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BOSOR5-PROGRAM FOR BUCKLING OF ELASTIC-PLASTIC COMPLEX SHELLS OF REVOLUTION INCLUDING LARGE DEFLECTIONS AND CREEP

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(This is an abridged version. See the full-length paper for more: bosor5.papers/1976.basic.pdf)

ABSTRACT

BOSOR5 can handle segmented and branched shells with discrete ring stiffeners, meridional discontinuities, and multi-material construction. The shell wall can be made up of as many as six layers, each of which is a different nonlinear material. In the prebuckling analysis large-deflection axisymmetric behavior is presumed. Bifurcation buckling loads are computed corresponding to axisymmetric or nonaxisymmetric buckling modes. The strategy for solving the nonlinear prebuckling problem is such that the user obtains reasonably accurate answers even if he uses very large load or time steps. BOSOR5 has been checked by means of numerous runs in which the results have been compared to other analyses and to tests.

The prebuckling and plastic bifurcation (eigenvalue) analyses are described, with the most important equations given. These equations are derived from a finite difference energy method. The strategy for solving problems simultaneously involving large deflections, elastic-plastic material behavior, and primary and secondary creep permits the use of rather large time and load steps without undue sacrifice in accuracy. This strategy is based on a subincremental iteration method in which the size of the subincrement is automatically determined such that the change in stress is less than a certain prescribed percentage of the effective stress. The theoretical treatment of discrete ring stiffeners, the material of which is elastic-plastic and can creep according to a primary or secondary creep law, is also given. Discrete rings of arbitrary cross-section are considered to be assemblages of thin rectangular elements.The structure of the BOSOR5 computer program, which runs on the CDC6600 and on the UNIVAC1108 and 1110, is described. (2011 NOTE: BOSOR5 runs on LINUX.)

The paper gives comparisons between test and theory for many configurations, including axially compressed cylinders and internally and externally pressurized shells of various shapes with and without ring stiffeners. The results of sensitivity studies are given in which the effect on predicted critical load of various analytical models of the ring-shell wall intersection area are explored. A method of predicting the effect of welding on buckling load is described, and an example involving a ring-stiffened doubly-curved shell is given. Welding the ring stiffeners to a shell introduces residual stresses and geometrical imperfections, both of which reduce the load-carrying capability.

1.1.5 Subincremental method. A subincremental method for the solution of problems involving large deflections, plasticity, and creep is used in BOSOR5. This method permits the use of large "major" load or time increments. (A "major" increment is one for which the governing equations are repeatedly solved by the Newton-Raphson method until convergence is achieved.) If creep is neglected, the "major" time increment, call it delta t, is subdivided into equal subincrements, dt, such that each effective strain subincrement, de, is less than 0.0002. It is assumed that the total effective strain increment delta t is subdivided into (delta t)/0.0002 equal subincrements, de. This strategy is also suitable for some cases in which secondary creep occurs. However, the strategy does not work well for primary creep or for cases in which the creep law has a high power on stress. For example, it is not possible to determine the creep-buckling pressure of a titanium shell with a reasonable amount of computer time, since the "major" increments have to be unreasonably small for early times. The strategy fails for early times because there is a relatively large amount of creep, which for reasonable time increments leads to prediction of substantial changes in stress. Unless unreasonably small time increments are used the change in state of the material as a function of time cannot be predicted with requisite accuracy.

