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Simulation of Blast Demolition of Reinforced Concrete Buildings

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1. INTRODUCTION

When using blast demolition, the variety factors control the collapsing behavior, direction of collapse and final deformation. They are columns and girders to be blasted(blast position), numbers of structural members to be blasted(blasting scale), blast sequence, delay time for blasting sequence(delay time) and whether walls and floors weakened in advance(precutting). A technique had been developed consisting of numerical analysis, to clarify the relationship between these factors and collapse behavior, and a visualizing system.

2. METHOD OF ANALYSIS

A space-framed structure that are composed of columns and girders is analyzed. Walls and floors slabs are supposed to have been removed in precutting, and their effects on collapse are disregarded. The structural members are modeled into a collective body of spherical rigid elements as shown Fig. 1(a). Each Element is connected to the neighbouring element with springs both in the normal and tangential direction and bending springs. The equation of motion is written for each spherical element:

$$m\ddot{u} + C\dot{u} + F = 0 \qquad (1)$$

$$I\ddot{\phi} + D\dot{\phi} + M = 0 \qquad (2)$$

where m is mass of spherical element, u is a displacement vector, F is a resultant force acting on element through spring, I is mass moment of inertia, ϕ is angulr displacement, M is a resultant moment acting on element through spring, C and D are damping coefficient , and dot means a derivative with respect to time. The displacement vector u and angular displacement ϕ is obtained step by step time integration in time domain.

Complete detonation of each blast position is assumed, when considering the blasting behavior, hence the structural members are severed and fragments of them scatter at the instant of blasting. This can be done by allowing spherical elements and connecting springs at the blasting position to disappear as shown in Fig. 1(b). The dead load resulting from the disappearance of supporting columns and the failure attributable to impact loading were taken into account. To do this, bi-linear hysteresis was attributed to the rotational spring. The tangential spring is assumed to disapper when the bending moment reaches the ultimate moment as shown Fig. 1(c). With regard to contact and impact, the concept of distinct element method is employed. When contact occurs, a contact spring in the normal direction and in the tangential direction as shown Fig. 1(d), is assumed to work between the elemnts.

3. COMPARISON WITH TEST

The numerical result is compared with the experiment using a half-sized frame structure model of a three story reinforced concrete building. The specimen was designed to fall towards the left. The collapse process of the structure was filmed by high speed cameras. The comparison between the numerical result and the test result is shown in Fig. 2. The following conclusions can be drawn:

(1) The analysis simulates the test result very well until the fifth blasting.

(2) After the sixth blasting(the final blasting), the analyzed model falls a little earlier than the tested structure.

(3) At the final stage, the analyzed model is piled up lower and wider than the test. It is because the thickness and restrained effect of the precast concrete slabs used as the counter weight are not considered in the numerical result.

(4)The displacement in the horizontal direction obtained by the analysis is smaller than that obtained by the experiment. The surviving reinforced bar after blasting, which is not considered in the analysis, is supported to affect the collapse pattern of the test.

4. CONCLUSION

A collapse simulation system of a reinforced concrete building by explosive demlition is developed, using a numerical method based on the improved distinct element method. To verify the accuracy of this system, a test of the half-sized model framed structure demolished by a controlled explosion is simulated. This system has been proved to have sufficient accuracy to simulate the demolition process.

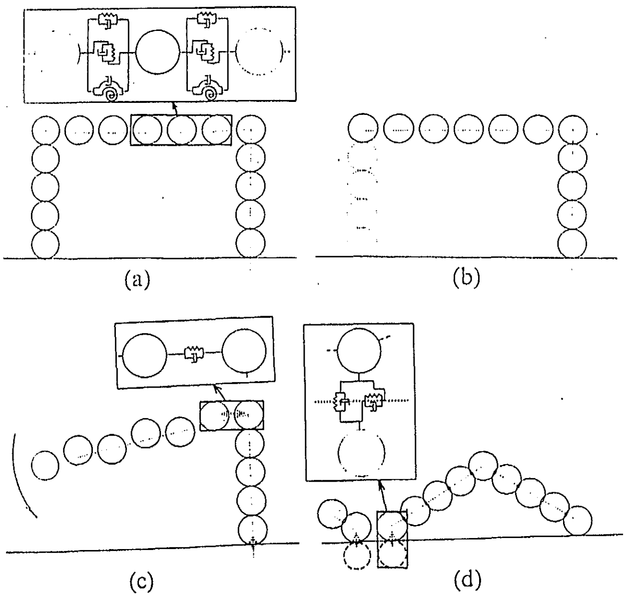
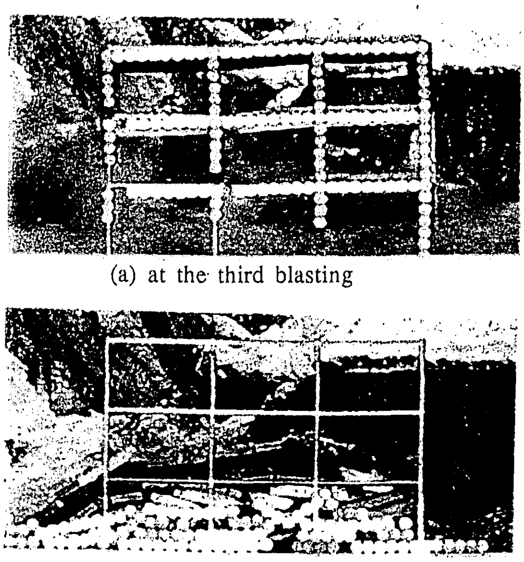


Fig. 1.Method of analysis:(a)phsical model;(b)blasting behavior;(c)rupture;(d)contact and collision.



(a) at the third blasting

(b) after the collapse

Fig. 2.Comparison between test and analysis