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BOND CAPACITY IN PIPE AND GROUTING CONNECTION

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Abstract

One of the requirements that must be met in the design of reinforced concrete construction is to achieve a perfect bonding between reinforcement and concrete. A perfect bonding ensured a composite action between reinforcement and concrete. The Implementation of the precast construction method leads to a mechanism that is not a monolith between steel and concrete. This condition can affect the lack of coherence which can lead to slip. In this study, the 30 concrete cylinders in 150 x 300 mm are used as pull out test specimens. On each specimen grown mounted on a steel reinforced sleeve pipe. In the sleeve pipe is inserted grouting material. Specified variables are the length of embedded, grouting thickness, and surface roughness of the sleeve pipe. The results of the study showed that the length of embedded of reinforcement a strong effect on the bond capacity. In undefined reinforcement, failure occurs due to slip between the reinforcement with a layer of grouting. While the grouting thickness and roughness together a strong effect on the bond capacity. The best results are given by specimens that grouting reinforcement with a layer thickness of 35 mm with a rough surface of the sleeve. Failure happens to resemble a failure on deformed steel reinforcement which is embedded directly in the concrete, reinforcing steel that is breaking up after passing the yield stress limit and the ultimate stress.

***Keywords**: bond capacity, grouting, pipe sleeve, reinforced concrete*

INTRODUCTION

Composite action between the steel and concrete in reinforced concrete construction is determined by the bond between steel and concrete. Therefore bond stresses are a major factor that will determine the performance of reinforced concrete construction when receiving either static load and dynamic load. Not achieving the perfect bonded between the steel and concrete will lead to a decrease in the performance of reinforced concrete construction. Bond is defined as 'the adhesion of concrete or mortar to reinforcement or to other surfaces against which it is placed', and bond strength is defined as 'the resistance to separation of mortar and cement from reinforcing steel and other materials with which it is in contact'. Bond describes the total interaction of the reinforcement with the surrounding material.

Some parameters related to the bond stress of them is friction between the steel reinforcement and concrete around the steel embedment length that will determine interlocking mechanism. If there is a failure or adhesion bond between the steel and concrete, the possibility of failure due to the construction of slip becomes very small. The interlock mechanism will prevent the occurrence of cracks along the embedded reinforcement due to tensile stresses that occur (Albarwary, 2013)

In the reinforced concrete construction is carried out with precast system, bonded factor becomes a serious problem because each precast components are not cast monolith. This study aims to

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determine the bond stress occurs between the concrete reinforcement that is not directly related. Bonded given by reinforcement with grouting material that is inserted into the pipe sleeve are embedded directly when casting concrete. In this condition, bond strength of reinforcement is strongly influenced by the bond between the pipes with concrete around and the bond between the steel reinforcement with grouting material in the pipe sleeve. Model installation of reinforcement in this method is expected to be put into one model of connection between precast components.

Bond stress between reinforcement and concrete is influenced: a. bond between the concrete and steel reinforcement; b. gripping effect (holding) concrete around reinforcement; c. prisoners friction against slip and interlock when experiencing tension reinforcement; d. Compressive strength of concrete; e. effect end anchorage reinforcement; and f. diameter, shape and spacing of reinforcement (Nawy, 1990).

The magnitude of the bond stress occurs can be determined by equation 1 below (SNI-2847, 2013):

$$u = \frac{P}{\pi . d_b . l_b} \tag{1}$$

Where u = bond stress (MPa), P = maximum tensile strength (N), d_b = diameter of steel reinforcement, and l_b = length of reinforcement embedment.

Research on the bond stress of steel reinforcement has been done with a variety of models. According to (Anis Rosyidah, Januari 2011) in the study about a pull-out test, the thickness of the grouting material is very decisive and strong adhesive bond failure model on a pilot test. This research was conducted with laboratory experimental methods, and used deformed steel bars 10 mm in diameter grown on cylindrical concrete specimens. Variations in the length of embedded are 100 mm and 200 mm. Variations in the thickness of Sikadur® 31 CF Normal are 2 mm, 3 mm. While (Ginting, 2008) states that the strong adhesion by direct tension reinforcement pullout bond tests should be reduced to take account of the strong adhesion real reinforcement in the beam.

An Experimental Program

Materials Research

In this study, the materials used are compressive strength of concrete fc '= 20 MPa, the diameter of deform steel threaded ф 13 mm , ф steel pipe 25 mm and 35 mm, and grouting materials. Thirty-diameter cylindrical test object 150 mm and high 30 mm. In concrete cylinders embedeed in the steel casing pipe centric. Further into the steel pipe mounted 13 mm diameter deformed bar steel . Installation is done centric. Then into the steel pipe filled material grouting, as shown in Figure 1 and Figure 2. The variables specified in the form of long anchorage (150 mm and 300 mm), the diameter of the casing pipe steel (25 mm and 35 mm), and the roughness of the pipe sleeve (rough and smooth).

