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Dynamic Analysis of RCC Frame Structure Subjected to Blast Loading

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ABSTRACT

The number and intensity of terrorist activities have increased our concern towards the safety of our infrastructure. An explosion due to air blast or any other dynamic loading in air generates a pressure bulb, which grow in size at very high rate. The resulting blast wave releases energy over a small duration and in a small volume, thus generates waves of finite amplitude travelling radially in all directions. A six storey RC frame structure with 3.00 m storey height in seismic zone IV has been considered in this present study, effect of charge weights 100 kg, 300 kg and 500 kg has been studied in three phases. The effect of different charge weights 100 kg, 300 kg and 500 kg has been studied for nodal displacements, velocity, acceleration and stress resultants in three Phases – 1, 2 and 3 for standoff distance 30 m, 35 m and 40 m respectively. The structure is modeled and analyzed by using software Staad Pro V8i-2007. The blast parameters are calculated for stand-off distances by adopting wave scaling law given in IS 4991-1968. Comparison of results is made for different parameters such as variation of blast loads, variation of standoff distances. Bending moment, shear force and axial forces in beams and columns are maximum on front face of the structure due to maximum explosive weight and minimum standoff distance 'Z'. As the weight of explosive (TNT) Increases, bending moment, shear force and axial force in beams and columns, lateral displacement and velocity at different floor levels increases. If standoff distance increases, bending moment, shear force and axial force in beams and columns, lateral displacement and velocity at different floor levels decreases.

Keywords: Dynamic Loading, Finite Amplitude, Pressure Bulb, Displacements, Velocity

I. INTRODUCTION

Explosives can be classified according to their rates of burning i.e. low explosive burns and high explosive burns, solid explosives are mainly high explosives. They can also be classified on the basis of their sensitivity of ignition as primary or secondary explosives. Materials such as mercury fulminate and lead azides are primary explosives. Secondary explosives when explode create blast (shock) waves which can result in widespread damage to surroundings. Examples include trinitrotoluene (TNT) and ammonium nitrate/fuel oil (AN/FO) [Ngo et al.].

Low explosives: Items those are capable of exploding but whose primary function isnot act as explosives includes natural gas, liquid fuels such as gasoline etc. It is usually mixture of combustible substances and oxidants those decomposes rapidly.

Blast Waves

Blast wave is an area of pressure expanding supersonically outward from an explosive core. It has a leading shock front of compressed gases. The blast wave is followed by a blast wind of negative pressure, which sucks items back in towards the center. If a strong gas explosion occurs inside a process area or in a compartment, the surrounding area will be subjected to blast wave. The magnitude of blast wave depends on:

- Source
- Distance from explosion

The detonation of a condensed high explosive generates gasses under pressure up to 300 kilo bar and a temperature of about 3000-4000 °C . the hot gas expands forcing out the volume it occupies.

Objective

The effect of different charge weights 100 kg, 300 kg and 500 kg has been studied for nodal displacements, velocity, acceleration and stress resultants in phase

II. LITERATURE REVIEW

Amol B.Unde, Dr.S C.Potnis(2013)-In this paper Author introduce us to finite elements software it is now possible to get to a reliable conclusion. The analysis and design of structures subjected to blast loads require a detailed understanding of blast phenomena and the dynamic response of various structural elements. The study is made to understand the properties of blast wave by estimating the blast wave parameters for various charge amounts placed at various distances. The effect of TNT (trinitrotoluene) explosive on a column foundation for various amount of TNT charge at various distances is investigated for model buildings of various floors and presented in this paper.

III. METHODOLOGY AND MODELLING

In the present study a six storied building was modeled and analyzed. The three different cases have different values of Z and W has been considered for present study. In the first case stand-off distance is taken as 30 m and the different values of charge weights 100 kg, 300 kg and 500 kg while in case 2nd the stand-off distance is taken as 35 m and the different values of charge weights 100 kg, 300 kg and 500 kg. In case 3rd the stand-off distance is taken as 40 m and the different values of charge weights 100 kg, 300 kg and 500 kg. The modeling and analysis of building subjected to blast loading was carried out using software Staad-pro V8i. The blast forces which are acting on contributing nodes are calculated.

