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Blast analysis on RC slab with various conditions of reinforcement

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ABSTRACT

This study numerically examines how the behavior of RC slabs subjected to blast load changes according to various reinforcement conditions. The numerical model for blast analysis uses the dynamic increasing factor (DIF) to account for the strain rate effect. A parametric study that changes the diameter, spacing, and yield strength of reinforcement confirmed each factor's influence on the behavior of RC slab.

1. INTRODUCTION

Many experimental and analytical studies on structures are being conducted to prepare for accidents caused by explosions (Su et al., 2021). Research has also been conducted to enhance the blast resistance of structural members. In particular, numerous studies have investigated the changes in blast resistance when advanced concrete materials, such as fiber-reinforced concrete (FRC) and ultra-high-performance concrete (UHPC), are applied to conventional reinforced concrete structures (Lee & Kwak, 2021). However, research on the explosive performance resulting from changes in steel reinforcement in RC structures is relatively scarce. In this study, numerical analysis was conducted to investigate how the behavior of RC slabs varies with different steel reinforcement conditions, such as the cross-sectional area, spacing, and yield strength.

2. NUMERICAL MODEL

2.1 Material models

Since blast loads cause rapid deformation in structures over a short period, structural behavior can be accurately simulated numerically only by considering the high-

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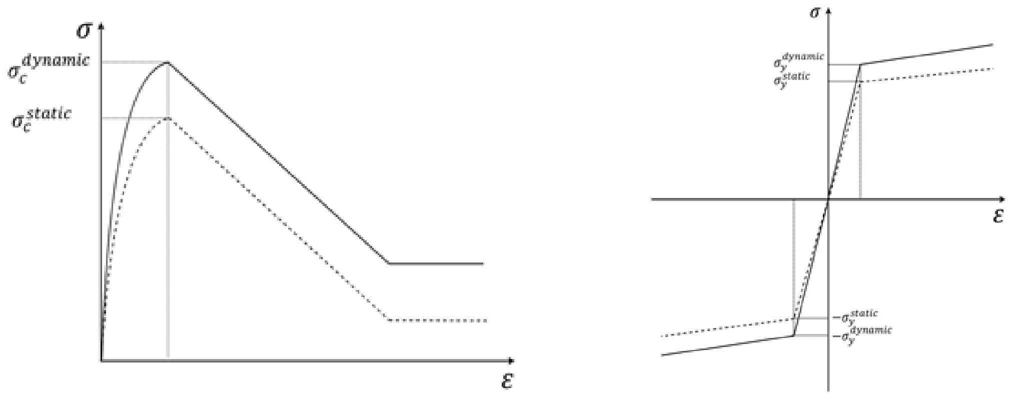
strain-rate effect of the material. It is generally known that when high-strain rates occur in concrete and steel, a strength increase is observed due to inertia and restraint effects. To apply this strength increase in the material model, design guidelines such as UFC (UFC, 2014) and CEB-FIP (CEB, 1993) suggest the use of a dynamic increase factor (DIF), as shown in Fig. 1.



(a) concrete (compressive region) (b) steel

Fig. 1 Examples of dynamic increase factors

2.2 Finite element model

A numerical model was constructed using Ansys LS-Dyna, a commercial finite element analysis program. To simulate the material characteristics resulting from an explosion, DIF was applied based on the Plastic Kinematic Model for steel and the Karagozian & Case Concrete Model for concrete. The CONWEP was used to estimate a blast load based on the weight and distance of the explosive. The RC slab member was modeled using 3D solid elements for the concrete and 1D beam elements for the steel reinforcement (see Fig. 2). Through the optimization of element size, the mesh size was set to 10 mm.