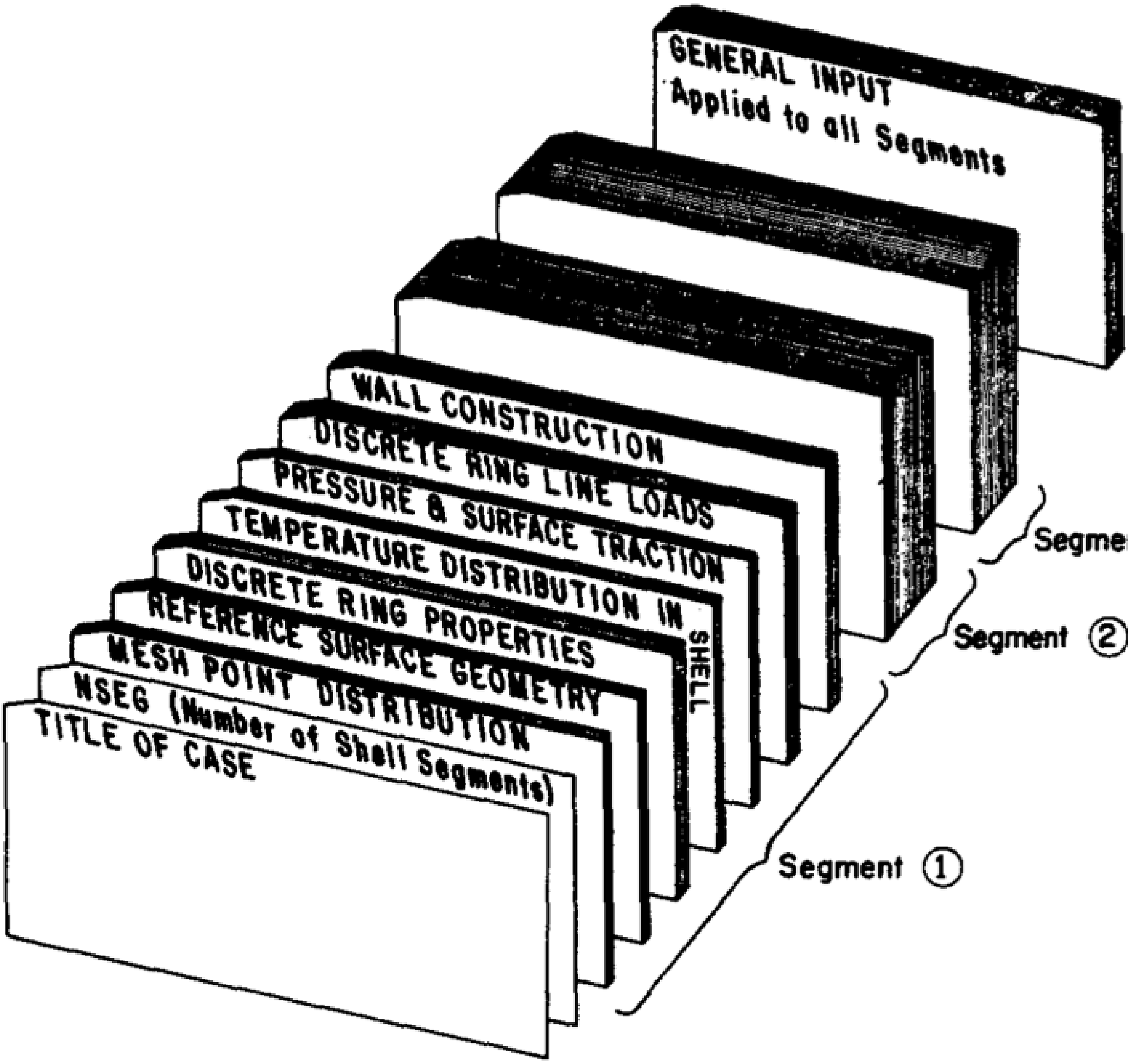


Fig. 4 BOSOR5 pre-processor (bosorread) input deck. (from Computers & Structures, Vol. 6, pp.221-239. 1976)

