



Ain Shams University
Faculty of Engineering
Structural Engineering Department

Behavior of Rectangular Partially Prestressed High Strength Concrete Beams

By

Shady Hesham Abdelmohaimen Bakr Salem

B.Sc. 2009, Structural Division
Civil Engineering Department
Ain Shams University

Thesis

Submitted in partial fulfillment of the
requirements of the degree of
MASTER OF SCIENCE
in
Civil Engineering (Structural)

Supervised by

Prof. Dr. Ahmed Sherif Essawy
Professor of Concrete Structures,
Structural Department,
Ain Shams University

Dr. Tarek Kamal Hassan
Professor of Concrete Structures,
Structural Department,
Ain Shams University

Dr. Khalid Hilal Riad
Lecturer, Structural Department,
Ain Shams University

Examiners Committee

Name, Title and Affiliation

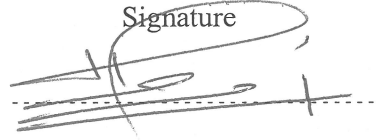
PROF. ASHRAF HASSAN EL ZANATY

Professor of concrete structures

Faculty of Engineering

Cairo University

Signature

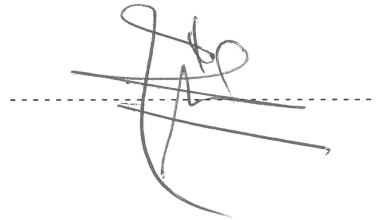
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PROF. OSAMA HAMDY ABDELWAHED

Professor of concrete structures

Faculty of Engineering

Ain Shams University

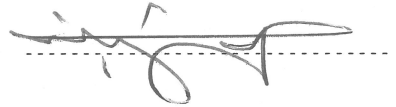
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PROF. AHMED SHERIF ESSAWY

Professor of concrete structures

Faculty of Engineering

Ain Shams University

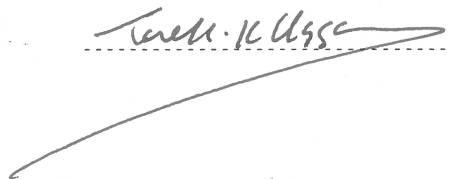
A handwritten signature in black ink, consisting of several loops and horizontal strokes, positioned above a dashed horizontal line.

DR. TAREK KAMAL HASSAN

Professor of concrete structures

Faculty of Engineering

Ain Shams University

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STATEMENT

This thesis is submitted to Ain Shams University, Cairo, Egypt, in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering (Structural).

The work included in this thesis was carried out by the author at reinforced concrete laboratory of the faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or qualification at any other university or institute.

Date : / / 2014

Name : Shady Hesham Abdelmohaimen Bakr Salem

Signature :

Dedication

I dedicate the work and accomplishment in this thesis to the people who devoted their lives for making me a successful person, my Father and Mother. Gratitude and appreciation words cannot describe my feelings towards them.

Special dedication to my grandparents for their continuous encouraging wishes. Specially my grandfather Ali Abdelrahman, who passed away during my thesis preparation for acting as my role model during my whole life.

I would like to thank my sister for all the support and care she is always providing me.

Acknowledgement

I would like to express my sincere appreciation to the committee chair Dr. Ahmed S. Essawy for his guidance, support and continuous encouragement throughout this research work. Without his guidance and persistent help this dissertation would not have been possible.

I would like to express my gratitude to my supervisor Dr. Tarek K. Hassan for the useful comments, remarks and engagement through the learning process of this master thesis.

I would also like to express my heartfelt gratitude to Dr. Khaled M. Helal. The work presented herein could not have been done without his continuous support and advice.

I would like to extend my thanks to Dr. Amr A. Abdelrahman for his guidance through the whole research phases.

I would like also to thank my colleague Tarek H. Elhashimy for proving the real meaning of friendship and research assistance.

Abstract

In the last few decades, prestressed concrete has been rapidly used in bridge engineering due to the enormous development in the construction techniques and the increasing need for long span bridges. High strength concrete has been also more widely spread than the past. It currently becomes more desirable as it has better mechanical properties and durability performance. Major defect of fully prestressed concrete is its low ductility; it may produce less alarming signs than ordinary reinforced concrete via smaller deflection and limited cracking. Therefore, partially prestressing is considered an intermediate design between the two extremes. So, combining high strength concrete with partial prestressing will result in a considerable development in the use of prestressed concrete structures regarding the economical and durability view points. This study presents the results of seven partially prestressed high strength concrete beams in flexure. The tested beams used to investigate the influence of concrete compressive strength, prestressing steel ratio and flange width on the behavior of partially prestressed beams.

