

In-Cabinet Response of a Battery Charger for Nuclear Power Plants and Chattering during Shaking Table Tests

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1. Introduction

An electric cabinet, a battery charger, which is supplied to Nuclear Power Plants (NPPs) was tested by a shake-table [1]. Several input loads [2,3] applied to the tests, and in-cabinet response was measured by sensors. Under specific seismic input load, chattering at the relays occurred and observed in the cabinet. In this study, response spectra of the input load and the in-cabinet location near the relays are obtained by utilizing the acceleration data measured at each sensor. To investigate on the chattering, the response spectra corresponding to each seismic load are compared to each other. In addition, the response of the battery charger was anticipated and analyzed by using a numerical analysis model developed in our former study [4].

2. Shaking Table Test

The battery charger was set on a shake table, as shown in Fig. 1.



Fig. 1. Test set-up and the sensors installed

Direction is added to the test figure in the shaking table test report [1]. Each sensor, an accelerometer, is installed as in Fig. 1. The sensor A1 is on the shake-table to gauge the input. A8 is located on the local panel where the relays are installed inside the battery charger.

3. Test Result

Amongst input loads, the last seismic load caused the chattering as shown in Fig. 2 [1]. The last seismic load was applied twice. The test report also issued the failure

of the weld joint of a device on the bottom of the battery charger.

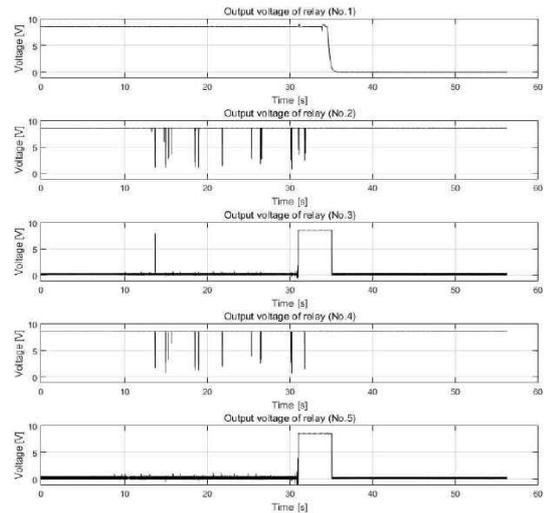


Fig. 2. Chattering during the seismic load, Fragility 10%

4. Analysis

The response spectrum of the sensor A1 and A8 is obtained by utilizing the measured data as represented in Fig. 3 and Fig. 4.

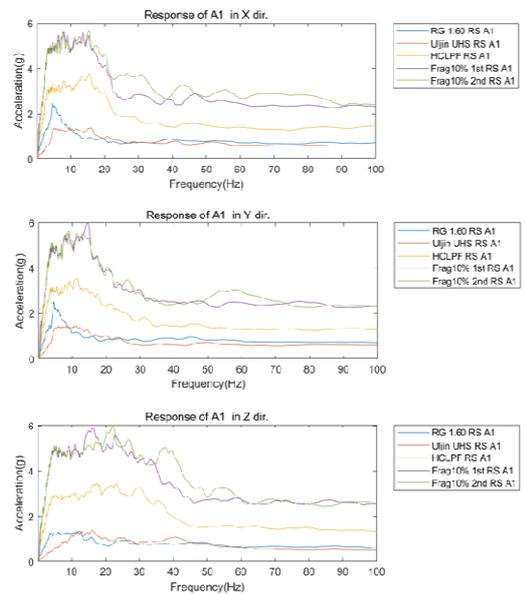


Fig. 3. Response Spectrum of seismic inputs measured at A1

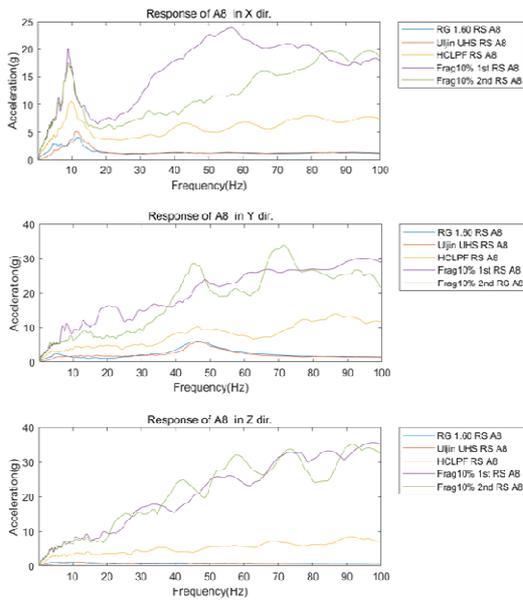


Fig. 4. Response Spectrum of in-cabinet panel, A8

The chattering only occurred under the seismic load, Fragility 10%. The Fragility 10% load has higher spectral accelerations than the other loads over all frequency as in Fig. 3. With comparison of the response spectrum at A1 and A8, amplification of the spectral acceleration in high frequency domain is noticeable. Under the larger seismic load, the more amplification is observed over 25 Hz in X dir., 60 Hz in Y dir., and 10 Hz in Z dir. as in Fig. 4. This amplification reveals clearer in the result of the transmissibility amplitude as shown in Fig. 5 to Fig. 7.