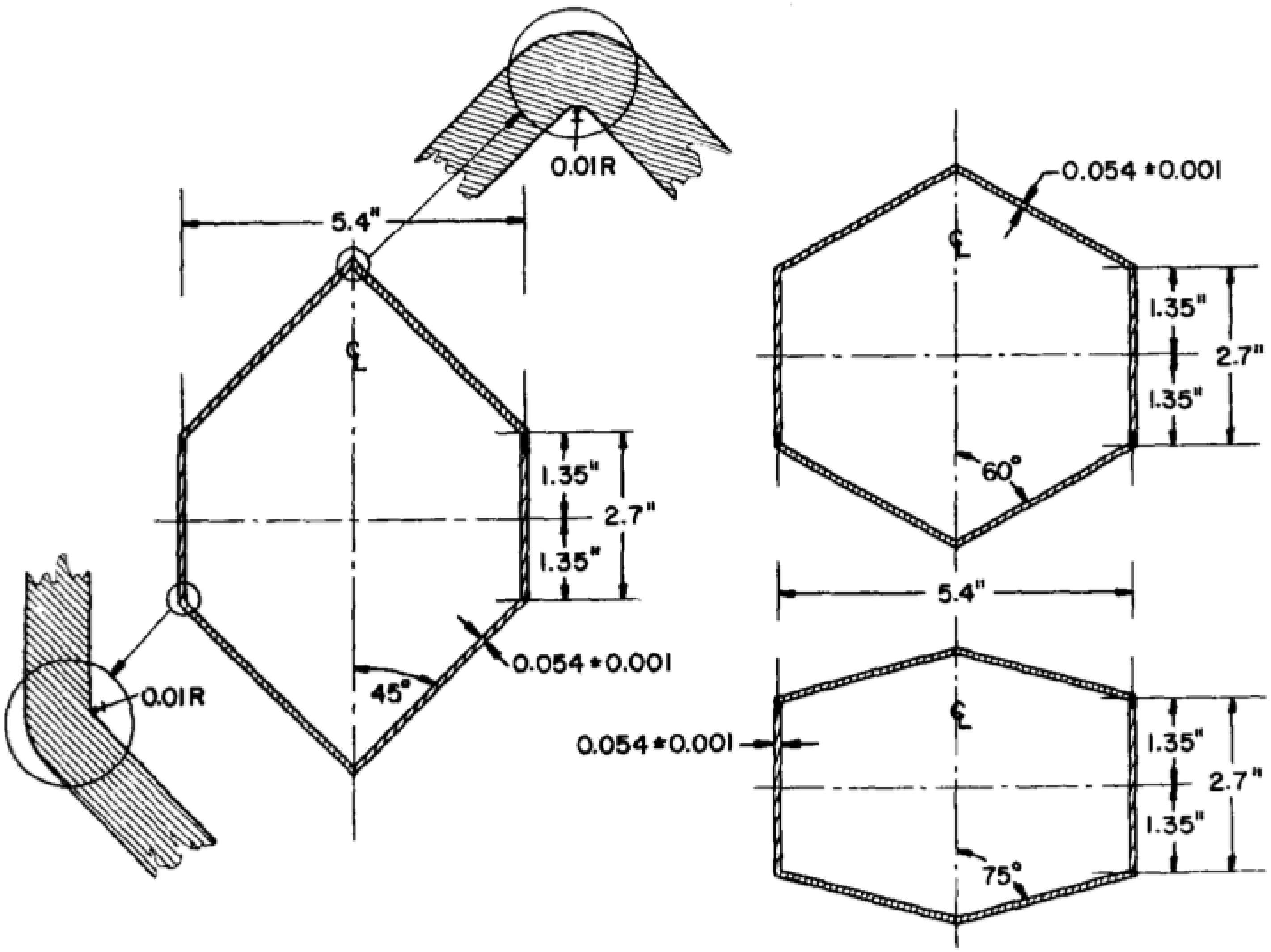
