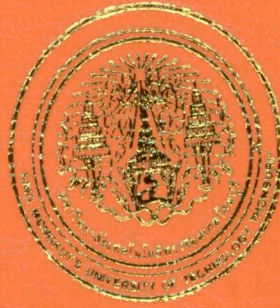


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PARAMETRIC INVESTIGATION OF SLAB ON GIRDER BRIDGE
USING 3-D FINITE-ELEMENT MODELING TECHNIQUES

MISS SUDATHIP TANGWONGCHAI

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY (CIVIL ENGINEERING)
FACULTY OF ENGINEERING
KING MONCKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

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Abstract

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The purpose of this study is to evaluate the effect of bridge geometries and truck loading characteristics on the negative and positive moments in concrete deck slab of composite highway bridges. The suitable finite element modeling (FEM) technique has been determined by verifying the models against the results based on a full-scale laboratory experiment performed by other researchers. Further extensive parametric study has been conducted based on this selective modeling technique. The parameters used in this study are the variation of girder spacing, truck position (transverse and longitudinal), number of vehicles on the bridge (multiple presence), and location along the span (support, quarter and mid span). The effects of boundary conditions and intermediate diaphragms are also taken into consideration at this time. For each combination of these parameters, the negative and positive slab moments due to live load are then evaluated. In addition, the influence of dead load of bridge deck on the slab moments is also investigated. The results show that the effect of dead load on the slab moments is insignificant compared with that of live load. From the comparative study of several design codes, analytical methods and the present study, an enhancement on assessment of negative and positive slab moments under live load scenario can be established. As a result, the required reinforcement area in the deck slab to resist the negative and positive moments can be achieved more realistically. Finally, empirical formulas have been proposed to readily calculate these negative and positive slab moments for a rational deck slab design.

Keywords: Parametric Study/ Deck Slab Bridge/ Composite Highway Bridge/ Three-dimensional Finite Element Analysis/ Moment in Slab-over-Girders

หัวข้อวิทยานิพนธ์	การวิเคราะห์เชิงตัวแปรของแผ่นพื้นบนสะพานคอมโพสิตโดยวิธีการจำลองด้วยไฟไนต์เอลิเมนต์แบบ 3 มิติ
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บทคัดย่อ

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วัตถุประสงค์ของการศึกษาค้นคว้าครั้งนี้คือ การประเมินผลกระทบของรูปทรงเรขาคณิตของสะพานและอิทธิพลของน้ำหนักบรรทุกที่มีต่อโมเมนต์ค้ำตามขวางในระนาบสามมิติ (โมเมนต์ลบและบวก) ของแผ่นพื้นสะพานคอนกรีตแบบคอมโพสิตด้วยวิธีการศึกษาเชิงตัวแปร แบบจำลองไฟไนต์เอลิเมนต์ 3 มิติของสะพานได้รับการพัฒนาขึ้น และตรวจสอบความถูกต้องของแบบจำลองกับผลการทดสอบแบบจำลองที่มีขนาดเท่าของจริงในห้องปฏิบัติการ (Full Scale Loading Test) ซึ่งได้มาจากการวิจัยที่เกี่ยวข้องก่อนหน้านี้ การศึกษาค้นคว้านี้ได้พิจารณาตัวแปรที่มีผลกระทบต่อโมเมนต์ค้ำตามขวางของแผ่นพื้นสะพานคอนกรีตได้แก่ รูปแบบการวางคานสะพาน (ระยะห่างระหว่างคาน) รูปแบบการวางตำแหน่งรถบรรทุก (ตามขวางและตามยาว) จำนวนรถบรรทุกบนช่องจราจร และตำแหน่งที่ทำการศึกษาลอดความยาวสะพาน (ตำแหน่งที่รองรับสะพาน ตำแหน่งหนึ่งในสี่ของช่วงสะพาน และตำแหน่งกึ่งกลางสะพาน) รวมถึงผลกระทบจากเงื่อนไขรองรับคาน (คานช่วงเดียวและคานต่อเนื่อง) และไดอะแฟรมตามแนวความยาวของคาน การคำนึงถึงตัวแปรต่าง ๆ ที่กล่าวมาแล้วนั้น ทำให้ทราบถึงการเปลี่ยนแปลงของค่าโมเมนต์ค้ำตามขวางในแผ่นพื้นสะพานได้อย่างละเอียดมากยิ่งขึ้น ผลจากการตรวจสอบอิทธิพลของน้ำหนักบรรทุกคงที่ของสะพาน พบว่าน้ำหนักบรรทุกคงที่ของสะพาน มีผลกระทบต่อค่าโมเมนต์ค้ำตามขวางน้อยมาก เมื่อเทียบกับผลกระทบจากน้ำหนักบรรทุกจร จากการศึกษาเชิงเปรียบเทียบค่าโมเมนต์ค้ำตามขวางกับค่าที่ได้จากงานวิจัยที่เกี่ยวข้อง และจากมาตรฐานการออกแบบ พบว่าการประเมินค่าโมเมนต์ลบและบวกภายใต้สถานการณ์รับน้ำหนักบรรทุกจร สามารถกระทำได้อย่างสมจริงมากยิ่งขึ้น งานวิจัยนี้นำเสนอสูตรสำเร็จสำหรับคำนวณค่า

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โมเมนต์ค้ำตามขวางเพื่อให้ออกแบบปริมาณเหล็กเสริมที่จำเป็นของแผ่นพื้นสะพาน โดยเป็นอีก
ทางเลือกหนึ่งในการออกแบบที่มีความสมเหตุสมผลมากยิ่งขึ้น

คำสำคัญ : การศึกษาเชิงตัวแปร/ แผ่นพื้นสะพาน/ สะพานทางหลวงแบบคอมโพสิต/ แบบจำลองไฟ
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LIST OF SYMBOLS

SYMBOL

D	flexural rigidity
E	modulus of elasticity
f'_c	characteristic compressive cylinder strength of concrete at 28 days
g	acceleration due to gravity, 9.81 m/s^2
H	torsional rigidity
t	slab thickness
M	transverse bending moments
P	concentrated load
w	vertical displacement from middle surface
x	coordinates along x -axis direction
y	coordinates along y -axis direction
z	coordinates along z -axis direction
ε	normal strain
φ	load factor
γ	density of concrete, 2400 kg/m^3
ν	Poisson's ratio
σ	normal stress of middle surface
τ	shear stress
∇^2	Laplace's differential operator
$\partial/\partial x$	differentiation along transverse x -direction
$\partial/\partial y$	differentiation along longitudinal y -direction
$\partial/\partial z$	differentiation along vertical z -direction

LIST OF TECHNICAL VOCABULARY AND ABBREVIATIONS

AASHTO	=	American Association of State Highway and Transportation Officials
BC	=	boundary condition
LRFD	=	Load Resistance Factor Design
FEA	=	Finite Element Analysis
FEM	=	Finite Element Method
psi	=	pond per square inch
ksi	=	kilopond per square inch