UNIVERSITI PUTRA MALAYSIA

PREDICTION OF LONG TERM DEFORMATION FOR BALANCED CANTILEVER PRESTRESSED CONCRETE SEGMENTAL BOX GIRDER

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2005

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ACKNOWLEDGMENTS

Expression of extreme thanks and appreciation to my supervisor, Associate. Prof. Ir. Dr Mohd Saleh Jaafar, Head of Civil Engineering Department Universiti Putra Malaysia for his support, giving knowledge, expertise and guiding the project from the beginning until completion.

Extension of gratitude to Associate. Prof. Ir. Dr Ismail Mohamad Taib, Director of Bridge Department, Public Works Department for his support and giving the opportunity to provide consultancy knowledge, report and drawings for the betterment of the project.

Lastly, thank you for everyone and all who are involved directly or indirectly in making this project a great success.

ABSTRACT

Long term deformation may be expressed as the sum of the instantaneous, creep and shrinkage strain. Generally, long term deformation will affects the durability of concrete structures. Creep is responsible for excessive deflection at service loads and cause excessive chamber or shortening in prestressed concrete member. While shrinkage may cause slightly cracking, this could lead to durability failures. In prestressed concrete construction, in addition to causing increase in deflection, both creep and shrinkage cause shortening of the concrete which in turn cause shortening of the prestressing tendons and reduction in prestressing force.

In the construction of prestressed concrete segmental box girder by balanced cantilever method, the long term deformation has to be predicted because the deflection due to creep and shrinkage is critical and will cause durability failures. Because of this, commercial computer software such as ADAPT Software and RM 2000 Software was generated to replace manual calculation so that the prediction of long term deformation can be made faster and efficient. But this available software is very expensive. As such a project entitled "Prediction of long term deformation for prestressed concrete segmental box girder" is carried out to generate new commercial computer software as alternative from available commercial software to predict long term deformation. The scope of the project is to determine short and long term deformation and generate new commercial computer software of the prestressed concrete segmental box girder.

From the study, it is found that the SAB 2005 program can be used as new commercial computer software to predict short and long term deformation of balanced cantilever prestressed concrete segmental box girder. Therefore, it is hope that the outcome of this project will contribute a new technology for the betterment of construction industry in Malaysia.

CHAPTER ONE

INTRODUCTION

1.1 An Overview

The three basic important long term deformation occur due to changes in materials characteristics, environmental and loading condition are instantaneous deformation, creep and shrinkage deformation. For concrete under constant load and temperature, the total long term deformation or strains may expressed as the sum of the instantaneous, creep and shrinkage strain.

Generally, long term deformation will affects the durability of concrete structure. For example, creep deformation is responsible for excessive deflection at service loads and cause excessive chamber or shortening in prestressed concrete members. Shrinkage deformation may cause slightly cracking which could lead to service ability or durability failures.

In prestressed concrete construction, in addition to causing increase in deflection, both creep and shrinkage cause shortening of the concrete which in turn cause shortening of the prestressing tendons and consequent reduction in prestressing force.

This loss of prestress may adversely affect the performance of the member at service loads and should be accounted for during design stage.

In order to predict the durability effect on concrete structures due to long term deformation, two basic prerequisites have to be considered:

a. Reliable data for creep and shrinkage characteristic of the particular concrete mix
b. Analytical method for the prediction of deformation effect during design stage.

In relation to reliable data, laboratory test may be under taken to determine long term deformation but this not often a practical alternatives. Structural engineers seldom have the time for long tests and then often cannot be sure that the concrete tested in the laboratory is the same as that which will later be used in the structure.

Therefore, the best account for long term deformation can be predicted in concrete structure by structural engineer is using analytical technique or commercial computer software. Therefore, in order to help structural engineer to predict long term deformation faster and accurately, a reliable computer program have to be generated to replace the analytical method. As such, a study entitled "Prediction of long term deformation for prestressed concrete segmental box girder" is carried out to help structural engineer to predict long term deformation during construction period.

1.2 Prestressed Concrete Segmental Box Girder

Segmentally constructed cast-in-place and precast concrete bridges have gained significant importance due to their economic advantages, adaptability to regions with difficult access, and also due to their minimal impact on environmentally sensitive terrain during the construction phase.

