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Predicting bridge piers backbone curve using fast/slow cyclic tests through an attention-based CNN-bidirectional CuDNNLSTM network

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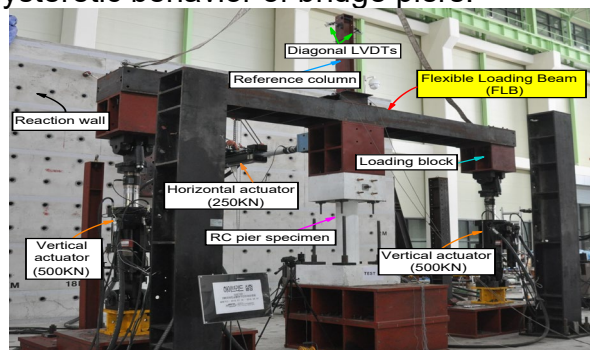
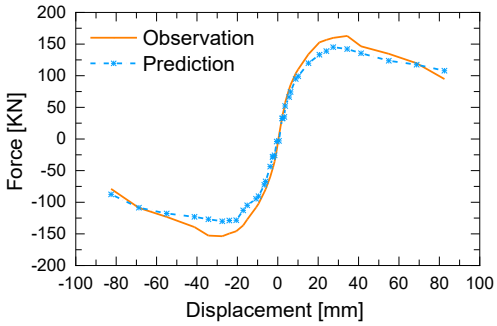
ABSTRACT

The objective of this paper is to introduce an approach that enables the automated prediction of hysteresis and backbone curves of bridge piers during fast and slow cyclic tests. The proposed approach utilizes a stacked CNN-bidirectional CuDNNLSTM network, incorporating skip connections and a custom task-specific attention layer to improve its performance. To construct the model, the authors leverage the functional API provided by the Keras library in Python and consider input features such as horizontal and vertical actuator loads, effective pier height, moment of inertia, and superstructure mass. To train, validate, and test the deep learning model, a large experimental database consisting of 10 fast and seven slow cyclic experiments is used. After 5000 epochs, the hybrid loss function, which combines mean square and mean absolute errors, demonstrates a gradual decrease towards nearly zero within the training and validation datasets. Furthermore, there is a strong correlation of over 93% between the predicted time series responses and empirical measurements, find Fig.1 as an example. Overall, the proposed deep learning model offers various benefits, including time and cost savings in experimental efforts by minimizing the need for conducting new tests, while providing a quick and accurate understanding of the hysteretic behavior of bridge piers.



(a) Experimental test setup



(b) Backbone curves

Fig. 1 Comparing the performance of the estimated and experimental backbone curves

REFERENCES

Yazdanpanah, O, Chang, M., Park, M., Chae, Y. (2023), "Force-deformation relationship prediction of bridge piers through stacked LSTM network using fast and slow cyclic tests". *Structural Engineering and Mechanics*, **85**(4), 469-484.

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