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# LEAP-ASIA-2019: Validation of centrifuge experiments and generalized scaling law onliquefaction-induced lateral spreading

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LEAP (Liquefaction Experiment and AnalysisProject) is an international collaboration project aimingat validating both experimental and analytical methodsto study liquefaction related phenomena. In addition tothe goals set by the LEAP-UCD-2017 (Kutter et al.,2019), LEAP-ASIA-2019 aims at validating thegeneralized scaling law (hereafter “GSL”) (Iai et al,2005) for the identical prototype with the one employedin UCD-2017. In ASIA-2019, 10 institutes conducted 23tests in total.

The following is an excerpt from”LEAP-UCD-2017 Model Specifications” which alsoapplies to the ASIA-2019. “The specific median soildeposit is a 4 m deep, 20 m long deposit of Ottawa F-65sand with a dry density of 1,652 kg/m$^3$ and a groundslope of 5$^o$. The specified median ground motion is aramped sine wave input motion similar to the targetmotion for LEAP-GWU-2015 (Manzari et al. 2018).The primary response quantity of interest is thedisplacement and deformed shape of the soil deposit.Important secondary response quantities include timeseries data from acceleration, pore pressure,displacement sensors.”

Validation of the GSL can be done by the modelingof models technique, i.e., prototype behavior of ModelA and Model B is examined. Execution of the followingcentrifuge model tests is requested for each institute:

Model A: A model identical to UCD-2017 (Fig. 1)whose response can be used to fill the gaps and furtherextend/establish/confirm the trends obtained in theUCD-2017 (Kutter et al. 2019).

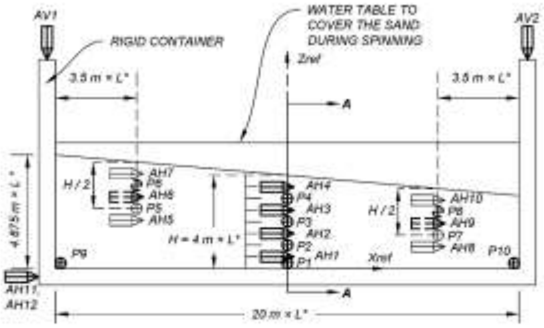


Fig. 1. Baseline schematic for LEAP-ASIA-2019 experiment for shaking parallel to the axis of the centrifuge. (After Kutter et al. 2019)

Table 1 Scaling factors in physical model testing (Iai et al., 2005)

| | (1) Scaling factors for 1g test | (2) Scaling factors for centrifuge test | (3) Generalized scaling factors |
|---|---|---|---|
| Length | $\mu$ | $\eta$ | $\mu\eta$ |
| Density | 1 | 1 | 1 |
| Time | $\mu^{0.75}$ | $\eta$ | $\mu^{0.75}\eta$ |
| Frequency | $\mu^{-0.75}$ | $1/\eta$ | $\mu^{-0.75}/\eta$ |
| Acceleration | 1 | $1/\eta$ | $1/\eta$ |
| Velocity | $\mu^{0.75}$ | 1 | $\mu^{0.75}$ |
| Displacement | $\mu^{1.5}$ | $\eta$ | $\mu^{1.5}\eta$ |
| Stress | $\mu$ | 1 | $\mu$ |
| Strain | $\mu^{0.5}$ | 1 | $\mu^{0.5}$ |
| Stiffness | $\mu^{0.5}$ | 1 | $\mu^{0.5}$ |
| Permeability | $\mu^{0.75}$ | $\eta$ | $\mu^{0.75}\eta$ |
| Pore pressure | $\mu$ | 1 | $\mu$ |

Model B: A model similar to Model A to validate the

GSL (Table 1). Upon constructing the model to betested, only the viscosity of pore fluid and the inputacceleration shall be scaled.

For each institute, the target relative density (Dr) andpeak amplitude of the input acceleration were assignedso that results were validated not by matching pinpointbut by the trend of output. As an input motion, theramped sin wave (Fig. 2) was input which wasevaluated by the effective PGA called $PGA_{eff}$ (Kutter et al., 2019). Figure 3 shows covered range of theinitial/input condition, i.e., Dr and $PGA_{eff}$ in both theUCD-2017 and ASIA-2019 series. In the latter series,having wider variation was intended, i.e., $PGA_{eff}$ varies from 0.1g to 0.4g. Achieved Dr, obtained by the established CPTcorrelation (Fig. 4), varies from45% to 85%.

