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Reinforced concrete design

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Preface to Fifth Edition

The purpose of this book is to provide a straightforward introduction to the principles and methods of design for concrete structures. It is directed primarily at students and young designers who require an understanding of the basic theory and a concise guide to design procedures. Although the detailed design methods are generally according to British Standards, much of the theory and practice is of a fundamental nature and should, therefore, be useful to engineers in other countries. Limit state concepts are used and the calculations are in SI units throughout.

The subject matter has been arranged so that chapters 1 to 5 deal mostly with theory and analysis while the subsequent chapters cover the design and detailing of various types of member and structure. In order to include topics that are usually in an undergraduate course, there is a chapter on earth-retaining and water-retaining structures, and also a chapter on prestressed concrete.

Important equations that have been derived within the text are highlighted by an asterisk adjacent to the equation number.

In preparing the fifth edition of this book, the principal aim has been to update the text to incorporate changes and amendments introduced in the 1997 version of BS 8110 and to include new material such as corbel and pile cap design. A completely new chapter on composite construction has been added.

It should be mentioned that standard Codes of Practice such as BS 8110 are always liable to be revised, and readers should ensure that they are using the latest edition of any relevant standard.

Extracts from the British Standards are reproduced by permission of the British Standards Institution, 2 Park Street, London W1A 2BS, from whom complete copies can be obtained.

Finally, the authors wish to thank Ms S. De-Voisey who assisted in the preparation of the diagrams, Mrs F. Zimmermann who typed most of the draft and final copies of the original manuscript, and Dr E. A. Dickin and Mr C. Thomas for assistance in the preparation of some of the material in this edition.

Notation

Notation is generally in accordance with BS 8110, and the principal symbols are listed below. Other symbols are defined in the text where necessary. The symbols ε for strain and f for stress have been adopted throughout, with the general system of subscripts such that the first subscript refers to the material, c – concrete, s – steel, and the second subscript refers to the type of stress, c – compression, t – tension.

Notation for Chapters 1 to 12

A_s	Cross-sectional area of tension reinforcement
A'_s	Cross-sectional area of compression reinforcement
A_{sb}	Cross-sectional area of shear reinforcement in the form of bent-up bars
A_{sv}	Cross-sectional area of shear reinforcement in the form of links
a	Deflection
a_{cr}	Distance from surface crack position to point of zero strain
b	Width of section
b_v	Breadth of web or rib of a member
b_w	Breadth of web or rib of a member
d	Effective depth of tension reinforcement
d'	Depth to compression reinforcement
E_c	Static secant modulus of elasticity of concrete
E_s	Modulus of elasticity of steel
e	Eccentricity
F	Ultimate load
f_{cu}	Characteristic concrete cube strength
f_{pu}	Characteristic strength of prestressing tendons
f_s	Service stress or steel stress
f_y	Characteristic strength of reinforcement
f_{yv}	Characteristic strength of link reinforcement
G_k	Characteristic dead load
g_k	Characteristic dead load per unit length or area
h	Overall depth of section in plane of bending
h_f	Thickness of flange
I	Second moment of area
k_1	Average compressive stress in the concrete for a rectangular–parabolic stress block
k_2	A factor that relates the depth to the centroid of the rectangular–parabolic stress block and the depth of the neutral axis
l_a	Lever-arm factor = z/d
l_e	Effective height of a column or wall

M	Bending moment
M_u	Ultimate moment of resistance
N	Axial load
N_{bal}	Axial load on a column corresponding to the balanced condition
n	Ultimate load per unit area
P_0	Initial prestress force (chapter 12)
Q_k	Characteristic imposed load
q_k	Characteristic live load per unit length or area
$1/r_x$	Curvature of a beam at point x
r_{crit}	Critical steel ratio to control thermal cracks
s	Depth of equivalent rectangular stress block
s_{max}	Maximum likely crack spacing
s_v	Spacing of links along the member
T	Torsional moment
u	Perimeter
V	Shear force
W_k	Characteristic wind load
w_{max}	Maximum likely surface crack width
w_u	Ultimate load per unit length
x	Neutral axis depth
z	Lever arm
α_c	Coefficient of thermal expansion of mature concrete
α_e	Modular ratio
γ_f	Partial safety factor for load
γ_m	Partial safety factor for strength
ε_{sh}	Shrinkage strain
μ	Coefficient of friction
ν	Shear stress
ν_c	Ultimate shear stress in concrete
Φ	Bar size
ϕ	Creep coefficient

Notation for composite construction, Chapter 13

A	Area of steel section
A_{cv}	Area of concrete shear surface per unit length of beam
A_{sv}	Area of transverse reinforcement per unit length of beam
B	Breadth of steel flange
B_e	Total effective breadth of concrete flange
D	Depth of steel section
D_p	Overall depth of profiled steel sheet
D_s	Overall depth of concrete slab
d	Clear depth of steel web
d_s	Diameter of shear stud
h	Overall height of shear stud
I_s	Second moment of area of the steel beam about major axis
I_T	Second moment of area of the transformed section about neutral axis
k_1	Reduction factor to stud shear capacity for positive moments

k_2	Reduction factor to stud shear capacity based on the dimensions of the profiled steel decking
M_c	Moment capacity of composite section
M_s	Moment capacity of steel section
M_u	Ultimate design moment
N	Number of shear connectors in a group
N_f	Number of shear connectors for full shear connection
N_p	Number of shear connectors for partial shear connection
p_y	Design strength of structural steel
Q_e	Effective strength of shear stud
Q_k	Characteristic strength of shear stud
R_c	Resistance of concrete flange
R_{cx}	Resistance of concrete above neutral axis
R_s	Resistance of steel section
R_{sf}	Resistance of steel flange
R_{sx}	Resistance of steel flange above neutral axis
R_v	Resistance of clear web depth
R_w	Resistance of overall web depth = $R_s - 2R_{sf}$
R_{wx}	Resistance of web above neutral axis
S	Plastic modulus of steel section
s	Longitudinal spacing centre to centre of a group of shear connectors
t	Steel web thickness
Z	Elastic modulus of steel section
z	Lever arm
δ	Deflection
ε	Constant, equal to $(275/p_y)^{1/2}$
ν	Longitudinal shear per unit length
ν_p	Longitudinal shear contribution of profiled steel sheeting per unit length
ν_r	Longitudinal shear resistance of concrete flange per unit length