THE EFFECTS OF TAPERED SLEEVE IN IMPROVING THE ANCHORAGE BOND OF REINFORCEMENT BAR

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To my beloved parents and siblings

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ABSTRACT

This research examine on the effectiveness of tapered sleeve connector in providing confinement effect to embedded reinforcement bar. The objectives of the investigation are to study the bond mechanism of grouted sleeve connector and to study the effects of confinement provided by the grouted sleeve connector. Two different configurations (welded bar sleeve and tapered sleeve) of sleeve connector were used in this study. Various sleeve diameters were used in this research to study their effects on the bond mechanism. The bond failure progression inside the grouted sleeve connector was observed visually as halved welded steel bar connector and tapered head connector were used. The experimental works consisted two phases where phase I was the testing of plain grouted sleeve. Phase II involved the testing steel fibre reinforced grout sleeve. Steel fibres of 0%, 0.5%, 0.75% and 1.0% were introduced to the connector in a way so the grout inside the connector will exhibit post-cracking behaviour. Pull-out tests were carried out and it was observed that the performance of tapered sleeve was better than welded bar sleeve due to higher confinement level. The provision of sufficient confinement stress able to delay the development of splitting cracks. The test result showed that welded bar sleeve was governed by splitting failure mode, whereas tapered sleeve failed in pull-out failure mode.

ABSTRAK

Kajian ini dijalankan untuk mengkaji kesan pengurungan oleh penyambung yang berbentuk tirus ke atas tetulang besi. Objektif kajian ini adalah untuk mengkaji mekanisma ikatan penyambung dan juga mengkaji kesan pengurungan oleh penyambung. Dua jenis konfigurasi penyambung digunakan dalam kajian ini iaitu penyambung berbentuk silinder dan penyambung berbentuk tirus. Diameter yang berlainan diagunakan dalam kajian ini untuk melihat kesannya ke atas mekanisma ikatan. Kegagalan ikatan yang berlaku dalam penyambung diperhatikan secara visual kerana penyambung yang digunakan dalam kajian ini adalah separuh daripada diameter penyambung. Eksperimen kajian ini terbahagi kepada dua fasa. Fasa pertama melibatkan ujian ke atas penyambung mengandungi 0% gentian besi. Fasa kedua melibatkan ujian ke atas penyambung mengandungi 0.5%, 0.75%, dan 1.0% gentian besi. Gentian besi ditambah ke grout dengan tujuan untuk memerhati jika penambahan gentian besi boleh melambatkan keretakan. Ujian *pull*-out dijalankan dan didapati bahawa prestasi penyambung berbentuk tirus lebih baik daripada penyambung berbentuk silinder kerana tahap tekanan pengurungan yang lebih tinggi. Tekanan pengurungan yang dikenakan oleh penyambung dapat melambatkan pembentukkan retak pecah-pisah. Keputusan Eksperimen menunjukkan bahawa mod kegagalan penyambung berbentuk silinder adalah mod retak pecah-pisah, manakala mod kegagalan bagi penyambung berbentuk tirus adalah kegagalan *pull-out.*

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W1	-	Welded Bar Sleeve 1
W2	-	Welded Bar Sleeve 2
T1	-	Tapered Sleeve 1
T2	-	Tapered Sleeve 2

LIST OF SYMBOLS

R_r	-	Relative rib area
h_r	-	Height of rib
s_r	-	Spacing between ribs
p	-	Nominal diameter of reinforcement bar
σ_q	-	Bearing Stress
σ_r	-	Radial Stress
σ_n	-	Normal Stress

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

Precast concrete construction involves the fabrication of structural member in factory. The prefabricated members are then transported to construction site to be erected. Precast concrete in comparison to conventional construction; is not affected by weather. Furthermore, the material and workmanship quality control of precast structure is easier to maintain as compared to conventional type of construction. Since all structural elements are manufactured in the factory, the progress of construction is much faster and the site area could be keep clean.

