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The Effect of Friction in the Hold Down Post Spherical Bearings on Hold Down Post Loads

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The stiffness of the MLP and HDP's was modeled using boundary element springs. This was thought justified due to the much greater stiffnesses of the MLP/HDP compared to the aft skirt. With hindsight, these springs are not adequate because the actual MLP/HDP stiffnesses are coupled; e.g. a horizontal HDP deflection causes a HDP bending moment. An improved model will include the appropriate coupling terms.

The aft skirt stiffness was calculated by the following procedure. A NASTRAN finite element model (FEM) of the skirt was released at all degrees of freedom (DOF's) except the nine DOF's needed for the 2-D model. A unit displacement was applied at one of these nine DOF's and the resisting forces at the nine DOF's were calculated by the NASTRAN model. These forces represented one column of the aft skirt stiffness matrix. The procedure was repeated eight times to yield the full 9 X 9 skirt stiffness matrix.

Initial versions of the model proved to be too stiff compared to measurements because the model did not consider the relative rotation between the bottom of the SRB and the top of the aft skirt. A rotationally soft element, of unit length, was attached to the top of the aft skirt to account for the "free play" in the skirt/SRB connection. This element had the SRB axial and shear stiffness, but a soft rotational stiffness. There were no coupling terms in this element's stiffness matrix in order to prevent large horizontal deflections due to the artificially soft rotational stiffness. The stiffness of the SRBs was modeled with a normal beam element.

The mass distribution in the axial (X) direction of each shuttle component was used to calculate the center of mass (C.M.) of the shuttle. The rotational inertia of the shuttle about the horizontal axis through the C.M. was then calculated. Only two lumped masses were used in the model: the translational mass at the C.M. and the rotational inertia.

Viscous damping equal to 1% of critical was applied at the two mass DOF's described above. Coulomb damping due to sliding friction at the skirt/HDP interface was also accounted for. The model checked to see if slip occurred at the interface by comparing the resisting force to the load on the interface. The force resisting slip was calculated by multiplying the normal force times

Conclusions

A simplified model of the shuttle response during SSME buildup was constructed. The model demonstrated that interface friction forces can cause large moments to develop between the SRB aft skirt and the MLP HDP's. Refinement of the model should improve our understanding of the role of friction on critical aft skirt loads.

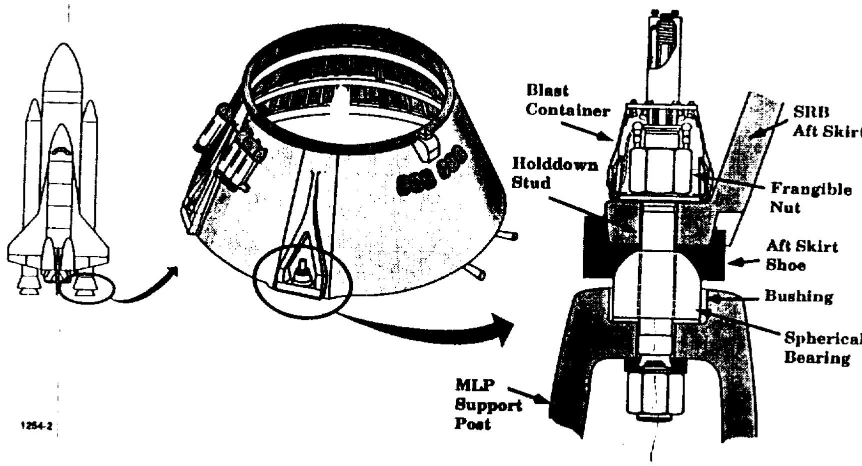

Figure 1. SRB Aft Skirt/MCP HDP Connection

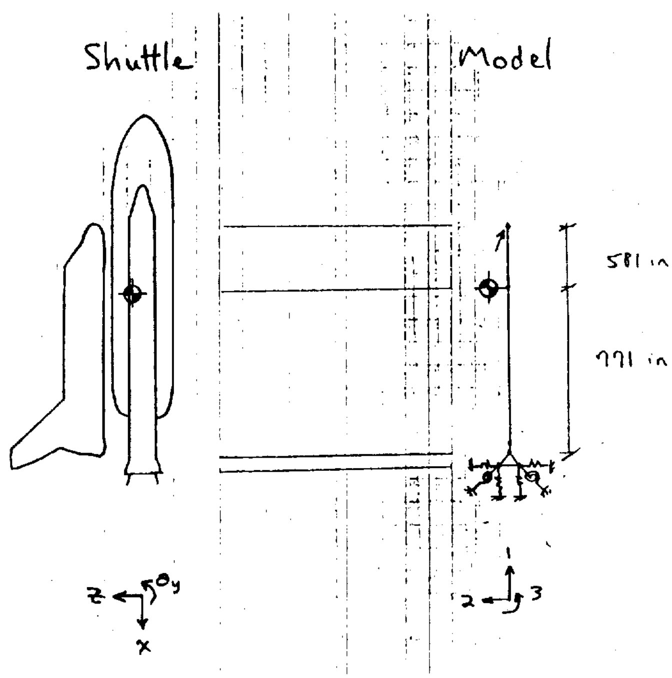

Figure 2. Simplified Model of Shuttle