

STRUCTURAL DESIGN OF PRESTRESSED CONCRETE SEMI PRESMATIC BRIDGE BEAMS

by

A. M. A. Krishanthi Alagiyawanna

LIDRARV UNIVERSITY OF LIORATUWA, SRI LANKA MORATUWA

A THESIS



Engineering Design

University of Moratuwa

012 # :

<u>91242</u>

Department of Civil Engineering University of Moratuwa Moratuwa

September 2007

91242

Acknowledgments

I would like to extend my sincere gratitude and appreciation to my thesis supervisor and chairman of the committee, Prof. M.T.R.Jayasinghe for his enormous guidance, support and suggestions throughout this work. Also, my thanks go to Dr. Mrs. M.T.P. Hettiarachchi Dr. Ruwan Weerasekara and Prof. W.P.Dias of the Department of Civil Engineering for their helpful suggestions and support.

I would like to thank my friends and colleagues whom I have met and known while attending the University of Moratuwa. I extend my utmost gratitude to my parents, and to my sister for their encouragement and support. Finally I especially thank my loving husband Shaminda for his great help, motivation and love which made this work a reality Electronic Theses & Dissertations www.lib.mrt.ac.lk

Krishanthi Alagiyawanna University of Moratuwa

Sep 2007

ŧ,

Table of Contents

h,

48

fe

Table of (Contents	iii
List of Fi	gures	v
ListofTa	bles	vi
Notation		/ii
Notation		
Chapter 1		. 1
Introdu	ction	. 1
11	General	. 1
1.2	Main Objectives	. 3
1.3	Arrangement of the Thesis	. 3
Chapter 2	2	. 5
Literatu	re Review	. 5
2.1	Introduction	. 5
2.2	Design Background	. 6
2.3	Behavior of Prestressed Concrete Continuous Beams	12
2.4	The Governing Criteria for Preliminary Design	22
2.5	Design Processiversity of Moratuwa, Sri Lanka	23
2.6	Cable Design for Continuous Prismatic Prestressed Spine Beams	25
2.7	Summary	29
	www.ii0.iiit.ac.ik	
Chapter 3	3	30
Propos	ed Design Technique for Semi Prismatic Spine Beams	30
3.1	Selection of the Smallest Practically Possible Cross Section	30
3.2	Design Considerations to Obtain the Adequate Section	36
3.3	Theory behind the Semi-Prismatic Prestressed Continuous Beams	40
3.4	Selection of Cable Forces and Profiles	41
3.5	Summary	42
Chapter 4	ł	43
Design	Examples	43
4.1	Selection of Section Dimensions	44
4.2	Calculation of Bending Moments	46
4.3	The Prestressing Cable force	55
4.4	Design Automation	55
4.5	Examples for Semi-Prismatic Spine Beams	57
4.6	Examples for Prismatic Spine Beams	62
4.7	Concrete Volume Comparison between Prismatic and Semi-prismatic	
	Beams	66
4.8	Summary	66

Chapter	5	67
Conclu	usions and Future Work	67
5.1	Conclusions	67
5.2	Suggestion for Further Research and Development	68
Appendi	ix A	
Refere	ences	70
Appendi	ix B	
Stress	limit criteria	
Appendi	ix C	75
Desig	n Spread Sheet for a Semi Prismatic Spine Beam	75



University of Moratuwa, Sri Lanka. Electronic Theses & Dissertations www.lib.mrt.ac.lk

