STRUCTURAL DESIGN OF A REINFORCED CONCRETE FLOATING PONTOON WITH AN ACCESS WALKWAY

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Universiti Malaysia Sarawak

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STRUCTURAL DESIGN OF A REINFORCED CONCRETE FLOATING PONTOON WITH AN ACCESS WALKWAY

TAN CHAN BOON

This report is submitted in partial fulfilment of the requirement for the Bachelor Degree in Civil Engineering (Hons.) from the Faculty of Engineering University of Malaysia Sarawak March 2002

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ABSTRACT

The project presented herein is the structural design of a reinforced concrete floating pontoon with an access walkway. For the analysis and design purposes, two structural softwares were adopted, which are Staad III and MicroFeap II.

This project is mainly concerned with the detail design of the reinforced floating pontoon, truss analysis and timber decking for walkway. The British Code of practices BS 8110, BS 5950 and BS 5268 are used respectively in this project.

The mooring and anchoring system is not included in this project. Energy absorption, for example, using rubber fenders or timber is also not included.

Output results generated by the software will be analysed and followed by the structural elements design state. Eventually, detail drawings are produced to illustrate how structure is to be constructed on site.

This thesis is concluded in improving the reinforced concrete floating pontoon with conclusion and some recommendations on the project are stated too.

ABSTRAK

Projek tahun akhir ini merangkumi rekabentuk struktur bagi konkrit pontun dan pelalu jalan kaki. Perisian struktur yang digunakan dalam rekabentuk adalah Staad III dan MircoFeap II.

Tumpuan utama diberi kepada merekabentuk struktur bagi konkrit pontun, kekuda dan kayu dek sahaja.Piawaian kode yang digunakan adalah BS 8110, BS 5950 dan BS 5268 dalam projek ini.

Sistem tambatan dan penyerapan tenaga oleh penangkis pukulan tidak termasuk dalam perbincangan projek ini.

Keputusan keluaran daripada perisian sturktur akan dikaji dan diikuti dengan peringkat merekabentuk struktur binaan. Selepas itu lukisan struktur akan dihasilkan untuk memberi gambaran mengenai struktur binaan sebenar di tapak binaan. Cadangan untuk kerja-kerja memperbaiki turut diberi.

iii

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LIST OF CONTENTS

ACKNOWLEDGEMENT		i
ABS	TRACT	ii
ABS	TRAK	iii
LIST	T OF CONTENTS	iv
LIST	OF SYMBOLS	viii
LIST OF FIGURES		xv
LIST	OF TABLES	xvi
СНА	PTER 1 INTRODUCTION	
1.1	Introduction	1
1.2	Project Objectives	2
1.3	Thesis Overview	2

CHAPTER 2 LITERATURE REVIEW

2.1	General	4
2.2	History of floating pontoon	5

CHAPTER 3 CASE STUDY AND METHODOLOGY

3.1	General	8
	3.1.1 Tides	8
3.2	Introduction to Reinforced Concrete Floating Pontoon	Design 11
	3.2.1 Reinforced Concrete Design	
	3.2.1.1 Objective	17
	3.2.1.2 Introduction to reinforced concrete design	17
	3.2.1.3 Reinforced concrete design	17
	3.2.1.4 Flanged Beams	18
	3.2.1.5 Procedures in designing Flanged Beam	19
	3.2.2 Slab Design	21
3.3	Truss Design	
	3.3.1 General	23
	3.3.2 Types of truss	23
	3.3.3 Bracing action in walkway – U Frame Analysis	25
	3.3.4 Connection	27
	3.3.5 Guidance on method of analysis	27
3.4	Timber Decking Design	
	3.4.1 General	28
	3.4.2 Introduction	28
	3.4.3 Procedures in designing timber decking	29
arri		×1
CHA	APTER 4 DETAIL DESIGN AND CALCULATIO	'N
4.0	General	32

4.1 Reinforced concrete floating pontoon design 32

	4.1.1	Assumptions made	33				
	4.1.2	Freeboard of the floating pontoon	37				
	4.1.3	Input Procedure for Staad III	38				
	4.1.4	Results (extracted from Appendix A1)	43				
	4.1.5	Summary of member end forces from Staad III analysis	44				
	4.1.6	Manual calculation	46				
	4.1.7	Slab design	57				
	4.1.8	Column Design	59				
	4.1.9	Discussion	60				
4.2	Walk	Walkway Design					
	4.2.1	Walkway design - Condition 1	61				
	4.2.2	Walkway design - Condition 2	62				
	4.2.3	Result	63				
	4.2.4	U-Frame analysis for walkway design	63				
	4,2.5	Pin supports design	65				
4.3	Timbe	er decking design	67				
4.4	Detail	structural drawing for reinforced concrete floating pontoon	70				
	with a	an access walkway					
CHA	PTER 5	CONCLUSION	74				
	5.1	Floating Pontoon	74				

