REINFORCED CONCRETE DESIGN

REINFORCED CONCRETE DESIGN

COMPILED & EDITED BY:
IR DR CHIN SIEW CHOO

Publisher
Universiti Malaysia Pahang
Kuantan
2020

First Published, 2020

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Fadzil Mat Yahaya

Reinforced Concrete Design / Fadzil bin Mat Yahaya,
Chin Siew Choo, Sharifah Maszura Syed Mohsin, Gul Ahmed Jokhio.
ISBN 978-967-2054-88-7
1. Reinforced concrete construction. 2. Buildings, Reinforced concrete.
3. Concrete construction. 4. Government publications--Malaysia.
I. Chin, Siew Choo. II. Sharifah Maszura Syed Mohsin.
III. Jokhio, Gul Ahmed. IV. Title.
624.18341

Published By:
Publisher
Universiti Malaysia Pahang
Lebuhraya Tun Razak, 26300 Gambang
Kuantan, Pahang Darul Makmur
Tel: 09-549 3273 Fax: 09-549 3281

Printing:
PNC Printing
No.2, Tingkat Bawah, Taman Damai Indah,
Peramu, 26600, Pekan, Pahang Darul Makmur
Tel: 09-425 2010

PREFACE

This book is written mainly to assist undergraduate civil engineering students who are currently taking the subjects of Reinforced Concrete Design I and II. The content of this module consists of design theories and principles, examples related to design in reinforced concrete structures as well as relevant problems related to the construction industry. This book is merely for internal circulation within Universiti Malaysia Pahang (UMP) for the usage of Undergraduate Degree of Civil Engineering students only.

The contents of this module are written based on Eurocode 2: Design of concrete structures (EN 1992: 2004) of the European Committee of Standardization. This book also covers some of the principles from the British Code, BS 8110 as well as Part 1 of Eurocode 2; general rules for buildings. Eurocode 2 is used along with Eurocode 0: Basis of structural design with reference primarily on the analysis and Eurocode 1: Actions on structures that covers loadings.

This book consists of eight chapters that covers the important topics in reinforced concrete design which necessary to be taught in the degree of Civil Engineering. This book provides all the principles and limit state design, design engineering problems, by providing information on fundamental knowledge. Based on that, students have to analyse, synthesize and evaluate the examples and problems provided in this book. Through this book, students would acquire knowledge to construct detailing for all structural elements in every topic. It is made known that the students must not limit themselves by referring only to this book but to refer all other possible sources of reference to obtain a full understanding of the subjects (Reinforced Concrete Design I and II).

ACKNOWLEDGEMENT

The authors would like to express their gratitude to all parties involved directly or indirectly in completing this book. Suggestions are most welcome from readers to further improve this book in any manner. Last but not least, the authors would like to thank God Almighty for the strength given to complete this book successfully.

GENERAL

Reinforced concrete buildings consist of several structural members (components). Each of these members interact to support the loads placed on the structure. The basic members of a reinforced concrete building as shown in Figure 1 include:

1. Beams : Horizontal members carrying lateral loads.
2. Slabs : Horizontal plate elements carrying loads.
3. Columns: Vertical members carrying primarily axial loads but generally subjected to axial load and moment.
4. Walls : Vertical plate elements resisting vertical, lateral or in-plane loads.
5. Foundations: Pads or strip footing supported directly on the ground that transmit loads from columns and walls to the ground.