List of Figures

*

•

¢

2.1	Typical Magnel diagram	9
2.2	Types of spine beams	12
2.3	Secondary moments in a continuous beam	15
2.4	The equilibrium system with the moment on both sides of i-th support and	d
	the corresponding support reactions	26
2.5	The secondary moments at supports - secondary moment	
	at j th support (M2)j	27
3.1	Cross section of a spine beam showing principle variables	30
4.1	Typical cross section used for design examples	44
4.2	Grillage model used for the design	46
4.3	Load Case for monolithic construction and dead load bending moment	
	diagram	47
4.4	Load cases considered for as built construction and dead load bending	
	moment diagram at each stage	48
4.5	Trapped moments for span by span construction	48
4.6	Load case considered for super-imposed dead load and bending moment	
	diagram	49
4.7	Load cases considered for live load bending moment diagram	55
4.8	Limits of line of thrust with the fine of thrust selected for dase 1	57
4.9	Cable profile zone with actual cable for case 1	58
4.10	Limits of line of thrust with the line of thrust selected for case 2	59
4.11	Cable profile zone with actual cable for case 2	59
4.12	Limits of line of thrust with the line of thrust selected for case 3	60
4.13	Cable profile zone with actual cable for case 3	60
4.14	Limits of line of thrust with the line of thrust selected for case 4	61
4.15	Cable profile zone with actual cable for case 4	62
4.16	Limits of line of thrust with the line of thrust selected for case 5	63
4.17	Cable profile zone with actual cable for case 5	63
4.18	Limits of line of thrust with the line of thrust selected for case 6	64
4.19	Cable profile zone with actual cable for case 6	64
4.20	Limits of line of thrust with the line of thrust selected for case 7	65
4.21	Cable profile zone with actual cable for case 7	66

List of Tables

h,

4

4'n

Minimum thicknesses required for the top flange	33
Web thicknesses required depending on the type of ducts	34
Bridge Beam Data used for Examples	43
The design parameters and results for Case 1	57
The design parameters and results for Case 2	58
The design parameters and results for Case 3	60
The design parameters and results for Case 4	61
The design parameters and results for Case 5	62
The design parameters and results for Case 6	64
The design parameters and results for Case 7	65
Concrete volume comparison with the type of the spine beam	66
	Minimum thicknesses required for the top flange Web thicknesses required depending on the type of ducts Bridge Beam Data used for Examples The design parameters and results for Case 1 The design parameters and results for Case 2 The design parameters and results for Case 3 The design parameters and results for Case 4 The design parameters and results for Case 5 The design parameters and results for Case 6 The design parameters and results for Case 7 Concrete volume comparison with the type of the spine beam



University of Moratuwa, Sri Lanka. Electronic Theses & Dissertations www.lib.mrt.ac.lk

Notation

٩

۰**۳**

A _c	Area of the concrete section
С	cover from edge of concrete to centre of tendon
COR	Cantilever Overhang Ratio as defined on page 34
d	Depth of section
e	Eccentricity of prestressing cable (measured +ve downwards from centroid)
e _{min}	Minimum eccentricity allowed considering cover limits
e _{max}	Maximum eccentricity allowed considering cover limits
e _p	Eccentricity of line of thrust
es	Eccentricity of cable profile
E	Young's modulus of the section
Ez	Young smodulus at a height z from the bottom flange. Electronic Theses & Dissertations
fc	Permissible stress of concrete in compression
fı	Permissible stress of concrete in tension
fiemp	Temperature stresses due to direct strain and curvature
I	Second moment of area about centroid
М	External moment acting on the section
Ma (act)	Minimum applied moment at the working load without secondary moments
Mb (act)	Maximum applied moment at the working load without secondary moments
Ma	Minimum applied moment at the working load with secondary moments
M _b	Maximum applied moment at the working load with secondary moments
M ₂	Secondary moment
(M ₂) _j	Secondary moment at internal support j

- N Number of webs of a box girder
- P Horizontal component of the prestressing force in cable at transfer
- P_{min} minimum prestressing force in cable
- P_{max} maximum prestressing force in cable
- R Loss Ratio
- RMR Reactant moment ratio as defined on page 20
- t_b Thickness of bottom flange
- tt Thickness of top flange
- t_w Thickness of web
- t_z Temperature at a height z above the bottom of the section
- w_b Width of the bottom flange
- w_s Clear spacing between webs
- wt Width of the top flange Electronic Theses & Dissertations
- w_c Width of the cantilever overhangac.lk
- y₁ Position of top fiber (-ve)
- y₂ Position of bottom fiber (+ve)
- z Distance measured from bottom fiber
- Z_1 Elastic section modulus of top fiber (I/y_1) (-ve)
- Z_2 Elastic section modulus of bottom fiber (I/y2) (+ve)
- β_j Distribution coefficient for M₂
- ψ_z Curvature due to temperature
- ε_{o} Direct strain due to temperature
- γ Cantilever overhang ratio (w_c/w_s)