

CONSTRAINED SELF-ADAPTIVE SOLUTIONS PROCEDURES FOR
STRUCTURE SUBJECT TO HIGH TEMPERATURE
ELASTIC-PLASTIC CREEP EFFECTS*

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Currently, the design of engineering structures which operate in a creep range involves the use of either approximate methods [1-3] or iterative/incremental schemes [4]. As has noted by Corum [5], Hayhurst and Krzeczowski [6], among others [7,8], the current status of time-iterative or incremental schemes in creep analysis is such that a poor choice of time step size can lead to instabilities in the solution or to erroneous results. Because of this, even the highly skilled user is faced with extremely expensive parametric studies in order to determine requisite time stepping.

In the context of the foregoing, the paper will develop a new solution strategy which can handle elastic-plastic-creep problems in an inherently stable manner. This is achieved by introducing a new constrained time stepping algorithm which will enable the solution of creep initiated pre/postbuckling behavior where indefinite tangent stiffnesses are encountered. Due to the generality of the scheme, both monotone and cyclic loading histories can be handled.

The solution to the foregoing problem is made possible through the use of closed piecewise continuous least upper bounding constraint surfaces which control the size of successive dependent variable excursions arising out of the time stepping process. Because of the manner of constraint, the overall algorithm in addition to being architectur-

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ally flexible has self adaptive attributes which enable the stable and efficient solution of problems involving elastic-plastic-creep properties exhibiting severe nonlinearities. Specifically, the scheme can be easily modified to handle a wide variety of constitutive formulations. Additionally, regardless of the constitutive relation employed, the approach can handle situations exhibiting indefinite tangent properties potentially leading to large deformation and strain pre-post-buckling behavior.

The presentation will give a thorough overview of current solution schemes and their shortcomings, the development of constrained time stepping algorithms, as well as illustrate the results of several numerical experiments which benchmark the new procedure. These give special attention to tracing the degradation of structural integrity and stability as cyclical loading proceeds.

As a preview of the paper, Fig. 1 illustrates the finite element simulation of an arch subject to a cyclical load history at elevated temperatures. Figure 2 depicts the force-deflection response of the arch as the external loading is cycled. As can be seen, while the loading is initially well below the buckling limit of the arch, due to significant structural distortion caused by creep, the load carrying capacity is severely degraded with increasing time. Since the problem involves very large kinematic distortions, the capability of the new constrained time stepping algorithm is clearly illustrated. The presentation will highlight several such examples as well as benchmark the approach with other schemes.

