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Numerical analysis of multiple blast effect on steel pipe

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ABSTRACT

Many infrastructures such as buildings and bridges collapsed or were severely damaged, and a lot of human lives were killed due to terrorist attacks. The method of most terrorist attacks was a bomb. The bomb has enormous energy and destructive power. Thus, explosives are used for attacking structures. Therefore, the purpose of the study of the explosion effect should be to protect assets and lives from unpredictable terrorist attacks using many kinds of explosives. Considering a possible terrorist attack, it needs to study the case of the simultaneous multiple explosions. This paper numerically investigates the effect of multiple explosion on a steel pipe. By changing the number of explosives, the blast effect of explosives was investigated and the study also compared a single explosive case with multiple explosives cases.

1. INTRODUCTION

Blast effect from the detonation of one explosive has been studied for many years. Considering the terrorist attack, it is possible that many explosives detonate simultaneously at different places. Proper arrangement of explosives has bigger blast effect than one explosive on the target structure. Therefore, the blast effect of multiple explosion is unlike a single-explosive case. Simultaneous multiple detonation experiment had been carried out by Hokanson (1973). He compared a single charge case and three horizontal array cases with same total explosive mass. He found out the blast reflected pressure was estimated differently for the testing cases.

In this paper, the multiple blast effect on steel pipe is investigated by numerical simulation. ALE (Arbitrary-Lagrangian-Eulerian) method and LS-DYNA program are used. To verify a model, experimental pressure and numerical pressure are compared for the incident pressure by referencing Luccioni (2006). That paper verified an incident pressure as the air burst case. Therefore before simulation, the procedure of verification was performed by comparing them. Then from the numerical simulation, the differences of multiple blast effect are found.

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2. Modeling

2.1 Finite element model

To use the ALE method, air and TNT should be modeled by finite element method. Air and TNT models share nodes on the boundary surface. Air size is 3m×1.6m×4m. Each element is a solid model. The weight of TNT is 100kg. The stand-off from TNT to the steel pipe is 0.8m. The steel pipe has shell elements. ANSI 40 is applied to model the steel pipe. Outer diameter is 400mm and thickness is 12.7mm. Length is 4.5m. The boundary condition of the steel pipe is constrained in the all direction on top and bottom nodes. Fig. 1 shows a combined ALE model.

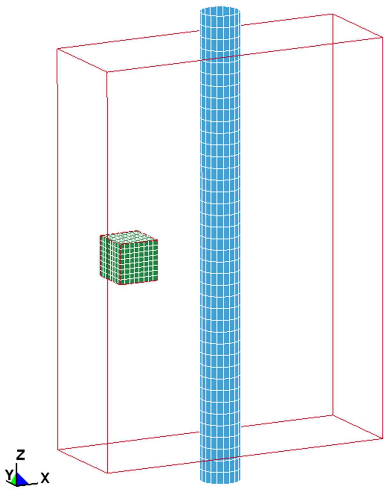

Fig. 1 Air-TNT-Steel Pipe model

2.2 Blast Pressure Verification

Incident pressure of TNT is compared CONWEP, ALE and Luccioni (2006). Fig. 2 shows each method has reasonable agreements. It means modeling technique is useful to analyze the blast effect by numerical method. Also, a dynamic response of plate had been verified in Kim (2012).

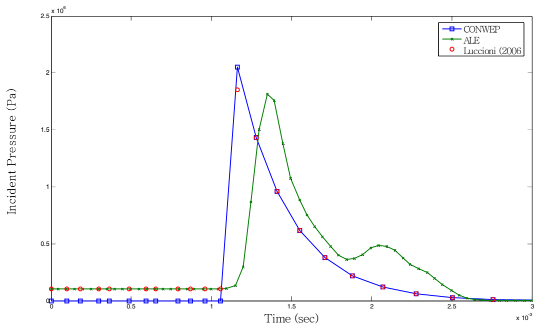

Fig. 2 Incident Pressure of CONWEP, ALE and Luccioni (2006)

