

**PRACTICAL FORMWORK
AND
MOULD CONSTRUCTION**

Second Edition



PRACTICAL FORMWORK and MOULD CONSTRUCTION

SECOND EDITION

(内部交流)

J. G. RICHARDSON, F.I.W.M.

*Lecturer, Cement and Concrete Association,
Fulmer, Bucks., England*



APPLIED SCIENCE PUBLISHERS LTD
LONDON

APPLIED SCIENCE PUBLISHERS LTD
RIPPLE ROAD, BARKING, ESSEX, ENGLAND

First edition 1962
Second edition 1976

ISBN: 0 85334 629 1

WITH 86 ILLUSTRATIONS
© APPLIED SCIENCE PUBLISHERS LTD 1976

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publishers, Applied Science Publishers Ltd, Ripple Road, Barking, Essex, England

Composed by Eta Services (Typesetters) Ltd., Beccles, Suffolk
Printed in Great Britain by Galliard (Printers) Ltd., Great Yarmouth, Norfolk

ACKNOWLEDGEMENTS

The writer wishes to thank the following for assistance with illustrations:

Balfour Beatty, Figs. 4.1, 6.1.

Cement and Concrete Association, Figs. 4.2, 6.3, 6.4.

Concrete Society, Figs. 5.1, 5.2.

Cubitt, Drake & Scull, Figs. 4.3, 11.2, 12.3.

Ductube Co. Ltd., Figs. 8.3, 8.4.

J. Laing Construction Company, Figs. 2.1, 10.10.

Rapid Metal Developments Co. Ltd., Figs. 10.8, 10.9.

Scaffolding (Great Britain) Ltd., Figs. 3.2, 4.4.

PREFACE TO SECOND EDITION

During the years that have elapsed between the publication of the first edition and this edition, the author has come to realise the need for specialisation particularly where such a broadly based topic as formwork is concerned. Each person is an expert in his own particular field, be it where a person is employed on a simple column and beam form system as constructed on site, or where another person works on a massive section of *in situ* concrete as required within a heavy civil engineering project.

Materials technologists, mechanical designers, formwork and falsework engineers as well as manufacturers and users of formwork, all seek at some time some particular information regarding formwork design, production and usage.

Thus whilst the author has set the scene and described formwork and mould arrangements within his own personal experience, he has also invited contributions from selected specialists on topics that include slipforms, special formwork, plastics and form construction.

In this way the scope of the book has not only been enlarged but has been updated. The original edition found acceptance among the more practically minded of those concerned with forming and moulding concrete, and it is hoped that this edition will continue to maintain that trend.

During the course of this revision the author has taken the opportunity to provide new and different illustrations related to formwork construction and practice and has added a bibliography, thus presenting the reader with an opportunity to increase further his knowledge of this important subject.

CONTENTS

PREFACE TO SECOND EDITION	vii
-------------------------------------	-----

CHAPTER 1

DEFINITION OF DESIGN AND THE APPROACH TO FORM AND MOULD CONSTRUCTION

1.1 Introduction	1
1.2 The architect	4
1.3 The engineer	6
1.4 The contractor or supplier and his staff	7
1.5 Sub-contractors and trades personnel	9

CHAPTER 2

PLANNING AND CONTROL OF FORM AND MOULD DESIGN

2.1 The formwork consultant	11
2.2 The contractor's design department	12
2.3 Design carried out on site	14
2.4 Mould design	15
2.5 Sub-contractors	15

CHAPTER 3

THE FACTORS THAT GOVERN FORM AND MOULD DESIGN

3.1 Specification and surface finish	17
3.2 Concrete considerations	19
3.3 Formwork construction	20
3.4 Placing considerations	22
3.5 Accuracy	24

3.6 Striking and demoulding	26
3.7 Striking times	28
3.8 Handling considerations	31
3.9 Mould requirements	32

CHAPTER 4

PRELIMINARY CONSIDERATIONS GOVERNING CONSTRUCTIONAL DESIGN

4.1 Interdependence of activities	35
4.2 Precast activity relationships	36
4.3 Planning arrangements	37
4.4 The activities of the formwork designer	37

CHAPTER 5

BASIS OF MODULAR DESIGN APPLIED TO MOULD AND FORMWORK

5.1 The optimum profile	43
5.2 Lifts and bay arrangements	46
5.3 Panel details	47
5.4 Vertical form section	49
5.5 Continuity and support	50
5.6 Precast concrete—mould design	52
5.7 The basic profile	54

CHAPTER 6

DETAILING THE FORMWORK SYSTEM

6.1 Choice of material	58
6.2 Provision of drawings and details	58
6.3 General assembly drawings	61
6.4 Sectional details	61
6.5 Panel details	64
6.6 Bay layouts and beam details	65
6.7 Sketches and schedules	67
6.8 Mould details	68

