HORIZONTAL SHEAR FORCE FOR DIFFERENT ARRANGEMENTS OF COUPLING BARS IN PRECAST CONCRETE SLAB WITH AND WITHOUT STEEL FIBRE

SAFIAH ZALEHA BINTI AWALUDIN

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...Dedicated to...

My beloved Father and Mother,
Awaludin bin Mohd Yusof and Athakah binti Othman,
my lovely sisters and younger brother.
Thank you from the bottom of my heart
for being my inspirations and supporters.
And lastly to all my friends,
thank you for supporting me.

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ABSTRACT

In precast concrete slab, the coupling bars and in-situ concrete act as the precast slab panel connection. The design of coupling bars based on Eurocode 2 must be able to resist the horizontal shear force and the U-loop bar must also be design to carry this force. The placing of coupling bars as the connection to the precast concrete floor is to ensure the continuity of precast floor diaphragm. In this study, in-situ steel fibre grouting was used to fill the connection between the precast concrete slab instead of the conventional method using in-situ concrete and at the same time, the number of coupling bars was also reduced. This study was conducted to determine the horizontal shear force for different arrangement of coupling bars with and without steel fibre. The experimental test using push-off test method was conducted. The results of push-off test for specimens with different arrangement of coupling bars were compared with the control specimen. The steel fibre grouting shows the improvement in term of ultimate strength and ductility of the in-situ grout. Besides, the additional of steel fibre in grout also influence the ultimate horizontal load of the specimen compare with the plain grout. The push-off test shows that the specimen that have only two numbers of coupling bars and with in-situ steel fibre grouting performed better than the control specimen.

ABSTRAK

Dalam papak konkrit pratuang, bar melintang dan konkrit bertindak sebagai sambungan kepada penal papak konkrit pratuang. Bar melintang yang direka bentuk berdasarkan Eurocode 2 mestilah dapat menahan daya ricih mendatar yg maksimum dan bar 'U-loop' juga mesti direka untuk membawa daya ini. Bar melintang yang diletak sebagai sambungan ke lantai konkrit pratuang adalah untuk memastikan kesinambungan diafragma lantai konkrit pratuang. Dalam kajian ini, grout yang mengandungi gentian keluli digunakan untuk mengisi sambungan antara dua panel papak konkrit pratuang berbeza daripada kaedah konvensional yang hanya menggunakan konkrit. Selain itu, bilangan bar melintang juga dikurangkan dalam kajian ini. Kajian ini dijalankan untuk mengenalpasti daya ricih mendatar untuk bilangan bar melintang yang berbeza dengan gentian keluli dan tanpa gentian keluli. Dalam kajian ini, ujian 'Push-Off' digunakan. Keputusan ujian 'Push-Off' untuk spesimen dengan bilangan bar melintang yang berbeza akan dibandingkan dengan spesimen kawalan. Grout yang mengandungi gentian keluli menunjukkan peningkatan dari segi kekuatan maksimum yang boleh ditanggung berbanding dengan grout yang tidak mengandungi gentian keluli. Selain itu, gentian keluli yang ditambahan dalam grout juga mempengaruhi beban mendatar yang boleh ditanggung oleh spesimen berbanding dengan grout biasa. Ujian daripada 'Push-Off' menunjukkan bahawa spesimen yang mempunyai dua bar melintang dengan grout yang mengandungi gentian keluli adalah lebih baik daripada spesimen kawalan.

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LIST OF ABBREVIATIONS

EC 2	-	Eurocode 2
DEMEC	-	Demountable Mechanical
LVDT	-	Linear Variable Differential Transformer
PVC	-	Polyvinyl Chloride
SFG	-	Steel Fibre Grouting
SFRC	-	Steel Fibre Reinforced Concrete

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Precast concrete floor diaphragms are the most popular form of construction. The floor diaphragms comprise large precast concrete panel connected through discrete embedded connections. This connections act to transfer vertical and in-plane forces between panels (Naito & Ren, 2005).