The experimental program was conducted on seven partially prestressed concrete beams with total length of 4800mm. The beams were simply supported with 4500mm clear span and 150mm projection at each end. All the beams were 150mm wide and 250mm deep for all the five rectangular sections. The web of the T-section

specimens was similar to the rectangular ones while flange widths were 350 and 550mm. The experimentally observed behaviors of all beams were presented in terms of the cracking load, ultimate load, deflection, cracking behavior and failure modes. Strains at the bottom longitudinal reinforcement steel and concrete (top and reinforcement levels) were also measured so as to monitor the strain propagation across the concrete cross section

The research program developed an analytical approach to predict the behavior of the partially prestressed high strength beams under the studied parameters. The program based on rational and empirical methods available in the literature to model both deflection and crack width of partially prestressed high strength concrete. Failure modes and ultimate carrying capacity of the beams were predicted and then compared to the experimental values.

Table of Contents

Dedication.....	i
Acknowledgment.....	ii
Abstract.....	iii
Table of contents.....	v
List of symbols.....	x
List of tables.....	xvi
List of figures.....	xvii
<i>1 Introduction</i>	1
1.1 General	1
1.2 Research objectives	2
1.3 Scope of work and methodology.....	3
1.3.1 Experimental investigation	3
1.3.2 Analytical investigation	4
1.3.3 Design recommendations.....	4
1.4 Thesis outline	5
<i>2 Literature review</i>	7
2.1 Introduction	7
2.2 High strength concrete (HSC).....	8
2.2.1 Definition, Advantages and Disadvantages of HSC.....	8
2.2.2 Mechanical properties of high strength concrete.....	12
2.2.3 Design considerations for high strength concrete.....	19
2.3 Partially prestressed concrete	23
2.3.1 General	23
2.3.2 Definitions in partially prestressed concrete.....	27
2.3.3 Cracked Section analysis	29
2.3.4 Short term deflection.....	30
2.3.5 Cracking behavior	42
2.3.6 Effective flange width.....	54

2.3.7	Ductility.....	55
2.4	Prestressed high strength concrete beams	57
2.4.1	General	57
2.4.2	Previous researches	57
2.4.3	Concluding statement.....	62
3	<i>Experimental program</i>	63
3.1	General	63
3.2	Specimens' design.....	63
3.3	Materials	69
3.3.1	Concrete	69
3.3.2	Conventional reinforcement.....	71
3.3.3	Prestressing reinforcement.....	71
3.3.4	Grout	71
3.4	Specimen preparation	71
3.5	Instrumentation.....	85
3.5.1	The internal instrumentation	85
3.5.2	The external instrumentation	86
3.6	Specimen actual dimensions	89
3.7	Prestressing losses	96
3.8	Test setup.....	98
3.8.1	The Test Setup	99
3.8.2	Loading mechanism	100
3.8.3	Loading criteria	102
4	Test results and discussion	104
4.1	General	104
4.2	Flexural behavior.....	104
4.2.1	R-0.264-70	106
4.2.2	R-0.264-40	107
4.2.3	R-0.264-90	108

4.2.4	R-0.373-70	109
4.2.5	R-0.528-70	110
4.2.6	T-0.264-70*	111
4.2.7	T-0.264-70**	112
4.3	Camber measurements	113
4.4	Failure modes	113
4.5	Strain distribution	115
4.6	Cracking behavior	119
4.7	Effect of concrete compressive strength	124
4.7.1	Load-deflection	125
4.7.2	Strain distribution	127
4.7.3	Cracking behavior	128
4.8	Effect of prestressing steel ratio	130
4.8.1	Load-deflection	130
4.8.2	Strain distribution	132
4.8.3	Cracking behavior	134
4.9	Effect of flange width	136
4.9.1	Load-deflection	136
4.9.2	Strain distribution	138
4.9.3	Cracking behavior	139
5	Analytical program	141
5.1	General	141
5.1.1	Introduction	141
5.1.2	Analysis procedure	141
5.1.3	Cracking moment calculation	143
5.1.4	Failure criteria	144
5.2	Material modeling	146
5.2.1	Concrete	146
5.2.2	Prestressing steel strands	146

