Malaysian Technical Universities Conference
on Engineering & Technology (MUCET) 2013

Performance of Grouted Splice Sleeve Connector Under Tensile Load

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Key words: Grouted sleeve connector, tensile load, development length, diameter, mode of failure

Abstract

Grouted splice sleeve connector system takes the advantages of bond-slip resistance of grout and mechanical gripping of reinforcement bars to provide resistance to the tensile force. In this system, grout acts as a load transferring medium and bonding material between bars and sleeve. This study adopted the end-to-end rebars connection method to investigate the effect of development length and sleeve diameter to the bonding performance of sleeve connector. The end-to-end method is referring to the condition where reinforcement bars were inserted into the sleeve from both ends and meet at the center before grout is filled. Eight specimens of grouted splice sleeve connector were tested under tensile load to determine their performance. Sleeve connector was designed using 5 mm thick circular hollow section (CHS) steel pipe and consisted of one external and two internal sleeves. The tensile test results show that connector with smaller external and internal sleeve diameter appear to provide better bonding performance. Three types of failure were observed in this research, which are bar fracture (outside the sleeve), bar pullout, and internal sleeve pullout. With reference to these failure types, development length of 200 mm is the optimum value due to its bar fracture type, which indicates the tensile capacity of the connector is higher than the reinforcement bar.

Introduction: A mechanical connector system can be defined as a system that utilized all components to facilitate the coupling of steel reinforcement bars and one of the type is steel sleeve-grout system [AC133, 2010]. This connector can be used to reduce the development length of rebars or to connect existing reinforcement bar to a new one where the development length available is limited. Application of sleeve in precast concrete structures as connection system can accelerate the speed of erection, significantly reduces required rebar lap length, and guarantees higher quality assurance [Ling, 2008]. This will ensure the continuity of reinforcement bars and sufficient bonding strength generated to transfer the loading by taking the advantages of bond-slip resistance of grout and mechanical gripping to provide tensile resistance. The objectives of this study are to study the effect of development length of reinforcement bars and the sleeve diameter to the performance of the grouted splice sleeve connector as well as determine the type of failure.

Methodology: In this study, eight specimens of grouted splice sleeve connector and one reinforcement bars (control) were tested under tensile load. Circular hollow section (CHS) steel pipe with 5mm thickness was chosen as external sleeve and internal sleeves. 20mm of diameter high yield reinforcement bars was used as reinforcement bar while non-shrink grout was used as the bonding material. The specimens were divided into two types namely Type A and Type B, detailed as shown in Table 1. The internal sleeves were positioned at both ends in external sleeve and connected with four M10 bolts. The steel bars were inserted into the sleeve in end-to-end configuration until the desired development length and were spaced approximately 10mm. The grout was mixed at pourable condition and poured manually into the sleeve. The specimens were tested under incremental tensile load until failure using Universal Testing Machine (UTM). The tensile test results were plotted for load-displacement graph to determined the ultimate tensile strength(f_u).

Table 1: Detail dimension of grouted splice sleeve connector

Specimen	External Sleeve (mm)		Internal Sleeve (mm)		Development Length (mm)
	Diameter	Length	Diameter	Length	
Control Bar	-	-	-	-	600
A-20-125	76.1	260	60.3	50	125
A-20-150		310			150
A-20-175		360			175
A-20-200		410			200
B-20-125	85.5	260	76.1	50	125
B-20-150		310			150
B-20-175		360			175
B-20-200		410			200

Result and discussion: Table 2 shows the result from the tensile test performed on eight grouted splice sleeve connectors and a control bar. The result shows that the tensile capacity of Type A and Type B connectors were increased as the development length increases. The ratio of ultimate tensile strength (f_u) to specified yield strength ($f_{y,s}$=136.6kN) of the connectors were compared and must be greater than 1.25$f_{y,s}$ as stated in ACI 318. Three types of failure were observed (i) bar fractured outside the sleeve (ii) bar pullout and (iii) internal sleeve pullout. Only connectors failed by bar fractured and greater than 1.25$f_{y,s}$ considered as satisfactory which were A-20-200 and B-20-200.
Theses two connectors also show that grouted splice sleeve connector only requires 10 times the diameter (10$Ø_{bar}$) of the reinforcement bar for the development length which is less than 40$Ø_{bar}$ stated in BS8110. The tensile capacity of Type A connectors was higher than Type B connectors could be due to smaller sleeve diameter used by Type A. Small reduction in sleeve diameter has sufficiently mobilized grout confining action [Einea *et. al*, 1995].

Table 2: Tensile test result of grouted splice sleeve connector

Specimen	f_u (kN)	$f_u/f_{y,s}$ (ACI 318) >1.25$f_{y,s}$	L_d / $Ø_{bar}$ (BS 8110 =40Ø)	Mode of Failure
Control Bar	207.3	-	-	Bar fracture
A-20-125	162.3	1.19	6.3Ø	Bar pullout
A-20-150	174.3	1.28	7.5Ø	Bar pullout
A-20-175	186.5	1.37	8.8Ø	Bar pullout
A-20-200	200.5	1.47	10Ø	Bar fracture
B-20-125	159.0	1.16	6.3Ø	Internal sleeve pullout
B-20-150	172.6	1.26	7.5Ø	Internal sleeve pullout
B-20-175	178.0	1.30	8.8Ø	Bar pullout
B-20-200	182.3	1.33	10Ø	Bar fracture

Conclusion: There were three types of failure identified which were bar fracture outside the sleeve, bar pullout and internal sleeve pullout. The development length of reinforcement bars effects the performance of the connectors where development length of 200mm gives a satisfactory result. Connectors with smaller sleeve diameters gives a better performance and bond strength.

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