N90-13486

Effects of Joints in Truss Structures

R. Ikegami
Boeing Aerospace Company
Seattle, WA 98124
Presented and Summarized by B. Wada

The response of truss-type structures for future space applications, such as LDR, will be directly affected by joint performance. Some of the objectives of research at BAC were to characterize structural joints, establish analytical approaches that incorporate joint characteristics, and experimentally establish the validity of the analytical approaches.

The test approach to characterize joints for both erectable- and deployable-type structures was based upon a Force State Mapping Technique initially proposed by E. Crawley and K. O'Donnell; it is shown in FIGURE 1. The approach pictorially shows how the nonlinear joint results can be used for equivalent linear analysis. Testing of the Space Station joints developed at LaRC (a hinged joint at 2 Hz and a clevis joint at 2 Hz) successfully revealed the nonlinear characteristics of the joints. The Space Station joints were effectively linear when loaded to ±500 pounds with a corresponding displacement of about ±0.0015 inch.

- **Reference:** **"Identification of Nonlinear System Parameters in Space Structure Joints Using The Force State Mapping Technique", E. F. Crawley and K. J. O'Donnell SSL #16-85, July 1985**
- **Represents force transmitted by joint as function of displacement and velocity across joint**
- **3 dimensional plot provides compact graphical description of nonlinear joint behavior**
  - **Established testing procedure**
  - **Common nonlinearities easily recognizable**
  - **Results directly usable for equivalent linearization analysis**

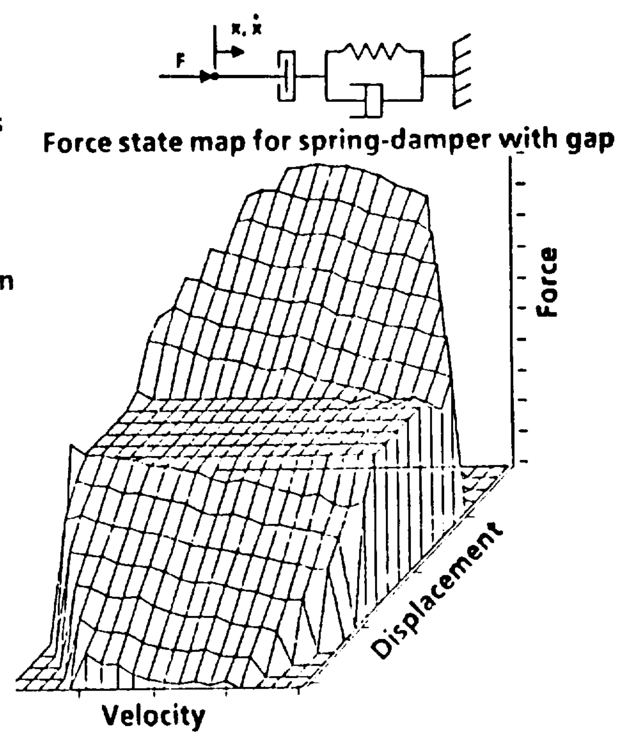

FIGURE 1. Joints Characterization - Force State Mapping

The analytical approach employed represented the characteristics of the joint as a superposition of a linear portion and a nonlinear portion. Thus, in the governing differential equations, the linear portion is retained with the terms representing the linear equations of the structure; these can be solved by many standard approaches. The nonlinear portion is represented as a forcing function to the linear equation and is referred to as the Residual Force. The Residual Force is a function of the relative motion and velocity of the joint. This approach has been applied to the 60 meter COFS truss, which has nonlinear joints, but remains to be validated by test.

A BAC Compact Deployable Space Truss, built of Graphite Epoxy members with clothes pin joints in the center of the members, has been tested. The objectives were to assess the difficulty in obtaining the experimental eigenparameters, and to validate the analytical predictions. Some success was achieved in predicting the of the lower modes, but difficulty was encountered in obtaining good modes at the higher frequencies, due to excitation of local modes and the non-linearities in the system.

The study indicated that good linear joints exist which are compatible with erected structures, but that difficulty may be encountered if nonlinear-type joints are incorporated in the structure.