Computerized elasto-plastic analysis of steel reticulated plates

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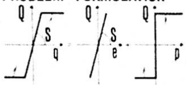
PROBLEM FORMULATION



$s = \max \omega$

$\varphi = A \Lambda + B \omega + k$

$\varphi^T \Lambda = 0 \; : \varphi, \Lambda, \omega \geq 0$

PLCP: Parametric Linear Complementarity Problem solvable by Linear Programming algorithm (Restricted Basis entry rule).

STEP-WISE SOFTENING

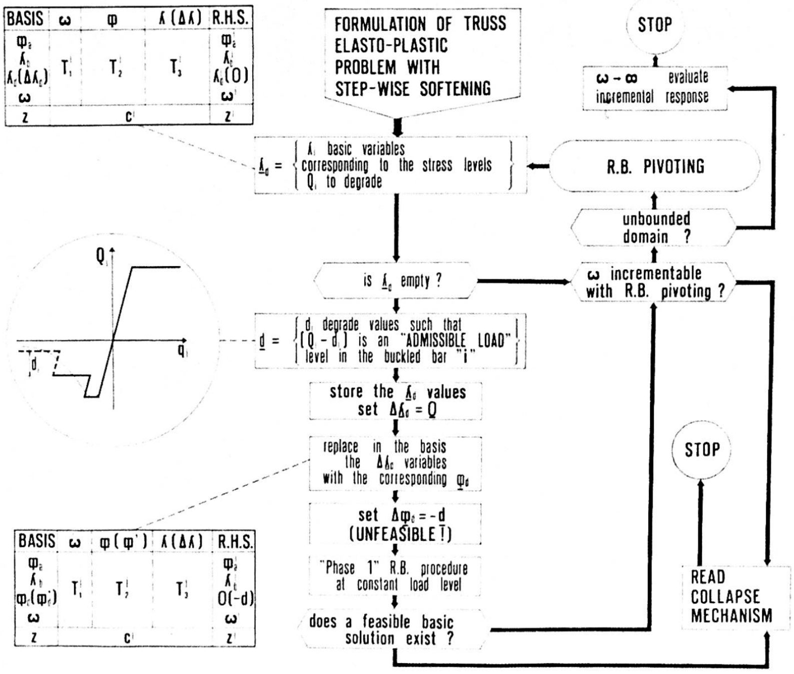
Incremental formulation from POST-CRITICAL UNLOADING (d = buckled bars):

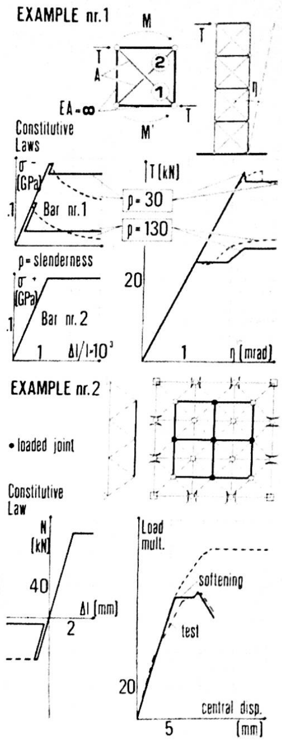
$\varphi_c = \varphi'_c + d = 0 \; ; \varphi'_c, d \geq 0$

$s = \max \Delta\omega$

$\begin{vmatrix} \varphi_a \\ \varphi'_c \end{vmatrix} = A \Delta\Lambda + B \Delta\omega + \begin{vmatrix} \dot{\varphi}_a \\ -d \end{vmatrix}$

$\begin{vmatrix} \varphi_a \\ \varphi'_c \end{vmatrix} \geq 0 \; ; \; \begin{matrix} \Delta\Lambda \geq 0 \\ \Delta\omega \text{ unr.} \end{matrix} \; ; \; \begin{vmatrix} \varphi_a \\ \varphi'_c \end{vmatrix}^T \Delta\Lambda = 0$





COMPUTERIZED ELASTO-PLASTIC ANALYSIS OF STEEL RETICULATED PLATES

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In the structural collapse analysis special emphasis must be given to the knowledge of all the parameters that characterize the reached limit state. In fact this is the only instrument for evaluating the agreement in truth of such a limit state, that the specific mathematical model allows to simulate. In the special case of trusslike structures such a problem is of primary importance, due to the presence of "physically unstable" elements in the collapse mechanism. This event can invalidate the quality of the results obtainable with the "classical" limit analysis methods. In this context we propose an approach to the problem that, still remaining in the Mathematical Programming method field, arrange the solution of the evolutive elasto-plastic analysis of this kind of structures as a particular Linear Programming Problem.

The formulation starts, as indicated in |1|, from the equilibrium,compatibility and stress-strain relationships for the whole structure in elastic-perfectly plastic behaviour: after some algebra it is possible to see that the collapse load factor is obtainable by the solution of the L.P. Problem shown in the Poster, where:

$\underline{q}$ = bar elongations	$\underline{Q}$ = bar forces
s = collapse load factor	ω = load multiplier
$\underline{\phi}$ = yield functions	$\underline{\lambda}$ = plastic multipliers
$\underline{k}$ = yield limits	$\underline{N}$ = diag {1 -1} = activable yield modes
$\underline{A} = - \underline{N}^T \underline{Z}\, \underline{N}$	$\underline{B} = - \underline{N}^T \underline{Q}^e$
$\underline{Q}^e$= elastic stress response to loads $\underline{F}$	$\underline{Z}$ = influence matrix of self-stresses due to imposed strains

Such a formulation must be completed taking into account the post-critical behaviour, simulated in the $Q_i - q_i$ law with a series of constant-load steps,decreasing more and more up to the asymptotic level. The logical operations that must be performed from a "degrading" point are shown in detail in the depicted "flowchart".

The first results of the numeric-experimental comparison, presently in effect, are very comfortable. From these applications we report here the most significant ones, according to us. In particular the Example n. 2 concerns the numerical simulation of a collapse test, performed on a prototype of reticulated grid.As it is possible to see, the calculated values are very close to the experimental ones both from a static and deformative point of view.

REFERENCES.

1. M. MEZZINA and A. TOSTO: Analisi elastoplastica di strutture reticolari in acciaio. Proc. of VII Congresso C.T.A., Torino, Italy, Oct. 1979.