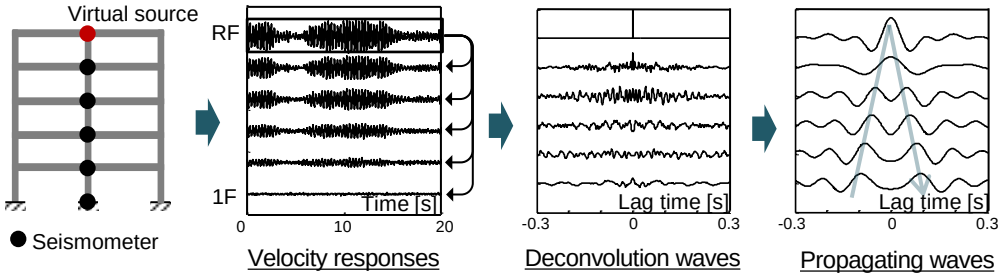
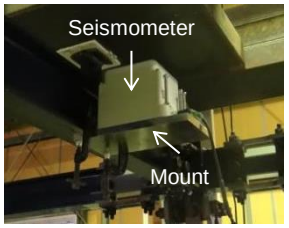
Building Damage Detection Using Wave Slowness Changes

Background: Shear wave propagating through buildings vertically can be extracted by applying seismic interferometry method to floor velocity responses under ambient vibration. The wave velocity estimated using two sensors at different floors depends on stiffness of stories between the sensors, from which the damage state of the stories suffered from earthquakes can be evaluated.

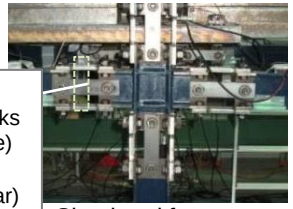
Methodology: We proposed an index called 'slowness change' of shear wave, which is a representation of the propagating time delay and is directly related to story stiffness. Propagating waves in a scaled 5-story steel frame are extracted by deconvolving microtremor record measured by seismometer of each floor. Beam-end fractures are simulated in the 3rd floor, and wave slowness change for each story is calculated using a pair of time delay of the waves in the upper and lower story, and is compared to the analytical estimates calculated from story stiffness obtained by a static analysis of the steel frame.



Velocity responses | Deconvolution waves | Propagating waves (3.6-11.5Hz)

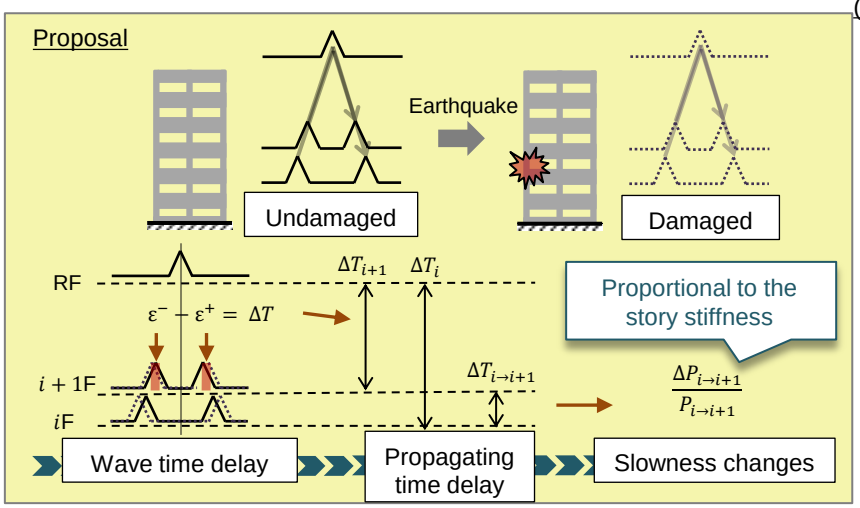


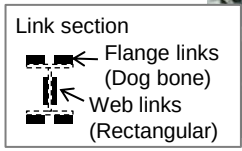
Seismometer installation

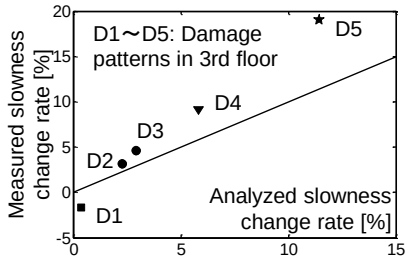


Simulated fracture

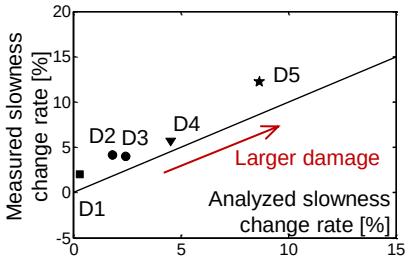
5-story steel frame







Slowness changes (below fracture)



Slowness changes (above fracture)

Conclusion: Propagating wave inside the steel frame was successfully extracted by applying deconvolution and 3.6-11.5Hz band-pass filter to the floor responses. The estimated propagation velocity was 46m/s, which was close to the theoretical value based on structural properties. The slowness change of the propagating waves in analysis and experiments matched well and increased in response to damage ratio.