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Research paper

Simulation on Concrete Structure Demolition using Explosive Method

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Abstract

Demolition of any structure is the process of destroying down or collapsing down of large buildings after its useful life period with the help of some equipment. There are several method used in demolition building structure applied around the world nowadays such as using wrecked ball, powered plant or demolition machines, hydro demolition, saw cut and explosive. The choice of choosing a demolition method depends on a number of factors such as the project conditions, site constraints, and sensitivity of the neighborhood and availability of equipment environment. However demolition work is one of the most dangerous operations in construction. One of the common reasons is easy to cause injury to human workers due to the difficulty of accessing into or working inside a building which is under demolition. Demolition using explosive is effective method to use compare too mechanically if we look down from degree of time. It is because the explosive charges used to tearing down a structure can shorten the time. Just in one blow the building structure is tearing down completely. The objective of this research is to simulate the demolition of five storey reinforced concrete structure frame using AUTODYN simulation software. A total 200 grams of TNT charge is placed at three different location of the structure column, which is at the bottom, middle and upper section of the column to study the effect of the explosive on the column. From the simulation results, it shows that location of the explosive on the upper point of the column damaged badly the structure as compare with the other location.

Keywords: Demolition , simulation , AUTODYN , explosive

1. Introduction

Demolition is the tearing down of buildings, facilities and other structures. There are several method used in demolition building structure applied around the world nowadays such as using wrecked ball, powered plant or demolition machines, hydro demolition, saw cut and explosive. The choice of choosing a demolition method depends on a number of factors such as the project conditions, site constraints, and sensitivity of the neighbourhood and availability of equipment environment etc [1]. Generally, in Malaysia the method usually used is mechanically using heavy conventional machines such as elevated work platforms, cranes, excavators or bulldozers. Top-down methods are popular method used if the building is situated in busy urban areas. The demolition equipment sector has a great future in Malaysia. Re-development of walled cities, better utilisation of land and rapid industrial advancement all demand easy availability of cost effective and well defined technologies.

As regards the requirements the demolition technology should fulfil, the ideal list goes like more to quicker, quieter, cheaper, and environment-friendly, which causes least disturbances in the neighbourhood, and minimal impact to the workers [2].Demolition work is one of the most dangerous operations in construction. One of the common reasons is easy to cause injury to human workers due to the difficulty of accessing into or working inside a building which is under demolition. Falling of smaller objects or debris from the demolishing building and falling of partially demolished structure also common accident to pay attention. Other cause is collapse of unstable structure due to original structure being disturbed [1]. This can be seen from the incident of collapse of Jaya Supermarket is a well-known landmark in Section 14, Petaling Jaya, Selangor, Malaysia. This building was built in 1974, it was one of the first supermarkets in Petaling Jaya, and originally lasted until its deconstruction and subsequent accidental collapse in 2009. The original building had four storeys of retail units, five storeys of office units and four storeys of car-parks. The building was earmarked for redevelopment, in which it would be demolished and rebuilt with additional loading bays, access roads and security in the late 2000s. On 28 May 2009, Jaya Supermarket collapsed while being torn down for redevelopment, killing seven Indonesian laborers and injuring an unspecified number of people in the busy commercial district. An investigative committee found that the deaths were due to mistakes in the demolition process, and made recommendations for improvements in Malaysia's regulations on demolition projects.

Figure 1 : An aerial view of the collapsed Jaya supermarket building[3]

From this incident Its shows that demolition using explosive is effective method to use compare too mechanically if we look down from degree of time. It is because the explosive charges used to tearing down a structure can shorten the time. Just in one blow the building structure is tear down completely and it is also known as the most safest method for demolition of building. This research paper is to simulate the demolition of five storey reinforced concrete structure frame using AUTODYN [5].

Implosion is the term that was coined in the late 1950s to describe the process of using the minimum amount of explosives with minimal structural preparation expense to get a structure to collapse in a controlled fashion. The term is technically incorrect, since implosion implies a collapse from external pressure. A true implosion usually involves a difference between internal (lower) and external (higher) pressure, or inward and outward forces, that are so large that the structure collapses inward into itself. Building implosion techniques do not rely on the difference between internal and external pressure to collapse a structure. Instead, the technique weakens or removes critical supports so that the building can no longer withstand the force of gravity and falls under its own weight. Implosion method is adopted for high raised buildings in urban areas, where the other demolition methods are not acceptable [6]. The typical demolition of building using explosive is shown in Figure 2.

