ENHANCING PROTECTIVE BUILDING DESIGN USING EXPLICIT DYNAMIC

Wisit Kawayapanik[1,*], Khanathip Prabuntrarik[1], Pornpen Limpaninlachat[1], Yasothorn Sapsathiarn[1], and Panon Latcharote[1]

[1] *Department of Civil and Environmental Engineering, Faculty of Engineering, Mahidol University, Nakhon Pathom, Thailand*

*Corresponding author: kawayapanik@gmail.com

1. INTRODUCTION

Careful design of public buildings is needed to provide an optimized response that accounts for various loading cases, such as seismic, wind, and blast loads. Effective building design needs to be well-balanced for various scenarios. Fundamental understanding of structural behavior and dynamic response is crucial for the protective building design under blast load, in which peak pressure is orders of the highest magnitude, but their durations are very short.

Numerical simulations can provide valuable insights into structural behavior under blast loads. It can be used to assess how various design factors affect the response of reinforced concrete structures, all while investigating their intricate and profoundly nonlinear behavior when exposed to blast loads.

2. METHODOLOGY

This study incorporated the explicit dynamics method into the investigation, mainly focusing on simulating fundamental components' structure and material properties. In general, explicit dynamics elucidates how structural elements react to explosive forces, providing a comprehensive view of global and localized effects. When applied rigorously, this method makes a substantial contribution toward advancing our comprehension of the fundamental principles that govern the behavior of structures in the face of explosive forces. This study used ANSYS and LS-DYNA to model the reinforced concrete panel under the blast load to study and investigate the behaviors. The TNT explosive was placed at a stand-off distance over the RC panel. For a blast scenario, a 3D air box was created around the panel to act as a domain for the analysis. The ANSYS explicit dynamics module created a 3D wedge filled with air and TNT materials and continued until the panel failure.

Implicit and explicit refer to two time integration methods used in dynamic simulations. Explicit time integration is more accurate and efficient for simulations involving shock wave propagation, large deformations and strains, non-linear material behavior, complex contact, fragmentation, and non-linear buckling. Typical applications include drop tests, impact simulations, and blast load analysis.

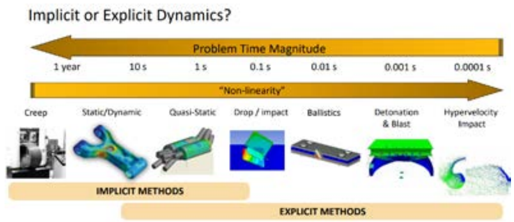

Figure 1. Implicit and Explicit problems.

The Lagrangian and Eulerian approaches are two fundamentally different ways of analyzing and simulating fluid dynamics. Here are the key differences between them.
In the Lagrangian approach, the frame of reference moves with the fluid particles. Each fluid particle is tracked individually as it moves through space and time. In the Eulerian approach, the frame of reference is fixed in space. It focuses on observing how fluid properties change at specific points or within cells in a fixed grid or mesh. In summary, the choice between the Lagrangian and Eulerian approaches depends on the specific characteristics of the fluid dynamics problem, the level of detail needed, and computational considerations. Lagrangian is suited for individual particle tracking and highly transient flows, while Eulerian is suitable for bulk flow analysis and grid-based simulations.

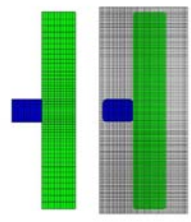

Figure 2. Reference frame.of Lagrangian and Eulerian

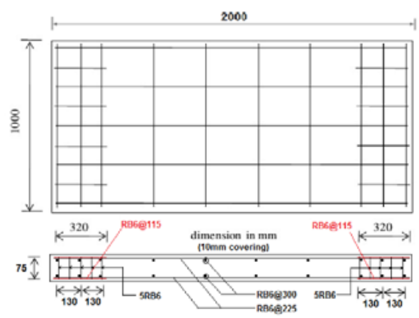

Figure 3. Concrete panel geometry and reinforcement detail [1]

Table 1. The specimen detail. [1]

Specimen name		NRC1LB	NRC2LB
Concrete compressive strength		55 MPa	
Steel reinforcement strength	Grade	SR24	
	Yield strength	305 MPa	
	Ultimate strength	440 MPa	
Explosive charge weight		1 lb	2 lb

3. RESULTS

According to the numerical simulation models showed that the reinforced concrete panel was subjected to surface blasting conditions. When a crack propagated through the middle of the slab, its behavior at that location was indicated by a red contour in Fig. 5. Additionally, blue-green contours appeared in the middle due to the erosion of surface elements.

Figure 4 Stress simulation of concrete panel under force of 1-lb TNT explosion
Figure 5 Crack propagation at the bottom surface of the slab

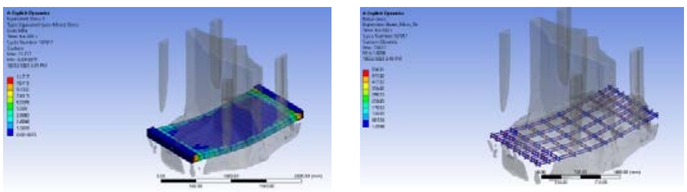

Figure 4 Stress simulation of concrete panel under force of a 1-lb TNT explosion (ANSYS Explicit dynamics)

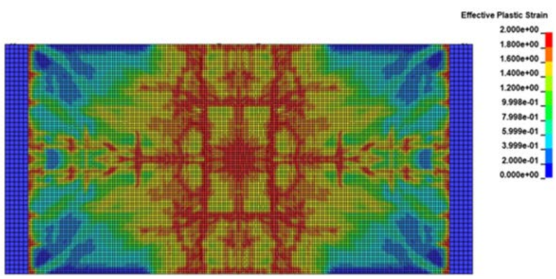

Figure 5 Crack propagation at the bottom surface of the slab (LS-DYNA)

4. CONCLUSIONS

Currently, investigations and findings on the structural behavior under blast loads are very limited which provide some recommendations to ensure greater strength in building structures that must withstand localized failure. However, a performance-based approach to design building members and structures under blast loads is still lacking. This study enhances our understanding of concrete structures under blast loads and utilizes finite element techniques to analyze their structural dynamic responses. These results can predict damage patterns for local failures, such as cracks and localized spalling, contributing to the expansion of design guidelines for RC structures subjected to shock waves.

5. REFERENCE

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6. AUTHOR BIOGRAPHIES

Wisit Kawayapanik. is currently a master's student at the Department of Civil and Environmental Engineering, Faculty of Engineering, Mahidol University. His research interests are focused on the behavior of RC structures under confined explosions.

Panon Latcharote obtained D.Eng. in Infrastructure Systems Engineering from Kochi University of Technology, Japan. He is currently an assistant professor at Department of Civil and Environmental Engineering, Faculty of Engineering, Mahidol University. His research interests include physics-based computational and simulation engineering, nonlinear structural response analysis, multi-hazard risk assessment, statistical modeling and uncertainty quantification, and geographic Information System (GIS).