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Shaking table tests on a cantilever retaining wall with reinforced and unreinforced backfill

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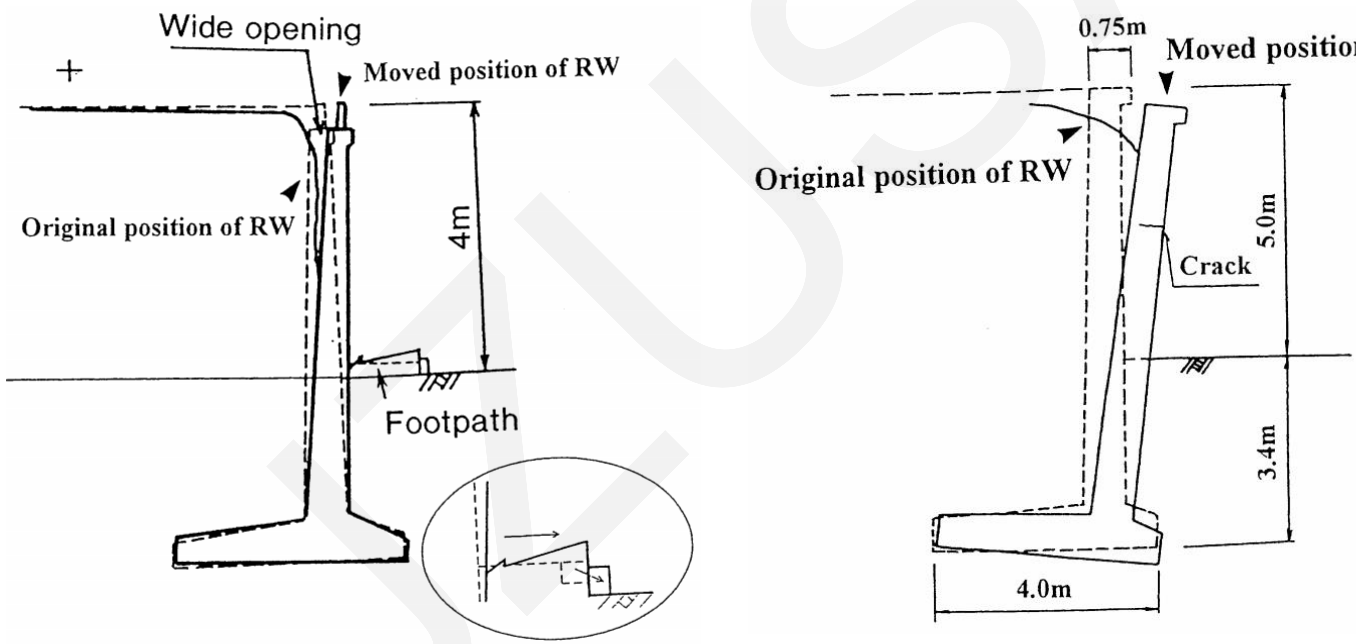
Key words: Cantilever retaining wall, backfill reinforcement, Seismic response, Shaking table test, Dynamic earth pressure, Phase shift

