CONSTRUCTION STAGE ANALYSIS OF A POST-TENSIONED SEGMENTAL CROSSHEAD

LIEW TIAN FUH

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To my beloved family.

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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.

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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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