IV. RESULT ANALYSIS

Nodal Displacement

Displacement profile of a structure represents the interaction of flexibility of its different components i.e. columns, beams. But the presence of infills provides extra

rigidity to the frame against lateral forces, thereby reducing the horizontal displacements.

The maximum values of nodal displacements at top storey are 6.75 mm, 15.4 mm and 23.1 mm for charge weights 100 kg, 300 kg and 500 kg respectively as noted from Tables 4.1, 4.5 and 4.9.

The time history variation of maximum displacement at top storey for charge weights 100 kg, 300 kg and

500 kg has been shown in Fig. 5.1.

The maximum displacement at top storey for charge weights 100 kg, 300 kg and 500 kg occurs at 0.132 sec, 0.14 sec and 0.14 sec respectively.

The variation of maximum nodal displacement along storey level is shown graphically in Fig. 5.4.

The maximum nodal displacement becomes 2.28 times and 3.43 times as charge weight increases from 100 kg to 300 kg and 100 kg to 500 kg respectively.

4.1.2 Velocity

The maximum values of velocities at top storey are 75.1 mm/sec, 174 mm/sec and 258 mm/sec for charge weights 100 kg, 300 kg and 500 kg respectively as noted from Tables 4.1, 4.5 and 4.9.

The time history variation of maximum velocity at top storey for charge weights 100 kg, 300 kg and 500 kg has been shown in Fig. 5.2

The maximum velocity at top storey for charge weights 100 kg, 300 kg and 500 kg occurs at 0.092 sec, 0.096 sec and 0.096 sec respectively.

The variation of maximum velocity along storey level is presented graphically in Fig. 5.5. The maximum value of velocity becomes 2.32 times as charge weight increases from 100 kg to 300 kg, whereas velocity becomes 3.43 times when weight increases from 100 kg to 500 kg.

Acceleration

The maximum values of accelerations at second storey are 7.45 m/sec^2, 15.7 m/sec^2 and 22.7 m/sec^2 for charge weights 100 kg, 300 kg and 500 kg respectively given in Tables 4.1, 4.5 and 4.9.2

The time history variation of maximum acceleration at second storey for charge weights 100 kg, 300 kg and 500 kg has been shown in Fig. 5.3.

The maximum acceleration at second storey for charge weights 100 kg, 300 kg and 500 kg occurs at 0.012 sec, 0.016 sec and 0.016 sec respectively

The variation of maximum acceleration along storey level is presented in Fig. 5.6.

The maximum acceleration becomes 2.10 times and 3.04 times as charge weight increases from 100 kg to 300 kg and 100 kg to 500 kg respectively.

4.1.4 Stress Resultants

From design consideration, variation of stress resultants gives an insight in the structural behavior. In the present study, stress-resultants variation can be studied under the following sub-heads:-

(a) Variation of moments.

(b) Variation of shear forces.

(c) Variation of axial forces.

4.1.4.1 Moments

Multi-storey buildings are mainly designed for flexure i.e. moments generated in members of a structure due to loadings.

Maximum values of moments for beams and columns along storey level for charge weights 100 kg, 300 kg and 500 kg have been given in Tables 4.2 to 4.4, 4.6 to 4.8 and 4.10 to 4.12.

(i) Maximum Moment M_z For Beams Parallel to X - Direction

The maximum moments Mz are 37.93kN-m, 84.73kN-m and 126.58kN-m for charge weights 100 kg, 300 kg and 500 kg respectively as noted from Tables 4.2, 4.6 and 4.10.

V. CONCLUSION

- Peak static over pressure Pso is found to be increase as charge weight increases
- Peak static over pressure Pso is found to be decreases as standoff distance increases. Peak Reflected over pressure Pr is found to be increases as charge weight of blast increases
- Peak reflected over pressure Pr is found to be decreases as standoff distance increases
- Blast pressure wave are inversely proportional to scale distance(z)

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