THE ULTIMATE LOAD DESIGN
OF
CONTINUOUS CONCRETE BEAMS

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PREFACE

This book is intended for the use of final year undergraduates and in the design office. It is an attempt to bridge the gap between conventional design procedures for continuous concrete beams, based on an elastic distribution of moments at working load, and the ultimate load approach, which is based on the plastic behaviour of concrete beams. The text assumes that the reader has an elementary knowledge of the elastic sizing of reinforced concrete sections and is reasonably familiar with the section of CP 114 : 1957 relating to design considerations. Chapter 1 discusses the limitations of elastic design and the basis of ultimate load design together with British, American and Russian design rules. Chapters 2 and 3 deal with the behaviour of reinforced and prestressed concrete sections under load. In Chapter 4 the formation of plastic hinges is discussed together with a summary of the work of Professor A.L.L. Baker. The final two chapters consider serviceability requirements, crack width limitations etc., and the problems of shear and torsion. Several worked examples are included in the text together with a comprehensive reference list and metric conversion table.

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CONTENTS

Preface	v
Principal Notation	ix
Metric Conversions	x
1. Limitations of Elastic Design	1
The need for minimizing structural depths — Research on ultimate load design — Elastic and load factor sizing — Distribution of moments in continuous beams — Comparison of British, Russian and American moment coefficients	
2. Behaviour of Reinforced Concrete under Load	20
Summary of properties of concrete — Compression, tension, shear, bond — Reinforcement — Behaviour of reinforced concrete under load — CP 114, A.C.I. building code, Russian recommendations — T & L beams — Doubly reinforced beams — Minimum percentage of reinforcement	
3. Behaviour of Prestressed Concrete under Load	38
Principles of prestressing — Pre-tensioning — Post-tensioning—load balancing technique — Continuity — Concordant cable profiles — Linear transformation — Advantages and disadvantages of continuity — Ultimate load capacity — Minimum percentage of reinforcement	
4. Plastic Design of Concrete Beams	65
Historical background to plastic design — Plastic hinges — Gradual and brittle failure — Calculation of permissible and actual hinge rotations — Limitations — Moment redistribution in prestressed beams	

5. Shear and Torsion	83
Limitations of CP 114 — B.R.S. Tests — A.C.I. recommendations — Reinforced concrete in shear and torsion — Prestressed concrete in shear and torsion	
6. Factor of Safety and Serviceability	101
Assessment of factors of safety — Load factors — Durability — Creep and shrinkage — Detailing — Deformation — Determination of crack widths, li- miting values — Recommendations for design	
References	112
Index	115

PRINCIPAL NOTATION

A_{sc}	Area of compressive reinforcement
A_{st}	Area of tensile reinforcement
b	Width of section
C_c	Crushing strength of concrete cylinders
C_u	Crushing strength of concrete cubes
d	Effective depth of section
E_c	Elastic modulus of concrete
E_s	Elastic modulus of steel
e	Eccentricity of prestress force
e_c	Strain in concrete
e_s	Strain in steel
f_{cb}	Permissible compressive stress for concrete in bending (p_{cb} , CP 114)
f_{st}	Permissible tensile stress in steel (p_{st} , CP 114)
f_{yc}	Yield stress of steel in compression
f_{yt}	Yield stress of steel in tension
l_a	Lever arm
M_u	Ultimate moment of resistance
nd	Depth from top fibre to neutral surface
P	Prestress force
p	Steel percentage = A_{st}/bd
Q	Resistance moment factor
w_d	Dead load per unit length
w_s	Superimposed load per unit length
w_t	Total load per unit length = $w_d + w_s$
Δ	Crack width

Symbols used in formulae quoted from building codes etc. are defined separately in the text.

METRIC CONVERSIONS

0.1	mm	=	0.004	in.
0.2	mm	=	0.008	in.
0.3	mm	=	0.012	in.
1.0	mm	=	0.04	in.
1.0	cm	=	0.4	in.
2.54	cm	=	1.0	in.
0.305	m	=	1	ft.
0.914	m	=	3	ft.
30.5	m	=	100	ft.
305	m	=	1,000	ft.
1.61	km	=	1 mile	= 5,280 ft.
1 lb. (avoirdupois)		=	0.454	kg
1 ton (2,240 lb.)		=	1.016	tonne
1 in ⁴ .		=	41.62	cm ⁴
1 lb./in. ²	=	0.000 703	kg/mm ²	
	=	0.0703	kg/cm ²	
100 lb./in. ²	=	7.03	kg/cm ²	
200 lb./in. ²	=	14.1	kg/cm ²	
500 lb./in. ²	=	32.5	kg/cm ²	
1,000 lb./in. ²	=	70.3	kg/cm ²	
2,000 lb./in. ²	=	141	kg/cm ²	
3,000 lb./in. ²	=	211	kg/cm ²	
4,000 lb./in. ²	=	281	kg/cm ²	
5,000 lb./in. ²	=	352	kg/cm ²	
10,000 lb./in. ²	=	703	kg/cm ²	
20,000 lb./in. ²	=	1,406	kg/cm ²	
40,000 lb./in. ²	=	2,812	kg/cm ²	
60,000 lb./in. ²	=	4,219	kg/cm ²	
29,000,000 lb./in. ²	=	2,039,000	kg/cm ²	