

CONSTRUCTION STAGE ANALYSIS OF A POST-TENSIONED
SEGMENTAL CROSSHEAD

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Civil - Structure)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JUNE 2015

To my beloved family.

ACKNOWLEDGEMENT

First of all, I wish to express my sincere appreciation to my supervisor, Associate Professor Baderul Hisham Ahmad for inspirations, endless support, and professional guidance from time to time throughout the duration of this Master's project. With his invaluable advices and constructive comments, this project is successfully completed.

My sincere thanks to all my great lecturers, whom had equipped me with necessary knowledge to complete this project. Their dedication in teaching had brought me to where I am now. Special thanks to those people who have helped in my project, including my helpful colleagues and fellow friends. Thank you for their support and assistance.

Last and but not least, I would like to express my very profound gratitude to my parents and to my wife for providing me with unfailing support and continuous encouragement throughout my years of study. Your love and support has always been the driving force for my pursuits, and I will always be grateful.

ABSTRACT

In the construction of post-tensioned segmental crosshead, the stresses in the crosshead vary in every stage of the construction as the addition of new segment increases the bending moment while post-tensioning of tendon reduces it. Furthermore, the bending moment in the crosshead during construction is not balanced as new segment are added at one side of the cantilever at a time together with other construction load that operates on the same side of the new segment. In this paper, a study was conducted with finite element method to investigate the response of various parameters and effect of construction sequences on a segmental crosshead erected by balanced cantilever method. For this operation, a segmental crosshead model was generated using a finite element software and it was analyzed with various construction sequence. The rate of changes in stresses in each stages of construction was investigated and it was found that the stresses were over the limit when construction stage analysis was performed. In addition to that, it was also found that the maximum design moment for pier design can only be obtained by a more rigorous construction stage analysis.

ABSTRAK

Dalam pembinaan 'crosshead' jenis konkrit pra-tegasan, nilai tegasan adalah berbeza di setiap peringkat pembinaan. Penambahan segmen baru akan meningkatkan momen lentur manakala penegasan tendon akan mengurangkannya. Tambahan pula, momen lentur semasa pembinaan adalah tidak seimbang kerana segmen baru ditambah di sebelah pada satu masa berserta beban pembinaan yang dikenakan pada segmen tersebut. Oleh itu, respon struktur semasa fasa pembinaan perlu dikaji selidik. Untuk penyelidikan ini, model struktur telah dibina menggunakan perisian unsur terhingga dan ia dianalisa dengan pelbagai urutan pembinaan. Kadar perubahan tegasan setiap peringkat pembinaan telah diselidik dan didapati bahawa tegasan telah melebihi had apabila analisa pembinaan dijalankan. Selain itu, juga didapati bahawa momen lentur maksimum bagi reka bentuk tetiang hanya boleh diperolehi dengan analisa peringkat pembinaan yang lebih terperinci.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF APPENDICES	xiv
1	INTRODUCTION	1
	1.1 Background of the problem	1
	1.2 Statement of the problem	2
	1.3 Objectives of the study	3
	1.4 Scope of Study	3
	1.5 Significance of the study	3
2	LITERATURE REVIEW	4
	2.1 Introduction	4
	2.2 History of Prestressing	5
	2.3 Principle of Prestressing	6
	2.4 Prestressing Concrete Methods	8

2.4.1	Prestressing by Pretensioning	9
2.4.2	Prestressing by Post-Tensioning	10
2.5	Segmental Construction	11
2.6	Types of Segmental Construction	12
2.6.1	Balanced Cantilever Construction	13
2.6.1.1	Balanced Cantilever by Launching Gantry	15
2.6.1.2	Balanced Cantilever by Lifting Frames	16
2.6.1.3	Balanced Cantilever by Cranes	18
2.6.1.4	Cast in Situ Balanced Cantilever Construction	19
2.6.2	Span-by-Span Construction	20
2.6.2.1	Span-by-Span by Launching Gantry	20
2.6.2.2	Span-by-Span on Falsework	21
2.6.3	Incremental Launching Construction	22
2.6.4	Progressive Placement Construction	24
2.7	Construction Stage Analysis	25
2.8	Action During Construction	26
2.9	Finite Element Modelling	29
2.9.1	Factors to Consider in Finite Element Modelling	29
2.9.2	Convergence of Finite Element Solutions	31
2.10	Pierhead	33
3	RESEARCH METHODOLOGY	34
3.1	Introduction	34
3.2	Finite Element in LUSAS	34
3.3	Data Collection	36
3.4	Modelling Assumptions	36
3.5	Precast Segmental Crosshead Geometry	36

