

# Very effective non-reflecting side-boundary manipulation for FDM solution of plane-wave incidence problems by source box methods

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In simulation of elastic wave propagation by FDM, special processing, namely, non-reflection side-boundary manipulation is necessary for wave field in the vicinity of artificial boundaries (Takenaka, 1999). If any measurement was taken at artificial boundary, then spurious reflection waves are created and they contaminate wave field. Especially in ordinary plane wave incidence problem wave always contacts with artificial boundaries and the points of contact emit cylindrical noise waves. What's more, when these cylindrical waves come up to near free surface, large amplitude surface waves emerge from upper part of both sides boundaries and this proceed toward the center of calculation region. This causes serious contamination of wave field. So wave field without contamination is limited before arrival of cylindrical wave. This is rather a serious problem for analysis.

To improve such case, many studies were done on non-reflection processing. Despite of these efforts, as far as authors know, almost no practical or effective non-reflection method for incidence plane wave problem is brought forward as of today. The only exception is source box method.

Source box method was originally developed for interior type solution method such as FDM or FEM to introduce source and take following process. At first get the solution of the problem that shares some parts with calculation region. Then this is input as incidence of wave toward the calculation region. In source box region, the solution that we want to get and the difference from reference solution (i.e. diffracted waves) is obtained numerically. Next incidence wave and diffracted wave is summed up to constitute total wave field to be given at boundaries of box region as input for calculation region. This is the process of source box method and is based on very tactful idea. But when analytical reference solution does not exist, numerical solution must be obtained previously and stored in memories. That's because this method rarely used excepts for the case of the configuration of medium in box region is very simple. In case which source box method is applied for non-reflection processing at side boundaries in plane wave incidence problem, at least vertically arbitrary heterogeneous medium is essential. So, preparation of the reference solution was too much troublesome to say nothing of by general numerical method, but even by use of pseudo analytical method such as Propagator matrix method. That's why researchers preferred to prepare enormously large calculation to spare time for such a skillful method.

On the other hand, we successfully overcame this problem with our method and almost perfectly wiped out the artificial cylindrical wave from both sides boundaries practically. We used reference solution of 3D plane wave incidence problem by FDM that obtained by the code developed by Tanaka and Takenaka (2005) for medium that varies only in depth direction. So we present this effective method this time.

In this method, when we use 2D or 2.5D FDM for the calculation of wave field, we lay region for calculation in the center and lay box regions at both sides. When we use 3D FDM, we make calculation region surrounded by rectangular tube shaped box region. Region for calculation and that for box have some grids in common (in case of fourth order precision: four grids, in case of second order precision: two grids). The necessary reference solution, namely, plane wave incidence for vertically heterogeneous medium is obtained in real time (dynamically) and the process is synchronized with calculation in calculation region. So we need not to get reference solution in beforehand and store in memories.

In this presentation we introduce the instance that we applied our method to 2.5D FDM (Takenaka and Okamoto, 1997) and show how effectiveness of the method.