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DEVELOPING PC-BASED DESIGNING TECHNIQUE FOR BLASTING DEMOLITION

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ABSTRACT

The number of old structures that are at the final stage of their average life has largely increased during the last years. Many of them are pulled down for rebuilding, and for the demolition of such structures, it is indispensable to choose and design controlled and efficient methods. One technically and temporally effective way of dismounting brickwork, reinforced concrete and steel constructions is blasting demolition by detonating explosives: Compared to other methods using breakers or systematically organized mechanical dismantling methods, demolition by blasting, usually with locally weakened structural parts (i.e., before blasting, some reinforcements are cut, or supporting parts are destructed with special machines), allows the teardown (collapse) of a structure within a relatively shorter period of time of operation [e.g., 1]. Because of this short time span and therefore possibly the minimum disturbance to the local business and transportation in the surroundings, the load to the environment by this method tends to be smaller. However, since blasting itself is an extraordinary dynamic event, demolishing structures by blasting unnecessarily gives rise to the anxiety of neighboring residents – The technical details of blasting design, i.e., the selection of the structural elements to be destroyed by the explosives and the amount and timing of ignition of the explosives, are still empirically determined by well-experienced engineers and it is very error sensitive if the building construction is complex. Unsafe situations may arise, if planned collapse is incomplete and the remaining parts of the structure must be removed manually. This may be one of the reasons blasting demolition is usually avoided in urban areas, and precise, quantitative evaluation of structural damage caused by blasting is needed for a more physics-based design of blasting demolition. From a physics point of view, blasting demolition consists of two dynamic stages: (1) wave propagation and development of fracture network in the structure upon detonation of explosives; and (2) the collapse of the structure, weakened by dynamic fracture, due to the gravitational effect. The safe destruction of a structure using controlled explosives requires detailed and reliable knowledge about impact,

wave dynamics and fracture mechanics related to the blast waves. Our goal here, therefore, is to establish firm but concise technique to simulate the physical process of blasting demolition of complex structures. We develop a fully three-dimensional numerical code, with the capability of setting arbitrarily different locations of multiple explosive loads with different delay time, based on the efficient finite difference technique originally developed on a PC (Windows) for wave and fracture propagation in solids (SWIFD [2, 3]). Then, we validate the code (simulator) by comparing the numerical results with the observations of the model experiment performed in the field using a RC (reinforced concrete) beam (Figure 1). We further simulate the real demolition of columns of a road bridge (the Fudo Bridge of the National Route 41 of Japan). Detailed computations have revealed that the effect of the reinforcing steel on dynamic wave propagation and damage generation may be negligible (and hence we can use coarser mesh grids for simulations of real structures), and surprisingly, the use of the simple fracture criterion based on the tensile strength of material (e.g., 2 MPa for concrete) can reproduce the fracture pattern very precisely.

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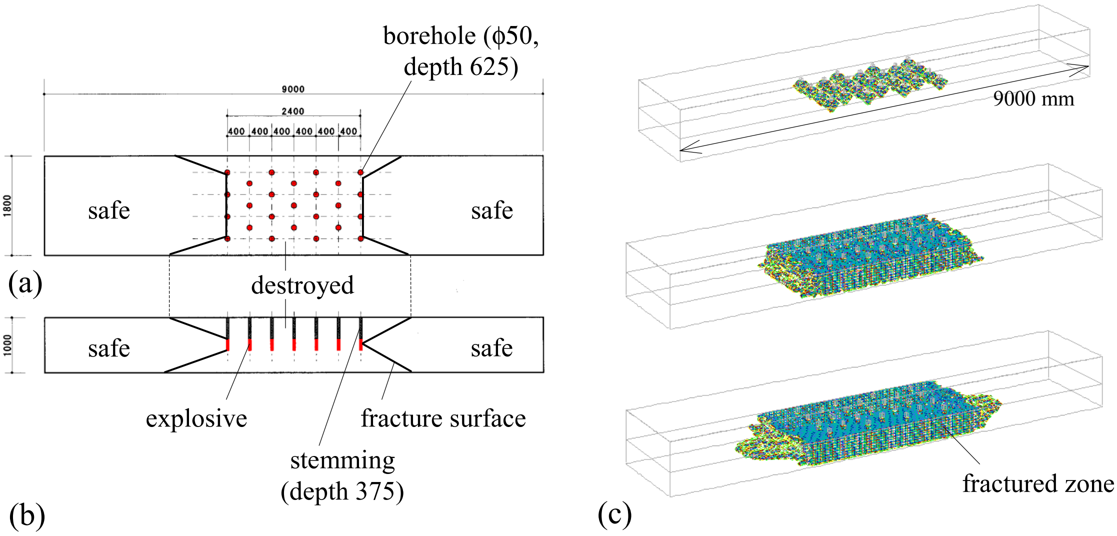

Figure 1. RC beam used for the field experiment of blasting demolition, performed at the Japan Construction Method and Machinery Research Institute: (a) Top and (b) side view of the beam and the observed damage [unit: mm]; and (c) snapshots of fracture evolution at 43 μs (top), 247 μs (middle) and 444 μs (bottom) after ignition, obtained by the numerical simulation using a smaller number (187×37×21) of orthogonal grid points. In this example, all the explosives are detonated simultaneously for the duration 50 μs with the maximum amplitude of 100 MPa. For graphical clarity, only the damage in the lower part is shown. *P* (*S*) wave speed in concrete is 4000 m/s (2500 m/s), respectively.