Many construction sequences used in concrete bridge construction may be classified as segmental or incremental. The most common segmental erection method used is the balanced cantilever construction as shown in Figure 1.0 and 1.1. Segments are cast and support either on a form traveler assembly as shown in Figure 1.0 or a combination of form traveler and ganry as shown in Figure 1.1. In cantilever construction, segments are cantilevered outwards from the pier tops, each segment being prestressed to the previously completed structure as it is built. After all segments have been erected, the ends of the cantilever girders are connected either to the abutments or to one another, thus forming a continuous structure. In many cases, additional continuity prestressing tendons are installed at the completion stage.

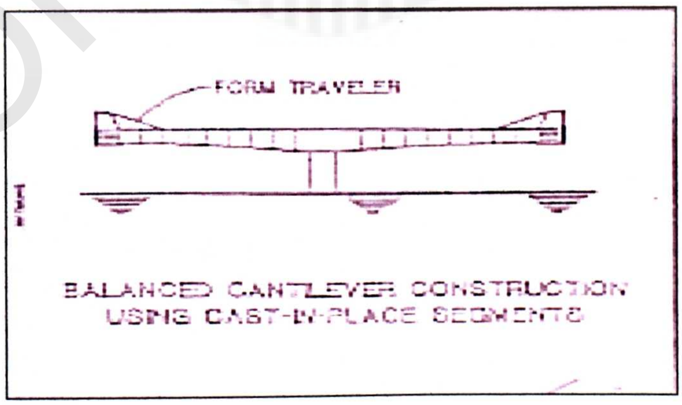

Figure 1.0 : Balanced cantilever construction using cast-in-place segments

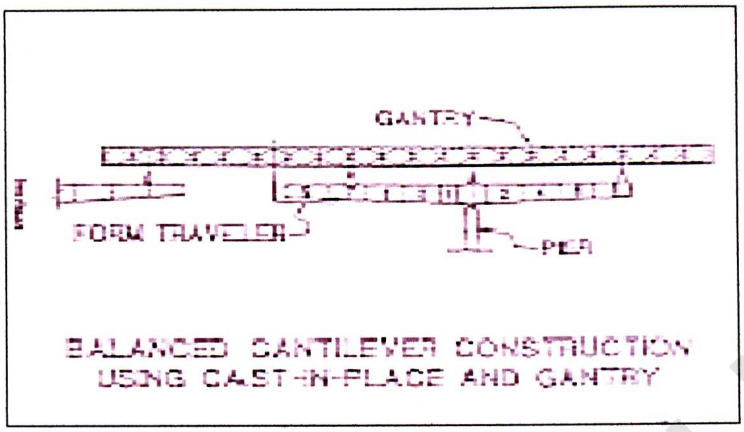

Figure 1.1 : Balanced cantilever construction using cast-in-place and gantry

In cast-in-place segmental construction, relatively young concrete, typically 2 - 5 days old, is prestressed and called upon to carry construction loading and weights of subsequent segments. Early age of concrete at loading, together with high stresses during the construction, often times of a magnitude higher than that expected at service condition, greatly magnify the impact of the time dependent deformations of concrete. An important factor in the design of segmental box girder is the inclusion of the influence of concrete creep and shrinkage. Further, loading at an early age, when the change in concrete's modulus of elasticity is significant necessitates accounting for the impact of aging of concrete in the analysis. Prestressing is heavily relied upon in the construction phase, for support of interim loading and for control of stresses and deflections. Stress losses in prestressing due to relaxation as well as stress losses caused by other deformations have a significant influence on the structure's deformation and must be part of the analysis.

Since the segments are generally young and are loaded as construction proceeds, they undergo continuous deflection during the construction. It is necessary to estimate and allow for these displacements, in order to avoid large discontinuities in girder profile at the closure segment, when the bridge is complete. The estimated construction displacements are generally compensated during the construction by cambering the vertical profile of the bridge so that no such discontinuities will exist. The construction camber adjustments are computed and made, such that the girder profile will be at a specified elevation when the bridge is completed.

Figure 1.2 (a) show an example, where a compensating pre-camber is used to pre-set the girder segment so that the vertical displacements at the end of construction would be equal to zero.

Figure 1.2(b) is the illustration of 27-year long term deflection. If required, the camber during the construction can be further adjusted to reduce the 27-year deflection to zero, or a net upward value. In this case the long term camber must be added to the construction camber.

Refer to Figure 1.3, after the closure segments are cast, the completed structure is indeterminate. The continuing creep strains resulting from the original stress distribution in the structure are restrained by the boundary condition on the completed structure. The constraint of the boundaries to these ongoing strains, together with loss of prestressing due to stress relaxation cause an overall shift in the shear and moment diagrams for the completed structure.

