UNIVERSITY OF MORATUWA

DEVELOPMENT OF PRESTRESSED CONCRETE BEAMS USING CONTROLLED DETENSIONING

BY

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DECLARATION

I hereby, declare, that the work included in this thesis in part or whole, has not been submitted for any other academic qualification at any institution.

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ABSTRACT

Pretensioned prestressed concrete can be produced in a number of ways. Among them several options can be considered depending on the structure constructed and how prestress is transferred. In the recent times radial and longitudinal cracks have been observed due to high tensile stresses developed in concrete around prestressing steel. In practice to eliminate these harmful conditions modifications are required to ensure serviceability functions of the composite high quality material.

Often excessive prestress is reduced by lowering the tensile stress in the prestressing steel or / and the magnitude of the eccentricity towards the end of the member which in vulnerable to this type of effect. In the global context debonding of tendons towards the end of a member, drapping of tendon towards the central portion of the member or controlled detensioning can be applied to achieve the desire outcomes. All these techniques require a sound basis for prestress transfer which is achieved by bond. Some of the practices are prohibitive to developing countries due to the high cost of holding down devices buried in the concrete. Further in third world countries cost of hardware is expensive as opposed to cheep labour encountered in production.

This research is aimed at strengthening our understanding of bond mechanism by extending cohesive cracking approach established by experiment and matched by a sound theoretical basis to complement each other. Currently some of the global practices are carried out by relying on intuition as opposed to theoretical formulations.

This study covers a comprehensive analysis of bond development for the controlled detensioned process. The experimental verification is not part of the present scope. However the parameters influencing such as strand diameter, initial prestress, concrete strength and cover or half the spacing have been identified as main influences to ascertain bond strength based on available test results exhumed from literature.

A parametric study has also been carried out and simplified empirical formulae have been developed to predict normal transfer bond length and the type of bond length required for controlled detensioning. The derived theory is also applicable even to debonded tendons as well as drapped tendons accurately. Further study is required to support these findings by providing experimental evidence.

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NOTATION

A	-area of the cross section
A_b	-area of prestressing strand
A_c	-area of concrete section
B_c	-concrete first moment about the reference axis
A_p	-area of prestressing steel
B	-first moment about the reference axis
c	-radius of outer surface concrete
c_y	-concrete cover to surface of prestressing strand
d_b	-strand diameter
e	-outer radius of cracked zone
e_y	-eccentricity of prestressing strand
E	-modulus of elasticity
E_c	- modulus of elasticity of concrete
E_{cr}	- reduced circumferential modulus of elasticity at the outer surface of cracked zone
E_p	- modulus of elasticity of prestressing steel
E_r	-modulus of elasticity in the radial direction
E_{ref}	-reference modulus of elasticity
E_z	- modulus of elasticity in the axial direction
E_θ	- circumferential modulus of elasticity of cracked concrete
f_{cz}	-axial stress in the concrete at a distance z from the free end
f_{pj}	-prestress prior to transfer
f_{si}	-initial prestress
f_{pu}	-ultimate strength of concrete
f_{pz}	-axial stress in the prestressing steel at a distance z from the free end
f_t	-tensile strength of concrete
f_{tr}	- reduced tensile strength of concrete at the outer surface
f_{ci}	-compressive strength of concrete at transfer
f_θ	-stress in circumferential direction
h, k, m	-constant in hyperbolic stress-crack width equation for cracked concrete
I	-second moment of inertia
I_c	--concrete second moment about the reference axis
l_t	-transfer bond length
l_{t_i}	-transfer length of concrete zone i
L	-gauge length
Lc	-extent of radial cracking
N	-number of radial cracks
p	-interface pressure
P	-prestressing force

P_j -jacking prestressing force

r -radial distance

r_o -radius of the unstressed prestressing strand

r_j -radius of the prestressed prestressing strand at jacking

r_n -radial distance to section n

R -radial distance to the inner boundary of elastic uncracked section

t -step size

u -radial displacement

u_o -radial displacement of outer surface of steel cylinder

u_j - radial displacement of inner surface of concrete cylinder

u_n -radial displacement at section n

ur_j -radial displacement of inner surface of cracked concrete

w -crack width of radial crack

y -vertical distance to prestressing steel from section centroid

z -distance from the free end of the prestressing steel

z_i -length of concrete zone i

$\Delta\varepsilon(t,t_o)$ -increased axial strain during the period t_o to t

ϕ -creep coefficient

ψ -curvature

Δf_i -detensioned pressure for the section i

$\Delta\overline{\sigma}_{pr}$ -reduced relaxation during the period t_o to t

ε -concrete strain

ε_{cs} -free shrinkage of concrete

ε_{cz} -axial strain of concrete at a distance z from free end

ε_{pz} -axial strain of prestressing steel at a distance z from the free end

ε_z -strain in the radial direction

ε_θ - strain in the circumferential direction

ε_o - strain at reference point o

μ -overall coefficient

ν -Poisson's ratio

ν_c - Poisson's ratio for concrete

ν_p - Poisson's ratio for prestressing steel

σ_r -normal stress in radial direction

σ_z - normal stress in axial direction

σ_θ - hoop stress acting in the circumferential direction

Σo -perimeter of the strand

τ -bond stress