Figure 2: Demolition of building using explosive [4]

2. Materials and Methods

2.1 Modelling of building frame

In this research, a five storey building frame is simulate using AUTODYN software as the target area. The data of reinforced column of the structure is used to form CAD model using the Solid work software. The data used to form this model are:

Type of Building: Five storey frame building
Type of Structure: Reinforced Concrete Structure
Type of Concrete: 35 MPa
Part of building: Column on first floor
Dimension of Column:
i. Length: 300 mm
ii. Width: 300 mm
iii. Height: 3000 mm

The 3D view and model of the structure is shown in Figure 3.

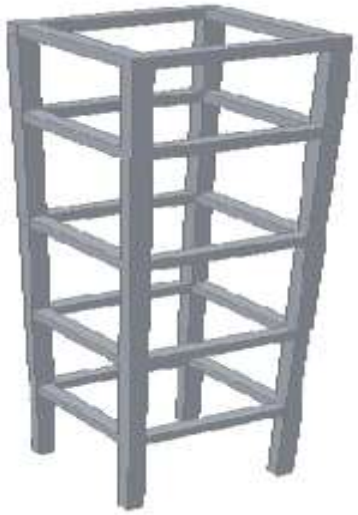

Figure 3 : Dimension of RC column

Solid work software is used to create the model of column The scope of modeling process is limited to the column on the 1st floor only because a numerical model of whole building is very large and required extensive and longer computational time to be simulated. It may take a week or even more because simulation progress is based on total number of element model was created. The model of 1st floor column with reinforcement is shown in Figure 4.

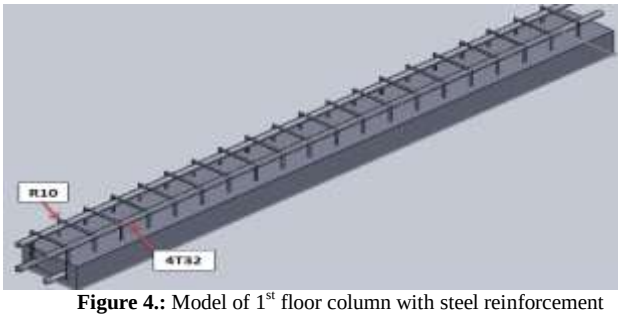

Figure 4.: Model of 1st floor column with steel reinforcement

The simulation is performed in 2D view. The use of 2D model is reduced the computational time compare to 3D model because the total number of element is slightly than 3D. Figure 5 shows the modeling of the structure column.

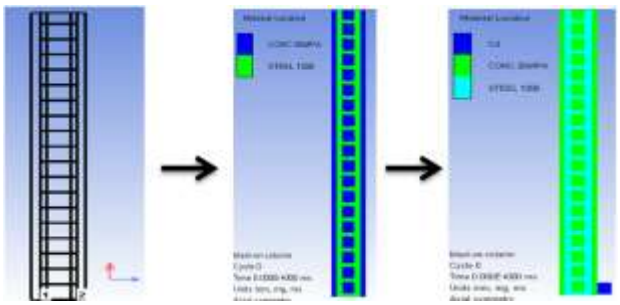

Figure 5 : Process of modeling 2D numerical model of column.

The standard Riedel, Hiermayer and Thoma therefore called RHT model. material model for concrete is used describe the behaviour of concrete is concrete with compressive strength of 35 MPa The Johnson Cook material model. Steel 1006 are used to modeled the steel reinforcement in the concrete column. Simulation process on reinforced column model are performed in 3 cases .This is as shown in Figure 6.

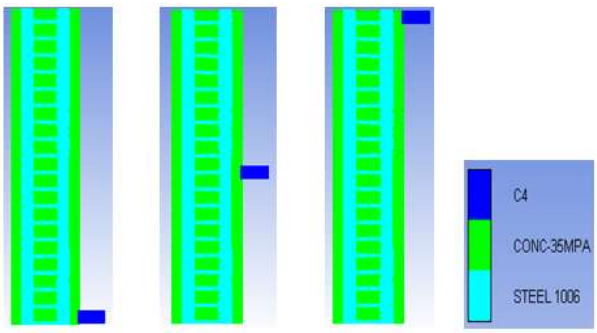

Figure 6: (a) lowest point (b) middle point (c) highest point (d) Indication of material

Based on Figure 6, the first case is an explosive charge is located on bottom of column. Second case, on middle of column and the third case the explosive is located on upper point of RC column model. A total 200 grams of TNT charge is located at the column at three different location which is lowest, middle and also upper point of the column. All of the 3 cases be simulated using same total amount of element in SPH solver for both concrete and steel reinforcement parts.