BACKGROUND

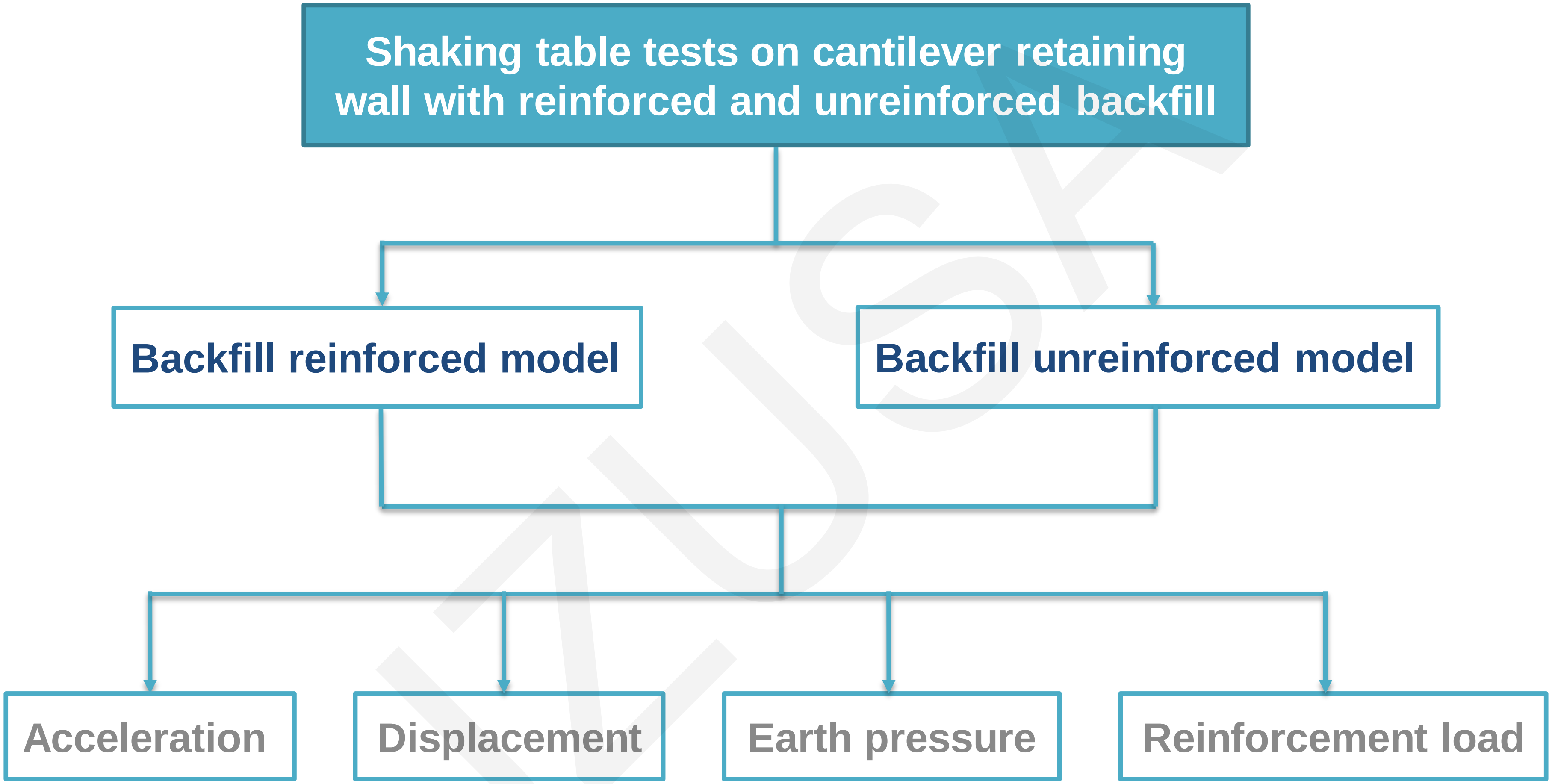
During the 1995 Hyogoken-Nanbu earthquake, many cantilever retaining walls sustained seriously damage. For example, the retaining wall tilted largely outward inducing a large settlement at the top of the railway embankment and cracks or even fractures in the cantilever section in the figure. (Tatsuoka et al., 1996).



