff distance 30 m is greater. Hence it has been concluded.

Keywords: • Blast loading • Blast pressure • Dynamic response • Explosion • Reinforced concrete structures

Introduction

The blast effects of an explosion are in the form of a shock wave composed of a high intensity shock front which expands outward from the surface of the explosive into the adjoining air. As the wave expands, it decays in strength, lengthens in duration and decreases in velocity. This phenomenon is caused by spherical divergence as well as by the fact that the chemical behaviour of Reinforced Concrete Framed Structure Subjected to Blast Loading reaction is completed, except for some afterburning associated with the hot explosion products mixing with the surrounding atmosphere [1-4]. The one-third portion of the chemical energy available in most high explosives is discharged during the ignition process. The residual two-third portion is discharged slowly as the detonation products combine with air and burn. This afterburning development has slight effect on the initial blast wave because it happens much slower than the original detonation process [5-9]. On the other hand, the next stages of the blast wave can affect by the afterburning, especially for blasts in confined spaces. As the shock wave spreads out, pressures reduce quickly owing to geometric divergence and the consumption of energy in heating the air. Pressures also decrease rapidly over time and have a very short period of survival, calculated in milli-seconds. An explosion can be envisaged as a sphere of extremely compressed air that attains balance after expansion.

Explosive events mainly originate from terrorist attacks targeting civilian or commercial structures. However accidental events such as explosions in storage facilities or gas explosions also occur from time to time at the oil refineries, petrochemical plants, gas gathering plants etc. Hence, it is essential to estimate and predict the effects of explosions and provide designs to protect structures against the potential explosive events. Explosions generated using the redistribution of subatomic particles is considered as nuclear explosions [10-15]. Basically there are two types of nuclear reactions namely "fission" and "fusion". Fission is the splitting of heavy atoms and Fusion is the joining of small & lightweight atoms that were used for nuclear explosions. The magnitude of energy released from a nuclear explosion is several orders of magnitude higher than the energy released from a physical explosion. Therefore, a small nuclear explosion can be much more devastating than an industrial level physical explosion. Creating a nuclear explosion requires highly skilled personnel and technology hence, it is quite rare for these to be used to target civilian and commercial structures [15-19].

Research Methodology

The development of an RCC framed model is detailed first and then the verified model is used an analysis tool to investigate the performance of building against explosion. The RCC Structure is also then analyzed forseismic load with zone V. The blast loading assessment is done by Time history analysis. The values of force and time are calculated from code UFC 3-340-02 (Figure 1).

Model Description Number of storey = G+6 Storey, floor to floor height being @ 3.00 meters.

Number of spans in × Direction = 5 (3.00 meters each), Number of spansin Z direction = 7 (3.00 meters each), Slab thickness being 125 mm.

Grade Concrete = M25.

Steel for reinforcement = Fe 415.

Steel for reinforcement Blast charge = 500 kg, 1000 kg and 1500 kg. The values of the different blast charges were calculated and are listed in Tables 1-3, these values are calculated for a span of 3.00 m.

Computation of blast loading for a seven storied framed structure

The study has been taken for the seven storied structures. Computation of blast loading for a five storeyed RCC structure has been carried out for the three cases of blast loading. Four categories of structure are considered

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Figure 1. Plan of the 7 storeyed RCC structure.

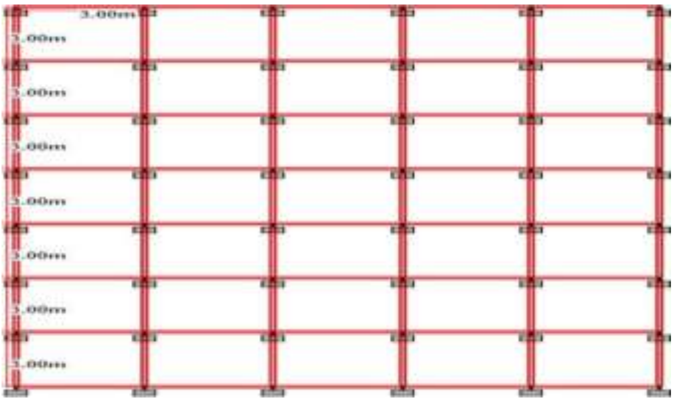

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Table 1. Blast parameters for W = 500 kg with different values of stand-off distance "R".