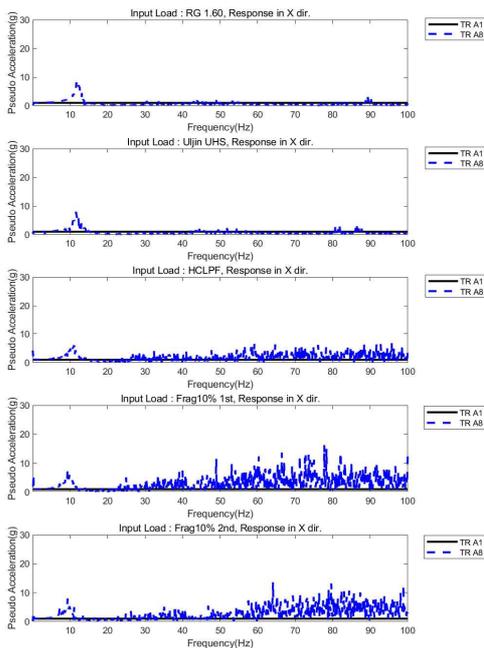


Fig. 5. Transmissibility amplitude of A8 over A1 in X dir.

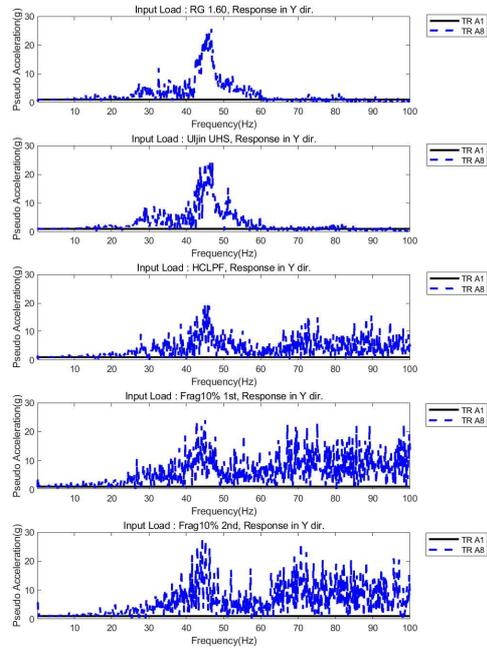


Fig. 6. Transmissibility amplitude of A8 over A1 in Y dir.

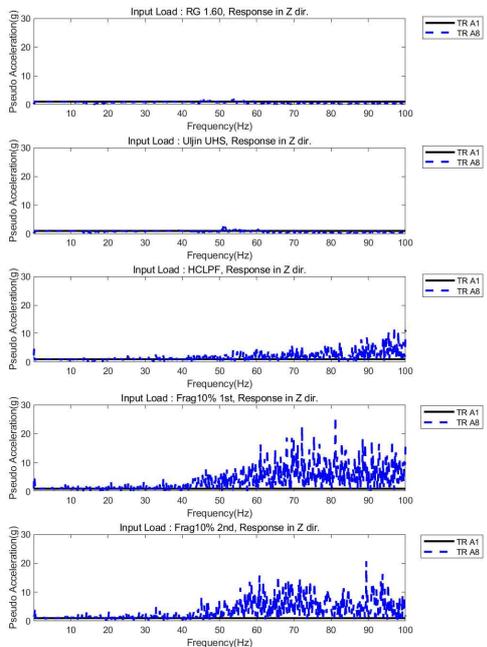


Fig. 7. Transmissibility amplitude of A8 over A1 in Z dir.

Especially, the response in vertical direction is significantly amplified under Fragility 10% than the other seismic loads.

5. Conclusions

The battery charger was tested by a shake-table and the measured test result is analyzed. Chattering occurred at Fragility 10% seismic load, which is the largest input. As the chattering was accompanied by the failure of the weld joint, that is considered as the failure mode of the

battery charger. So the Fragility 10% seismic load can be regarded as the equipment TRS (test response spectrum). Then, the seismic capacity of the battery charger can be calculated for the fragility evaluation. The response spectrum and transmissibility amplitude at sensor A8 show the in-cabinet response amplification in high frequency domain. From this result, the exact root cause of the chattering is still vague. To find that, the ultimate capacity of the relays shall be investigated and the report on the qualification test may be helpful. Remarkable amplification in vertical direction, however, could be a strong contender for that.

Acknowledgement

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