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**DEVELOPMENT OF PRESTRESSED CONCRETE BEAMS
USING CONTROLLED DETENSIONING**

BY

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A THESIS

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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 is 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 desired 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 cheap 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 draped 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_{ti} | -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 |
| $\Delta\epsilon(t, t_o)$ | -increased axial strain during the period t_o to t |
| ϕ | -creep coefficient |
| ψ | -curvature |
| Δf_i | -detensioned pressure for the section i |
| $\Delta\sigma_{pr}$ | -relaxation during the period t_1 to t_2 |
| 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 |



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