R (m)	Z (ft/lb1/3)	Pr (psi)	Pso (psi)
20 m	5.97	92	30
30 m	8.96	31	13
40 m	11.95	21	8.5

Table 2. Blast parameters for W = 1000 kg with different values of stand-off distance "R".

R (m)	Z (ft/lb1/3)	Pr (psi)	Pso (psi)
20 m	4.74	190	50
30 m	7.11	60	20
40 m	9.48	28	10.10

Table 3. Blast parameters for W = 1500 kg with different values of stand-off distance "R".

R (m)	Z (ft/lb1/3)	Pr (psi)	Pso (psi)
20 m	4.14	300	70
30 m	6.21	90	30
40 m	8.28	39	15

as per IS code 4991:1968 for blast resistant designing purposes. In the first case the equivalent TNT charge weight W has been taken as 500 Kg and the actual effective distance from explosion i.e., "R" is taken as 20 m, 30 m, and 40 m. In the second case W has been taken as 1000 Kg and "R" as 20 m, 30m, 40 m, in the third case charge weight W has been taken as 1500 Kg and"R" is again varied as 20 m, 30 m, and 40 m. Height of building is 21.00 m.The plan and elevation of the building is shown below: Then the analysis is done. The results are discussed along with the comparative studies between blasting and seismic. Conclusion of the study has also been discussed (Table1 and Figures 2-4).

Load combination for design in compliance with IS: 4991 – 1968

Wind or earthquake forces shall not be assumed to occur simultaneously with blast effects. Effects of temperature and shrinkage shall be neglected.

Live load on floors shall be considered as per IS: 875 - 1987 depending upon the class of building. No live load shall be considered on roof at the time of blast (Tables 2 and 3).

Load combination = 1.5 DL + 1.5 LL + 1.5 Blast Load.

Blast pressure parameters as per UFC 3 – 340 – 02

Computations

W = 500 kg or 1102.3 lbs.

Standoff distance at ground = 20.00 m or 65.61 ft. W" = 1.2 X 1102.30 lbs = 1322.76 lbs.

Scaled Distance, Z = R/NW = 5.976 ft/Nlb Values of Pr, Pso, ta:

Peak Reflected Overpressure, Pr = 92 psi Peak Static Pressure, Pso = 30 psi

ta/NW = 1.7

Arrival time, ta = 18.66 milli-sec. to/NW = 1.7

Duration of Positive Blast Wave, to = 18.66 milli-sec. Z at 3.00 m height = 6.042 ft /Nlb.

Peak Reflected Overpressure, Pr = 90 psi, Peat Static Pressure, Pso = 28 psi,

ta/NW = 1.8,

Arrival time, ta = 19.75 milli-sec, to/NW = 1.9, Duration

of Positive Blast wave, to = 20.85 milli-sec

Results

Variation of blast pressures and their displacement is described in Figures 5-7.

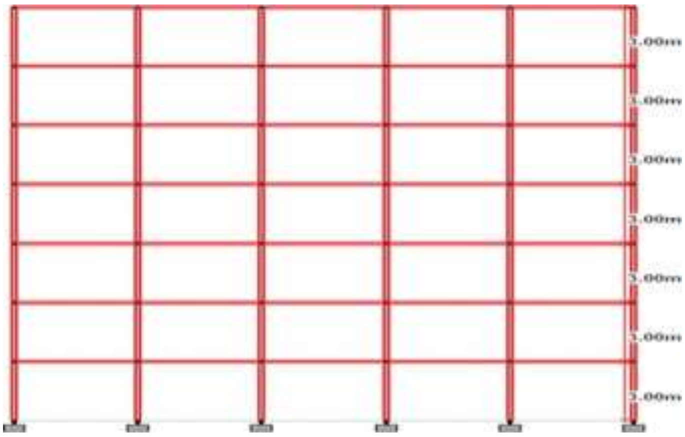

Figure 2. Elevation of the 7 storeyed RCC structure.