CHAPTER 7

**FORM AND MOULD MATERIALS 1—PURPOSE MADE
AND PROPRIETARY STEEL FORMWORK**

7.1 Steel formwork	72
7.2 Sheathing arrangements	74
7.3 Adjustable steel props	75
7.4 Telescopic centres	77
7.5 Tie arrangements	78
7.6 Release agents	79
7.7 Retarders	81

CHAPTER 8

**FORM AND MOULD MATERIALS 2—TIMBER, TIMBER-
DERIVED MATERIALS, CONCRETE AND PLASTICS**

8.1 Timber	83
8.2 Plywood	87
8.3 Hardboard	90
8.4 Particle board	91
8.5 Plaster and concrete	91
8.6 Plastics	92
8.7 Alloys and other materials	94
8.8 Formers for hollows and through-holes	95

CHAPTER 9

THE MANUFACTURE OF FORMWORK AND MOULDWORK

9.1 Timber mould and form manufacture	98
9.2 Steel mould and form fabrication	104
9.3 Plastics working	107

CHAPTER 10

**CONSTRUCTION OF *IN SITU* WORK 1—FOUNDATIONS
AND WALL FORMATION**

10.1 Foundations and ground beams	108
10.2 Kickers	112
10.3 Column bases	115

10.4	Ducts and pockets	115
10.5	Fixings and fastenings	117
10.6	Wall forms	119
10.7	Single-sided walling	128
10.8	Stairs and landings	130
10.9	Wall construction—general details	132
10.10	Circular and conical walling	135

CHAPTER 11

CONSTRUCTION OF *IN SITU* WORK 2—COLUMN, BEAM AND SLAB FORMATION

11.1	Column forms	140
11.2	Beam forms	149
11.3	Stair formwork	154
11.4	Standing supports	155
11.5	Reinforced concrete slab formwork	159
11.6	Stopends	163

CHAPTER 12

CONSTRUCTION OF MOULDS FOR PRECAST CONCRETE

12.1	General considerations	167
12.2	Precast piles	168
12.3	Floor units and decking panels	171
12.4	Moulds for mass production	173
12.5	Moulds for frame components	175
12.6	Mould construction—general	176
12.7	Stopend construction	181
12.8	Bridge beam moulds	183
12.9	Stack casting	184
12.10	Ducts for tendons	185
12.11	Precast stairs	186
12.12	Textured finishes	186
12.13	Ducts, culverts and subways	188
12.14	Precast products	189
12.15	Tilting frame manufacture	189

CHAPTER 13

CONSTRUCTION OF FORMWORK FOR SPECIAL APPLICATIONS, ARCHITECTURAL FEATURES AND SCULPTURE

13.1	Sculpture and low relief work	191
13.2	<i>In situ</i> moulded surfaces	192
13.3	General considerations	193

CHAPTER 14

MODERN STEEL FORMWORK SYSTEMS

(I. Dunkley, Managing Director, Datron Gel Ltd.)

14.1	Wallform	196
14.2	Tableform	198
14.3	Tunnel forms	202
14.4	Special forms	204
14.5	Precasting	206
14.6	General	207

CHAPTER 15

PLASTICS AS A MOULD MATERIAL

(Peter J. Owen, Director, Bondeglass-Voss Ltd.)

15.1	What does a plastics mould material offer?	208
15.2	Glass reinforced plastics (grp)	209
15.3	Storage of materials	209
15.4	Tools and equipment	210
15.5	Measuring equipment	210
15.6	Polyester resins	211
15.7	Catalyst (hardener)	211
15.8	Glassfibre	212
15.9	The master mould	212
15.10	Release agents	213
15.11	Mould reinforcement	213
15.12	Laminating	213
15.13	Usage	214
15.14	Release oils	215

15.15 Thermoplastics moulds	215
15.16 The method	216
15.17 Concrete	216
15.18 Two-part polyurethanes	217
15.19 As a mould material	217
15.20 Other plastics mould products	219
15.21 Expanded plastics	219
15.22 Materials	220

CHAPTER 16

SPECIAL STEEL FORMWORK—A CASE STUDY

(*P. R. Luckett, Technical Director, Stelmo Ltd.*) 225

CHAPTER 17

SLIPFORM

(*C. J. Wilshire, John Laing Design Associates Ltd.*)

17.1 Introduction	235
17.2 Detailed description	236
17.3 Structural design considerations	237
17.4 Equipment	237
17.5 Organisation	238
17.6 The start	239
17.7 Holes and pockets	240
17.8 Special aspects	240
17.9 Conclusion	240

