Research Report for the ERI Visit from 01 April 2019 to 31 September 2020

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Introduction

It is likely that the Tokyo metropolitan area will be hit by one or more major earthquakes (magnitude greater than 7) in the near future [1]. Any of this seismic events can potentially create a disaster due to Tokyo being one of the most intensive urbanized area of the country and one of the most important financial and economical hubs of Japan. Traditional inspection procedures present large uncertainty in quantifying the damage severity after major events [2], and they can significantly either underestimate or overestimate the state of health of a structure. This compromises the safety of people in the worst case scenario and disrupts the economy in the best one. In fact, since the damage information is limited, buildings might be assessed as safe when they should not be. This error has led to cases of structural collapse with loss of lives in the past [3]. Similarly, the current way of operating can cause a significant economic loss, because residents and businesses may have been unnecessarily evacuated from a safe building for long periods of time, which they could have otherwise occupied. To improve the current damage assessment procedures, the use of sensors has been proposed in the last few years as a potential solution to diagnose the real time status of the building, also known as structural health monitoring (SHM) [4]. Among the available techniques, the capacity curve method developed by Kusunoki et al. (2018) [5] represents a promising data analysis procedure to extract the equivalent Single Degree of Freedom (SDOF) response of a structured during an earthquake (Fig1).

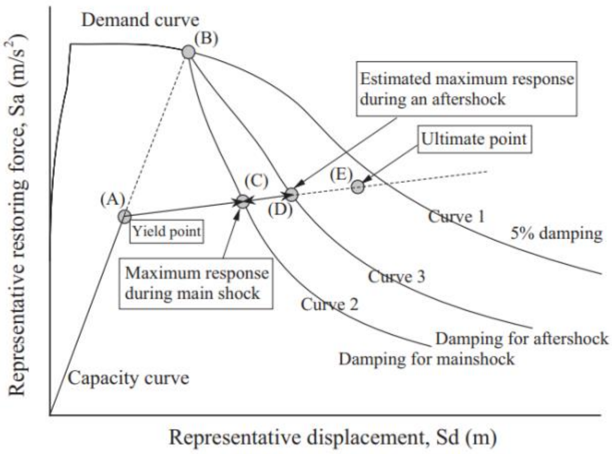

Figure 1 Capacity curve method proposed by Kusunoki et al. (2018)

Objective

The original plan was to use machine learning as a supporting tool for the capacity curve method. After some numerical simulations however, it was identified that the accuracy of the capacity curve method procedure strongly depends on the accuracy of how inter-storey displacements are computed. In fact, the procedure relies on double-integrating the accelerations data after digital filtering using wavelets [6], which however presents some challenges, such as:

1) Discretionality of the filtering properties (also known as "ranks selection")
2) Correct identification of residual displacements

Hence, it was recognized that improving the capacity curve by better assessing displacements would have been way more beneficial and impactful than using machine learning to add additional data. To achieve such goal, it was decided then was to take advantage of an innovative sensor (Displacement Assessment Detector, DAD) previously developed by the hosted researcher in New Zealand to improve the capacity curve method developed by the hosting researcher.

Experimental campaign & preliminary results

Between October 15 and October 27, a full scale 5 storey reinforced concrete building was tested on the shake table at E-Defense laboratory (Fig 2a). On top of traditional instrumentation, such as laser transducers and accelerometers, the DAD sensor was also installed at the first (Fig 2b) and second floor.

Figure 2: a) view of the specimen and b) installation of the DAD sensor at the first floor.

Data are currently being processed, but preliminary results (Fig 3) show a very good agreement between the displacements recorded by the DAD sensors and the displacements recorded by the traditional laser transducers. If such results will be proven consistent, the DAD sensor could be used in further applications to improve the capacity curve method.

Further collaboration

The original project was supposed to have a duration of 9 months. However, given the positive outcome of the JSPS application Kusunoki-sensei will extend our collaboration beyond the original deadline of the project.

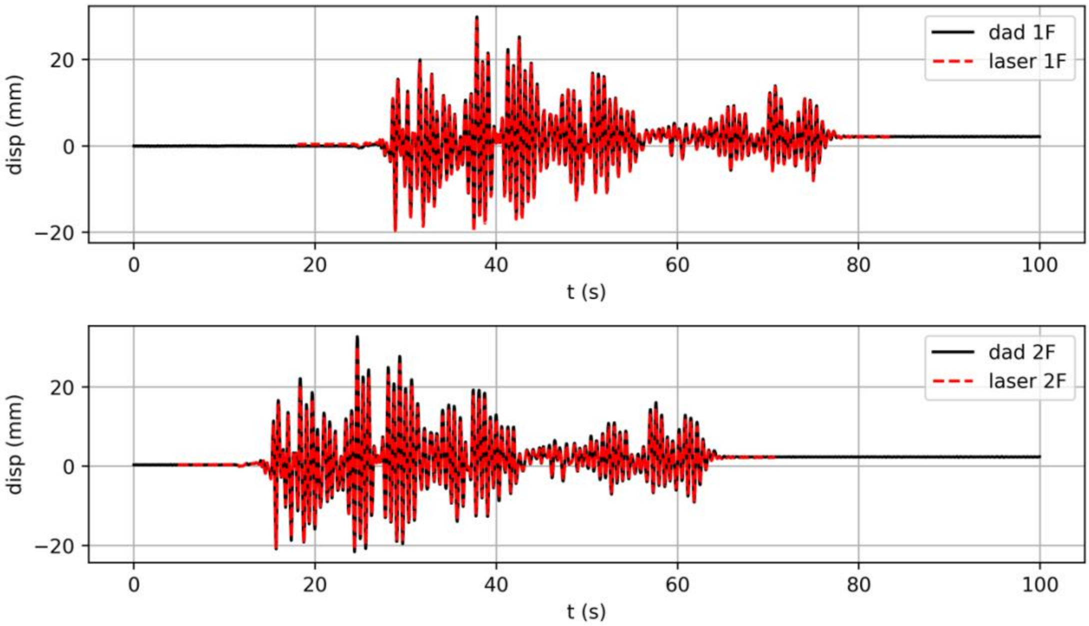

Figure 3 Comparison between laser transducers and DAD displacements.

Acknowledgements

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