5.2	Steel truss	and cross	member	for the	walkway	76
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REFERENCES		77
APPENDIX A	STAAD III INPUT AND OUTPUT DATA FOR	78
	REINFORCED CONCRETE FLOATING PONTOON	
APPENDIX B1	STAAD III INPUT AND OUTPUT DATA FOR	100
	WALKWAY DESIGN - CONDITION I	
APPENDIX B2	STAAD III INPUT AND OUTPUT DATA FOR	112
	WALKWAY DESIGN - CONDITION II	
APPENDIX C	TABLE PROPERTIES OF THE STEEL SECTION	124
APPENDIX D	U-FRAME ANALYSIS USING MICROFEAP II :	127
	INPUT AND OUTPUT DATA	

SYMBOLS

For the purpose of this Chapter, the following symbols have been used. These have largely been taken from BS 8110. Note that in one or two cases the same symbol is differently defined. Where this occurs the reader should use the definition most appropriate to the element being designed.

GEOMETRIC PROPERTIES

b	Width of section
d	Effective depth of the tension
h	Overall depth of section
x	Depth to neutral axis
z	Lever arm
d	Depth to the compression reinforcement
1	Effective span
C	Nominal cover to reinforcement

BENDING

F_k	Characteristic load
g_k , G_k	Characteristic dead load

$\mathbf{q}_{\mathbf{k}}, \mathbf{Q}_{\mathbf{k}}$	Characteristic imposed load
\mathbf{w}_k, W_k	Characteristic wind load
$\mathbf{f}_{\mathbf{k}}$	Characteristic strength
\mathbf{f}_{cu}	Characteristic compressive cube strength of concrete
$\mathbf{f}_{\mathbf{y}}$	Characteristic tensile strength of reinforcement
γι	Partial safety factor for load
γm	Partial safety factor for material strength
K	Coefficient given by M/f _{cu} bd ²
М	Design ultimate moment
M_{u}	Design ultimate moment of resistance
As	Area of tension reinforcement

SHEAR

f_{yv}	Characteristic strength of links
8v	Spacing of links along the member
V	Design shear force due to ultimate loads
v	Design shear stress
Vc	Design concrete shear stress
Asv	Total cross-sectional area of shear reinforcement

For this purposes of this section, the following symbols have been used. These have largely been taken from BS 5268.

GEOMETRICAL PROPERTIES

b	Breadth of beam
h	Depth of beam
А	Total cross-sectional area
i	Radius of gyration
I	Second moment of area
Z	Section modulus

Bending

L	Effective span
М	Design moment
M_R	Moment of resistance
σ _{m,n} , j	Applied bending stress parallel to grain
$\sigma_{m,g }$	Grade bending stress parallel to grain
σm.adm.]	Permissible bending stress parallel to grain

Deflection

$\delta_{\rm t}$	Total deflection
$\delta_{\rm m}$	Bending deflection
δ_{v}	Shear deflection
$\delta_{\rm p}$	Permissible deflection

E	Modulus of elasticity
E_{mean}	Mean modulus of elasticity
G	Shear modulus

Shear

F_{ν}	Design shear force
τ_a	Applied shear stress parallel to grain
$\tau_{\rm g}$	Grade shear stress parallel to grain
Tadm	Permissible shear stress parallel to grain

bearing

F	Bearing force
tb	Length of bearing
$\sigma_{c,a,\pm}$	Applied compression stress perpendicular to grain
$\sigma_{c,g,\perp}$	Grade compression stress perpendicular to grain
$\sigma_{c,a,dm_{\perp}}$	Permissible bending stress perpendicular to grain

Compression

Le	Effective length of a column
λ.	Slenderness ratio
N	Axial load
Gc.a.]	Applied compression stress parallel to grain
σ _{e.it.}]	Grade compression stress parallel to grain
σ _{c,adm}	Permissible compression stress parallel to grain

 $\sigma_{c,j}$ | Compression stress = $\sigma_{c,g,j}$ | K₃

σ_e Euler critical stress

For the purpose of this section, the following symbols have been used. These have largely been taken from BS 5950

GEOMETRIC PROPERTIES

А	Area of section
Ag	Gross sectional area of steel section
В	Breadth of section
В	Outstand of flange
D	Depth of section
D	Depth of web
I_{x}, I_{y}	Second moment of area about the major and minor axes
L	Length of span
$r_x, \ r_y$	Radius of gyration of a member abut its major and minor axes
S _x , S _y	Plastic modulus about the major and minor axes
т	Thickness of flange
Т	Thickness of web
U	Buckling parameter of the section
Х	Torsional index of section
Zx, Zy	Elastic modulus about major and minor axes

Bending

A_{ν}	Shear area
Е	Modulus of elasticity
\mathbf{F}_{t}	Tensile force
$\mathbf{F}_{\mathbf{v}}$	Shear force
L	Actual length
LE	Effective length
M_{max}	Maximum moment
Mc	Moment capacity
M_b	Buckling resistance moment
$\mathbf{P}_{\mathbf{v}}$	Shear capacity of a section
pe	Compressive strength of the steel
рь	Bending strength of the steel
ру	Design strength of steel
Е	Constant=(275/py)1/2
λ	Slenderness ratio
δ	deflection