CHAPTER 18

FORM CONSTRUCTION—TIE ARRANGEMENTS

(*C. J. Weller, The Sunderland Forge & Engineering Co. Ltd.*) 244

CHAPTER 19

THE ACTIVITIES OF THE FORMWORK DESIGN DEPARTMENT

(*K. Adams, Chairman, Joint Formwork Committee, Institution of Structural Engineers*)

19.1 Factors that dictate the decisions made	256
19.2 The importance of attention to detail	257

Contents

xv

19.3	Preparation of drawings	258
19.4	Floor slab construction	259

APPENDIX

GROUP EXERCISES ON FORMWORK TOPICS

Formwork exercise I	263
Formwork exercise II	273
Planning a concreting operation	286

BIBLIOGRAPHY	287
--------------	-----

INDEX	289
-------	-----

Chapter 1

DEFINITION OF DESIGN AND THE APPROACH TO FORM AND MOULD CONSTRUCTION

1.1 INTRODUCTION

In dealing with the design and construction of moulds and formwork for reinforced concrete it becomes necessary at an early stage to define the word design. It is not the intention of this book to instruct the reader in pure mechanical design, product of formulae and calculation, the fine approach of the engineer to problems of forces and moments, but rather to deal with the practical design of a mould or form for a given application. A design should be based on the constructional aspects, the choice of materials, the methods of incorporating them into moulds and the form systems in such a way that the materials fulfill the many requirements of the specification and the practical demands of use and re-use.

While the preparation of a design is frequently the province of the drawing office staff, much useful constructive design work is carried out on site or in the works itself. Practical arrangements for a mould or unit are frequently devised by those people who are engaged in utilising an existing system, with a view to improving methods employed in later stages of a project or on subsequent contracts.

At the design stage, when consideration is being given to the practical methods and the construction of the mould and formwork components, a bad decision may result in poor surface finishes and deformed concrete or units, or possibly damaged moulds, any of which can prove expensive if not dealt with at an early stage in the course of construction. Good mould and formwork design allows

sound construction of a concrete structure or unit. Lack of attention to details such as striking or removing forms from concrete, or concrete from a mould, can destroy all the care and attention that has been expended on the gauging of the concrete mix, or the placing and compacting of the concrete within the form. A badly designed mould or form, although only a small part of the whole contract can, through lack of care, mar the completed work and upset the results of many other trades.

When sufficient attention has been given to the construction of a mould or system of formwork, and once the initial problems that can arise out of the first uses of what is probably a new and unusual approach to a problem have been solved, the mould or form system can be organised into a series of economic re-use operations. These operations can be designed to be carried out by operatives trained in a method of working in such a way, that the requirements of all who are concerned with the finished product are satisfied.

Provided that the construction is sound, and the members employed are mechanically correct, the system should lend itself to refinement and modification so that a complete form or mould system will have been attained.

In the succeeding chapters the many interesting facets of form construction will be examined, and a variety of methods of casting concrete will be discussed, although, of course, they present but a small proportion of the methods available to the constructor. It is the remarkable scope for invention and ingenuity, with rarely the same problem arising in the same way in similar work, that provides the interest in the subject.

A remarkable diversity of opinion is expressed regarding methods of carrying out the various operations and it is interesting to note that though there are certain accepted practices and specified methods, the approach to a given problem varies from person to person and from manufacturer to contractor. This book will describe accepted practice and mention possible innovation.

Craftsmen dealing with a trade use their knowledge of construction principles and skills which have been developed during years of fellow tradesmen's experience. As yet in mould and formwork there is little by way of a Code, and there are few set solutions to which reference can be made and carried into practice. Mould and formwork is a modern craft in which large volumes of plastic material are moulded and formed while hardening takes place and the material

takes on a structural capacity, a comparatively new problem to those involved in building and civil engineering operations. The casting of metals has been carried out for centuries, the principles involved in providing a negative form or mould being shared with concreting. Here the similarity ends. The casting of steel or alloys has generally been regarded as a means of providing an approximation of a given shape for subsequent fettling.

In some instances expensive patterns are used and a fair copy of the given pattern is produced in the casting. In concrete work, however, it is normally impracticable to employ a pattern, the negative mould being constructed in the first instance and tolerances are laid down for the finished product. The work is frequently left with the face finish imparted by the mould or formwork thus providing a direct reflection of the ability and craftsmanship of those concerned in constructing the mould. The art of forming concrete is an exact one as exhibited in many structures, particularly those involving modern precast and prestressed concrete where individual units are cast to extremely fine limits.

The problems which provide the interest to the subject are rarely insurmountable and can, with the observance of sound construction principles, be solved in diverse ways. No writing on the subject should be considered as being complete since the ultimate in method to one person may prove to be the starting point from which another may begin to evolve a completely different solution or way of approach. Any one of a dozen methods while efficiently meeting the requirements of a particular authority, can also be more economical or quicker to construct.