For most cantilever bridges, such as shown in Figure 1.3, moment redistribution causes a reduction of negative dead load moments near the supports and an increase of positive dead load moments at the point of closure at center of span.

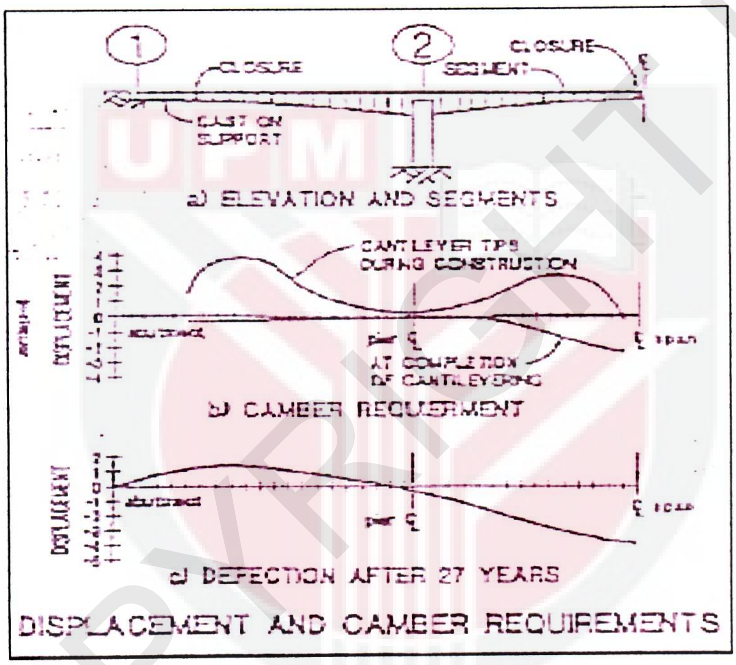

Figure 1.2 : Displacement and camber requirements

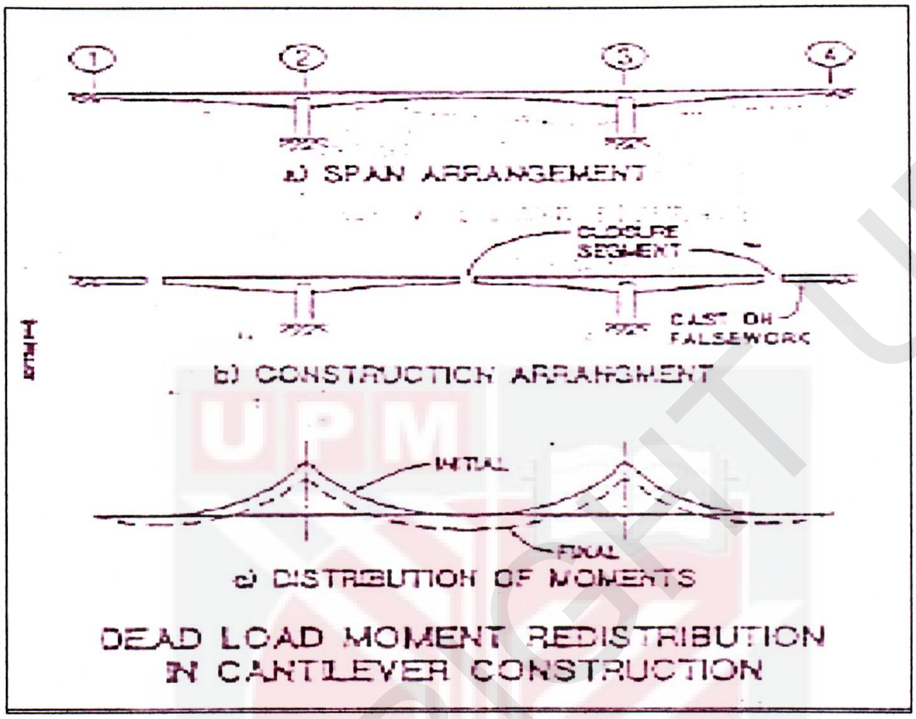

Figure1.3 : Dead load moment redistribution in cantilever construction

1.3 Aim

The aim of this project is to generate a computer program as a tool to predict long term deformation in prestressed concrete segmental box girder.

1.4 Objective and Scope

The objective and scope of this project are outlined as follows :

i. To determine short term deformation in prestressed concrete segmental box girder.

ii. To analyze long term deformation in prestressed concrete segmental box girder.

iii. To generate a new computer programmed for prediction of long term deformation.

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