Creep Influence on Reliability and Stability of Concrete Structures

Gnida SOSSOU
PhD, Senior Lecturer in Civil Engineering, Kwame Nkrumah University of Science and Technology (KNUST)
P.O. Box KS 14479, Kumasi, Ghana
gnidas59@gmail.com

Gnida SOSSOU, born in 1959, received his civil engineering degree from the Zaporojie Industrial Institute in Ukraine and his PhD from the Dniepropetrovsk Civil Engineering Institute in Ukraine

Summary

Precast and prestressed concrete slabs and beams have been investigated. For structural and crack predictions, the virtual work principles have been successfully used to estimate specifically for the slabs (a) transient bi-directional strains due to the concrete creep and shrinkage, (b) the resulting time-dependent bi-directional stress redistribution, as well as (c) bi-directional displacement variations in the slabs and finally (d) bi-directional prestressing losses in the prestressed tendons. A series of test experiments with once evaluated strength parameters has been successfully used to provide encouraging support for the numerical evaluations said at above points (a) - (d) in addition to (e) calibrating the parameters likely to enable the estimation of the above said losses, (f) predicting the beams and slabs sections' stiffness and hence, (g) devising a definition for durability and integrity, with regards to the concrete stress-strain relationship under prolonged service loads.

Keywords: concrete beams and slabs, quality, stiffness, reliability, durability, concrete creep, shrinkage, nonlinear equilibrium differential equations, prestressing losses, steel tendons.

1. Introduction

The actual concern for scientists in applied mechanics of prestressed concrete structures [1, 2, 3, 4, 5, 7, 9, 10, 11, 12] is the failure of the structural material to meet the design safety of prestressed concrete structures especially beams and slabs. This present long-term study, according to applied mechanics of prestressed concrete structures, has been based on nonlinear differential equations of the concrete creep theory which reflects the correlation between the concrete matrix stress and strain by its modulus of elasticity, using the nonlinear strain function for the beams and the well-known geometrical preconditions of the theory of elasticity concerning thin plates with small flexural deformations for the slabs.

2. Slabs – Analytical and Experimental Concepts

2.1 Main concepts for numerical analysis

The main concepts of this numerical study relate to the details of a unified method for analytical prediction of various durability, reliability and structural integrity characteristics of the slabs, precast and prestressed in both directions (Fig. 1). This analytical procedure is aimed to ensure the quality, stiffness, strength, reliability and durability at the planning phase, and the nonlinear creep behaviour of these said slabs. It has been assumed [1, 2, 6, 8], by the hypothesis of straight normal according to which:

https://doi.org/10.2749/222137809796205647

$$\varepsilon_x^c = \varepsilon_x + \Re_x z; \qquad \varepsilon_y^c = \varepsilon_y + \Re_y z; \qquad \gamma_{xy}^c = \gamma_{xy} + 2\Re_{xy} z, \qquad (1)$$

where $\varepsilon_x^c = \varepsilon_x^c(x, y, z, \phi)$; $\varepsilon_y^c = \varepsilon_y^c(x, y, z, \phi)$; $\gamma_{xy}^c = \gamma_{xy}^c(x, y, z, \phi)$ are normal and shear strains of the slab layer, separated by the distance z_e at the medium-level surface (Fig. 1);
$\varepsilon_x = \varepsilon_x(x, y, \phi)$; $\varepsilon_y = \varepsilon_y(x, y, \phi)$; $\gamma_{xy} = \gamma_{xy}(x, y, \phi)$ are suitable strains of medium-level layer of the slab; $\Re_x(x, y, \phi)$; $\Re_y(x, y, \phi)$; $\Re_{xy}(x, y, \phi)$ are flexural curvature and torsion of the slab and ϕ, the parameter of conditional time.

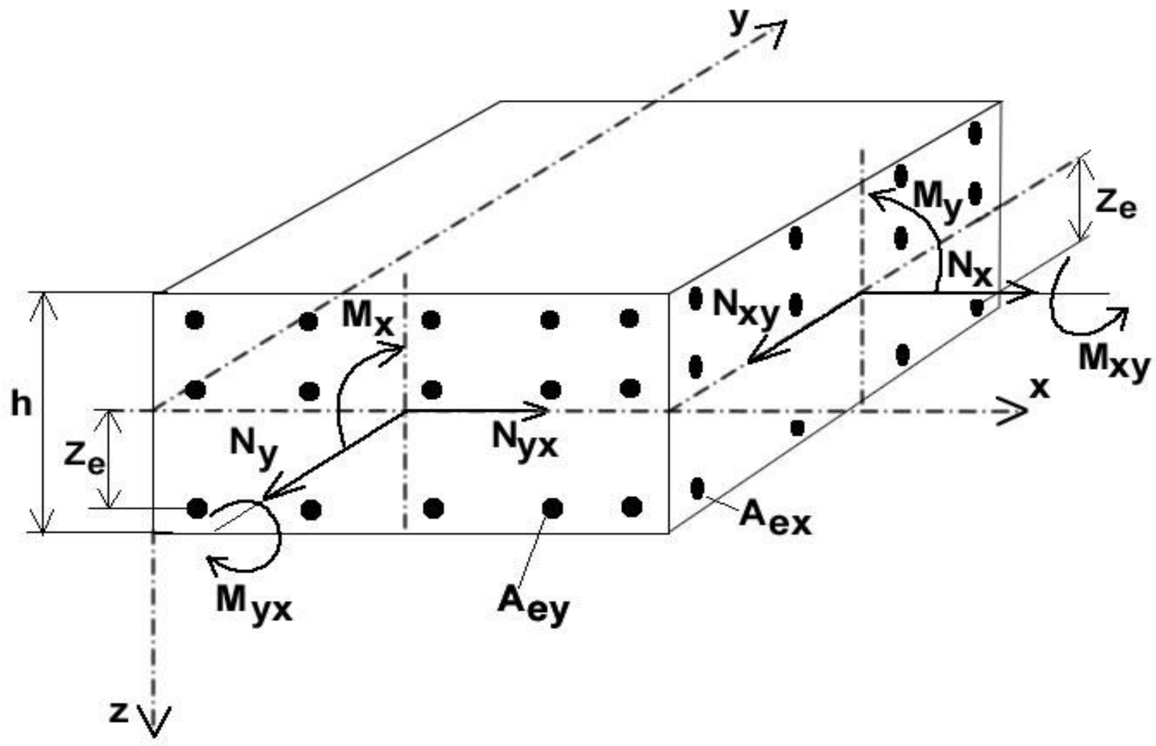

Fig. 1: Slab Element

3. Discussion and Conclusions

For the beams, the comparisons of numerical and experimental results [1, 3, 5] have shown that the nonlinear theory described in this report, is quite adequate and can be applied for practical use. Experimental results have indicated that the finite-difference method based on the displacement formulation is suitable and effective to solve systems of nonlinear equilibrium differential equations.

It is hoped to confirm at the end of the study that nonlinear concrete creep is able to contribute to stress redistribution. This said redistribution is able to provoke the accumulation of natural initial stresses in the steel reinforcement tendons and in the concrete, which are equivalent to the artificial initial stresses due to the prestressing forces in the steel reinforcement tendons. This could reduce stress losses and, like consequence, could be able to increase the durability, the reliability and finally the exponents of the slabs' and the beams' limit states.

The consideration of this proposed design and experimental model, and these said time-dependent effects can be able to ensure interdependence of design and construction for economy of reinforcement up to 5 % - 15 %.