COMPRESSION

Ag	Gross sectional area of steel section
L	Actual length
$L_{\rm E}$	Effective length
M_b	Buckling resistance moment

CONNECTIONS

Т	Thickness of ply
Е	End distance
F	applied shear force
\mathbf{F}_{t}	Applied tension force
\mathbf{f}_{v}	Shear stress
\mathbf{P}_{bb}	Bearing capacity of a bolt
\mathbf{P}_{bs}	Bearing capacity of parts connected by ordinary bolts
P,	Shear capacity of a bolt
рьь	Bearing strength of a bolt
p_{bg}	Bearing strength of parts connected by friction grip fasteners
рыя	Bearing strength of parts connected by ordinary bolts
p _n	Shear strength of a bolt
рı	Tension strength of a bolt
pw	Design strength of a fillet weld
S	Leg length of a fillet weld

LIST OF FIGURES

Fig. 3.1	Side Elevation showing possible position of floating pontoon	10
Fig. 3.2	Beam sections: (a) Singly reinforced; (b) doubly reinforced;(c) T- section; (d) L-section	18
Fig. 3.3	Common types of trusses	23
Fig. 3.4	Steel truss walkway plan for the project	24
Fig. 3.5	Buckling of main beams of half-through girder	25
Fig. 3.6	U-frame restraint action.(a) Components of U-Frame, (b) U-Frame elastic support stiffness	26
Fig. 3.7	Buckling made for half-through construction with flexible and frames	26
Fig. 4.1	Geometry modelling of floating pontoon using Staad III program	34
Fig. 4.2	Top key plan of floating pontoon	35
Fig. 4.3	Bottom key plan of floating pontoon	36
Fig. 4.4	Pontoon overall layout, elevation and details	71
Fig. 4.5	Pontoon key plan, beam and slab details	72
Fig. 4.6	Pontoon walkway plan and sectional details	73

LIST OF TABLES

Table 3.1 Tide levels

9

Т	Thickness of ply
E	End distance
Fe	applied shear force
\mathbf{F}_{t}	Applied tension force
$\mathbf{f}_{\mathbf{v}}$	Shear stress
\mathbf{P}_{bb}	Bearing capacity of a bolt
\mathbf{P}_{bs}	Bearing capacity of parts connected by ordinary bolts
P.	Shear capacity of a bolt
рьь	Bearing strength of a bolt
\mathbf{p}_{bg}	Bearing strength of parts connected by friction grip fasteners
pba	Bearing strength of parts connected by ordinary bolts
\mathbf{p}_{s}	Shear strength of a bolt
\mathbf{p}_t	Tension strength of a bolt
$\mathbf{p}_{\mathbf{w}}$	Design strength of a fillet weld
S	Leg length of a fillet weld

CHAPTER 1

INTRODUCTION

1.1 General

Floating pontoon is a broad, flat-bottomed floating structure generally rectangular in shape, used for many purposes in a port, as a ferry landing place, a pier head, or alongside a vessel to assist in loading or discharging.

Historically floating pontoons are used chiefly to support a bridge, to raise a sunken ship, or to float a hydroplane or a floating dock. Pontoons have been built of wood, of hides stretched over wicker frames, of copper or tin sheet metal sheathed over wooden frames, of aluminum, of concrete and of steel.

Pontoons for raising sunken ships are watertight cylinders that are filled with water, sunk, and fastened to the submerged ship; when emptied by compressed air, they float the ship to the surface. A pontoon lifeboat consists of a raft supported by watertight cylinders.

The modern permanent pontoon is composed of many compartments, so that if a leak occurs in one compartment, the pontoon will not sink. Permanent pontoons are fastened together and several anchors are dropped from each. However in this project, the pontoon unit is small. Therefore no compartmentation is introduced. The partition wall makes the reinforced concrete box unit too heavy.

1.2 Project Objectives

The main objective of this project is to perform a structural design of a reinforced concrete floating pontoon with an access walkway based on BS 8110: Part 1 (1985), BS 5950 (1990), BS 5268 (1996) and BS EN 388 (1995).

In designing the reinforced concrete floating pontoon, computer analysis and manual calculation are used. For steel truss and cross members design, computer software is used. Timber decking design is based on manual calculation according to BS 5268 (1996).

Detail structural drawings are also included to illustrate how the structure is constructed on the site.

1.3 Thesis Overview

This thesis describes the project of structural design of a reinforced concrete floating pontoon with an access walkway. Following the introduction, the next chapter gives an overview of the floating pontoon including a brief history and background of floating pontoons.

2

The description about the case study and methodology are in Chapter 3 of this report where it focuses on the specification and the procedures involved in designing the reinforced concrete floating pontoon, timber decking and access walkway design. Chapter 4 is concerned with the detailed design and calculation of reinforced concrete floating pontoon with an access walkway. Chapter 4 also included the detailed structural drawings for reinforced concrete floating pontoon and access walkway. The thesis is concluded in Chapter 5.