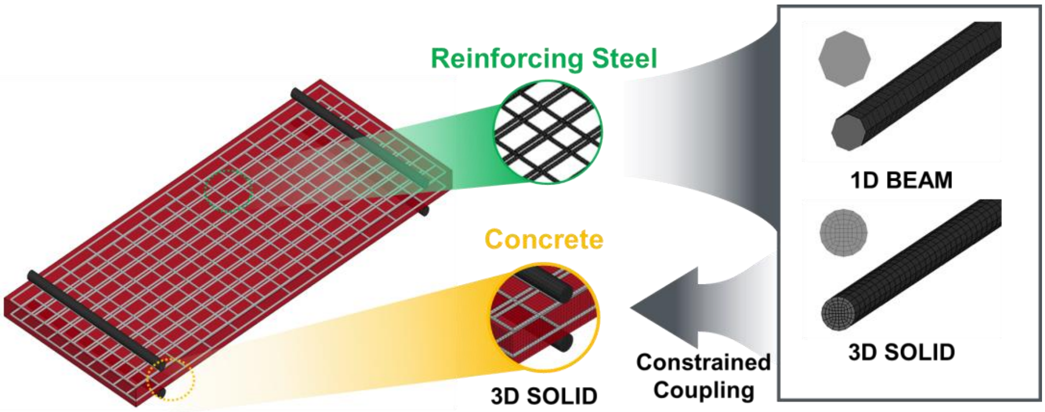
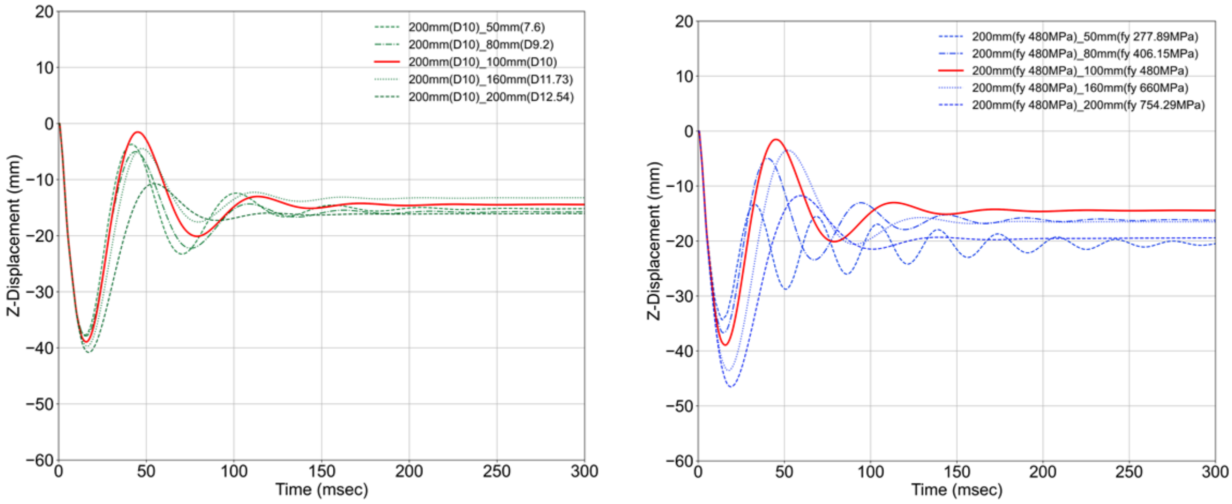


Fig. 2 Finite element model

3. INFLUENCE OF THE STEEL REINFORCEMENT

To investigate the effect of steel reinforcement on the behavior of RC slabs, a parametric study was conducted, in which the spacing and yield strength of steel reinforcement were varied in the numerical analysis model. The spacing of the steel reinforcement was varied as 50, 80, 100, 160, and 200 mm, and the yield strength was set to 400, 480, and 600 MPa. The displacement-time curves of the RC slab were then compared for different reinforcement spacings and yield strengths as shown in Fig. 3.



(a) spacing (b) yield strength

Fig. 3 Displacement-time curves with changes in steel reinforcement conditions

In the case of steel reinforcement with the same cross-sectional area, as the spacing between reinforcing bars increased, the maximum displacement and residual displacement increased. In the case of the same amount of steel reinforcement, the tendency of structural behaviour was different depending on the combination of yield strength and spacing.

4. CONCLUSIONS

In this study, numerical analysis was conducted to investigate the influence of varying steel reinforcement conditions on the behavior of RC slabs subjected to blast loading. Additionally, an optimized combination of yield strength and spacing of steel reinforcement enhances structural performance of RC slab against explosive loads.

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