Connection comprises of several structural elements and joints between them. The design of connection takes into consideration the interaction between these structural elements when loading is applied. Connection must possess the ability to transfer forces between structural elements. The force transfer in a connection comprises of compression, tension, shear, flexure, and also torsion. Besides that, the connection must be able to resist accidental load to prevent from structural instability; accidental load here refers to unexpected event such as explosion, fire, collision.

Connection in precast concrete structure is very important in ensuring the stability of the structure. The tensile capacity of connection could be achieve by few methods such as bolting, grouting of steel reinforcement at site, or welding. Mechanical rebar splicing system is then introduced.

Mechanical connector in comparison to conventional method is more reliable as they do not depend on concrete for load transfer. Besides that, installation of mechanical connector could prevent from steel reinforcement congestion at lap zone. Mechanical connector also eliminates the occurrence of rock pocket. Lapping zone often experiences rock pocket problem as concrete cannot pass through the space between lapped bar, leaving voids in between which could weaken the structural system as the bonding between the reinforcement bar and the vicinity of concrete is weak.

Previous researcher has done a lot of studies on bond mechanism by doing finite element modeling. However, the behavior of the bond mechanism cannot be observed physically. Hence, this research is carried intending to study and observe the bond mechanism physically. Besides that, smaller tapered sleeve connector is developed which is more economical since previous connector was bulky and expensive.

1.2 Research significance

The understanding of bonding mechanism is essential as it plays important role in affecting the behavior of a structure. The significant of the research is to study about the bonding mechanism within the sleeve connector due to confinement stress. A close up study on the bonding mechanism allows the investigation on how confinement provided by the sleeve connector affects the bond strength of the embedded steel bars. Besides that, it also allows the development of smaller

connector with similar strength or higher strength capability then previous connector by improving the crack resistance.

1.3 Research Objectives

Phase I

1. To study the bond mechanism of grouted sleeve connector.
2. To study the effects of confinement provided by the tapered sleeve.
3. To determine the magnitude of bond stress as a result of tapered confinement.

Phase II

1. To study the effects of steel fibers on the bond mechanism of grouted sleeve connector.

1.4 Problem Statement

Bonding is the interaction between the contact surface of embedded reinforcement bar and concrete or grout, where a deformed bar leads to the formation of shear force along the surface of the steel bar. Bond strength is often related to the surface characteristic of steel bar such as the roughness of the steel bar or the relative area of the bar lug. Besides that, bond strength is also related to the cement particle.

The application of confinement pressure onto embedded steel bar is believed to increase the bond strength. Exceeded confinement stress would result in bond failure. However, the failure mechanism has remained blurry as it occurs within the concrete and cannot be observed physically. Studies on bond mechanism done by previous researches was by doing finite element modelling where the analysis of bond mechanism is known to be governed by three primary mechanisms. These three primary mechanisms are chemical adhesion, friction, and interlocking mechanism.

Therefore, this research proposes the on the investigation of half circular tapered sleeve and half circular welded bar sleeve. The study of half tapered sleeve allows the understanding of bond mechanism in which the step by step failure mechanism will be observed physically. The method of observing the bond mechanism physically allows us to monitor the crack pattern throughout the application of loading process.

Previous study on grouted sleeve connectors showed that this splice bar connection system has similar flexural capacity as in conventional construction. Conventional construction usually applies the method or reinforcement bar lapping in order to ensure the continuity of the connected precast structural members.

However, the previous grouted sleeve connector was very big and bulky causing them to be expensive and heavy. Thus, a small tapered sleeve could be proposed from this research by understanding the cracking behaviour within the grouted connector; where this small tapered sleeve would also possesses similar capacity as in the previous grouted sleeve connector.

1.5 Scope of Research

The scope of this research is limited to:

1. The study of grouted tapered sleeve connector for connecting two steel reinforcement bars.
2. The experimental work was only involving half circular sleeve.
3. Only one type of bar diameter, rib face angle, rib height, and rib spacing was used in this study.

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