SIMPLIFIED INVERSION IN SURFACE WAVE METHOD BY FINITE ELEMENT MODELING

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Introduction

As a kind of non-destructive seismic method, Surface-wave methods could be performed on surveying the stiffness of near-surface. Procedures of the methods are data acquisition, processing and inversion. The method we used in site investigation were same as Common Mid Point Cross Correlation Analysis (CMPCC)[1). Geophone array of CMPCC is similar to Multichannel Analysis of Surface Waves Method (MASW) which requires Multichannel acquisition system consisting of 24 geophones and a seismograph. But for CMPCC, the difference is that seismic sources will be created between every two geophones by sledge hammer. Spectral analysis are used for inversion in conventional methods. Once we acquire data of wave , using CMP Cross-correlation Analysis can assist us in inversion processing and derive S-velocity structures. This research proposes a new simplified method for inversion by comparing first arrival between finite element modeling and in-situ investigation. By employing the FEM, any problems for various boundary conditions and heterogeneous media, can be easily solved. We created 2D finite element model with same scale as field observation and apply loads in short period. Then we compared the response of FEM models with data obtained from field observation to calculate errors. By adjusting parameter (Young’s moduli) of FEM models, we can minimize errors and regard this parameter as our solution.

Field Survey

In this research, we used data acquired at embankment of an earth-fill dam, which is located in Okayama. 24 geophones were set straight with 2m spacing on top of the levee, and 25 impacts were made between those receiver. Figure 1 shows array of geophones and shot gathers at first impact.

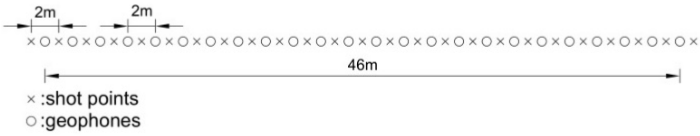

Figure 1(a) array of geophones and shot points

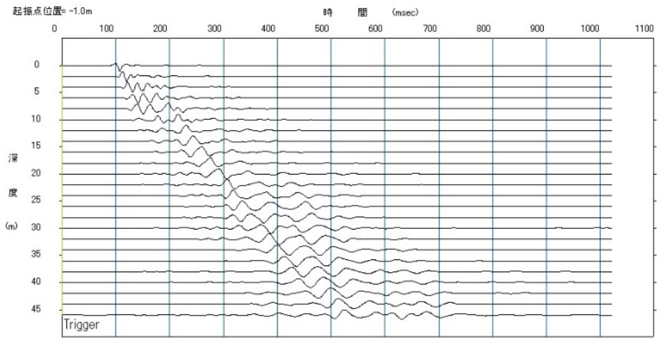

Figure 1(b) An example of observed shot records.

FEM Simulation

An FEM software named Quake3D[2) was performed on simulating wave propagation. The 2D model is 90 meters in length and 20 meters in height. Even though length of the line which have been surveyed is just 46m, we need a longer model to eliminate the influence of refraction at boundaries, cause we have not implemented viscous boundary on this model. Figure 2 shows the model. In the main area, the size of elements in horizontal direction are set to 1m and 2.5m in vertical direction. To remove spurious oscillations[3), the elements, around every shot point whose interval is 2m, were divided into 40 meshes on horizontal direction.

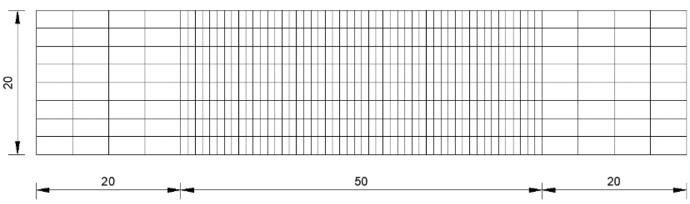

Figure 2 FEM simulation model

F

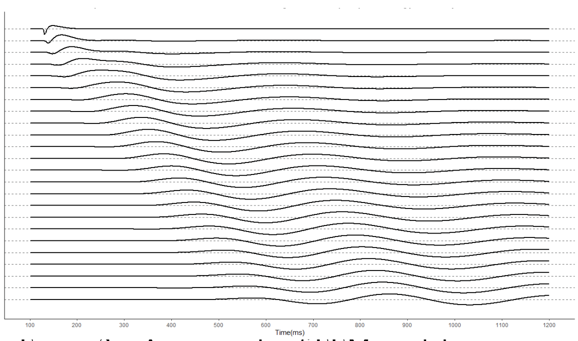

Figure 3 An example of FEM model response

In line with the field survey, the dynamic load should be applied on different nodes and response should be solved every times corresponding to the load changes. In other words, we need to solve one model 25 times with different loads.

Optimization

The errors between FEM simulation and field survey can be defined as difference between each first arrival. We used the method introduced by JGS Standards[4] to distinguish first arrival from record of field survey manually. As for FEM simulation , because there is no disturbance in records, it is ease to distinguish first arrival when the amplitude exceeds a certain value. Regarding the first arrival of geophone which is most close to shot point as beginning can make it easy to create objective function Eq. (1).

$$F = \sum_{j=1}^{j=25} \sum_{i=1}^{i=24} \left[(t_{ij} - t_{1j}) - (T_{ij} - T_{1j}) \right]^2 \quad (1)$$

t_{ij}: first arrival recorded in field survey shot gathers

T_{ij}:first arrival in FEM simulation

Golden-section search[5] are performed on finding the minimum of the objective function.

The solutions is shown in Figure 4.

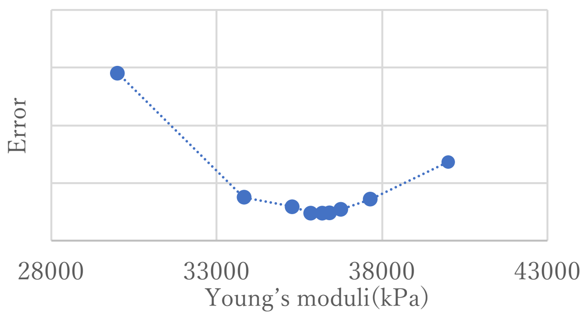

Figure 4 The solutions of Golden-section search

After 6 searchs, we can asertain ,with this model, that the Young's moduli which lead a minimum error could be in (35835.95, 36393.21) kPa. The nearest value we calculated is 36180.30kPa and a comparison of first arrivals between simulation and field survey in this situation is shown in Figure 5. In this research that value is the solution of inversion process.

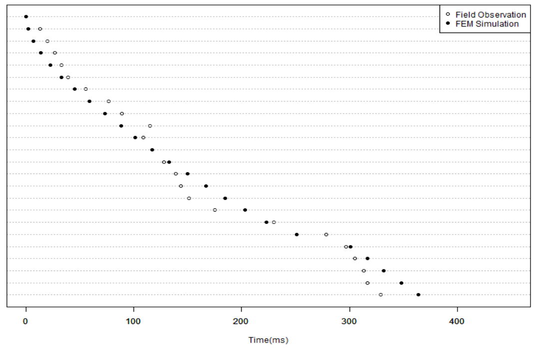

Figure 5 A comparison of first arrivals between simulation and field survey

Conclusion

This research have tried to study a new simplified method for inversion of surface wave methods by combining finite element modeling and optimization. Finite element modeling can be a tool for finding a first arrival of surface wave with certain parameters. Simple optimization technique performed well while using homogeneous medium for finite element simulation. Although the complicated model for the heterogeneous ground ask for complicated techniques to find optimal solution, such grounds will be solved as a next step.

References

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