SERVICEABILITY ANALYSIS OF CONTINUOUS BOX-GIRDER BRIDGES CONSTRUCTED USING DIFFERENT TECHNIQUES

By

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Declaration

The work included in this thesis in part or whole has not been submitted for any other academic qualification of any institution.

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Abstract

There are different construction methods practiced in the bridge industry to erect bridge super structures. Among these, segmental Box-girder is the latest trend in the industry, which facilitates fast, versatile construction. In contrast to monolithic construction, these bridges consist of pre-cast pretensioned elements joined together by post-tensioning to form continuous bridge structures. Composite bridge cross-sections adopted in segmental construction use dissimilar materials such as precast concrete, prestressing and non-prestressing steel components. Behaviour of these continuous bridges, are often influenced by time-dependant nature of the materials used.

This study focuses on the analysis of time-dependent properties associated with the bridges constructed using different techniques. To analyse the short, medium and long term behaviour of the bridges, a rational analytical approach is chosen so that it can assess the time-dependant effects such as creep and shrinkage of concrete and relaxation of prestressing steel. So the structural analyses can model mathematically all associated changes in geometrical forms, statical conditions and material properties which are important with segmental construction.

A computer program available, and which follows the above procedure has been enhanced by introducing a pre-processor to ease complications arising from the large number of analyses encountered with solution of continuous segmental bridge problems.

In this research different construction techniques such as span-by-span construction, balanced and progressive Cantilever methods and incremental launching have been examined. A four span continuous bridge example where each span is fabricated using eight equal segments have been studied under different construction techniques. These involve evaluating the effects of loads arising from force or displacement induced changes which occur during construction stages and perhaps be temporary or permanent depending on the circumstances. Also it has been possible to compare results and identify both advantages and disadvantages of the various methods. The study reveals the effect of serviceability indices such as stresses and deformations which are affected in different forms depending on the method of construction.

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Dedication

To my parents and my teachers.

Table of contents

List of Tables

List of Figures

Notations.

B - Buoyancy.

BM - Bending moment

CF - Centrifugal force.

D - Dead load.

E - Earth pressure.

EI - Flexural stiffness of the beam.

E_nI_n -Flexural stiffness of the nose.

EQ - Earthquake.

G - Modulus of rigidity.

H - Hours.

I - Live load impact.

ICE - Iice pressure.

K- Wobble friction coefficient.

L - Live load.

LF - Longitudinal force from live load.

M_o - Moment due to dead load on the structure.

Ms - Moment due to live load and dead load on the structure.

N - Number of cycles.

R - Rib shortening.

S - Shrinkage.

SF - Stream flow pressure.

T - Temperature.

W - Wind load on structure.

WL - Wind load on live load.

X,Y,Z - Global orthogonal coordinate system.

A_t - Pre-steaming period.

B_t - Temperature rise period.

C_t - Constant temperature period.

D_t - Cooling period.

C^o- Celsius.

F^o- Furan height

E_c- Modulus of elasticity.

M_B - Bending moment at support B.

S_o - A range of stresses.

e - Exponential of a value.

f - Real number

l- Effective span between piers.

h- Box-girder Height

q - Unit weight of the beam.

r - Corresponding slope of the stress diagram.

t- Time.

x,y,z- Local orthogonal coordinate system.

d_p. Depth to the centroid of the prestressing steel.

l_n - Length of the launching nose.

q_n - Unit weight of the nose.

$(L+I)_n$ - Live load plus impact load.

A_{ps}- Cross section area of tendon

β - Coefficient, see table 3.22.1.A (Ref: 1)

γ - Load factor, see Table 3.22.1.A (Ref: 1)

ν - Poison's Ratio.

χ - Aging coefficient.

ψ - Corresponding curvature of the stress diagram.

σ - Stress

f_{pi}- Initial stress in steel.

f_p- Characteristic strength of steel.

f_{pu}- Ultimate strength of steel.

f'_c- Characteristic strength of concrete.

f_{cu}- Ultimate strength of concrete.

μ- Curvature friction coefficient.

$\sigma_c(t_o)$ - Concrete stress at age t_o

$d\sigma_c(\tau)$- An elemental stress applied at age τ.

$E_c(t_o)$- Modulus of elasticity of concrete at age t_o.

$E_c(\tau)$- Modules of elasticity of concrete at age τ.

$E_c(t,t_o)$- Age adjusted elasticity modulus.

$\varepsilon_c(t_o)$ - Strain occur in age t_o.

ε_{so} - Total shrinkage of concrete up to time infinity.

to, t– Ages of concrete when the initial stresses applied and when the strain considered.

$\varepsilon_{cs}(t,t_o)$ – Strain develops due to free shrinkage between two ages of concrete t_o and t.

$\Delta\sigma_c(t)$-stress increment introduced at the age t_o and sustained to age t.

$\phi(t, t_0)$ – Ratio of creep to the instantaneous strain.

β_s - A dimension less time function.

$\varphi(t,\tau)$ – Coefficient of creep at time for loading at age τ.

$\varphi(t,t_0)$ - Creep coefficient.