Ain Shams University
Faculty of Engineering

"Effect of Shear Connectors Distribution and Reinforcement Layout at Grouting Pockets on the Connection between Pre-cast Concrete Girders and Pre-cast Deck Panels"

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B.Sc. (2009)
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A Thesis
Submitted in Partial Fulfillment of the Requirements
of the Degree of Master of Science in Civil Engineering (Structural)

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STATEMENT

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering (Structural).

The work included was carried out by the author at reinforced concrete laboratory of the Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

TITLE: "Effect of Shear Connectors Distribution and Reinforcement Layout at Grouting Pockets on the Connection between Pre-cast Concrete Girders and Pre-cast Deck Panels"

Submitted by: Hussein Salah Marzouk Youssef

Supervised by: Prof. Dr. Amr H. Zaher

Dr. Khaled Mohammed Hilal

Precast concrete decks have begun to revolutionize the bridge design industry due to their rapid constructability, reduction in overall mobilization and high quality control. Several precast elements are available to meet with all construction requirements. It is often preferable to transport beams and deck slabs separately to reduce the weight of each element. The interfacial shear transfer between the top slab and the supporting beams is of great significance to the overall deck load carrying capacity and performance. According to international codes it was found that distribution of shear connectors is one of the most important factors that has an effect on the capacity of the connection. Previous research and design guidelines suggest the use of two different approaches to quantify the required interfacial shear strength, namely based on the maximum compressive forces in the flange at mid-span or the maximum shear flow at the supports.

The research objectives can be summarized in evaluating the structural behavior and load carrying capacity experimentally and analytically for precast girders and precast slabs connected through shear connectors in grouting pockets in the case of regular or concentrated shear connectors distribution at support. In addition the effect of adding horizontal rebars around the grouting pockets in the deck slab was determined.

Seven composite RC T-beams with 2.00 m span were tested under static loading conditions, flexural tests were performed to study the parameters mentioned previously and to quantify peak and post-peak behavior of the interface between P.C beams and P.C deck slabs.

TABLE OF CONTENT

NOTATIONS

A_c = Area of the cracked interfacial surface (mm^2).

A_{vf} = Area of vertical reinforcement crossing interface or, shear connectors area (mm^2).

b = Interface width (mm).

b_v = Section width at the interface between the precast beam and deck (mm).

C,T = Total compression or tension in the flange (kN).

d = Effective member depth (mm).

f_y = Reinforcement yield stress (MPa).

f_{cu} = Concrete cubic compressive strength (MPa).

f_c = Concrete cylindrical compressive strength (MPa).

d_v = Distance between tension and compression resultant forces (mm).

I = Moment of inertia (mm^4).

I_x = Moment of inertia of the composite section (mm^4).

jd = Distance between the tension and compression resultant forces (mm).

K_1 = Fraction of concrete strength available to resist interface shear.

K_2 = Limiting interface shear resistance (MPa).

k_c = Cohesion factor.

l_v = Length of the interface (mm).

P = Percent of steel crossing interface (%).

P_n = Permanent net compressive force (N)

P_c = Permanent net compressive force normal to the shear plane; if force is tensile, $P_c = 0.0$ (N).

Q = First moment of the area above (or below) the fiber being considered (kN).

Q_y = Vertical shear force at the section considered (kN).

τ_z = Horizontal shear stress (MPa).

S_h = Static moment of area of the slab or flange about the neutral axis of the composite section (mm^3).

s = Shear connector spacing (mm).

v_h = Horizontal shear stress (MPa).

v_n = Ultimate horizontal shear strength (MPa).

V = Vertical shear force at section (kN).

X = Effective depth (mm).

Y = Ultimate shear stress capacity (MPa).

$\rho_v f_y$ = Clamping stress (MPa).

μ = Empirical coefficient of friction.

ϕ = Strength reduction factor for shear.

CHAPTER (1)
INTRODUCTION

1.1 General:

Precast concrete decks are commonly used in the construction of highway bridges due to their rapid constructability, reduction in overall mobilization, lightweight components and high quality control. Several precast elements are available to meet with all construction requirements. It is often preferable to transport beams and deck slabs separately to reduce the weight of each element. The interfacial shear transfer between the top slab and the supporting beams is of great significance to the overall deck load carrying capacity and performance. According to international codes it was found that distribution of shear connectors is one of the most important factors that has an effect on the capacity of the beams. Previous research and design guidelines suggest the use of two different approaches to quantify the required interfacial shear strength, namely based on the maximum compressive forces in the flange at mid-span or the maximum shear flow at the supports.

This thesis investigates the structural behavior and load carrying capacity experimentally and analytically for precast girders and precast slabs connected through shear connectors in grouting pockets in the case of regular distribution for shear connectors along beam span or concentrate of distribution near the supports, in addition the effect of adding horizontal rebar around the grouting pockets in the deck slab.

Seven composite RC T-beams with 2.00 m span were tested under static loading conditions, flexural tests were performed to study the parameters mentioned previously and to quantify peak and post-peak behavior of the interface between P.C beams and P.C deck slabs.

1.2 Research Objective:

The main objective of this research is to evaluate the interfacial shear behavior of grouted pockets connection between P.C beams and P.C slabs in RC T-beams. The various specific objectives of the study may be summarized as evaluating following parameters:

1. Regular distribution for shear connectors along beam span versus concentrated distribution at supports.
2. Adding horizontal rebars around the grouting pockets in the deck slab.
3. Using grout layer along the interface between slab and beam.

1.3 Research Scope and Contents:

This study consist of experimental and analytical studies to evaluate the behavior of precast girders connected with precast deck slabs with steel connectors with different distributions. Based on the results of the experimental and theoretical calculations, design recommendations will be proposed for the pocketed connection . This research work includes three phases, experimental, analytical, and design recommendations. Each part of this study is discussed briefly in the following subsections.

Phase I: Experimental Program:

The experimental program consisted of testing seven specimens, first specimen (B1) is considered as control beam, other six specimens divided into two groups depending on different parameters. The first group (specimens B2 to B5) consisted of five specimens varying in the shear connectors' distribution along the beam span to connect the web with the slab panels with different pockets details and interface grout.

The second group consisted of two specimens (B6 and B7), which varying in shear connectors ratio in addition adding horizontal rebars around the grouting pockets in the deck slab.

The overall dimensions of the beams were 150 mm width, and 300 mm depth and the slab panels were 450 mm width, and 80 mm depth. The clear span of the specimens was 2000 mm. Different pocket details are described briefly in the (Chapter3). The beams were tested using a four-point loading setup up to failure, with different shear connectors ratio and distribution. The load, deflection, cracking record and steel strain at which transverse shear failure occurs will be measured.

Phase II: Analytical Study:

The analytical phase of the research included a rational analysis for the calculation of the horizontal shear transfer in the interfacial surface between precast beams and precast deck panels using international codes and strut-and-tie method. The interfacial shear failure load calculated from strut-and-tie and codes was compared with experimental results.

Phase III: Design Recommendations:

Based on the experimental results of the tested beams and the analytical work, several conclusions are introduced to give an understanding of the behavior of the connection between the pocketed connection of precast beam and precast deck slab.

To fulfill the previously mentioned objectives, this research was divided into the following chapters:

Chapter (1): Introduction

This chapter is a general introduction to discuss the objective and scope of the research program.

Chapter (2): Literature Review

This chapter covers the available literature on the precast bridge deck-panel system, the horizontal shear stress in composite members and presents