Precast concrete slab panels are usually used for large floor systems in buildings and parking structures. This systems are not only quick to erect and economical in cost, but provide good resistance to service demands. Besides, it serves as the gravity-load-carrying system, which the floor diaphragms play an important role in the lateral-load-resisting system by transferring inertial forces between the diaphragms and shear walls (Naito & Cao, 2004)

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Generally, precast concrete slabs are placed directly on the top of the beam and the coupling bars is placed on-site into the slot made by opening the core of the precast floor units. The opening cores and the narrow gap between the precast floor units to facilitate the placement of shear connector and coupling bars are then filled with in-situ concrete as shown in Figure 1.1.

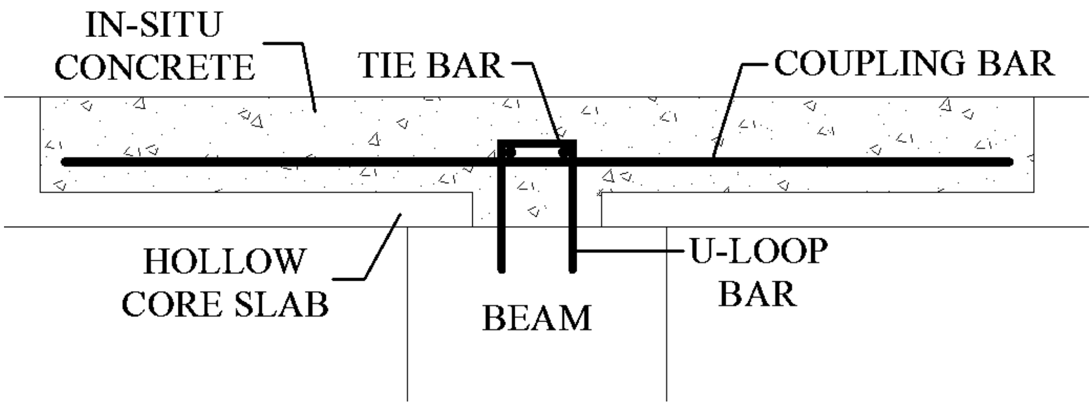

Figure 1.1 Connection between hollow core slabs

This study is focusing on the connection of the precast concrete slab using coupling bars. The coupling bars also known as the transverse reinforcement is used to ensure a smooth transfer of the longitudinal force via the shear connector into the slab and also as encroachment reinforcement against tensile splitting of the composite slab (Lam *et al.*, 2000). Moreover, the placing of these bars as the connection to precast floor is to ensure continuity of precast floor diaphragm. Moreover, by using coupling bar as connection can eliminate the use of concrete topping on top of the floor diaphragm, hence, minimize the cost of concrete used.

The in-situ concrete that used to cover the steel bars is also play an important role in resisting the lateral and vertical forces. The concrete is a brittle material, with a low tensile strength and low strain capacity. Therefore, in order to avoid the sudden brittle failure, the steel fibre is mixed in the concrete or grout in order to increase the tensile strength and strain capacity of the concrete.

Generally, for structural applications, steel fibres should be used in a role supplementary to reinforcing bars. Steel fibres can reliably inhibit cracking and improve resistance to material deterioration as a result of fatigue, impact, and shrinkage, or thermal stresses (Milind, 2012).

Besides, the role of randomly distributes discontinuous steel fibres is to bridge across the cracks that develop provides some post- cracking “ductility”. If the fibres are sufficiently strong, sufficiently bonded to material, and permit the Steel Fibre Grouting (SFG) to carry significant stresses over a relatively large strain capacity in the post- cracking stage.

Generally, concrete that contains steel fibres are much higher in strength than ordinary concrete. The previous researches also shows that the steel fibre is tend to resist crack as they have the ability to resist force after the concrete matrix had failed. These unique characteristics of concrete when mixed with steel fibre have led to this research. The concrete with additional steel fibre cause the concrete become ductile material with high tensile strength and high strain capacity. Therefore, this research is carried out to see whether the number of coupling bars in precast concrete slab can be reduce when the SFG use to replace the ordinary grout.