5.2.1	Conventional reinforcement.....	147
5.3	Cracking and ultimate moment	149
5.4	Deflection prediction	151
5.4.1	Integration of curvature.....	152
5.4.2	Simplified method.....	176
5.4.3	Source of deviation	181
5.4.4	Design recommendations.....	183
5.5	Camber calculations	185
5.6	Crack pattern prediction	187
5.6.1	Introduction.....	187
5.6.2	Influence of major parameters	188
5.6.3	Stress calculation at the conventional reinforcement	191
5.6.4	Crack width calculation	191
5.6.1	Design recommendations.....	205
5.7	Ductility.....	206
5.8	Applicability of the Egyptian code of practice	208
6	Summary, conclusions and recommendations	209
6.1	Summary.....	209
6.2	Conclusions	210
6.3	Recommendations	212
	References.....	213
	Appendices.....	220
	Appendix A	221
	Material properties	221
	Course and fine aggregates:.....	222
	Silica fume:	225
	Chemical admixtures:	231
	Conventional reinforcement	235
	Grout	240

Sika® form oil	242
Appendix B	244
Donut load cell	244
Introduction.....	245
Definition of the load cells	245
Basic idea of the load cells	245
Components of the used load cell.....	247
Experimental program	249
Experimental Results & Observations.....	252
Appendix C	257
Detailed results.....	257
Deflection.....	258
Cracking.....	272

List of symbols

a	Depth of the equivalent rectangular stress block in the compression zone of concrete section.
A	Effective concrete tension area divided by number of bars or wires.
A_r	Concrete area in tension below neutral axis.
A_{cr}	Cross sectional area of transformed cracked section.
A_s	Area of longitudinal tension reinforcement within effective tension.
A_{cef}	Area of effective concrete section in tension.
A_{st}	Area of prestressing and equivalent conventional steel.
A_{ps}	Area of prestressed reinforcement.
A_g	Gross section area of concrete.
A_{ns}	Area of non-prestressed reinforcement.
c	Concrete cover
\bar{c}	Neutral axis depth from the extreme compression fiber.
C_s	center-to-center distance of tensile reinforcements (mm).
d_c	Concrete cover to the center of reinforcement.
d_p	Depth of the prestressing reinforcement from the extreme compression fiber.
e	Eccentricity of prestressing force based on gross section properties.
e_{cr}	Eccentricity of prestressing reinforcement with respect to neural axis of the transformed cracked section.
E_c	Concrete modulus of elasticity.
E_{As}	Conventional reinforcement modulus of elasticity.

E_{ps}	Prestressing steel modulus of elasticity.
E_s	Average modulus of elasticity for conventional and prestressing steel reinforcement.
E_{total}	Total energy.
$E_{elastic}$	Elastic energy.
f_{cu}	Concrete characteristic cube compressive strength at 28days.
f_c'	Concrete specified cylinder compressive strength.
f_{cm}	Mean value of concrete cylinder compressive strength.
f_{ck}	Concrete characteristic cylinder compressive strength at 28days.
f_{ctm}	Mean axial tensile strength.
$f_{ck,cube}$	Concrete characteristic cube compressive strength at 28days.
f_r	Concrete average modulus of rupture.
$f_{ctm,fl}$	Concrete average modulus of rupture.
$f_{ct,sp}$	Concrete indirect tensile splitting strength.
f_{ctr}	Concrete tensile splitting strength.
$f_{ct,sp}$	Concrete average modulus of rupture.
f_{ps}	Stress in the prestressing reinforcement at the ultimate stage.
f_c	Stress at any level of loading.
f_{ps}	Stress at the prestressing steel reinforcement.
f_{ps}	Stress at the prestressing steel reinforcement.
f_y	Yielding stress at prestressing and conventional reinforcement.
f_c	Stress at any level of loading.
f_{sr}	Stress in longitudinal steel at the tension zone, based on the analysis of cracked section due to loads causing first cracking.

f_s	Stress in longitudinal steel at the tension zone, based on the analysis of cracked section under permanent load.
h	Total member depth
I_e	Effective moment of inertia.
I_g	Gross moment of inertia.
I_{cr}	Moment of inertia of the cracked section ignoring the concrete in tension.
I_{eL2}	Effective moment of inertia for moment corresponding to a downward (net positive) deflection.
k	Factor to increase the decay of stresses.
k_1	Ratio of the average compressive stress to the maximum compressive stress.
k_2	Ratio of the depth of the resultant compressive force to the depth of neutral axis.
k_3	Ratio of the maximum compressive stress to the compressive strength of concrete cylinder.
k_1	Coefficient depending on reinforcement bond properties.
k_2	Coefficient depending on strain distribution.
k_1	Coefficient depending on the reinforcement geometry.
k_2	Coefficient depending on the concrete quality.
k_3	Coefficient depending on the arrangement of reinforcement.
k_1	Coefficient depending on the reinforcement type.
K	coefficient depending on the support and loading conditions.
L	Effective length of the member.