Images courtesy of Tatsuoka et al. 1996

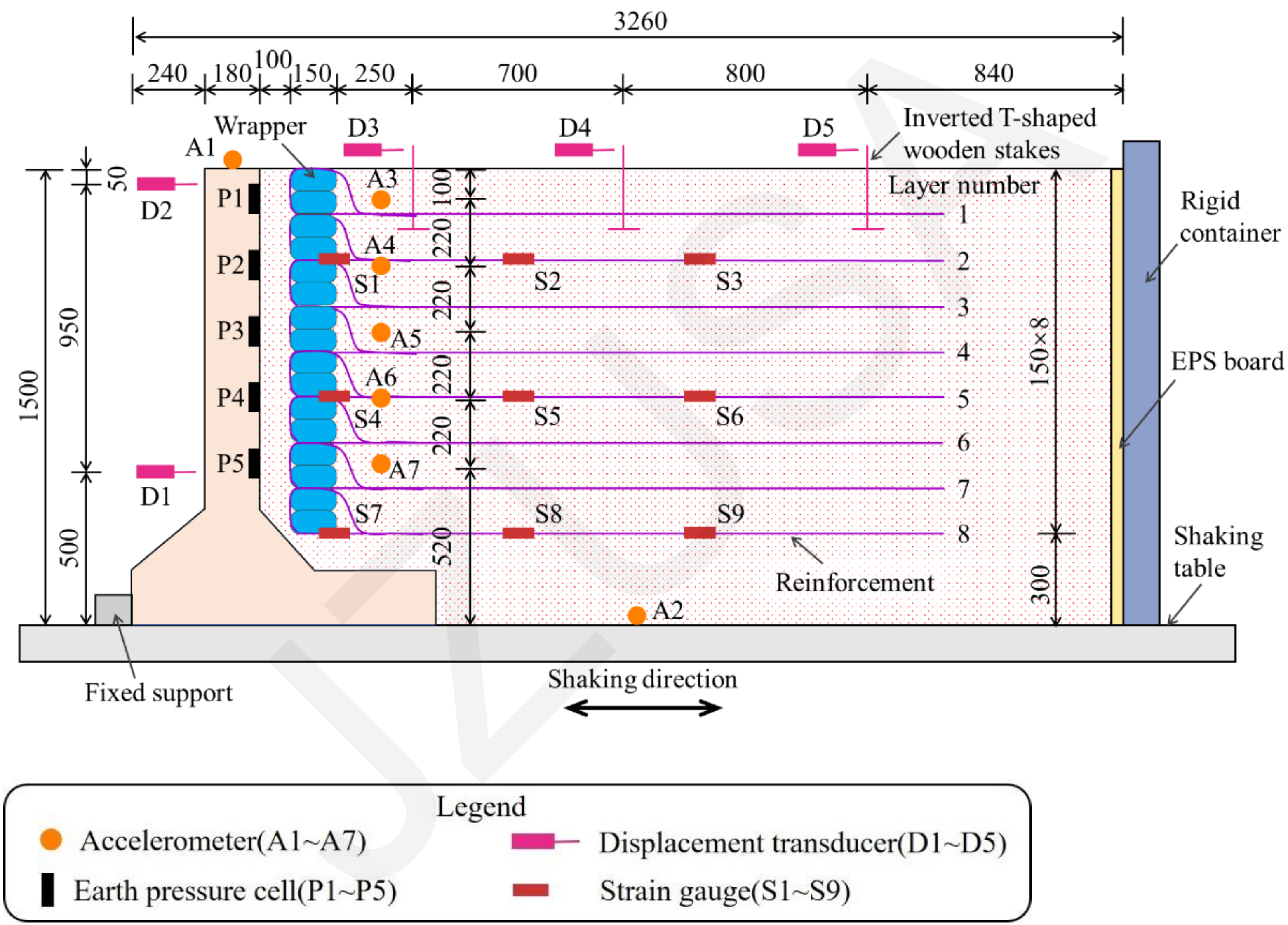
QUESTION: How to improve the seismic performance of cantilever retaining wall? What about backfill reinforcement?

