EFFECTS OF SPIRAL ON THE BOND STRESS-SLIP RELATIONSHIP IN THE SPLICE SLEEVE CONNECTOR

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Dedicated to my faithful wife, beloved mother and devoted father.

Words cannot describe how much they mean to me.

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ABSTRACT

Connections are defined as the system to transmit the forces among the precast element and provide the strength and ductility. Therefore, the connection system of the precast concrete structure must be designed in such way that its structural performance is equivalent to that of a monolithic concrete structure. Connections can exactly be as the critical points of a precast concrete structure especially when it involves in the aspect of bonding between reinforcement and concrete. Current study evaluates the relationship of the bond stress-slip of reinforcing bar joined by spliced sleeve connectors. Twenty one specimens in which three of them were control specimen with different variables such as pitch distance and spiral diameter. Those splice sleeve connectors utilized mild steel pipe, spiral surrounding the main bar and four steel bars as a shear keys that were welded into the inner surface of steel pipe. All the specimens were filled with Sika grout 215 and tested under incrementally tensile load. The experimental tests examined the bond stress, slip and failure modes. The results suggest that reducing the pitch distance and spiral diameter of spiral lead to higher ultimate bond stress. Also, the splice sleeve connector with pitch distance of 25mm contributed to the ultimate bond stress with lower amplitude of slip. It means that the pitch distance of 25mm has the main role to control the range of slip in comparison with the others. Thus, using the spiral with a smaller pitch distance will give the best performance of the splices sleeve connector.

ABSTRAK

Penyambung adalah suatu sistem yang berfungsi untuk memindahkan daya di antara elemen pratuang dan ia turut menyumbang kepada kekuatan dan ketahanan kepada sesebuah struktur. Oleh itu, sistem penyambung untuk konkrit pratuang harus direkabentuk di mana ia mampu mewakili keupayaan struktur tersebut sama seperti apabila struktur tersebut di bina di tapak. Penyambung adalah titik kritikal sesuatu struktur konkrit pratuang terutamanya apabila ia melibatkan aspek ikatan antara tetulang dan konkrit. Kajian ini bertujuan untuk mengkaji hubungan di antara tengasan ikatan kegelinciran pada tetulang. Penyambung sambat dua puluh satu spesimen, tiga daripadanya dijadikan spesimen kawalan dengan berbeza-beza ciri seperti jarak antara gegelung dan diameter gegelung. Penyambung sambat ini menggunakan paip keluli, gegelung mengelilingi tetulang utama dan empat batang tetulang utama sebagai kekunci ricih yang telah dikimpal di bahagian dalam permukaan batang paip besi. Kesemua spesimen diisikan dengan mortar Sika 215 dan diuji dibawah daya terikan yang bertambah. Hasil uikaji ini mengkaji aspek pengikat, kegelinciran dan mod kegagalan. Hasil keputusan uikaji tersebut menunjukkan pengurangan jarak gegelung dan diameter gegelung menghasilkan tengasan pengikat maksima yang tertinggi. Selain itu, penyambung sambat lengan dengan jarak gegelung 25mm telah menghasilkan tegasan ikatan maksimum pada amplitud kegelinciran yang rendah. Ini bermakna, jarak gegelung 25mm telah memainkan peranan yang penting dalam mengawal kadar kegelinciran berbanding jarak gegelung yang lain. Justeru itu, gegelung dengan jarak gegelung yang lebih rapat dapat meningkatkan prestasi penyambung sambat.

