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REINFORCED CONCRETE DESIGN BY COMPUTER

R. Hulse

*Department of Civil Engineering
Coventry (Lanchester) Polytechnic
and
Nanyang Technological Institute
Singapore*

W. H. Mosley

*School of Civil and Structural Engineering
Nanyang Technological Institute
Singapore*

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Neither the publisher nor the authors warrants the given programs to execute other than the displayed output of the given design examples and only then if the programs and data are correctly entered into a computer.

Any use of the programs to solve problems other than those given is the sole responsibility of the user as to whether the output is correct and is correctly interpreted and whether the use of the program is appropriate for the situation in which it is being used.

To Jean and Wendy

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Preface

The aim of this text is to demonstrate how the principles and methods of limit state reinforced concrete design can be incorporated into simple, easy-to-use computer programs and provide an understanding of the role of small computers in the design and detailing of reinforced concrete structures.

At the present time many practising engineers and students of Civil/Structural Engineering have some familiarity with the application of the powerful yet inexpensive computers that are now available. Further developments in computer aided design techniques will ensure that there will be a growing interest in this area so that it will become an essential subject to be studied and understood by most Structural Engineers.

This book will assist in the understanding of the fundamental concepts of combining reinforced concrete design methods with computing techniques. It will enable an engineer to create and implement his own suite of programs in order to carry out routine design calculations or to more easily perform the more complex design requirements of modern limit state design methods. It will also aid the student engineer's understanding of the logical application of the limit state approach to reinforced concrete design.

Each chapter in the book presents a series of programs, written in the BASIC language, covering the more important and/or numerically orientated aspects of reinforced concrete design. The techniques involved are explained with written text, flow charts and examples. Throughout the book emphasis is placed wherever possible on developing programs from the fundamental principles of structural behaviour, and these principles are presented, together with the requirements of the British Standard, BS 8110, at the beginning of each section.

The programs given are intended to be a source of study and further development by the reader. They should not be seen as complete and comprehensive design programs but rather as the foundations of a design system which can be developed further. Suggestions for possible further development are given at the end of some of the program sections and these can be treated as programming/design exercises which, together with the introduction of some of the features discussed in the final chapter, can lead to the development of a comprehensive suite of design programs. The programs have been written in simple BASIC, so that they can be readily understood by the reader who is

familiar with the BASIC language and can be implemented on any computer with only the minor changes necessary to suit the variations to be found on different machines. A list of the BASIC statements used can be found in the appendix. A bibliography is also provided for the benefit of the reader who wishes to pursue in more detail the theoretical background to limit state design methods.

The first chapter discusses the role of the computer in design. Chapter 2 gives programs for the analysis of the continuous beam and substitute frame. Chapters 3–6 are concerned with the design of beams, slabs, columns and foundations at the ultimate limit state while chapter 7 covers serviceability requirements. The final chapter discusses techniques for incorporating features which will enhance the use and presentation of the programs, combining the programs into a design suite using computer file systems and the use of computer graphics.

Finally the authors would like to thank Miss Jamillah Sa'adon who typed most of the manuscript and Miss Suzie Ding for helping with the program listings. Also our thanks to Professor Chen Charng Ning, Dean of the School of Civil and Structural Engineering at Nanyang Technological Institute, Singapore, for his encouragement during the time that the authors worked at NTI.

Notation

The notation used throughout the book is in accordance with BS 8110, and symbols used are defined in the text. In the programs a set of variable names has been adopted which generally reflects this notation. For example, all stresses have variable names commencing with the letter 'F' to reflect the use of the lower case 'f'.

As many variables, such as the characteristic strength of concrete, are common to a number of programs, a set of variable names has been 'reserved' to have the meanings given in the list below. Other variable names unique to a particular program are given in the description of that program. For the sake of conciseness, variables used only as, for example, loop counters are not given in the description.

<i>'Reserved' variable name</i>	<i>BS 8110</i>	<i>Description</i>
A	A_c	Area of concrete
AC	A'_s	Area of compression reinforcement
AS	A_s	Area of tension reinforcement
AV	—	A_{sv}/s_v ratio for shear links
B	b	Breadth of section
BF	—	Breadth of flange
BW	b_w	Breadth of web
CM	—	Minimum cover to reinforcement
D	d	Effective depth of tension reinforcement
D1	d'	Depth to compression reinforcement
DI	φ	Bar diameter
E	ϵ	Strain
EC	E_c	Young's modulus of concrete
ES	E_s	Modulus of elasticity steel
FU	f_{cu}	Characteristic concrete cube strength
FV	f_{yv}	Characteristic strength of link reinforcement
FY	f_y	Characteristic strength of reinforcement

GK	G_k	Characteristic dead load
H	h	Overall depth of section
HF	h_f	Thickness of flange
I2	I	Second moment of area
L	l	Length
M	M	Bending moment
MR	α_e	Modular ratio
MU	M	Ultimate moment of resistance
N	N	Axial load at section
QK	Q_k	Characteristic imposed load
RO	ρ	$= 100A_s/bd$
SV	s_v	Spacing of links along a member
T	T	Torsional moment due to ultimate loads
T\$	—	Title used as first item of input data to each program
X	x	Neutral axis depth