This book can only outline the observations of the author which have been made while engaged on several sections of a lively and growing industry. By making clear the reasons for the adoption of any of the methods described, it is intended that a basis should be presented for sound mould and form construction and planning.

In order to consider the problems presented by a particular casting operation or the detailing of a system of mouldwork or formwork it is necessary to consider the authorities that govern the execution of the work. Each professional member or tradesman has a particular approach when laying down his requirements, whether it be by drawing or writing of a specification, and these must be borne in mind when the casting methods and formwork systems are designed.

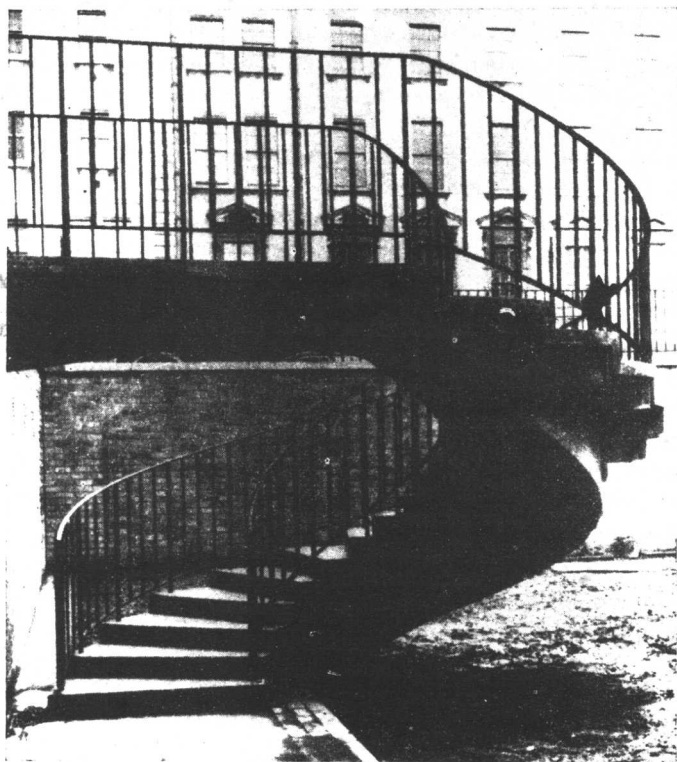


FIG. 1.1. All the skills of the formwork designer and formwork carpenter are called into play when geometrical work and special features are incorporated by the architect and engineer.

1.2 THE ARCHITECT

The architect is primarily concerned with the aesthetic aspects of any project. Until quite recently, concrete was regarded as a material economically suited to the formation of foundations or heavy structural work, which could be suitably concealed by facings or dressing. Now the architect uses the material in functional and decorative roles, and frequently directs that the concrete be left as struck from the moulds or forms to provide some desired effect. The architect may express large areas of concrete in walls and columns, or alternatively he may incorporate a light precast and prestressed

concrete skeleton, which can provide a delicate supporting medium for modern lightweight flooring and cladding systems. He can demand glasslike finishes to the concrete face or take advantage of the techniques of exposed aggregate work to provide ruggedly textured finishes. Concrete is essentially a functional material and it is not unknown for architects to require that the marks produced by the casting face of the mould or form be emphasised to add to the functional effect resulting from the use of large areas of the material. A smooth, even texture or featured surface may be specified to offset some other material incorporated in the design. Architects frequently turn to concrete to take advantage of the ease with which it can be moulded to provide the shapes and profiles of contemporary design, quite apart from its pure structural value.

In modern commercial architecture, concrete is the foremost constructional material and generally the specification will call for high quality surface finishes, which can be produced by the use of wrot timber, or ply sheathing or clean steel panels that constitute the face materials of the mould-or form. Where large areas of concrete occur such as in silos, chimneys and similar structures, the architect may well call for modular features to be applied to, or recessed into the face of the concrete. Such features while undoubtedly complicating the formwork do much to enhance the appearance of the structure. Where decorative panels are required or exposed aggregate finishes are specified a variety of techniques can be used to express the exotic aggregates used within the concrete mix. Grit blasting, the use of retarders and washing techniques will still demand excellent formwork in the initial stages of construction. Precast concrete walling panels which are employed as permanent formwork may be used to enhance the colour and architectural form in the concrete structure.

In the design of schools and public or industrial buildings, architects are now taking advantage of the shell forms of concrete construction to provide large areas which are uninterrupted by supporting columns. Lattice frame forms of precast and prestressed concrete construction also achieve the same result. Concrete structures can be designed which give scope for large areas of glazing or light screening, and the degree of accuracy of the structural components obtainable through the use of carefully constructed forms and moulds are obviously of great interest to the architect. Modular cladding and glazing units can only be used successfully when the