3. Results and Discussion

3.1 Case 1- Charge Weight Located at the bottom of the Column.

For case 1, the explosive charge is located on lowest point of reinforced concrete column. Figure 7 show the blast wave impact the reinforced column model in 2D .

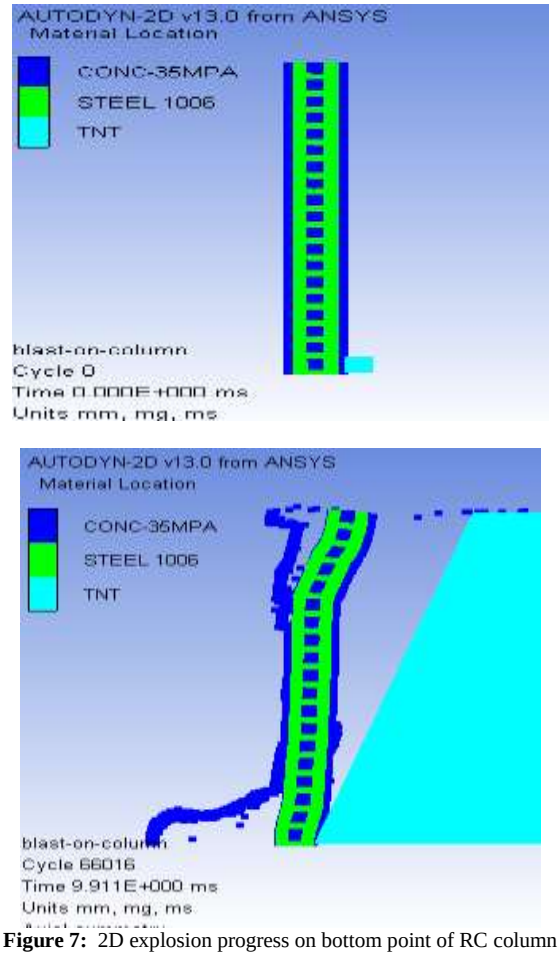

Figure 7: 2D explosion progress on bottom point of RC column

From the simulation results, it show that the steel reinforcement is partly bend and the concrete steel not damaged due to the explosion on 200 grams of TNT charge.

3.2 Case 2- Charge Weight is Located at the Middle Section of the Column.

For case 2, the TNT charge is located on the middle point of reinforced concrete column model. Figure8 show the 2D simulation process propagation of blast wave until 100 000 cycles.