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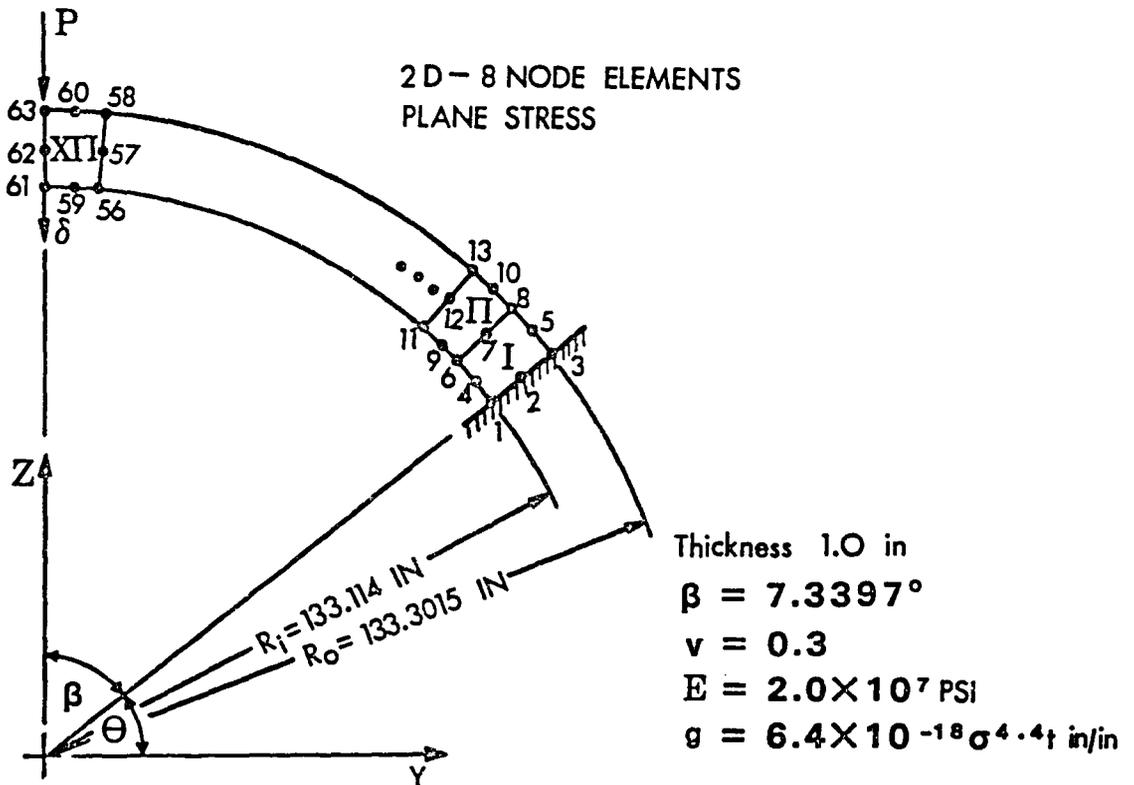


FIG. 1 GEOMETRY, MATERIAL PROPERTIES AND FE MESH OF CENTRALLY LOAD ARCH.

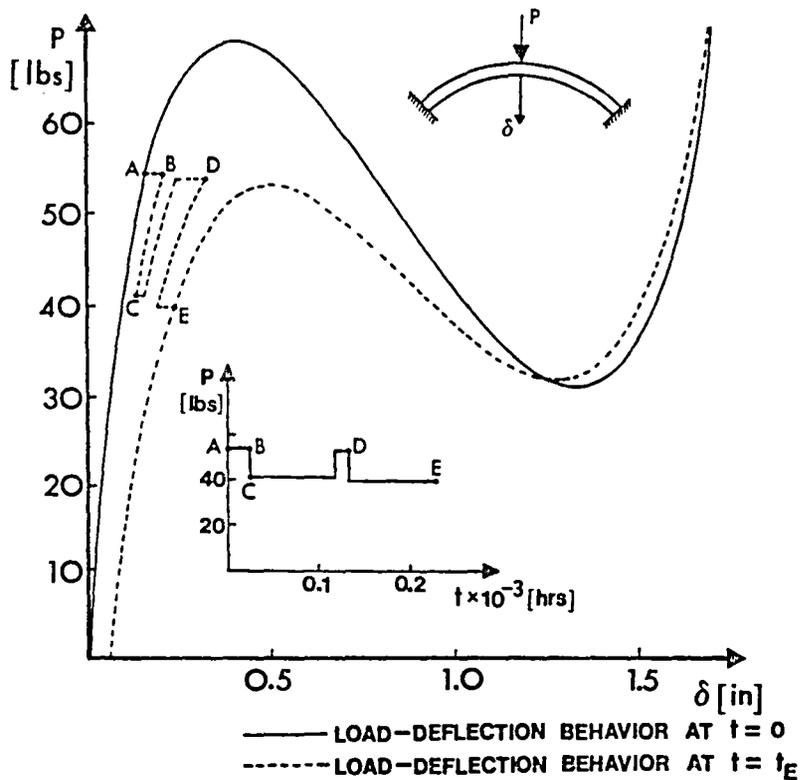


FIG. 2 RESPONSE OF ARCH TO CYCLIC EXTERNAL LOADING AT ELEVATED TEMPERATURE.