METHOD



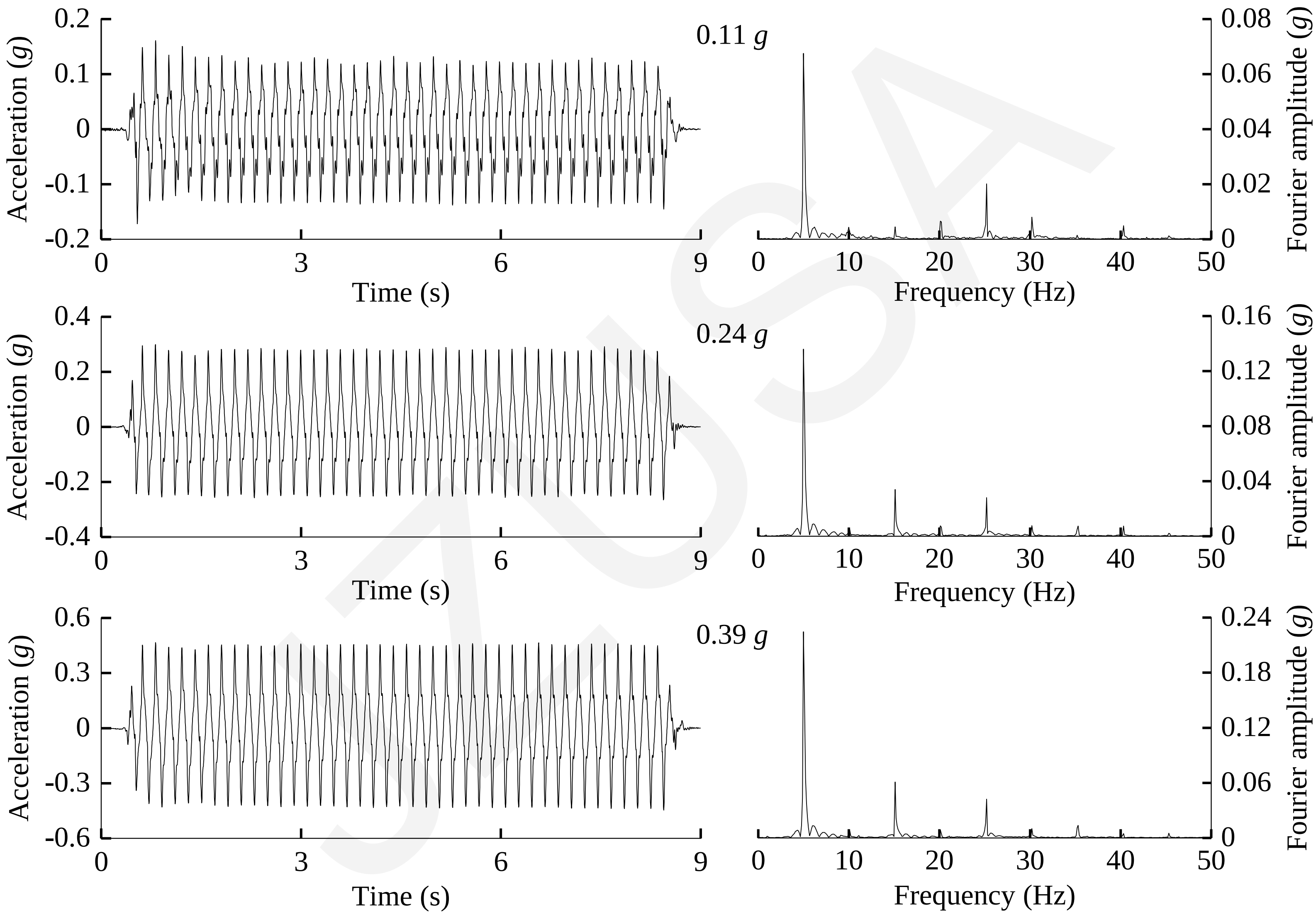
The effect of backfill reinforcement on the seismic response of cantilever retaining walls is analyzed by comparing the response quantities of acceleration, displacement, earth pressure and reinforcement load between the two groups of models.

TEST PROGRAM



Profile view of backfill reinforced model

LOADING SCHEME



Acceleration time histories and Fourier spectra of the input harmonic waves

RESULTS AND CONLUSIONS

- Both models show a decrease in fundamental frequency with increasing input acceleration, and there is a degradation in stiffness and potential damage to the wall-soil system. The reinforced model reduces its fundamental frequency more than in the unreinforced model, indicating that reinforcing the backfill can enhance the integrity of the wall-soil system and reduce seismic damage.

- Based on root mean square acceleration, the amplification factor increases nonlinearly with increasing height, reaching its maximum at the top of the wall. However, design codes or pseudo-static approaches assume that the acceleration amplification factor stays constant throughout the height of the wall. A smaller acceleration amplification factor for the reinforced model than the unreinforced one indicates that backfill reinforcement can mitigate the amplification effect of the input motion.

- The seismic displacement of cantilever retaining walls increases nonlinearly at larger load amplitudes. Reinforcement has a restraining effect on wall/soil displacement that depends on the input acceleration. The capacity of backfill reinforcement to restrain displacement is constrained by the phenomenon of “backfill chasing the wall” at 0.39*g* loading.

RESULTS AND CONLUSIONS

- During a period when the wall is subject to the greatest inertia force away from the backfill, the wall is considered most unstable. The inclusion of reinforcement yields a phase difference between the actions of the wall inertia force and the dynamic earth pressure under 0.11g and 0.24g loading. The wall inertia forces and dynamic earth pressures of both models were synchronized during 0.39g loading, but the resultant force in the reinforced model was still 18.3% less than in the unreinforced one.

- During seismic excitation, the reinforcement longitude exhibited a nonlinear dynamic tensile force and the reinforcement load distribution along the wall height did not follow a constant pattern. In an approximate failure surface, the upper half of a piecewise polyline is vertical and the lower half is curved over the heel. The measured dynamic tensile force increased nonlinearly at a larger input acceleration amplitude.