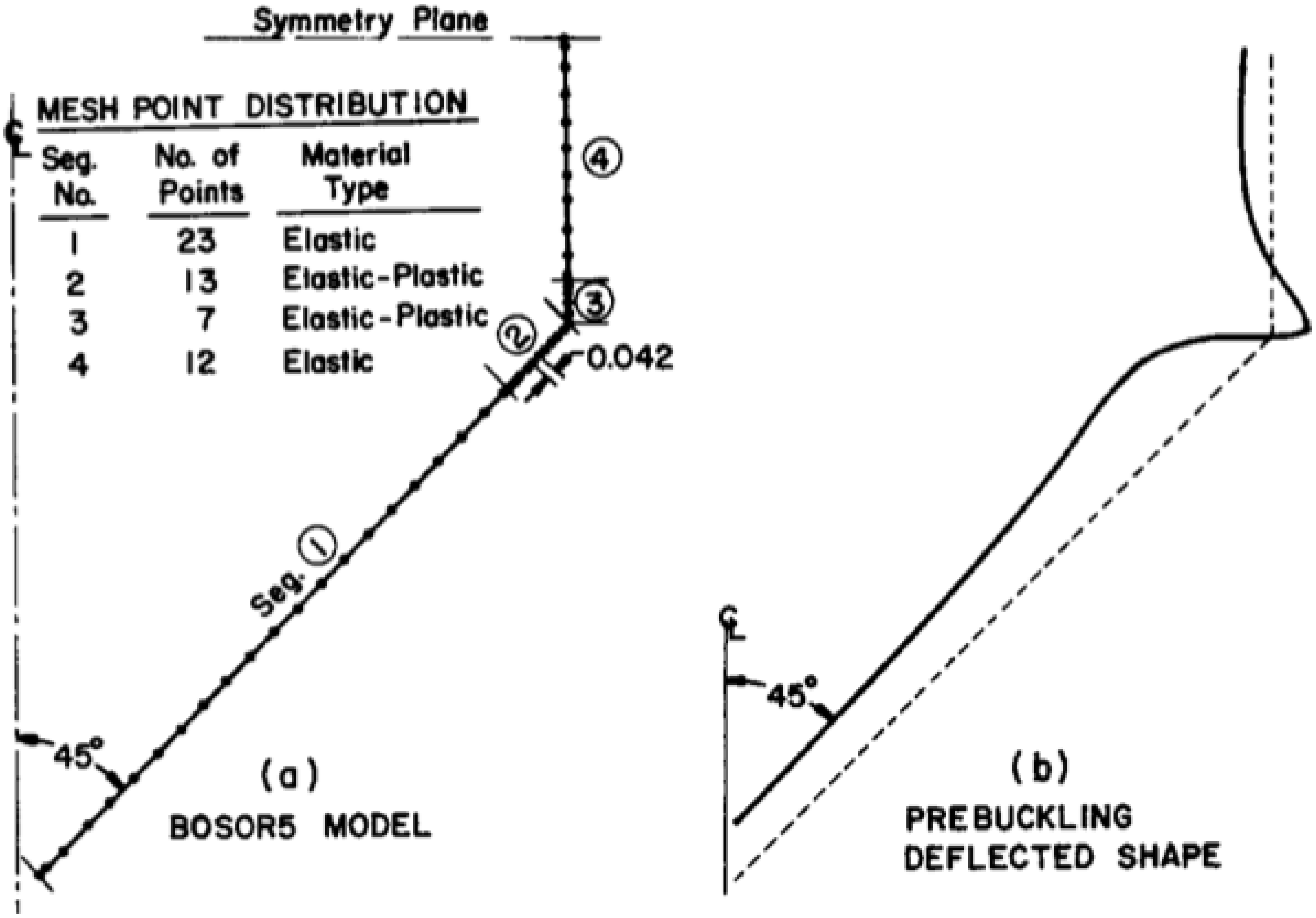


