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JIONT STIFFNESS IDENTIFICATION OF A PIN IN STRUCTURAL SYSTEMS WITH VARIABLE FASTENING FORCES

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The modeling and dynamic response prediction techniques for individual structural components have been well developed. Using Finite Element (FE) models and various model validation techniques, a valid component model that produces accurate predictions can be developed. However, when the similar procedure is extended to an assembled structural system that consists of at least two components, the prediction quality quickly deteriorates proportional to the number of components in the assembled system.

There are two possible reasons in those deteriorations. Firstly, the component models are not accurate enough; certain properties that do not affect the component model, hence, have not been validated, may affect the assembly model. Secondly, which is a more likely situation, the connection mechanism between the components is not sufficiently represented. Structural modeling of mechanical joints has been studied quite extensively[1-7].

There are two different approaches for the modeling of joint: one is an FEA based detailing modeling and the other is an experiment based equivalent modeling. The detail modeling treats the joints as isolated entities. Very detailed joint models are constructed in order to explain complex phenomenon in the connecting interface. A detail modeling can provide physical insight, but they are too large to be incorporated into the assembly model due to computational cost. A detail modeling indicates that most of the mechanical jointsô behavior is nonlinear, which complicates the whole situation further. The experiment based equivalent modeling treats the joins as linkage entities. Transfer characteristics of the joints are inversely estimated from test data, such as frequency response data, and modal data. However, in most cases, the test data is not available whereas numerous candidate designs of a joint which should be examined exist in a design stage of structural system.

In this study an analytical approach to simply identify the stiffnesses of a joint is proposed. Consider a structure connected by a pin joint as shown in figure 1. The first step of the proposed procedure is to quantify a contact region occurred in an assembling process of the fastened assembly system using an FE analysis which includes nonlinear behaviors in, for example, clamping force, gravity, etc. Next step is to generate two reference points (named ñgrid 1ò and ñgrid 2ò) as shown in figure 1. Two grids are used to impose the boundary conditions and loads, respectively in order to identify the equivalent stiffnesses of the pin joint. And then, nodes on the contacting region of the pin with Part A are rigidly connected to grid 1 while nodes on the contacting region with Part B are to grid 2. Finally, the equivalent stiffnesses for all directions can be estimated using the pin model with fixed boundary condition on grid 1 and unit displacements on grid 2 for each direction.

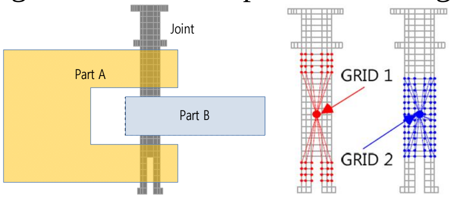

Figure.1 concept of joint

Figure.2 Validation model

A pin-pendulum specimen is prepared for the validation of the proposed procedure (figure 2). An impact test result is shown in figure 3. Note that the natural frequencies of the pin-pendulum structure are shifting according to different clamping force (preload) levels. It means that the equivalent joint stiffnesses are dependent upon the connecting interface condition. The relationships between the connecting interface condition and joint stiffnesses will be identified with respect to the clamping forces using the proposed identification procedure. The identification results will be verified with experimental results obtained under a torque control by a force sensor as shown in figure 4. The identification process is now in progress and the result will be presented in the final abstract.

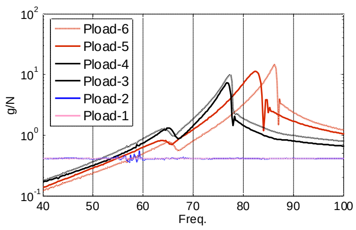

Figure.3 Impact test result

Figure.4 Load washer

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