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NONLINEAR FINITE ELEMENT ANALYSIS OF STEEL-CONCRETE COMPOSITE SLABS USING EXPLICIT DYNAMICS PROCEDURE

MOHAMMAD JOSHANI

A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Engineering (Civil-Structure)

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APRIL 2010

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TO MY BELOVED MOTHER AND FATHER
FOR THEIR ENDLESS LOVE AND SUPPORT

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ABSTRACT

Composite slab construction using permanent cold-formed steel decking has become one of the most economical and industrialized forms of flooring systems in modern building structures. Structural performance of the composite slab is affected directly by the horizontal shear bond phenomenon at steel-concrete interface layer. This study utilizes 3D nonlinear finite element quasi-static analysis technique through explicit dynamics procedure to analyze the shear bond damage and fracture mechanics of the composite slabs. Cracking of the plain concrete over the corrugated steel deck has been modeled considering the mixed modes fracture mechanisms by means of concrete damaged plasticity model available in ABAQUS software version 6.9. The interface layer damage was simulated with cohesive elements presented in ABAQUS software considering three modes of fracture. Cohesive fractures properties such as fracture energy and initiation stress have been derived from horizontal shear stress versus end slip curves which were extracted from bending test of a series of small scale specimens. The proposed model is verified through comparison with experimental data which demonstrated that the results of the numerical analyses match with valid experimental results. Therefore these calibrated and validated models can predict the structural response of steel-concrete composite slabs. This will reduce the cost of empirical works which in accordance with present design specifications are mandatory in order to investigate the behavior and load bearing capacity of such structural systems.

ABSTRAK

Pembinaan papak rencam dengan menggunakan deck keluli terbentuk sejuk yang kekal merupakan salah satu jenis sistem papak yang paling ekonomi bagi struktur bangunan moden. Prestasi struktur bagi papak rencam dipengaruhi secara langsung oleh fenomena ikatan ricih mengufuk di antara muka keluli dan konkrit. Dalam kajian ini, analisis 'quasi-static' unsur terhingga 3D yang menggunakan prosedur 'explicit dynamics' telah dijalankan bagi menilai kerosakan ikatan ricih mengufuk dan mekanik retakan pada papak rencam. Retakan pada konkrit di atas dek keluli beralun telah dimodelkan dengan mengambil kira mekanik retakan dengan mod tergabung. Model kemusnahan plastic yang terdapat dalam perisian ABAQUS telah diguna dengan mengambil kira tiga mode retakan. Kemusnahan pada antara muka keluli dan konkrit telah dimodel dengan unsur 'cohesive'. Sifat retakan 'cohesive' seperti tenaga retakan dan tegasan pemula telah diterbitkan daripada geraf tegasan ricih mengufuk lawan gelangsaran hujung yang diambil daripada ujian lenturan bersaiz kecil. Model analisis yang dicadangkan dalam kajian ini disahkan kejituannya dengan mebuat perbandingan antara hasil analisis dengan data ujikaji. Hasilnya, model analisis ini boleh diguna untuk menilai gerak balas struktur papak rencam. Hal ini boleh mengurangkan kerja ujikaji yang dahulunya mesti dilakukan untuk menentukan kelakuan sebenar dan kebolehtanggungan beban system papak rencam.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

NOMENCLATURES

b	Unit width of slab
d	Midspan displacement
d_d	Depth of profiled steel deck
d_s	Steel deck depth
E	Modulus of elasticity / Young's modulus
E_{11}	Modulus of elasticity in longitudinl direction
E_{22}	Modulus of elasticity in transverse direction (2-axis)
E_{33}	Modulus of elasticity in transverse direction(3-axis)
E_c	Modulus of elasticity of concrete
E_s	Modulus of elasticity of steel deck
f'_c	Concrete compressive strength
F_y	Minimum yield strength of steel sheeting
F_u	Ultimate strength of steel sheeting
G_{12}	Stiffness modulus in plane 1-2
G_{13}	Stiffness modulus in plane 1-3
G_{23}	Stiffness modulus in plane 2-3
h_c	Concrete cover depth above deck top flange
h_t	Total slab thickness
L	Total slab span
L_s	Shear span
M	Bending moment
P	Point load
t	Steel sheeting thickness
t_c	Concrete thickness

U1	Movement in axis 1
U2	Movement in axis 2
U3	Movement in axis 3
UR1	Rotation movement in axis 1
UR2	Rotation movement in axis 2
UR3	Rotation movement in axis 3
w	Uniform load
υ	Poisson's ratio
δ	Vertical deflection
τ	Shear bond stress