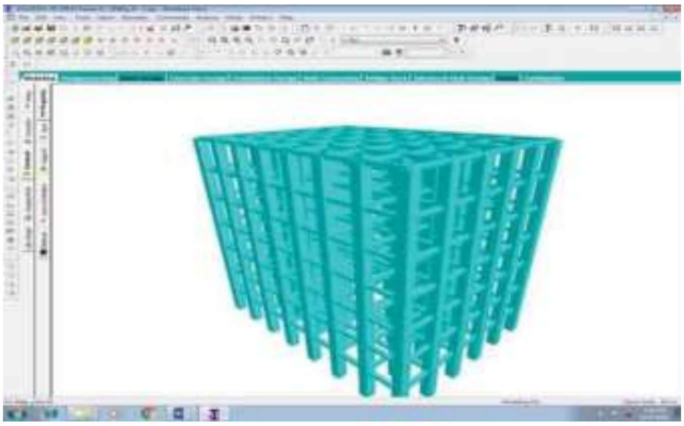

Figure 3. Isometric view of the structure in STAAD Pro V8i model.

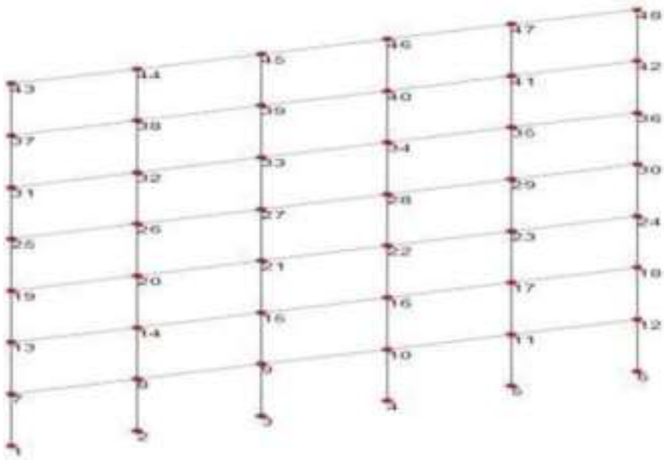

Figure 4. STAAD Pro model showing blast forces acting on the nodes.

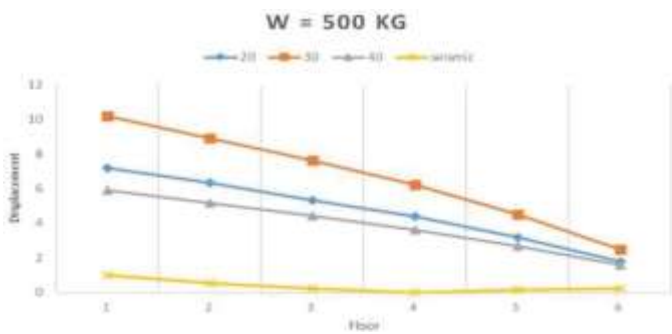

Figure 5. Displacement in mm at each floor for charge 500 kg.

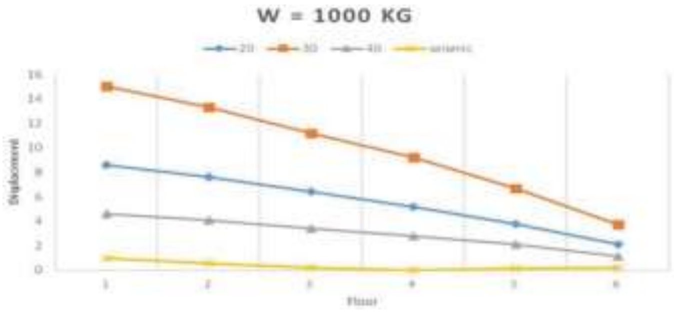

Figure 6. Displacement in mm at each floor for charge 1000 kg.

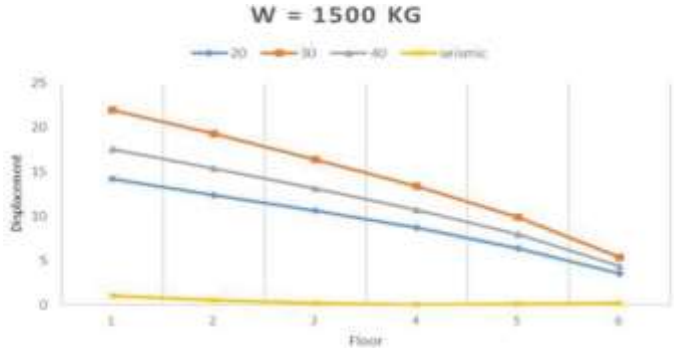

Figure 7. Displacement in mm at each floor for charge 1500 kg.

