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学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　博士（工学）　氏名　金 学晩

学 位 論 文 題 名

Control of dynamic fracturing in concrete pile head breakage by blasting
(発破による杭頭処理における動的破壊の制御)

Deep foundations generally include piles, drilled shafts, caissons and piers. In many countries, drilled shafts have been utilized as a foundation of ground structures because these can resist both axial and lateral loads and minimize the settlement of the foundation. However, in the case of cast-in-place concrete piles, a top part of the concrete pile, i.e. concrete pile head, should be adjusted to the bottom level of main foundation and, thus, the breakage of concrete pile head is required. However, the breakage of concrete using mechanical methods involves with various risks with respect to safety. Therefore, alternative methods to solve the problem are required.

This dissertation investigates a new dynamic fracturing method for the breakage of concrete pile head by blasting. The dissertation consists of six chapters.

In chapter 1, the background and purpose of the dissertation are described and the literature related to dynamic fracturing of rock-like materials by blasting are reviewed. Especially, it is pointed out that knowledge of 3-dimensional fracture process by cylindrical charge is indispensable to consider the optimal blasting condition for the concrete pile head breakage.

In chapters 2 and 3, Dynamic Fracture Process Analysis for axisymmetric problem (DFPA-A) is proposed and the fracture process in a cylindrical body with a cylindrical charge is discussed. In chapter 2, DFPA for 2-dimensional plane strain problem is reviewed and DFPA-A is formulated. In chapter 3, a numerical code of DFPA-A is developed and its applicability is verified. In DFPA-A, two kinds of tensile fracture, i.e., the tensile fractures within r-z plane and normal to r-θ plane in the cylindrical coordinate (r, z, θ), are taken into account. In the modeling of the tensile fracture within r-z plane, inter cracking method is used to simulate crack initiation, propagation and coalescence and the cohesive law is adopted to simulate the nonlinear crack opening behavior due to the existence of fracture process zone near the crack tip. In the modeling of the tensile fracture normal to r-θ plane, the stress-strain relation in each element is used to express the decohesion of crack surface. A concept of Crack Opening Strain (COS) is proposed for the modeling of cohesive law where COS is defined as the ratio of the Crack Opening Displacement (COD) to arch length of subdomain which includes one predominant crack. Numerical results of fracture process under various conditions are shown and it is clarified that the conical crack pattern was formed from the bottom of charge hole as well as predominant cracks radially extending from the charge hole in the axisymmetric condition. This result indicates that, in the concrete pile breakage, the propagation of conical cracks should be controlled to prevent the damage in the remaining part of the pile. Additionally, the fracture process obtained from axisymmetric condition is compared with that from plane strain condition, and the validity of the proposed method as well as the range in which plane strain condition is applicable are discussed.

In chapter 4, for the controlling of the conical cracks from the bottom of charge hole, the laboratory scale experiment and numerical analysis of the dynamic fracturing in cylindrical concrete pile with steel plate as a crack arrester are performed. The influences of applied loading conditions and spacing between the bottom of the charge hole and steel plate on the fracture process of concrete pile are investigated and the optimal condition to prevent the damages on remaining part of concrete pile are clarified.

In chapter 5, for the controlling of the crack propagation direction by the use of wedged charge holder, DFPA for 2-dimensional plane strain condition is performed and the influence of loading conditions on the resultant fracture patterns are investigated. By analyzing numerical results, the optimal pressure function to obtain smoother fracture plane and to minimize damage in the remaining part is clarified. Furthermore, the relation between the crack propagation speed and crack branching is discussed.

In chapter 6, the obtained results are reviewed and some suggestions for future work are given.