3.6	Precast Segmental Crosshead Construction Sequence	43
3.7	Structural Modelling in LUSAS	45
3.7.1	Geometry Definition	45
3.7.2	Attribute Definition	46
3.7.2.1	Mesh Attribute	46
3.7.2.2	Geometric Attribute	48
3.7.2.3	Material Attribute	48
3.7.2.4	Support Attribute	49
3.7.2.5	Loading Attribute	50
3.7.3	Prestress Definition	50
3.7.4	Staged Construction Analysis	52
3.8	Analysis and Output in LUSAS	58
4	RESULT AND DISCUSSION	60
4.1	Introduction	60
4.2	Comparison in Stresses	61
4.2	Comparison in Bending Moment	65
4.3	Comparison in Deflection	66
5	CONCLUSION AND RECOMMENDATION	68
5.1	Conclusion	68
5.2	Recommendation	69
	REFERENCES	70
	Appendices A-B	72

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Balanced cantilever by launching gantry typical erection cycle	16
2.2	Balanced cantilever by lifting frames typical erection cycle	17
2.3	Balanced cantilever by cranes typical erection cycle	19
2.4	Cast in situ balanced cantilever typical erection cycle	20
2.5	Span-by-span with launching gantry typical erection cycle	21
2.6	Span-by-span on falsework typical erection cycle	22
2.7	Incremental launching method typical erection cycle	23
2.8	Construction loads from EN1991-1-6	27
2.9	LRFD stability analysis construction loads	28
2.10	Effect of aspect ratio to the accuracy of solutions	29
2.11	Example convergence of finite element to analytical solution	32
3.1	Prestressing Cable Particulars	42
3.2	5 Construction Stage Sequence	43
3.3	5 Construction Stage with Temporary Bar Sequence	43
3.4	20 Construction Stage with Temporary Bar Sequence	44
3.5	List of Beam Elements in LUSAS	47
4.1	Pier bending moment for 20 construction stage model	65
4.2	Pier bending moment for 5 construction stage model	66
4.3	Pier bending moment for 5 construction stage with temporary bar model	66
4.4	Maximum horizontal displacement at top of pier/column and vertical displacement at cantilever end for 20 construction stage model	67

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Prestressed vessel by Egyptians in 2700B.C.	5
2.2	Barrel staves compressed with hoops	6
2.3	Reinforced concrete beam under load	7
2.4	Reinforced concrete and prestressed concrete beams	7
2.5	Stages in pretensioning	9
2.6	Post-tensioning	10
2.7	Typical Post-Tensioning Anchorage Hardware for Strand Tendons	11
2.8	Match Casting Process	13
2.9	Typical Construction Sequence of Continuous Bridge by Balanced Cantilever Method	14
2.10	Typical Balanced Cantilever Segment	15
2.11	Balanced cantilever with launching gantry	16
2.12	Balanced cantilever with lifting frames	17
2.13	Balanced cantilever with cranes	18
2.14	Cast in situ balanced cantilever	19
2.15	Span-by-span with launching gantry	21
2.16	Span-by-span on falsework	21
2.17	Incremental launching construction cycle	23
2.18	Incremental launching method	23

2.19	Progressive placement construction	24
2.20	Unbalanced construction loads for balanced cantilever construction	28
2.21	Problems modelled with different aspect ratios	29
2.22	Elements with poor shapes that tend to promote poor results	30
2.23	Poor element connections, (a) two bilinear elements and one quadratic element, (b) two quadratic elements, (c) two quadratic elements connected at a and b but not at c.	30
2.24	Triangular element as transition elements	31
2.25	Finer mesh at stress concentrated location	31
2.26	Approximation of π (a) Inscribed Polygon (b) Circumscribed Polygon	32
2.27	Example convergence of finite element analytical solution	32
2.28	Typical pier types for bridges	33
3.1	Methodology Flow Chart	35
3.2	Plan View of Crosshead	37
3.3	Elevation View of Crosshead	37
3.4	Segment S1R Typical Dimension	38
3.5	Segment S2R Typical Dimension	39
3.6	Segment S3R Typical Dimension	40
3.7	Tendon Profile	41
3.8	Section Details	41
3.9	Segment and Temporary Bar Marking	43
3.10	Geometry of Segmental Crosshead in LUSAS	45
3.11	Line mesh for beam	46
3.12	Section calculator in LUSAS	48
3.13	Structural supports definition in LUSAS	49
3.14	Multiple Tendon Prestress Wizard in LUSAS	50

