DYNAMIC ANALYSIS OF STRUCTURAL SYSTEMS WITH INTERNAL GAPS UNDER AXIAL IMPACT LOADING

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SUMMARY

Repetitive impact loadings can occur in systems in which the structural arrangement may be changed due to the opening and closing of internal gaps. The vibrations of the system and the impact loadings originated by the changing of gaps are in interaction, thus impacts are depending on the vibration of the structure.

A method of dynamic analysis of such systems is described which is based on the following assumptions:
— linear elastic behaviour;
— one-dimensional longitudinal vibrations, where the gaps can open or close only due to normal stresses.

Based on the dynamically formulated Finite Element Method the differential equations are solved uncoupled by Modal Analysis. The integration procedure is a Runge-Kutta process of fourth order.

The elements used are one-dimensional rod-elements. Gaps are simulated by gap-elements. The gap-elements are:
— in the open state: of very low stiffness and of indefinite magnitude;
— in the closed state: very stiff and with no extent.

In the analysis these extreme stiffnesses are approximated by finite values. As the numerical analysis showed, there is no difference in the dynamic behaviour of systems in which a change of state for a gap can not occur, to a calculation without using gap-elements, comparing five digits.

These approximate factors are:
10^{-5} for open gaps
10^{+5} for closed gaps
referred to an average stiffness value.

The change of state for a gap takes place:
— if the difference displacement of the bounds of an *open gap* becomes negative;
— if the sign of the stress in a reference element, lying beside a *closed gap* becomes positive.

A transformation of the reference displacement is to be performed if a primary open gap comes to close, so that two different degrees of freedom will reduce to one. Because of the numerical integration procedure inaccuracy becomes visible, thus the velocity- and stress-vibrations oscillate relative to an exact function calculated by the elementary theory. The divergences are investigated in the modal analysis regarding to:
— the number of eigenvalues used;
— the application of a consistent or lumped mass matrix.

The method is proved by comparison with known solutions of elementary impact problems.