(III－113) Dynamic Soil-structure Interaction Analysis by Transmitting Boundary

群馬大学　学生会員　李　強
群馬大学　正会員　鵜飼恵三

In the dynamic analysis of structures on soil foundation, the soil foundation is actually acted as an unbounded medium. At present, the transient coupling BEM-FEM is still the most theoretically powerful approach to handle this problem, however, it is global in time and so impractical in numerical analysis. Various approximate methods with less computational effort have been proposed to simulate the behavior of unbounded soil.

In this paper, a comparative study is performed using two kinds of approximate methods, i.e., the multi-directional transmitting boundary (Higdon, 1992) and the doubly asymptotic (DAAs) boundary (Underwood & Geers, 1981), in the elasto-plastic dynamic analysis of a slope. In our study, the soil is simulated by the simple elasto-plastic MCDP model. The two lateral boundaries of the slope tend to infinity, and are simulated by the transmitting boundary or doubly asymptotic boundary. The earthquake excitation is input through the base of the slope.

The slope is shown in fig.1. In order to avoid the failure by tensional stress near lateral boundaries, three layers of elastic elements are introduced. This elastic transition material is also needed in the implementation of multi-directional transmitting boundary. The material parameters are listed in table 1.

Table.1 The material parameter

Material No.	E	ν	ϕ	ψ	C	ρ	α	β
1 (foundation)	2600	0.4	33°	0	0	1.70	0.05	0.02
2 (slope)	1000	0.4	7.5°	0	1.75	1.80	0.05	0.02
3 (transition)	2600	0.4	33°	0	0	1.70	0.05	0.02

The initial stress state is determined by nonlinear static analysis. Three cases are studied according to the different treatment of lateral boundaries. In case 1, the conventional truncated FE mesh is adopted, with two lateral boundaries both fixed; in case 2 the DAAs boundary is adopted; in case 3, the multi-directional transmitting boundary is adopted.

As shown in fig.1, the bottom boundary is taken as prescribed displacement boundary on which a seismic motion of sinusoid wave with period of T=0.80s is input. The amplitude of the acceleration of the input wave is 2.0m/s^2, i.e., $u(t) = u_0 \sin(2\pi t/T)$ when $t \le 8.0s$ and $u(t) = 0$ when $t > 8.0s$. Here u_0=0.032423 (m).

It is well known that DAAs boundary is only accurate in high and low frequency limit; the multi-directional transmitting boundary is conditional stable (Wolf & Song ,1996). The improved transmitting boundary proposed by Wolf & Song fails in this example, as the seismic source is too close to the artificial boundary.

Fig.2 shows the results by the case 1 and case 2. The difference can be ignored. In this example, the material damping filters out the high frequency component, and the mesh is quite accurate for static limit. So for the case 1, the function of the DAAs boundary is automatically satisfied.

Due to the same reason, the result by the case 3 can be taken as accurate . Fig.3 shows the results by case 1 and case 3. From fig.3, we can see the response by conventional FEM is quite large due to the multi-reflection of the wave.

Through this example, we can get the following conclusions:

(1) The conventional FEM by truncated mesh generally get larger response because of the multi-reflection of the intermediate high frequency wave, even when higher material damping is adopted;

(2) Material damping can filter out high frequency wave automatically, and improve the numerical performance of

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〒376 群馬県桐生市天神町 1-5-1 群馬大学工学部建設工学科 Tel (Fax): 0277-30-1620

multi-directional transmitting boundary.

(3) The DAAs boundary can treat the high and low frequency limit successfully.

(4) The stability of the improved multi-directional transmitting boundary by Wolf, et. al needs further study.

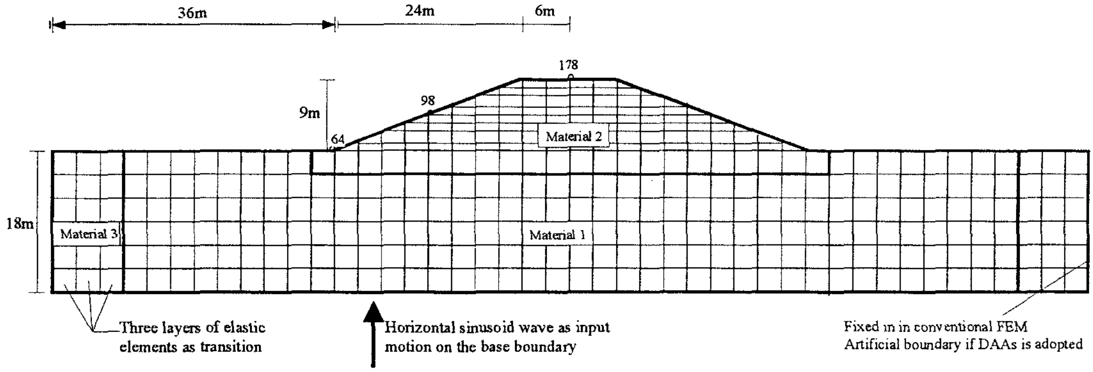
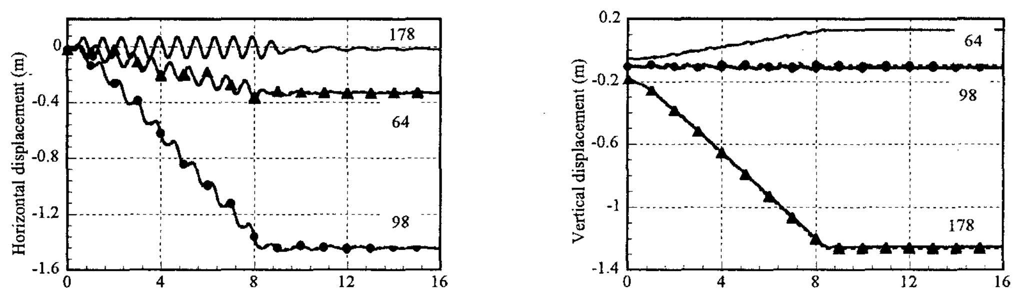
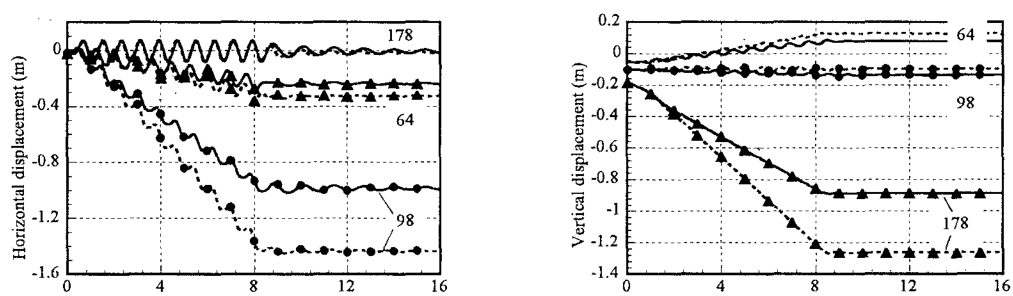


Fig.1 The elasto-plastic dynamic analysis of the slope



Full line: doubly asymptotic boundary; Broken line: conventional FEM

Fig.2 Comparion of case 1 and case 2



Full line: multi-directional transmitting boundary; Broken line: conventional FEM

Fig.3 Comparion of case,1 and case 3

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