Conclusion

From the results it is clear that as the stand-off distance increases from the building, the magnitude of blast pressure reduces significantly. As the weight of blast increases i.e. from 500 kg to 1000 kg at stand-off distance of 20 m, the pressure increases by 106.527% and when the blast weight increases from 1000 kg to 1500 kg at same distance then the pressure increases by 226%.Ifthe stand-off distance increases from 20 to 30 m for 500 kg blast weight then the blast pressure reduces by 66% and if distance changes from 20 to 40 mfor 500 kg blast, then the pressure reduces by 77%.It was also observed that ifthe distance of blast changes from 20 m to 30 m for 1000 kg of blast then the blast pressure reduces by 68.4% and if distance of blast changes from 20 to40 m for 1000 kg blast, then the pressure reduces by 85.2%.

References

1. Dusenberry, Donald O. *Handbook for blast resistant design of buildings.* John Wiley& Sons, NY, USA. (2010).
2. Research Engineers International (REI). STAAD. Pro Technical Reference Manual. 4 (2008): 98-105.
3. Luccioni, Bibiana Maria, Ricardo Daniel Ambrosini, and Rodolfo Francisco Danesi. "Analysis of building collapse under blast loads." *Eng Struct* 26 (2004): 63-71
4. Design Basis for the Design of Blast Loads on Structures, Engineers India Ltd, New Delhi.
5. Remennikov, Alex M and Timothy A. Rose. "Modelling blast loads on buildings in complex city geometries." *Comput Struct* 83 (2005): 2197-2205
6. Ngo, Tuan, Priyan Mendis, Anant Gupta, and J. Ramsay. "Blast loading and blast effects on structures–An overview." *Electron J Struct. Eng* 7 (2007): 76-91
7. Zhu, F., and G. Lu. "A review of blast and impact of metallic and sandwich structures." *Electron J Struct Eng* 7 (2007): 92-101
8. Van der Meer, L. J, M. C. M. Bakker, J. G. M. Kerstens and J. Weerheijm. "Dynamic response of high-rise building structures to blast loading." *Technische Universiteit Eindhoven* (2008).
9. Moon, Nitesh. "Prediction of blast loading and its impact on buildings." PhD diss (2009)
10. Nassr, A.G. Razaqpur, M.J. Tait, M. Campidelli, and S. Foo, Evaluation of Nonlinear Response of Steel Members under Blast Loading. 2nd Specialty Conference on Disaster Mitigation.(2010)
11. Hussein, Assal T. "Non-linear analysis of SDOF system under blast load." *Eur J Sci Res.* 45 (2010): 430-437.
12. Mohamed S. Al-Ansari. "Building response to blast and earthquake loading." *Int J Civ Eng Technol* 3 (2012): 327-346.
13. Jayashree, S. M., R. Rakul Bharatwaj, and Helen M. Santhi. "Dynamic response of a space framed structure subjected to blast load." *Int J Civ.Eng* 4 (2013): 98
14. Unde, Amol B and Dr SC Potnis. "Blast analysis of structures." *Int J Eng Res Technol* (2013): 2278-0181
15. Geringer, J. R., C. Y. Tuan, and P. D. Lindsey. "Assessment of software for blast loading and structural response analysis using a lightweight steel-joist roof as a test case." *J Perform Constr Facil* 27 (2013): 144-154.
16. Jayashree, S. M, B. R. Rakul and Santhi M. Helen. "Flexural behavior of SIFCON beams." *Int J Eng Res Technol* (2013): 1-7
17. Coffield, Amy and Hojjat Adeli. "An investigation of the effectiveness of the framing systems in steel structures subjected to blast loading." *J Civ Eng Manag* 20 (2014): 767-777
18. Yusof, Mohammed Alias, Rafika Norhidayu Rosdi, Norazman Mohamad Nor and Ariffin Ismail, et al. "Simulation of reinforced concrete blast wall subjected to airblast loading." *J Asian Sci Res* 4 (2014): 522-533
19. Kulkarni, A. V and G. Sambireddy. "Analysis of blast loading effect on high-risebuildings." *Civil and Environmental Research* 6 (2014).