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LIST OF SYMBOLS

Δl	-	Small longitudinal length of the pipe
Ts	-	Tangential (hoop) force in a small length Δl of the pipe
εs	-	Tangential strain in the pipe
t	-	Thickness of the pipe wall
E	-	Modulus of elasticity of the pipe
d_i	-	Inside diameter of the pipe
U	-	Bond strength of concrete
f_n	-	Lateral confining pressure
f_c'	-	Concrete compressive strength
fb	-	Bond stress
fs	-	Steel stress
X	-	Distance from loaded face pull-out bond
x	-	Distance from center of embedded bar
Δ	-	Slip of reinforcing bar
P	-	The force in the bar
L_d	-	minimum embedment length
β	-	Coefficient dependent on bar type
φ	-	Nominal bar diameter (for calculation of the bond stress at bar)

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CHAPTER I

INTRODUCTION

1.1 Introduction

In modern world, precast structures were first built in Liverpool in 1905 by John Alexander Brodie. Although this idea was less popular in England, it was taken extensively all over the world especially in the East Europe.

Precast concrete system proposes an infinite variety of products and design options for construction. For today's construction, precast concrete system offers the most convenience and sustainable building materials. That is available from the largest fundamental projects to the smallest architectural details. Thereby there are few reasons for progressing the precast concrete continues in popularity between engineers, architects.

The fabrication of the precast structure is often easier, faster and less expensive compare to others type of structure. It also requires a reduced probability

of future problems and less continuous maintenance which results a lower total cost over the life cycle of a structure.

The main aim of connections is to transmit forces among the precast element and provide the strength and ductility. The connection system of the precast concrete structure can be designed in such way that its structural performance is equivalent to that of a monolithic concrete structure but lack of information on the behavior of precast connection affect the whole structure. (ACI committee 550R-96)

There are two ways to have suitable monolithic connections. The simple and applicable methods are the conventional lapping reinforcement bar but it has own problem such as congestion in the connection or void in concrete if precaution is not taken during curing. The mechanical grouted splice sleeve connector is another way. It is cylindrical coupler, used to join reinforcement bars for precast elements. To develop a continuous connection, the sleeve can be poured with non shrink high strength grout.

1.2 Problem Statement

Connections can exactly be identified as the weakest and most critical points of a precast concrete structure especially when it seen in the aspect of bonding between reinforcement and concrete. In view of this, the importance of bond is emphasized in a precast concrete structure that is subjected to severe loading. This includes the importance of the bond stress between concrete and steel interface, and also the capacity of transmitting stress in the interface of concrete and steel when it starts to decline at specific load levels. This bond stress reduction or damage

progressively spreads to the surrounding materials and important displacements between two materials can take place.

Some researchers strengthen the bond between the grout and reinforcement bar in splice sleeve connector by use of spiral confinement. Unfortunately there is rarely available information about influence of the spiral confinement and its optimum details. It is not clear this key factor how affects on the bond stress and corresponding slippage of rebar and cover our expectation in performance.

1.3 Objectives of Study

The specific objectives of this study are as follows:

1. To study the effect of pitch distance on the relationship of bond stress-slip of the rebar.
2. To obtain the effect of spiral diameter on the bond stress-slip relation
3. To optimize the performance of connector with parameters being increased or decreased.

1.4 Scope of Study

The main purpose of current study is to evaluate and model the relationship of bond stress-slip of reinforcing bar. Twenty one specimens which three of them

were control specimen with different variable such as pitch distance and spiral diameter was prepared. Those splice sleeve connectors utilized mild steel pipe, spiral surrounding the main bar and four steel bars as a shear keys that were welded into the inner surface of steel pipe. Two Y16 bars have to be joined at sufficient embedded length which was placed inside the sleeve. Axial tension load was applied on several specimens to investigate the contribution of the bond stress-slip.

1.5 Significant of Study

The bond stress and slippage behavior of connection in precast system has significant effect on the rigidity and stability of the structure. In this research, the experimental test was carried out to evaluate the behavior and application of the steel pipe sleeve with spiral confinement by changing in the pitch distance and spiral diameter. The characteristics and properties of spiral can be applied in Industrial Building System (IBS) to optimize the mechanical splice sleeve connector and guarantees higher quality of construction and provides an alternative for conventional lapping reinforcement bar.

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