INTERNATIONAL CENTRE FOR MECHANICAL SCIENCES

COURSES AND LECTURES - No. 236

M. ESSLINGER - B. GEIER
INSTITUT FÜR FLUGZEUGBAU
BRAUNSCHWEIG

POSTBUCKLING BEHAVIOR OF STRUCTURES

SPRINGER - VERLAG WIEN - NEW YORK

Contents

		page
1.	Introduction	3
2.	Plates and foldes structures	10
2.1	Rectangular plates	10
2.1.1	Effective width	10
2.1.2	Experimental investigations of a thin panel	12
2.1.3	Theoretical investigations of a perfect panel	20
2.1.4	Panel as element of a folded structure	24
2.2	Welded box beams	28
2.2.1	Preliminary remarks	28
2.2.2	Experimental investigations	29
2.2.3	Theoretical investigations	38
2.2.4	Comparison with results, obtained for cold formed sections	48
2.3	Open profiles of cold formed steel	49
2.3.1	Preliminary remarks	49
2.3.2	Experimental investigations	49
2.3.3	Theoretical investigations	55
2.4	Arches under bending	60
2.5	Web subjected to shear	62
2.5.1	The tension field	62
2.5.2	The flanges	65
2.5.3	The struts	65
2.5.4	Application	66
2.6	Some remarks on optimization	66
2.6.1	Preliminary remarks	66
2.6.2	Perfect structures	67
2.6.3	Imperfect structures	71
2.6.4	Stability in the initial post-buckling region	75
3.	Thin-walled circular cylinders	82
3.1	Isotropic cylinders under external pressure	82
3.1.1	Experimental investigations	82
3.1.2	Theoretical investigations of perfect cylinders	88
3.1.3	Theoretical investigations of imperfect cylinders	91
3.2	Isotropic cylinder under axial load	101
3.2.1	Preliminary remarks	101

page

3.2.2 Experimental investigations of stable equilibrium states 102
3.2.3 Theoretical investigations of stable equilibrium states 109
3.2.4 Experimental investigations of disturbed cylinders 116
3.2.5 Experimental investigations of unstable equilibrium states 122
3.2.6 Theoretical investigations of unstable equilibrium states 124
3.2.7 Concluding remarks 130

3.3 Short isotropic cylinder under axial load 132

3.4 Isotropic cylinders under torsion 135

3.5 Orthotropic cylinders 140
3.5.1 Introduction 140
3.5.2 Cylinder under external hydrostatic pressure 144
3.5.3 Cylinder under axial load 148

3.6 Discretely stiffened cylinders 157
3.6.1 Preliminary remarks 157
3.6.2 Axially loaded cylinders 158
3.6.3 Cylinders subjected to external hydrostatic pressure 163

3.7 Isotropic cylinders under combined axial load an internal pressure 169
3.7.1 Experimental investigations
3.7.2 Theoretical investigations 174

3.8 Isotropic cylinders under combined axial load and external pressure 181
3.8.1 Buckling investigations 181
3.8.2 Postbuckling investigations 181

3.9 Axially loaded cylinders buckling in the plastic region 186
3.9.1 Preliminary remarks
3.9.2 Circular cylindrical tubes with low yield limit 187
3.9.3 Circular cylindrical tubes with high yield limit 193
3.9.4 Channel section with closing plate 195

4. Spherical shell 202

4.1 Initial imperfection sensitivity 202

4.2 Complete sphere 204

page

4.2.1 Test specimens 204
4.2.2 Experimental equipment and procedures 205
4.2.3 Experimental results 208
4.2.4 Theoretical results 216
4.2.5 Discussion of the experimental and theoretical results 220

4.3 Spherical caps
4.3.1 Buckling investigations 222
4.3.2 Postbuckling investigations 223

5. Analysis 230

5.1 Cylindrical shells 230
5.1.1 Notations 230
5.1.2 Differential equations 233
5.1.3 Survey on some proven solution methods 243
5.1.4 Series expansion 246
5.1.5 Solution of the compatibility condition 251
5.1.6 Solution of the equilibrium condition 254
5.1.7 Shortening and potential energy 256
5.1.8 Execution of calculations 258

5.2 Spherical shells 260
5.2.1 Notations
5.2.2 Survey 262
5.2.3 Basic equations 263
5.2.4 Compatibility equation 265
5.2.5 Total potential energy 265
5.2.6 Matching conditions 271
5.2.7 Method of solution 271
5.2.8 Numerical results 273