DESIGN OF DOWELS FOR SHEAR TRANSFER AT THE INTERFACE BETWEEN CONCRETE CAST AT DIFFERENT TIMES: A CASE STUDY

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Degree of Master of Engineering in Structural Engineering Design

Department of Civil Engineering

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DECLARATION

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ABSTRACT

Enlargement of original cross-sections or replacement of defective concrete layers with new concrete are usual situations in strengthening operations of reinforced concrete structures. In these situations, the shear strength between concrete cast at different times is crucial for the monolithic behavior of the strengthened members. Most design standards for concrete structures present design procedure for estimating the shear resistance between concrete layers based on the shear friction theory.

The study includes three-dimensional and two-dimensional finite element model (FEM) analysis for calculation of shear stresses and comparison of three different code approaches, i.e. BS8110, ACI 318 and EN 1992, for determination of design shear resistance at an interface between concrete cast at different ages of a pile cap supported on precast concrete piles.

Based on the results of the analysis carried out, it can be stated that complicated three dimensional finite element model analysis is not always essential for analysis of structures, which are having complex geometrical shapes. It is possible to transform three-dimensional problems to a simplified two-dimensional problem based on the level of accuracy required.

For the selected surface characteristics and r/f percentage, the estimated design shear resistance based on recommendations of EN-1992-1-1-2004 was found be lower than the corresponding estimated value based on ACI 318M-11 recommendations. It was further observed that BS 8110-1-1997 recommendations gives the highest value for the design shear resistance independent of r/f percentage provided.

EN-1992-1-1-2004 can be used to compare contribution of concrete interface roughness and interface reinforcement on design shear resistance without any limitation of design shear stress as specified in ACI 318M-11. Furthermore, the EN-1992-1-1-2004 recommends a conservative value for design shear resistance compared to other two standards.

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LIST OF ABBREVIATIONS

EN-1992-1-1-2004

v_{Edi}	=	Design value of shear stress
v_{Rdi}	=	Design shear resistance
β	=	Ratio of the longitudinal forces
V_{Ed}	=	Design value of applied shear force
z	=	Lever arm of composite section
b_i	=	Width of the interface
c	=	Factor related to adhesion
μ	=	Coefficient of friction
ρ	=	Ratio (A_s/A_i)
f_{ctd}	=	Design value of concrete tensile strength
σ_n	=	Stress per unit area caused by external normal force
f_{yd}	=	Design yield strength of reinforcement
α	=	Angle
v	=	Strength reduction factor
f_{cd}	=	Design vale of concrete compressive strength
f_{ctk}		Characteristic axial tensile strength of concrete
γ_c	=	Partial factor for concrete
A_s	=	Area of the reinforcement crossing the interface
A_i	=	Aria of the joint
f_{ck}	=	Characteristic compressive cylinder strength of concrete at 28 days
α_{cc}	=	Coefficient
α_{ct}	=	Coefficient
b_w	=	Breadth of the web of the member
$\rho_{w.min}$	=	Nominal shear reinforcement ratio
A_{sw}	=	Area of nominal shear reinforcement

ACI 318M-2011

V_u	=	Factored shear force
ϕ	=	Strength reduction factor
V_{nh}	=	Nominal horizontal shear strength
b_v	=	Width of the cross section
d	=	Distance from extreme compression fiber to centroid of of longitudinal tension reinforcement
A_{vf}	=	Area of shear friction reinforcement
f_y	=	Yield strength of reinforcement
μ	=	Coefficient of friction
f'_c	=	Specified compressive strength of concrete
A_c	=	Area of concrete section resisting shear transfer
λ	=	Modification factor
s	=	Spacing of shear links
ρ_v	=	Ratio of tie reinforcement area to contact surface area
f_{yt}	=	Yield strength of transverse reinforcement
b_w	=	Web width, wall thickness
v_u	=	Design shear stress

BS 8110-1-1997

V_h	=	Horizontal shear force
C	=	Compressive force
T	=	Tensile force
v_h	=	Horizontal shear stress
l	=	Length between points of maximum moment and zero moment
A	=	Cross sectional area of nominal links
b_v	=	Width of the contact surface

$S_{l.max}$ = Maximum longitudinal spacing between links

$S_{t.max}$ = Maximum transverse spacing between links

f_{yk} = Characteristic yield strength of reinforcement

S_v = Spacing of shear links

h_f = Minimum thickness of the in-situ concrete

A_h = Total area of shear reinforcement

M = Bending Moment

b = Width of the section

d = Effective width of the tension reinforcement

f_{cu} = Characteristic cube strength of concrete

FEM = Finite Element Model
2D = Two Dimensional
3D = Three Dimensional
2D-L = Two Dimensional-Longitudinal
2D-T = Two Dimensional-Transverse
ULS = Ultimate Limit State
RC = Reinforced Concrete
SFD = Shear Force Diagram
BMD = Bending Moment Diagram