A GENERAL NUMERICAL MODELLING APPROACH FOR BLAST LOADS ON A BUILDING

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A blast load acting on a structure can be considered as an amalgamation of overpressure and impulse over an extremely short duration, which can cause catastrophic exterior and internal damage. Such blast loads can be generated due to either intentional or accidental actions. Due to growing threats, over the years, researchers have given special attention to studying the behaviour of structures when subjected to blast loads, and numerical modelling is a common approach used for such studies due to its practicality. However, existing modelling methods using advanced Finite Element Modelling (FEM) software can be complicated and computationally expensive and, in most cases, aims at studying the localised behaviour due to blast loads. On the other hand, Advanced FEM tools may require specialised expertise, limiting their accessibility for day-to-day structural design activities. This study aims to develop a general yet accurate model to simulate the complex behaviour of blast loads on a multi-storey building. To achieve this aim, two objectives are defined as identifying the applicable blast load parameters to represent the blast event accurately and simulating the behaviour of a building under positive overpressure due to blast loads. The approach approximates the blast load as a force at each node in the front face by multiplying the pressure by the tributary area and is implemented using finite element analysis. The approach is validated against data from open literature shown to be effective in predicting the response of structures to blast loads at a conservative level (49% difference for near-field explosions while 23% difference for far-field explosions). In this study, reinforced concrete buildings with three, six, and twelve storeys were modelled with blast loads of 1000 kg TNT at standoff distances of 5 m, 10 m, and 30 m from the building. Here, when the standoff distance is 5 m, it represents a near-field explosion, whereas when the standoff distance is 30 m, it represents a far-field explosion. The top-storey displacement due to the blast load was obtained as the main result, and a comparison was made to analyse the effect of blast load when there are shear walls and see the effect of slabs in resisting blast loads. The analysis was carried out using the commercially available finite element package, Midas Gen. The results demonstrate the potential of the proposed modelling technique to model the effects of the blast event with reasonable accuracy. However, it must be noted that the scope of this proposed approach is limited to structures that only need an initial blast load analysis and are not categorised as being vulnerable to blast loads. The results indicated that this method is more accurate for far-field explosions than for near-field explosions, where the expected behaviour of the structure is global and local, respectively. The top floor displacement is less than the no-shear wall scenario when there are shear walls. Also, the top floor displacement is less when there are slabs than in the no-slab scenario. In both situations, the rigidity of the structure due to laterally applied blast loads is high with shear walls and slabs. When the standoff distance is higher from the structure, it results in a uniform blast load on the front face, and at the same time, when the height of the buildings increases, they behave as cantilevers, and hence the top floor displacement is high. When the standoff distance is lesser from the structure, the blast load is localised, and the variation of top floor displacement is opposite to that in the far-field explosion.

Keywords: Blast load, Finite Element Modelling, Midas Gen, Far-field blast

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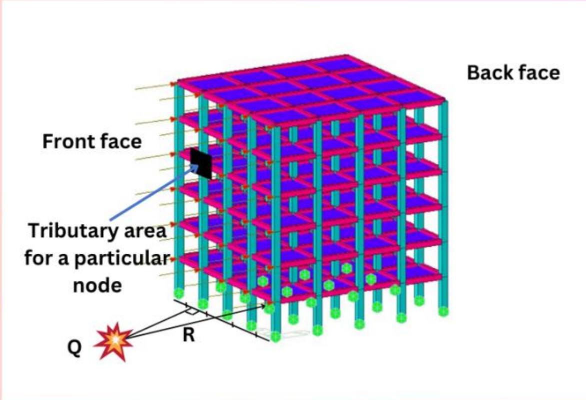
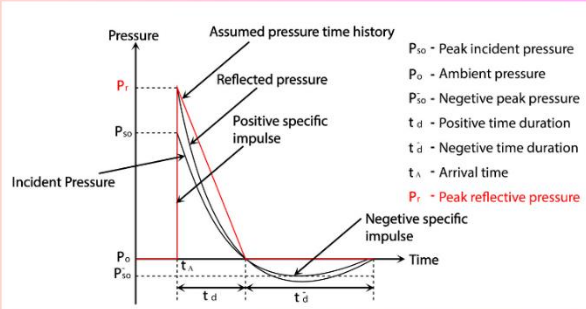
Blast load is applied as a dynamic nodal load at each beam column joint at front face

Following Cases are considered By varying the Standoff distance
- Case1: 1000 kg TNT at 5 m
- Case2: 1000 kg TNT at 10 m
- Case3: 1000 kg TNT at 30 m





Methodology

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Modelling techniques used to model the blast loads

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Identifying the blast wave behaviour

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Develop the FE model and validation

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Analysis of results

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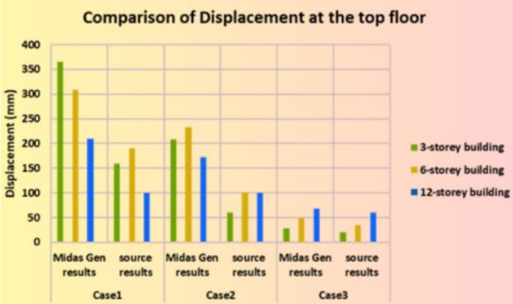
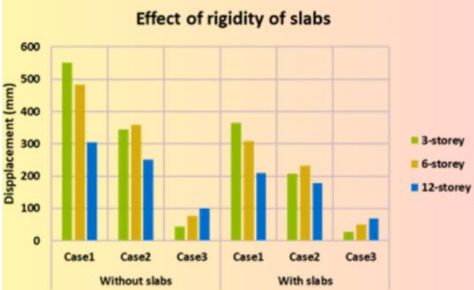
Identifying the method of improving the blast resistance

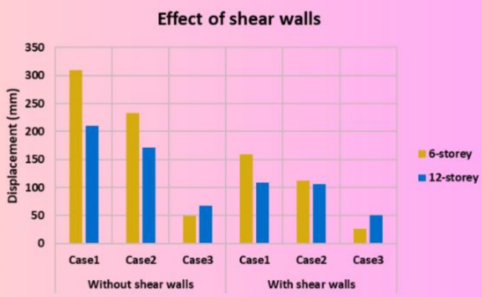
Results



Far-field explosions R↓ → When height of building ↑ R↓ for the topmost floor → Blast load is uniform

Near-field explosions R↑ → When height of building ↑ R↓ for the topmost floor → Blast load is localized





The effect of rigidity coming from the slabs has an effect on the deflection of the structure for the laterally applied blast loads.

The presence of shear walls significantly reduces the deflection of the structure due to the laterally applied blast loads