

Contents

	Page No.
Chapter 1. Introduction	
1.1 Introduction	
1.2 Applicability of the method	
Chapter 2. Plastic analysis of structures under uniaxial stress – Fundamentals	
2.1 Uniaxial Stress-Strain Relations	
2.2 Plastic Bars and Yield Hinges	
2.2.1 Plastic Moment	
2.2.2 Plastic Hinge	
2.3 Limit analysis	
2.3.1 Introduction	
2.3.2 Theorems of Limit Analysis	
Chapter 3. Plastic Limit Analysis	
3.1 Plastic Potential	
3.2 Upper Bound Theorem	
3.3 Finite Element Solution	
3.4 Lower Bound Evaluation	
3.5 Refinement procedure	
Chapter 4. Continuous beam under pure plastic bending.	
4.1 Introduction	
4.2 Discretisation	
4.3 Plastic element dissipation	

4.4 External loads work.

4.5 Optimization problem.

4.6 Solving the nonlinear system. Picard's method. Upper bound evaluation.

4.7 Lower bound evaluation. Element equilibrium

4.8 Refinement process

4.9 Examples

Chapter 5. Plastic analysis of structures under uniaxial stress. Combined plastic bending and compression or tension.

5.1 Generalized plastic hinge.

Chapter 6. Continuous beam and frames under the combination of plastic bending and compression (or tension).

6.1 Introduction

6.2 Discretisation

6.3 Plastic element dissipation

6.4 Plastic element dissipation. Rectangular cross section.

6.5 Plastic element dissipation. Double T cross section.

6.6 External loads work.

6.7 Examples

Chapter 7. Conclusions and recommendations

REFERENCES

Acknowledgements

I would like to thank Professor J. Bonet for his guidance and help.

I would like to thank the University of Wales Swansea for letting me to use its facilities.

Also, I would like to thank Sonia Fernandez and the whole department of Matematica Aplicada III at UPC for making possible that I could develop my thesis abroad.

Nomenclature

σ	Stress
σ_y	Yield stress
ε	Total strain
ε_e	Elastic strain
ε_p	Plastic strain
$\dot{\varepsilon}$	Plastic strain rate
\hat{D}_{int}	Plastic dissipation per unit of volume
M_p	Plastic moment
h	height
b	width
l^e	Element length
e_p	Plastic extension
D_{int}	Plastic dissipation
θ	Rotation
W_{ext}	External work
\hat{W}_{ext}	Unitary external work (per unit of load multiplier)
\mathbf{b}	Volume loads vector
\mathbf{t}	Surface loads vector
\mathbf{F}	Point loads vector
\mathbf{v}	Nodal displacements vector
\mathbf{f}	External loads vector
$\hat{\mathbf{f}}$	Unitary external loads vector
μ	Load multiplier
\mathbf{d}	Deformation tensor
$\dot{\bar{\mathbf{e}}}(\mathbf{d})$	Equivalent strain rate given by Lubliner (1990)
\mathbf{d}'	Deformation deviator tensor
\mathbf{u}	Collapse mechanism
X	Space of motions compatible with boundary conditions
\underline{X}	Reduced space of X
X_H	Solution space when we consider a mesh the body studied
\underline{X}_H	Reduced space of X_H
X_h	Reference mesh
\underline{X}_h	Reduced space of X_h
\hat{X}_h	Broken space
$\underline{\hat{X}}_h$	Reduced space of \hat{X}_h
$\hat{\mathbf{u}}_h$	Collapse mechanism in the reduce space $\underline{\hat{X}}_h$
\mathbf{q}	Edge forces vector
\mathbf{p}_H	Particular choice of \mathbf{q}
\underline{Z}_h^e	Reduced space of one macroelement

$\hat{\mathbf{u}}_h^e$	Collapse mechanism of one reduced space of one macroelement
g	Gap
g^e	Gap of one element
η^e	Contributions of one element to the gap
$v(x)$	Displacement normal to the bar
$u(x)$	Displacement longitudinal to the bar
(v_i, θ_i)	Degrees of freedom of node i
N_i	Shape function i
\mathbf{N}	Shape functions vector
\mathbf{B}	Second derivation respect x of \mathbf{N}
$\hat{\mathbf{F}}_i^j$	External nodal loads
\mathbf{k}^e	Stiffness matrix of one element
\mathbf{v}^e	Nodal degrees of freedom of one element
\mathbf{K}	Stiffness matrix of the structure
C_i	Gauss-Legendre factors
ξ_i	Gauss-Legendre points
t	Tolerance
t_v	Tolerance respect \mathbf{v}
t_u	Tolerance respect \mathbf{u}
e_v	Relative error related to \mathbf{v}
e_u	Relative error related to \mathbf{u}
\mathbf{T}	Internal loads vector
\mathbf{u}_R	Rigid body displacement vector
(u_i, v_i, θ_i)	Degrees of freedom when we consider contribution of normal forces
\mathbf{N}_u	Shape functions vector associated with \mathbf{u}
\mathbf{N}_v	Shape functions vector associated with \mathbf{v}
\mathbf{B}_u	Second derivation respect x of \mathbf{N}_u
\mathbf{B}_v	Second derivation respect x of \mathbf{N}_v
y_i	Coordinate integration point
e_i	Plastic extension for $y = y_i$