Each variable was made 3 specimens. The test results will be compared with the test results bond strength to the steel reinforcement which is directly embedded in concrete without using pipe sleeve and grouting. The material used for grouting should be considered, among other requirements: a. Easy to use, simply by adding water; b. Has the characteristics of easy-flowing; c. Good adhesion to the structural elements; d. Early strength very quickly; e. High compressive strength. f. Resistant to shrinkage; g. Resistant to shock and vibration; h. Do not cause corrosion, and i. non-toxic.

Details of the test specimens specifications are as follows:

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Table 1. Details of the test specimens specification

Code of specimen	Θ pipe sleeve (mm)	Roughness of the pipe sleeve	Length of reinforcement embedment (mm)
A1 A2 A3	25	Smooth	300
B1 B2 B3	25	Smooth	150
C1 C2 C3	25	Rough	300
D1 D2 D3	25	Rough	150
E1 E2 E3	35	Smooth	300
F1 F2 F3	35	Smooth	150
G1 G2 G3	35	Rough	300
H1 H2 H3	35	Rough	150
I1 I2 I3	-	-	300
J1 J2 J3	-	-	150


Figure 1. Making test specimen

Figure 2. Test specimens of bond pull out

RESEARCH METHODOLOGY

The study was carried out experiments in the laboratory. Tests carried out on 30 pull out cylindrical specimen measuring 150 x 300 mm which is referred ASTM 234-91a. Bond pulls out tested was performed using Universal Testing Machine (UTM) against specimen that has been aged 28 days. Bond pulls out tested was performed by giving a tensile force to the reinforcing steel embedded in concrete cylinders.

The data obtained is an increase in tensile force to achieve the maximum tensile force that is required until a failure occurs. In the testing process also noted that the extension occurs in the steel as a result of the withdrawal and the data on the condition of slip that occurs. Data on the magnitude of the increase in the load until the load was achieved as a powerful test object reaches its limit further processed in order to describe the behavior of the test specimen due to pull out bond. Bond stress testing mechanism as shown in Figure 3.

Figure 3. Seting Bond Pull Out Testing

RESULT AND DISCUSSION

Bond Strength

Based on the test results shown that the diameter of the pipe sleeve, the length of embedded of reinforcement, and the type of surface of a pipe sleeve effect the bond stress of reinforcement and the model of the failure. Model of the failure can be divided into two kinds, they are slip of the pipe sleeve

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and broke the steel reinforcement. The relationship between bond stress to the diameter of the pipe sleeve, the length of embedded of reinforcement, and the type of surface the pipe sleeve shown in Figures 4 and 5. The test results show a variety of bond pull out failure pattern as shown in Figure 6 and Figure 7.

The test results indicate that the bond strength that is generated by the grouting system is unbelievably influenced by the mean diameter of the pipe sleeve and the grouting material thickness, the length of embedded of steel reinforcement in concrete / grouting, and the type of surface of pipe sleeve. The use of grouting material produces bond streets approximately equal to the results generated by the bond stress are directly cast steel reinforcement in concrete. This suggests that the grouting material used in this study can be recommended for use as a grouting material in the precast construction system. The results obtained from testing the bond pull out also reinforce the results of research conducted by (Ahmad Baharuddin Abd. Rahman, 2015) which states that the thickness of the layer of grouting a significant influence on the bond strength.

Based on Figure 4 shows that the diameter of the pipe sleeve to contribute significantly to the bond stress increase of steel reinforcement. The larger the pipe sleeve, then grouting layer that surrounds the thicker the steel reinforcement so that the adhesion between the surface of the steel reinforcement and grouting material is great and can increase the required pull tension of force.

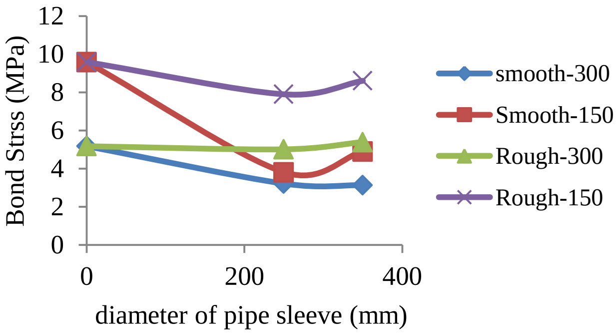

Figure 4. The relationship between the diameter of the pipe sleeve with bond stress

Figure 5 shows that the type of surface of the pipe sleeve affects the amount of bond stress occurs. On the rough surface of the sleeve provides greater friction so as to provide resistance to the pull tension of force required when compared to the smooth surface of the pipe sleeve.