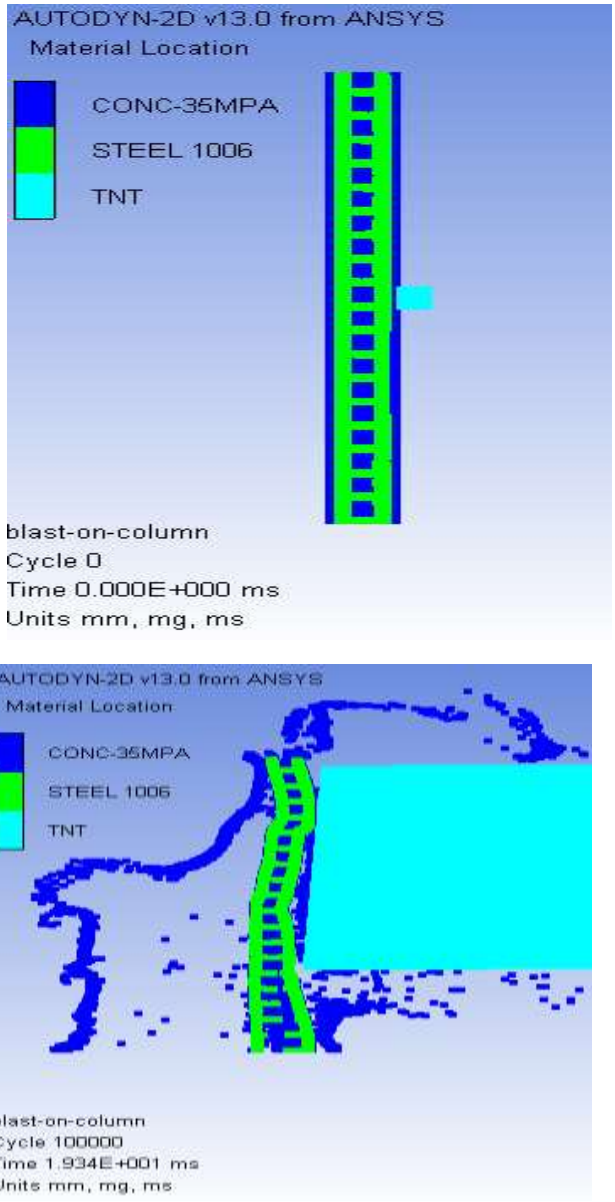

Figure 8 : 2D explosion progress on middle point of RC column

Figure 8 show the concrete totally failed which clearly apart for each other and distributed on free space. The steel reinforcement still firm and indicate that the reinforcement is still support the structural of column at 19.34millisecond. The bottom part of steel reinforcement is seem start to failed by to the link of rebar is tear apart. The model is look like still firm where only concrete part is tear off. The sign of steel reinforcement failure can be detected on bottom part of model.

3.3 Case 3 – The explosive charge is located on the top point of the column.

As for the case 3, the explosive charge location is placed on top point of reinforced column model. Figure 9 show the propagation of blast wave impact the reinforced column until 100 000 cycles on 2D perspective.

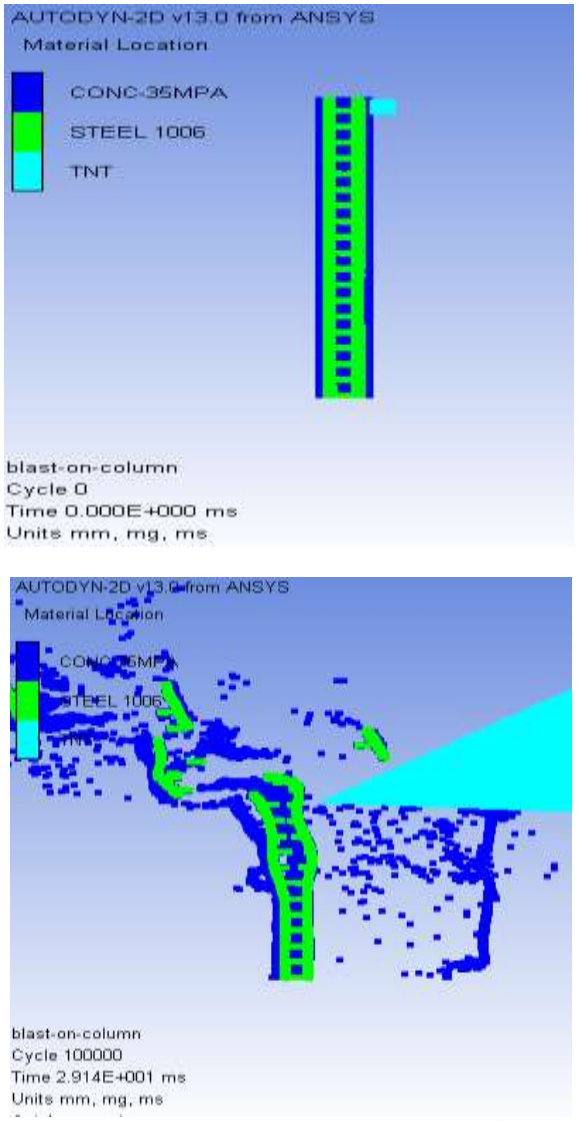

Figure 9 : 2D explosion progress on top point of column

Based on Figure 9 the propagation of blast wave reached to 100 000 cycle at time 29.14millisecond on top point of reinforced concrete column model. At this rate, the half of column model is tear off either column part or steel reinforcement part. At this rate, the column has reached its failure characteristic whereas the concrete and steel part is tearing off from each other.

4. Conclusion

It can be conclude that the location of explosive charge on upper point have given an excellent result compared two others location in terms of damage rate obtained on column model on 100 000 cycle. This may be because where the explosive charge is located on the top of column model has produced a higher pressure compare to other cases.

Acknowledgement

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