As an example, the measured accelerationsare shown in Fig.5, in which both model A and B show similar spikyresponses due to dilation near the surface, which may validate the GSL on acceleration. As expected, when the ground is soft (CU, IFSTTAR and ZJU), lateral displacements (Fig. 6) are larger(about 300 – 600 mm). In these cases, the observed differences among the corresponding responses measured for Model A and B are also larger. This may be indicating a limitation of the GSL and should be carefully examinedin the future.

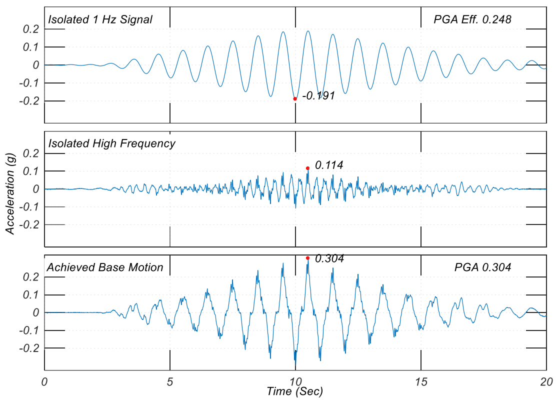


Fig. 2. Input base acceleration: Top) Isolated 1Hz signal, Mid) Isolated high frequency, and Bot) Achieved base motion (KyU-A1).

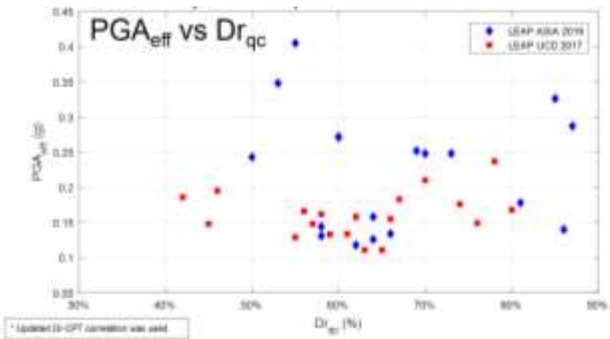


Fig. 3. Range of relative density and base excitation covered inLEAP-UCD-2017 and LEAP-ASIA-2019.

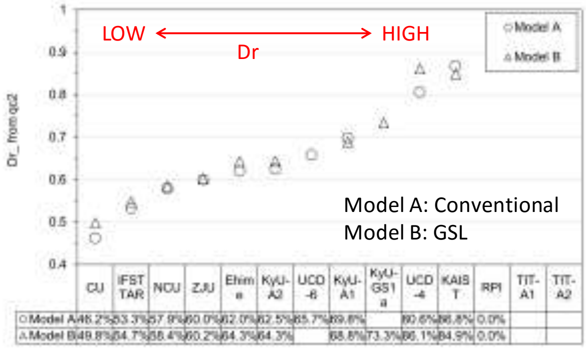


Fig. 4. Achieved relative density obtained from the CPT measurements.

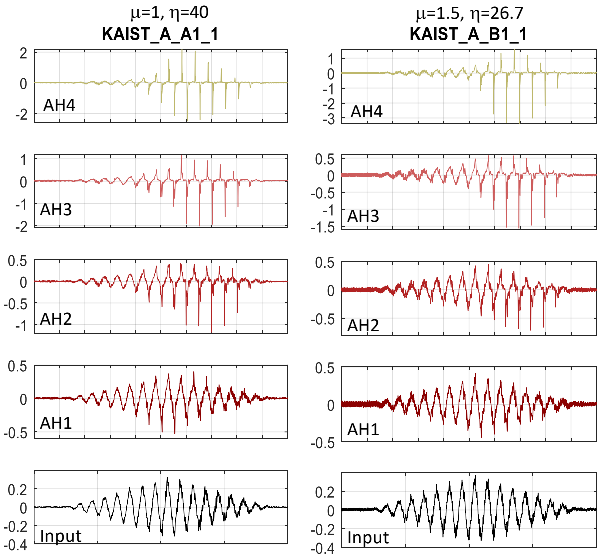


Fig. 5. Comparison between Model A and B (KAIST).

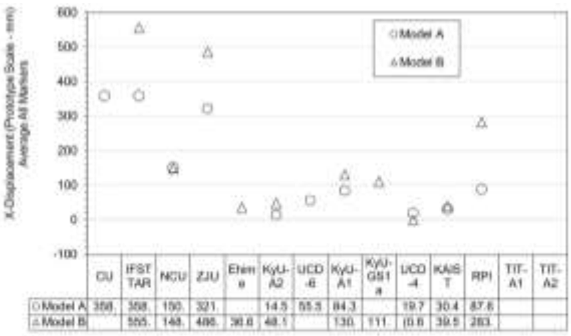

Fig. 6 Measured surface lateral displacements.

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