1.2 Problem Statement

The main propose of using the precast structure are to reduce the cost of construction such as the use of scaffolding and formwork, inherent fire properties, and time-saving (Nurul Nabila, 2012). The installations of precast floor usually take longest time compare to other structural element due to the quantity of the precast floor unit. Moreover, the installations of coupling bars will cause the additional work load to the labours; hence, lengthen the time of construction.

Besides, there is one problem that usually arises during the installation of coupling bars in hollow core slab, which is the mismatch of the hollow core slab as shown in Figure 1.2. This problem occurs during the placing and arranging the hollow core unit onto the beam. The mismatch hollow cause the coupling bars difficult to be installed in the hollow core slab. In some cases, the worker had to bend the coupling bars so that the coupling bars can be fixed in the mismatch hollow. But, by bending the coupling bars may reduce the strength of the bars itself.

Figure 1.2 Bending of the coupling bars

Therefore, one of the solution to reduce the time of construction and the problem arise during the installation of precast hollow core slab is by reducing the number of coupling bars. But, by reducing the number of coupling bars also lead to the reduction of strength of the precast concrete slab connection. Hence, in order to increase the strength of the precast concrete connection, the plain concrete or grout are added with the steel fibre.

1.3 Objectives of the Study

The objectives of this study are:

a) To design the required coupling bar in precast concrete slab based on Eurocode 2.
b) To carry out experimental test on the connection between precast concrete slab with and without steel fibre.
c) To determine the maximum horizontal shear force for different arrangement of coupling bar with and without steel fibre.

1.4 Scope of the Study

The scopes of study for this study are:

a) Ready mix concrete of grade C40 is used for the precast concrete slab while cement grout is used to fill the connection of the 40 mm deep slots.
b) A total of four specimens are prepared in this study, which are the control specimen with 3 coupling bars and cement grout, second specimen with 3 coupling bars and steel fibre grouting, third specimen with 2 coupling bars and steel fibre grouting and the forth specimen with 1 coupling bar and steel fibre grouting.
c) The design coupling bars are based on Eurocode 2.
d) H10 steel with 1110 mm length is used as the coupling bars and H12 steel with 100 mm spacing is used as the u loops bars.
e) The volume fraction of steel fibre mixed together with the cement grout is fixed at 1%. The length of steel fibre is 60 mm with 0.75 mm diameter giving an aspect ratio of 80.

f) Concrete strain and load-displacement relationship of the precast concrete floor is determined by applying the push-off test method.

g) In the push-off test, the horizontal load applied on the precast floor is less than 200 kN. The result from the DEMEC gauge and LVDT is recorded at every 10 kN loading increment.

1.5 Significant of the Study

The precast structure are widely used because its can reduce the cost and time of construction. But, the installations of precast concrete slab usually take longest time due to the quantity of the precast floor unit. Moreover, the installations of coupling bars have cause the additional work load to the labours; hence, lengthen the time of construction. In order to reduce the work load and time of construction, conventional method needs to be improved. Therefore, this research is conducted to investigate whether the reduction of coupling bars able to sustain the horizontal load as in conventional method with the help of steel fibre grouting. By reducing the number of coupling bars, the time of construction can be reduced.

1.6 Research Structure

This study was conducted to achieve the following objectives:

i. Chapter 1 described briefly the introduction regarding the connection of the precast concrete slab panel and the concept of precast throughout the study conducted.

ii. Chapter 2 described a review from the previous research related to the objectives of the study.

iii. Chapter 3 described the experimental work, sample preparation and also the procedure for the push-off test.

iv. Chapter 4 analyzes and discusses the experimental results

v. Chapter 5 concluded and made recommendation for further investigation.

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