ISSN: 2347-3487

INTRODUCTION TO CAMBER CONTROL, PRESTRESSED CONCRETE BRIDGE GIRDERS

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ABSTRACT

When designing a bridge, serviceability usually controls and is a more important factor than the ultimate capacity of the bridge or the allowable stresses. Therefore, the behaviour of the bridge girder deflection and camber must be predicted as accurately as possible. Therefore, excessive camber has become one of the most common problems when constructing concrete bridges. Different methods have been developed to overcome this problem. The most common and widely used is using haunch with adjustable pedestals to overcome the excessive camber. However, this method has limitations that must be considered. Therefore, this study is evaluating the effectiveness of using post tensioning jacking strands at the top flange of simply supported bridge girders to reduce the excessive camber and make it equal to the design camber.

KEYWORDS

Camber, Camber Control.

COUNCIL FOR INNOVATIVE RESEARCH

Peer Review Research Publishing System

Journal: Journal of Advances in Physics

Vol 4, No. 2

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www.cirjap.com

Introduction

Camber in pressurising concrete bridge girders is the upward deflection that is caused due to the pressurising forces applied on the bridge girder. Engineers have been trying to predict its amount and optimize it to make it vanish when placing the deck of the bridge. However, camber is affected by many factors, most of which are time dependent like creep, shrinkage, and priestess losses, causing camber to grow. This growth will lead to an excessive camber causing differential camber. Many problems will be presented due to differential camber such as: increasing haunch depths, jutting of bridge girders into the bottom of the slab and increase in time for setting up the forms for deck slabs, cracking, ride and overall performance of the bridge. Also, for adjacent box girders and deck bulb tees, the difference in camber causes problems during the fit up process. This unnecessarily increases the time and cost of construction Camber in pressurising concrete bridge girders is the upward deflection that is caused due to the pressurising forces applied on the bridge girder. Engineers have been trying to predict its amount and optimize it to make it vanish when placing the deck of the bridge.

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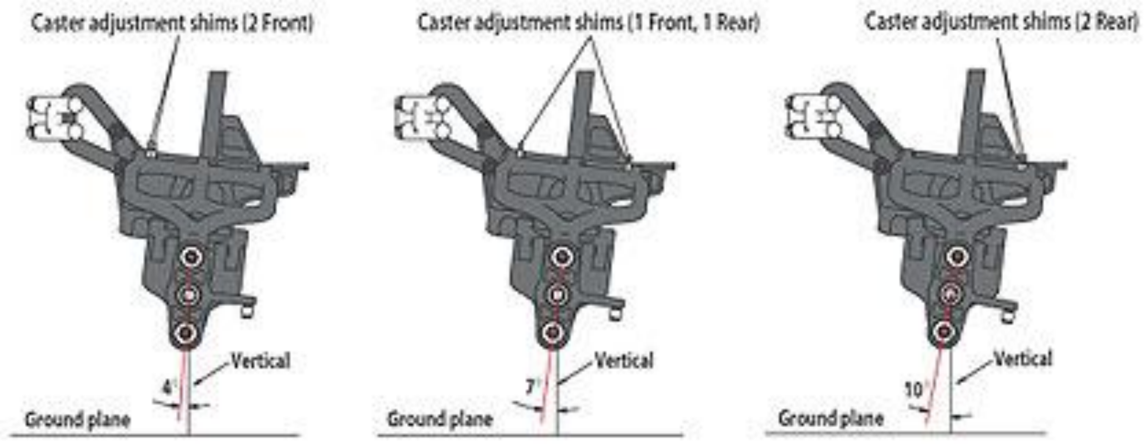

Figure 1 camber adjustment

Basic Assumptions

Camber computations will be based on the following assumptions:

- The maximum concrete tensile strain does not exceed strain at cracking εcr at the stage prior to the deck placement
- Shear deformation is neglected
- The pretensioning strands profile for the PCI-8 girder and AASHTO type-4 girder has double depression points. However, the AASHTO B54x48 box beam has a straight pretensioning strands profile

Initial Camber

Initial camber is the resultant of summing the upward deflection caused by the effective pretensioning force Pe and the downward deflection due to the beam self weight. For illustrative purposes, the rectangular section is used to calculate the initial camber εcte is the concrete strain at the top outermost fibber and εcbe is the concrete strain at the bottom outermost fibber due to effective priestess force Pe. Ag is the gross sectional area of the beam. I is the moment of inertia of the cross section. Knowing both the strain at top and the bottom of the beam enables calculating the position of the neutral axis kd.

