STRUCTURAL DESIGN OF PRESTRESSED CONCRETE CONTINUOUS DOUBLE TEE BEAM BRIDGES

A Thesis submitted for the partial fulfillment of the degree of Master of Engineering in Structural Engineering Design

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Abstract

One of the applications of prestressed concrete is in continuous bridges. These can be either double tee or box girders. The longitudinal shape can be prismatic, semi-prismatic or non- prismatic. The design of these bridges offer a considerable challenge to the design engineer due to the presence of secondary moments which are induced due to the prestressing forces. These introduce a considerable complexity to the design process. In this research, an attempt is made to develop a design method that would minimize the complexity associated with the design of prismatic prestressed concrete double tee bridges.

In concrete bridges, generally the minimization of self weight is important. This is used as the criterion to start the design process. The governing criteria for the various components of the cross section is used to determine the smallest section that is practically possible. The methods to take account of short term and long term effects such as creep and shrinkage are also included for the cross section selected. Once the cross section is available, it is necessary to find appropriate cable forces. Design methods for both constant and variable cable forces are presented based on the line of thrust. It is shown that the use of variable cable forces could reduce the total cable forces thus leading to a saving in tendons.

For the selected cable forces, it is necessary to ensure that cable profile will be available within the selected section. The line of thrust can be transformed to fit within the section by selecting a suitable set of secondary moments. Thus, the secondary moment can be selected in a straightforward manner for both constant and variable cable forces.

Thus the cable profile selected should ensure that it fits within the limits of cable profile zone and also generate the selected secondary moments. This is not a trivial task. In order to simplify this task, a design method was introduced for both constant and variable cable forces. In the case of variable cable forces, there is a possibility to have point moments and forces acting at the cable force change points. A method to deal with such forces is also introduced.

Therefore, it is possible to consider that this thesis presents a complete design method for the preliminary design of prismatic double tee prestressed concrete beam bridges either with constant or variable cable forces. It has also shown that it is possible to minimize the complexity of difficult design tasks by approaching the problem in modular fashion.

Keywords - Prestressed Concrete, Double Tee bridges

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Notation

A_c	Total cross-sectional area
c	Cover from edge of concrete to center of tendon
d	Overall depth of beam
e	Tendon eccentricity
e_{max}	Maximum eccentricity at which tendon can be placed ($y_2 - c$)
e_{min}	Minimum eccentricity at which tendon can be placed ($y_1 + c$)
e_p	Eccentricity to the line of thrust.
e_{p-min}	Eccentricity to the upper limit of line of thrust
e_s	Eccentricity to cable profile.
f	Limiting stress condition
f_{cu}	Concrete cube strength
f_{cw}	Permissible compressive stress at the working load (-ve)
f_{tw}	Permissible tensile stress at the working load (+ve if tensile)
I_c	Second moment of area of the section.
M	Applied moment
M_{monoli}	Dead load bending moment due to monolithic construction
$M_{as-built}$	Dead load bending moment due to as-built construction
$M_{sup\ dead}$	Bending moment due to super imposed dead load
$M_{live\ min}$	Minimum bending moment due to live loads.
$M_{live\ max}$	Maximum bending moment due to live loads.
$M_{a(act)}$	Minimum applied moment at the working load without secondary moments
$M_{b(act)}$	Maximum applied moment at the working load without secondary moments
M_a	Minimum applied moment at the working load with secondary moments
M_b	Maximum applied moment at the working load with secondary moments

M_2 Secondary moment.

$(M_2)_j$ Secondary moment at internal support j

P Prestressing force in cable at transfer

P_B Cable force corresponding to point B of Magnel diagram.

P_i Forces acting on i thsystem

$P_{n(i)}$ Cable force in the new cable at the i thcable force change point.

$P_{r(i)}$ Cable force in the running cable at i th cable force change point.

R_{ik} Reactions due to loading on beams.

y_1 Position of top fibre (-ve)

y_2 Position of bottom fibre (+ve)

Z_1 Elastic section modulus of top fibre (I/y) (-ve)

Z_2 Elastic section modulus of bottom fibre (I/y) (+ve)

R loss ratio

f_c Concrete compressive stress.

f_t Concrete tensile stress.

Z Elastic section modulus.

M_{dl} Elastic Dead load moment.

E Elastic modulus of concrete.

ρ Secondary moment ratio.

β_1 Distribution coefficient for secondary moment over first internal support.

β_2 Distribution coefficient for secondary moment over second internal support.