3. Numerical Analysis

3.1 Analysis Case

The proposed 4 simulation cases have the same total TNT weight but the number and the location is different. But all of the cases have the same stand-off that is 0.8m. All TNTs are located on the X-axis. Variations of simulation are TNT weight and Z-axis gap. Case B has two 50kg TNT bombs placed at the same level (Z-axis). Case C has 0.8m gap on Z-axis between one TNT bomb and the other TNT bomb but a vertical center of two TNT bombs is the same with others cases. In Case D the gap was increased to 1.6m. Fig. 3 shows the locations of TNT bombs.

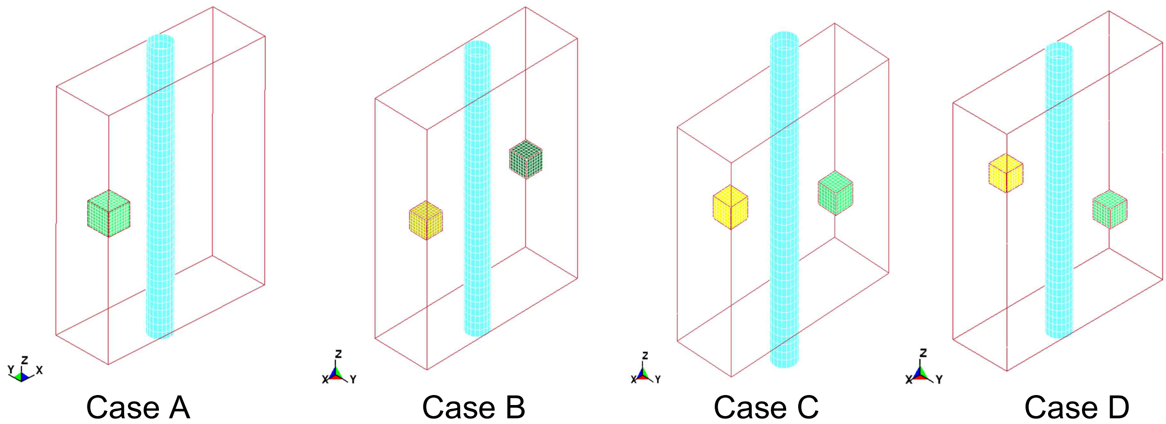

Fig. 3 Multiple explosion cases

3.2 Results

After running an LS-DYNA explicit program, steel pipe was changed and deformed by blast power. Fig. 3 shows an effective plastic strain value of steel pipe. Also, we can see the deformation shape. Case A has the longest horizontal transition. The top and bottom parts were influenced by a horizontal transition of the center part. Also, effective plastic strain takes place at the top and bottom of the steel pipe. But in other cases, it doesn't.

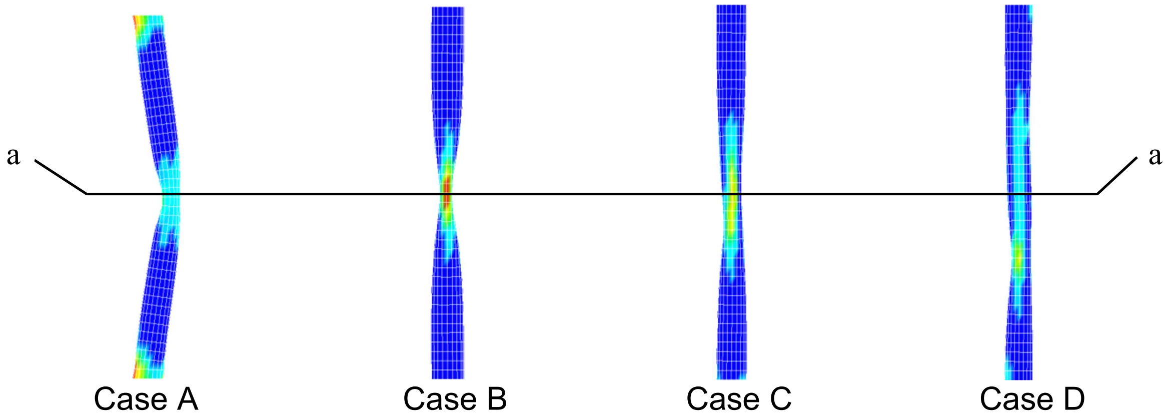

Fig. 3 Multiple explosion cases (left side view)