3.15	Tendon Loading in LUSAS	51
3.16	Prestressing force defined along tendon profile	51
3.17	Equivalent prestressing force defined along mesh	51
3.18	Deactivation and activation of elements	52
3.19	Single stage model definition	52
3.20	5 construction stage model definition	53
3.21	5 construction stage model with temporary bar definition	54
3.22	Stage 1-8 for 20 construction stage model definition	55
3.23	Stage 9-14 for 20 construction stage model definition	56
3.24	Stage 15-18 for 20 construction stage model definition	57
3.25	Stage 19 and 20 for 20 construction stage model definition	58
3.26	Loadcases definition in LUSAS	59
3.27	Layer control to show analysis results	59
4.1	Segmental crosshead model with prestressing tendon stress contour for single stage model	61
4.2	Top fibre stress for 5 construction stage model	62
4.3	Bottom fibre stress for 5 construction stage model	62
4.4	Top fibre stress for 5 construction stage with temporary bar model	63
4.5	Bottom fibre stress for 5 construction stage with temporary bar model	63
4.6	Top fibre stress for 20 construction stage model	64
4.7	Bottom fibre stress for 20 construction stage model	64

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Precast segmental crosshead construction drawing	72
B	Analysis output from LUSAS	75

CHAPTER 1

INTRODUCTION

1.1 Background of the Problem

The first precast segmental concrete box girder bridge in Malaysia is the Batang Kemena Bridge on the Bintulu-Tatau road, which is part of Pan Borneo Highway. This bridge consists of 11 spans with total length of 457m and was completed in 1983 (Low Keng Kok *et al.*, 2004). It was precursor for the various segmental constructions of precast segmental box girder concrete bridges in Malaysia. Example of segmental box girders launched using launching gantries are STAR LRT and PUTRA LRT in 1997, the Malaysia-Singapore Second Link and the Ampang-Kuala Lumpur Elevated Highway. In year 1998, the first match cast concrete segmental box girder launched without travelling gantries was introduced for the Besraya Highway viaduct over the KL-Seremban Highway in Kuala Lumpur. The match casting techniques was further developed and pioneered by the earlier Besraya viaduct contractor to be used in other bridge elements such as the segmental pier cross head construction in New Pantai Expressway. This new technique enables piers for viaducts built over existing roads to be constructed economically without partial closing of the road below as compared with the traditional cast in situ portals or the hammerhead piers.

Construction of bridges is associated with high uncertainties. The stochastic nature of the operation makes computer simulation an appropriate tool to model the construction of a bridge. Abraham and Halpin (1998), developed a simulation model for the construction of cable-stayed bridges. The developed model accounts for different scenarios and resources of the construction operation and estimates the duration for each case. Yamin-Lopez (2000), utilized a computer simulation to evaluate the feasibility of three different construction proposals for the construction of the Alamillo Bridge in Seville. Huang et al. (1994), used a general purpose simulation language (DISCO) to model the construction of cable-stayed bridges. Marzouk et al. (2007), developed a special purpose simulation model, devoted to the planning of incremental launched bridges.

This master project present a finite element model of the segmental crosshead and analyses each construction stage to study the response of various parameters in segmental crosshead.

1.2 Statement of the Problem

The resistance and stability of segmental crosshead during construction stage should be given concern as the structure is uncompleted and have not reach the full resistance as designed. Thus consideration of construction loads and stresses during construction is as important as permanent load on final structure. Construction loads can be due to temporary loads caused by the sequence of construction stages, forming, falsework, construction equipment, and action of lifting and placing of precast members. In crosshead construction, the segments were added at one side of the cantilever at a time, and due to this construction sequence, the selfweight of the structure is unbalanced and this instability is further amplified by construction loads which operate on the same side of the new segments. Therefore it is essential to understand the response of the structure during construction stage as to ensure ample safety factor against failure.

1.3 Objectives of the Study

The objectives of this study are as follows:

- (1) To perform construction stage analysis on selected finite element model of precast segmental crosshead.
- (2) To determine response of various parameters in segmental crosshead at each stage of construction.
- (3) To determine the effect of construction sequences on a segmental crosshead erected by balanced cantilever method.

1.4 Scope of Study

The scope of study will focus on a precast segmental crosshead as per Appendix A. The crosshead spans 26.54m with a height of 11m and consist of 6 segments. A finite element model is constructed and analyzed according to predetermined construction stages. The extreme fibre stress, bending moment, and displacement is studied.

1.5 Significance of the Study

It is necessary to know about the structure behavior in regards with changes in geometry, boundary conditions, internal forces as well as the material properties and other structural details in segmental construction process in order to control the deformation and stress state throughout the process. Temporary construction loads and changing of boundary conditions during construction, depending on the method and sequence of erection can produce considerable stresses in the uncompleted structure. A simulation of the construction process according to each stages of construction is investigated to determine the state of stress and deformation of each stage of the construction process.

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