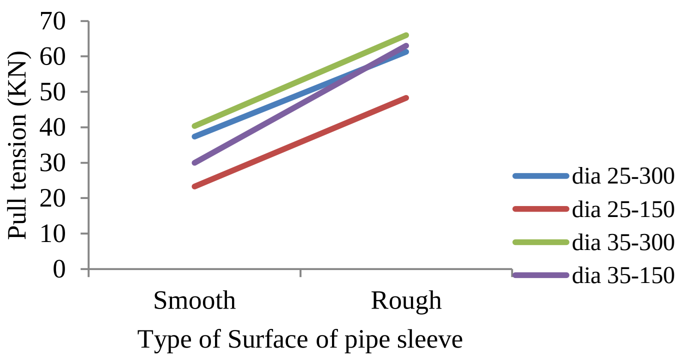

Figure 5. The relationship between the type of surface sleeve with pull tension of force

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Model of Collapse

Model of collapse happened due to pull out the test also determined by the thickness of grouting or diameter of pipe sleeve, the length of the embedded and the type of pipe sleeve surface. The type of pipe sleeve, smooth surface produces a smaller bonded compared with rough surfaces due to friction between the surface of the concrete pipe becomes smaller. As a result, the model failures are slipping on the surface of the pipe with concrete.

As for the rough surface of the pipe sleeve, the failure model is also influenced by the length of embedded of reinforcement and the thickness of the layer of grouting. The best results are given by the specimen with a steel pipe diameter of 35 mm, the type of rough surfaces, and the planting of 300 mm length. This is determined by its failure model test, which broke on the steel reinforcement after passing the limit of its melting and adhesion tension value large enough. The test results show a variety of bond pull out failure pattern as shown in Figure 6 and Figure 7.

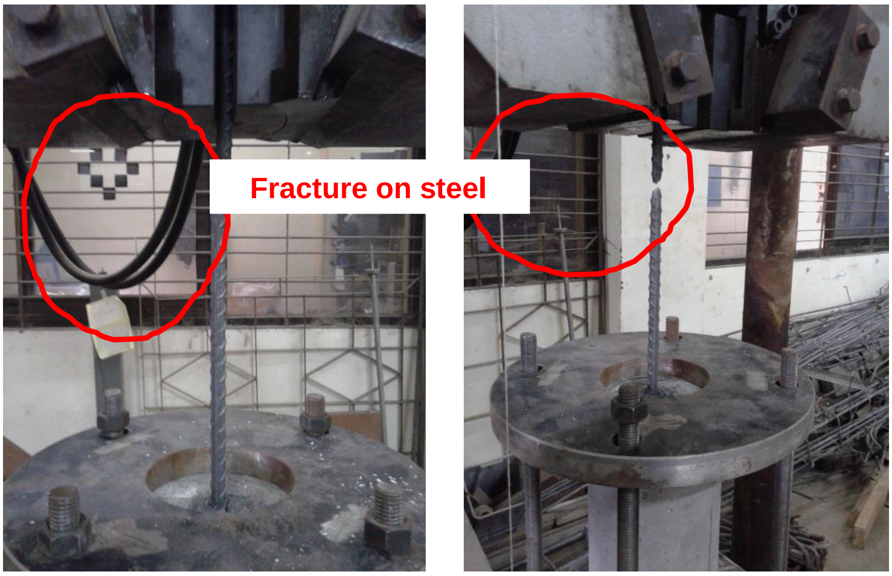

Figure 6. The test results fracture the steel reinforcement

Figure 7. The test results slip on pipe sleeve

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CONCLUSSIONS

Based on the analysis of the test results can be concluded that the strong adhesion between the steel reinforcement in the concrete is cast monolith, can be modified by means of grouting system. The grouting system could be developed for construction of precast concrete components. Modifications grouting system usage by embedded pipes sleeve into the concrete as shells and filled with grouting material after mounted steel reinforcement.

This modification should be done with attention to the factors that influence the amount of bond strength and model of the failure. The factors that determine the diameter of the pipe sleeve is thick layers of grouting, the length of embedded of steel reinforcement into the grouting material and the type of pipe surface.

In this study, the best results are given by the specimen with a steel pipe diameter of 35 mm, the type of rough surfaces, and the embedment of 300 mm length. This is determined by its failure model test, which broke on the steel reinforcement after passing the limit of its melting and the tension force pull out greatest.

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