Fig. 5 Aluminum cone-cylinder specimens tested under external pressure by G. Galletly and his colleagues at the University of Liverpool. (from Computers & Structures, Vol. 6, pp.221-239. 1976)



MESH POINT DISTRIBUTION

Seg. No.	No. of Points	Material Type
1	23	Elastic
2	13	Elastic-Plastic
3	7	Elastic-Plastic
4	12	Elastic

Fig. 6 Discretized model of the 45-degree cone-cylinder specimen and exaggerated view of the prebuckling deflected shape at the buckling pressure. (from Computers & Structures, Vol. 6, pp.221-239. 1976)

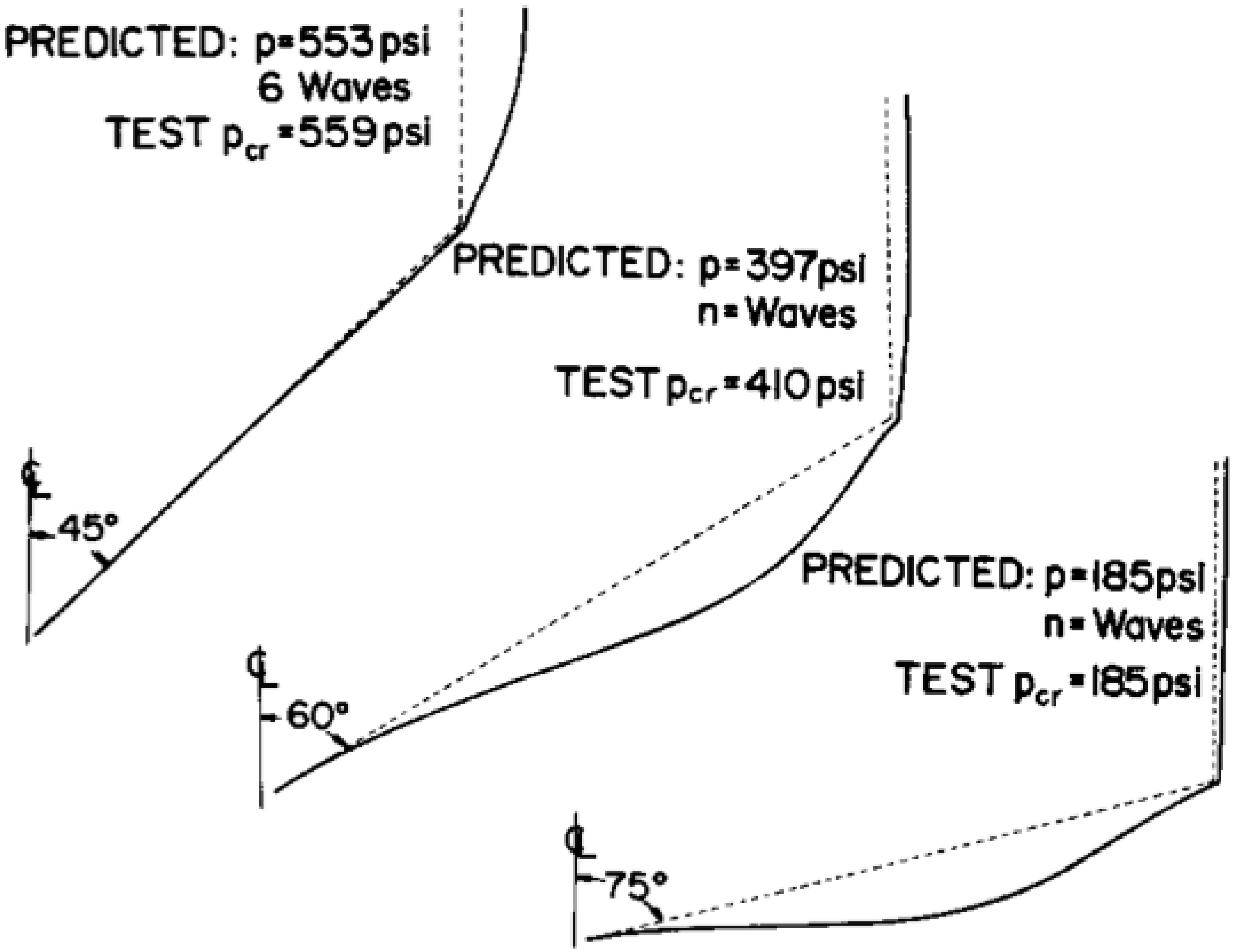


Fig. 7 Bifurcation buckling modes and comparison with test results obtained by Professor G. Galletly and his colleagues at the University of Liverpool. (from Computers & Structures, Vol. 6, pp.221-239. 1976)