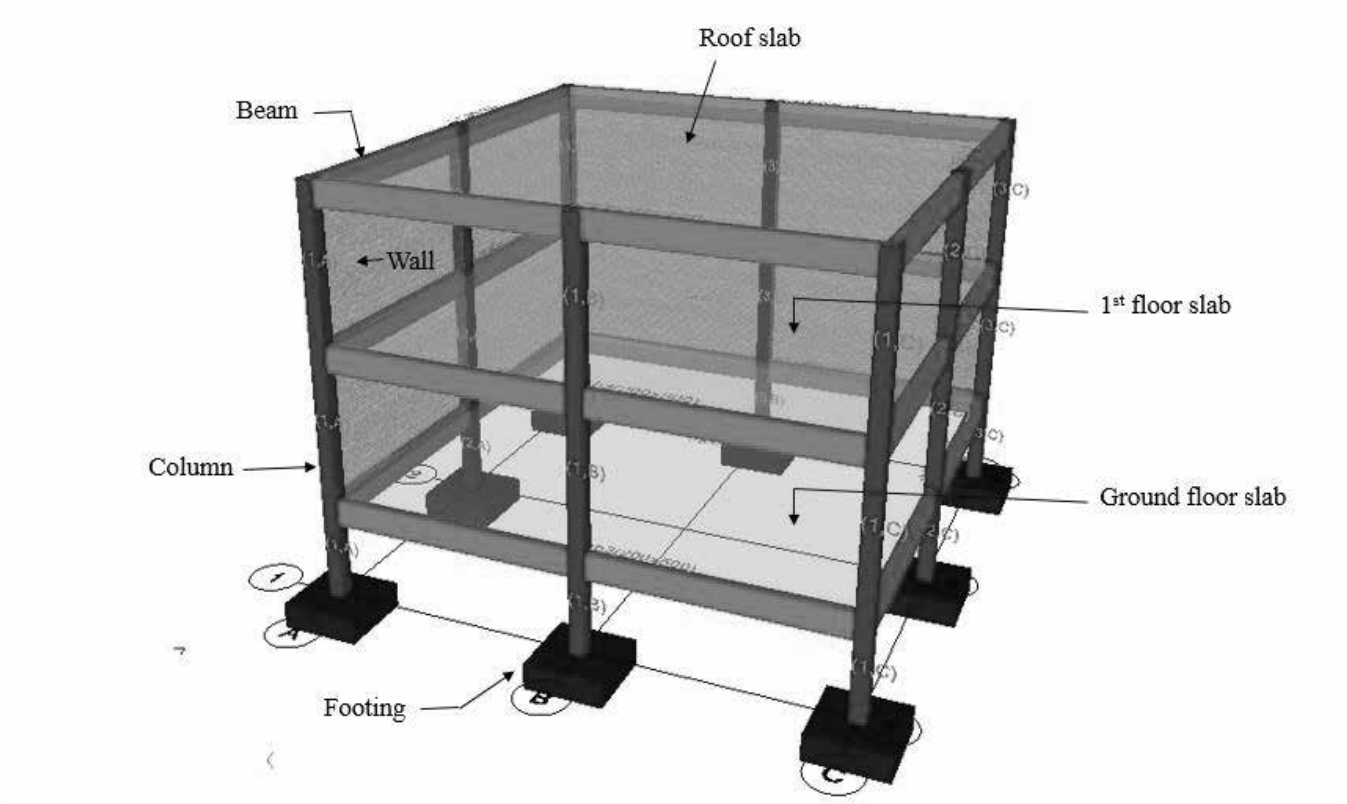

Figure 1: Structural members of a reinforced concrete building

TABLE OF CONTENTS

CHAPTER 5: DESIGN OF COLUMNS

CHAPTER 6: DESIGN OF FOUNDATIONS

CHAPTER 7: RETAINING WALL DESIGN

CHAPTER 8: INTRODUCTION TO PRESTRESSED CONCRETE

CHAPTER 1: INTRODUCTION TO FIRST PRINCIPLE AND BEAM DESIGN

Reinforced Concrete

Reinforced concrete (RC) is a combination material between concrete and steel. As known, concrete has low tensile strength and ductility compared to steel. This low tensile material is counteracted by the inclusion of reinforcement having higher tensile strength. The reinforcement is usually, though not necessarily, steel reinforcing bars (rebar) and is typically embedded passively in the concrete before the concrete sets. Reinforcing schemes are generally designed to resist tensile stresses in particular regions of the concrete that might cause unacceptable cracking and/or structural failure. Modern reinforced concrete can contain varied reinforcing materials made of steel, polymers or alternate composite material in conjunction with rebar or not. Reinforced concrete may also be permanently stressed (in compression), so as to improve the behaviour of the final structure under working loads. In the United States, the most common methods of doing this are known as pre-tensioning and post-tensioning. Table 1.1 shows the properties of concrete and steel with its strength.

Table 1.1: Characteristic of reinforced concrete components

Properties	**Concrete**	**Steel**
Strength in compression	Good	Good, but slender bar will buckle
Strength in tension	Poor	Good
Strength in shear	Fair	Good
Durability	Good	Poor (Corroded), if unprotected
Fire resistance	Good	Poor

For a strong, ductile and durable construction, the reinforcement needs to have the following properties at least:

- High relative strength
- High toleration of tensile strain
- Good bond to the concrete, irrespective of pH, moisture, and similar factors
- Thermal compatibility, not causing unacceptable stresses in response to changing temperatures
- Durability in the concrete environment, irrespective of corrosion or sustained stress for example

1.1 Structural Design

Structural design is the purpose of determination of reliable structural system, selection of suitable materials and obtaining the optimum member sizes for the structure to be built. The aim of structural design is to ensure that the structure performs satisfactorily during its design

life. The basic requirements in which the structure should comply with can be summarized as follows:

1) Fitness for purpose
2) Safety and reliability
3) Economy
4) Maintainability

1.2 Code of Practice

Code of practice is a document that gives recommendations for the design and construction of structures. It contains detailed requirements regarding loads, stresses, strengths, design formulae and methods of achieving the required performance of completed structures. The codes have evolved from the collective wisdom of expert structural engineers, gained over the years. These codes are periodically revised to ensure that they are in line with current research, technology and often trends.

1.3 Basic Design Requirement

1.3.1 Design Working Life

The design working life is a term used for which a structure or part of it is to be used for its intended purposed with anticipated maintenance but without major repair being necessary. MS EN 1990: Cl.2.3 stated the design life for structure to be used during design. Table 1.2 shows the design life in years as given by The Malaysia National Annex to Eurocode.

Table 1.2: Design working life categories with structures design purpose

Design working life category	Indicative design working life (years)	Examples
1	10	Temporary structures
2	10 to 30	Replaceable structural parts e.g. gantry girders, bearings
3	15 to 25	Agricultural and similar structures
4	50	Building structures and others common structures
5	120	Monumental building structures, bridges and others civil engineering structures

(Source: Table NA1: MS EN 1990: National Annex)

1.4 Limit State Design

The design method discussed in Eurocode 2 is based on limit state principle. A limit state can be defined as the state of a structure which represents the acceptable limit of an aspect of structural behaviour. The criterion for safe design is that the structure should not become unfit