Design Camber

The design camber is calculated by summing three components: upward deflection due to effective pretensioning force, downward deflection due to bridge girder self-weight, and downward deflection due to post-tensioning jacking force Δd is the camber after applying the post tensioning force. It should be stressed that this study considers reducing the camber as long as the concrete is not cracked. Relationships between design camber and post tensioning jacking forces have been generated for the PCI-8 girder based on assumptions

- The post tensioning jacking force varies linearly with the design camber which means materials are still in the linear behaviour region

- The PCI-8 girder tends to have higher camber with higher specified concrete compression strength

- Using a higher distance coefficient α required higher post tensioning jacking force to produce the same design camber

Relationships between the post tensioning jacking stress and the design camber are derived for the AASHTO type -4 girder and AASHTO B54x48 box beam which are presented. Using the data obtained from this study enabled generating a general formula for the PCI- 8 girder to represent the required post tensioning jacking stress to reduce the camber to be equal to the design camber.

Concrete

Concrete is a versatile composite material of very complex nature, yet it can be approached at any desired level of sophistication. The simplest is when only its compressive strength is specified for design. Concrete is made by mixing several components, mainly water, cement and aggregate (fine and coarse). The behaviour of concrete is usually non linear. However, a standard stress-strain curve of concrete with normal weight is uniaxial. The curve consists of two main parts: an ascending portion up to the peak point which represents the maximum stress $f\,c'$ and a descending portion. In this study, the short term concrete compression stress-strain relation that is adopted is the one suggested by Hognestad for short term monotonic.

Mild Steel

The behaviour of mild steel offers a number of simplifications when compared to concrete. Mainly steel has the same modulus of elasticity, linear elastic portion in their stress-strain.

Relationship, and manufactured under strict quality control that satisfies a number of ASTM standards. As a result, little variability happens between specified properties and the nature of the material. In this study, the CALTRANS mild steel stress-strain modified model for grade 60 will be used and its properties. Also, it is assumed that mild steel behaves similarly under tension and compression stresses; therefore the same model will be used to compute the tensile and compressive stresses in the steel.

The concept of using post tensioning strands to reduce camber in pressurised concrete bridge girders. Based on equilibrium conditions, strain compatibility, and material constitutive laws, the study generated relationships for the post tensioning jacking force vs. the design camber. Those relations are important to understand the behaviour of the bridge girders. This study considered the effect of four variables: priestess losses, bridge girder length, specified concrete compression strength, and the distance coefficient of the c.g.s of the pretensioning strands. Also, the present's findings regardless of the effect of the post tensioning jacking force on the moment capacity of the bridge girders. These findings are listed below:

1- The post tensioning jacking force required producing a specific design camber varies linearly with the design camber

2- The PCI-8, ASSHTO type-4, and ASSHTO B54x48 box beam tends t have higher camber with higher specified concrete compression strength

3- Using a higher distance coefficient α required higher post tensioning jacking force to produce the same design camber

4- Results obtained from equations derived to represent relationships between the post tensioning jacking force and the design camber coincide with the actual data obtained from the study

5-The reduction in the moment capacity per $100x10^3$ lb of applied post tensioning jacking force is1.15% for the PCI-8 girder, 2.9% for the AAHTO type-4 girder, and 0.33% for the AASTO b54x48 box beam

The post tensioning strands is a viable method to reduce camber in PCI-8, ASSHTO type-4, and ASSHTO B54x48 box beam. The major findings based on the results of the research reported in this thesis are presented as follows:

1- The post tensioning jacking force required producing a specific design camber varies

Linearly with the design camber

2- Using higher compressive strength of concrete reduces the amount of post tensioning force

3- Using a higher distance coefficient α increases the post tensioning jacking force

4- The highest reduction in the moment capacity is taken place for the AASHTO type-4 girder by 2.9% per $100x10^3$ of post tensioning jacking force

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