I-119 SIMPLIFIED ULTIMATE LOAD ANALYSIS OF THIN-WALLED MEMBERS

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1. INTRODUCTION

Among the several constitutive equations proposed in the literature, the tangent modulus approach and the flow theory of plasticity in conjunction with von Mises yield criterion have been commonly employed to derive the inelastic beam equations. As the existing flow theory based analyses take account of the contribution of St. Venant shear stress to the yielding, it showed more versatility and efficiency than the ones based on the tangent modulus which do not consider this contribution. In the present study, however, because it leads to a relatively simple formulation, the tangent modulus approach has been adopted and the contribution of the shear stress of St. Venant to yielding was considered. The numerical solution of the developed equations was obtained using the F.E.M technique and a Newton-Raphson type iterative procedure.

2. METHOD OF ANALYSIS

Unlikely determined from the knowledge of the total strain, the tangent modulus, as it is widely accepted, leads to a reasonable lower bound estimates of the strength of such members. Here the equivalent total strain from which the yielding is judged, is assumed to be a function of the axial and shear strains and determined from the yield criterion of von Mises. The distribution of this equivalent strain across the thickness of each small segment of the profile is shown in Fig.1. ε_y and ε_s represent, respectively, the tensile strains at which yielding and hardening of the material initiate. The cross sectional stiffness parameters at any nodal cross section are evaluated numerically by summing up the contribution of all the small segments. This can be done easily since the elastic and plastic zones and subsequently the tangent moduli distribution have been obtained. F.E.M with iterative procedure has been adopted to solve the obtained equations.

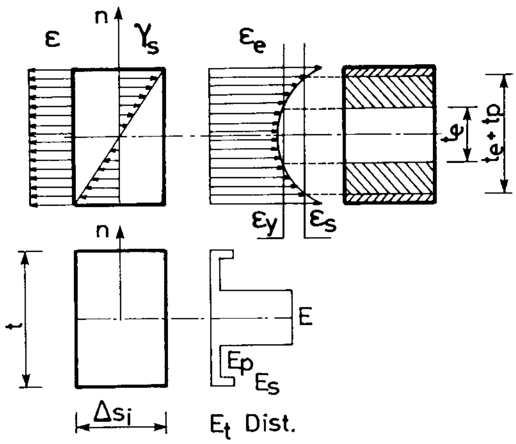

Fig.1 Location of the yielded zones and distribution of the tangent modulus in each interval.

3. NUMERICAL EXAMPLES

In order to show the efficiency and versatility of this analysis, a theoretically more sophisticated analysis based on the flow theory of plasticity and able to account for the contribution of the shear stresses due to warping and bending to the yielding is developed and comparison between their results and those of experiments is carried out.

As a first example in Fig.2, a wide flange cross section (5x6H) column with residual stresses ($\sigma_c = -0.145\ \sigma_y$) subjected to axial compressive load P applied eccentrically with respect to both y and z axes (principal axes), is examined up to failure. For the tangent modulus based analysis, the profile of the cross section is divided into 44 segments while 192 were required for the other.

As a second example in Fig.3, a cantilever with wide flange cross section dedicated to fit a specimen HT-2 of Ref.3, is examined numerically to make sure the ability of the presented analysis in treating problems where torsion is dominant.

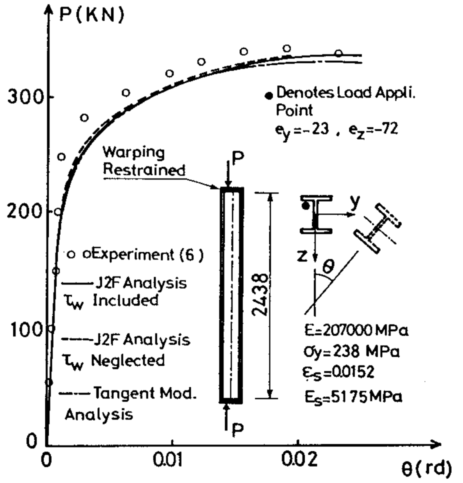

Fig.2 Eccentrically compressed member.

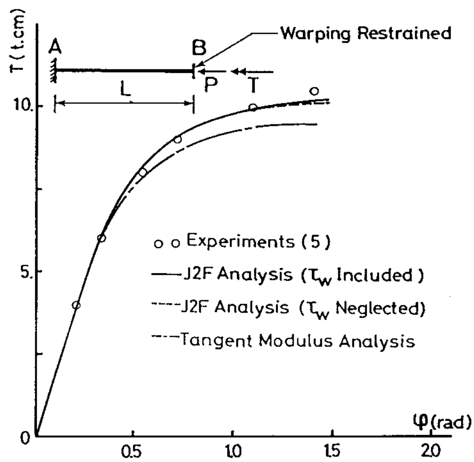

Fig.3 Member subjected mainly to torsion.

4. CONCLUSIONS

An inelastic F.E.M. analysis of arbitrary thin-walled member with open cross section, is presented and a variety of problems for which experimental results exist, have been examined numerically.

Compared with the more sophisticated analysis (analysis based on the flow theory of plasticity), the presented analysis has adopted a rather simplified constitutive equation that keeps St. Venant torsion uncoupled with other deformations. Thus the plastic flow is prevented and the layering of the wall thickness seems to be unnecessary. In spite of this, satisfactory results for a large range of applicability have been obtained.

In addition to this, the required computation time has been found to be less than the one needed for the other analysis. This is a consequence of the way of discretization of the profile and the minimization of the non-zero cross sectional stiffness parameters.

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