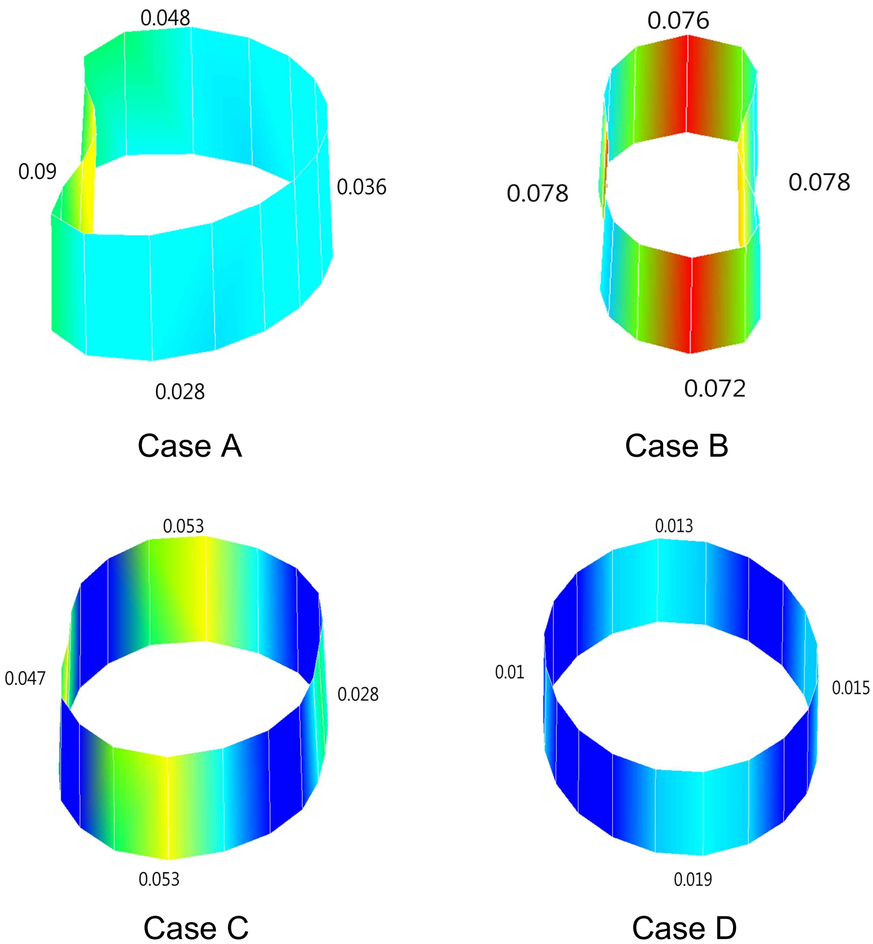

Fig. 4 a-a section (top view)

We can see the deformation shape and effective plastic strain values at each direction. Comparing case B, case C and case D, case B gets bigger damage on steel pipe. From that, we can conclude that direct placement of TNT is more powerful in influencing the target. Also, plastic deformation is almost the same at all directions in case B. Case C and case D show side parts were deformed more than front and backward parts.

4. CONCLUSIONS

Numerical simulation was conducted about multiple explosion cases. The main variation is the TNT weight and the vertical distance. Four cases was compared and analyzed. The single charge case has more focused power than multiple cases but case B shows the highest damage in terms of a steel member.

Therefore, a single charge has more blast power than multiple charges in a global structure scope but multiple charges can damage the steel pipe efficiently in a local member scope.

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