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Withdrawal Performance for Different Embedment Depths of Dowel Made from Chengal Species

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Abstract*: the goal of this study is to obtain the withdrawal capacities or Chengal Dowelled connection with the effect of various dowel embedment depths. The embedment depth tested for this study are 30, 60, 90 and 120 mm. Withdrawal test was used in order to obtain the withdrawal capacity using Shimadzu Testing Machine with 50 kN capacity and referring to ASTM D-1037. The samples were prepared referring to National Design Standard (NDS). The average withdrawal capacity of Chengal dowelled connection with 30, 60 90 and 120 mm embedment tested was 1.27 kN (coefficient of variation [COV] 50.5%), 1.79 kN (COV 50.2%), 1.71 kN (COV 53.8%) and 1.90 kN (COV 74.55%) respectively. This study generates data that prove the highest embedment depth has the higher withdrawal capacity. Nevertheless, the percentage different of withdrawal capacity between 120 mm and 60 mm embedment depth is only 6.3% which shows that double the embedment does not contributes to double its strength.

Keywords: Chengal Dowelled, (COV 53.8%).

I. INTRODUCTION

Timber industry in Malaysia is one of the stable sectors that generate exports earnings. Many initiatives have been taken by the governments in order to enhance the economics growth through timber industry. The usage of timber in construction industry is one of the initiatives could be taken and it support green building concept.

Connection is one of the weakest member in timber structure. This prove that connection is important in timber structure. Study were conducted in early 80's in order to provide alternatives regarding connections problems. Connections with the varieties of parameters yield predictable outcomes for the failure modes, ultimate strength and ductility[1]. The failure modes were strongly relies on the number of fasteners per joint [2]

One of the famous connection used in timber construction is dowel. It is one of the most effective connections that understands the mechanical behaviors. Apart from that, dowel is one of the connections that often use for large scales structures. An author stated that numerical and experimental studies will needed in order to improve the design standard for timber connections [3].

Most of the connection used for timber structure are made from steel. Steel and timber shared different behaviour thus could result to poor connection system. The contraction and expansion of steel due to temperature leads to tearing of timber thus resulting failure. The usage of timber as dowel is one of the alternative to overcome the connection problem. A Japanese researcher conducted an investigation on their local timber and used wood as the dowel. The author comes to a conclusion that the jointing method using wood dowel only suitable for a small scaled structure[4]

II. WITHDRAWAL CAPACITY

Withdrawal test, is one of the way to investigate the uplift capacity on a connection withstanding vertical forces. Several researches regarding connections for construction in order to learn the properties and characteristics. [5]conducted a research and concluded that there are no specific effect on the method of driving the connections

Wood dowel have been implemented in the timber construction industry for quite some time but there a limitations of study for Malaysian tropical timber. One of the study by [6]used Malaysian species, Nyatoh, Ramin and Rubberwood. The researcher tested dowel made of Nyatoh onto the other species. The investigation proved the usage of same species as connection fastener results greater withdrawal capacity as the structure element and the connector shares the same behavior.

According to[7], the embedment depth of dowel effect the withdrawal strength as the higher depth result higher capacity. This shows that it is better to have a larger embedment depth in order to have a higher withdrawal capacity. Therefore, this study is aiming to study the effect of embedment depth of dowel made of Chengal Species.

Chengal or its Standard Malaysian Name, *Neobalanocarpus heimii* is a heavy construction timber that usually used for heavy duty structure. Strength group for Chengal is SG 1. The air-dry density is 915-980kg/m3 and has good working properties and produces smooth finishes. Unfortunately, it has very poor nailing properties [8].

III. METHODOLOGY

The timber species used in this test is Chengal with grade SG1. The Chengal species were cut and shaped as detailed dimension of the sample is as in figure 1.

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The sample will be prepared referring to National Design Specifications (NDS) for dowel-type fastener [8].

A cylindrical shaped dowel in 16 mm diameter were prepared from Chengal. The process of making dowel is by undergoing five stages. First, the dowel will be shaped into a small rectangle to ease the process. Then, the edges of the rectangle shaped wood will be scrapped a little in order to made it slightly rounder shape. In order to make the wood smoother and rounder, grinder machine will be used. After the wood become a stick, it will be placed and knocked into a mold so that the diameter will be precisely as desired. The final stage is to rub the wood dowel with sand paper to smoothen the surface.

Shimadzu 50 kN were used for withdrawal test as shown in figure with 1 mm/min loading rate. The embedment depths were 1/3, 1/2, 3/4 and 1 of the sample rafter's depth (120 mm). 30 replicates were performed for each embedment depth as shown in Figure 4.

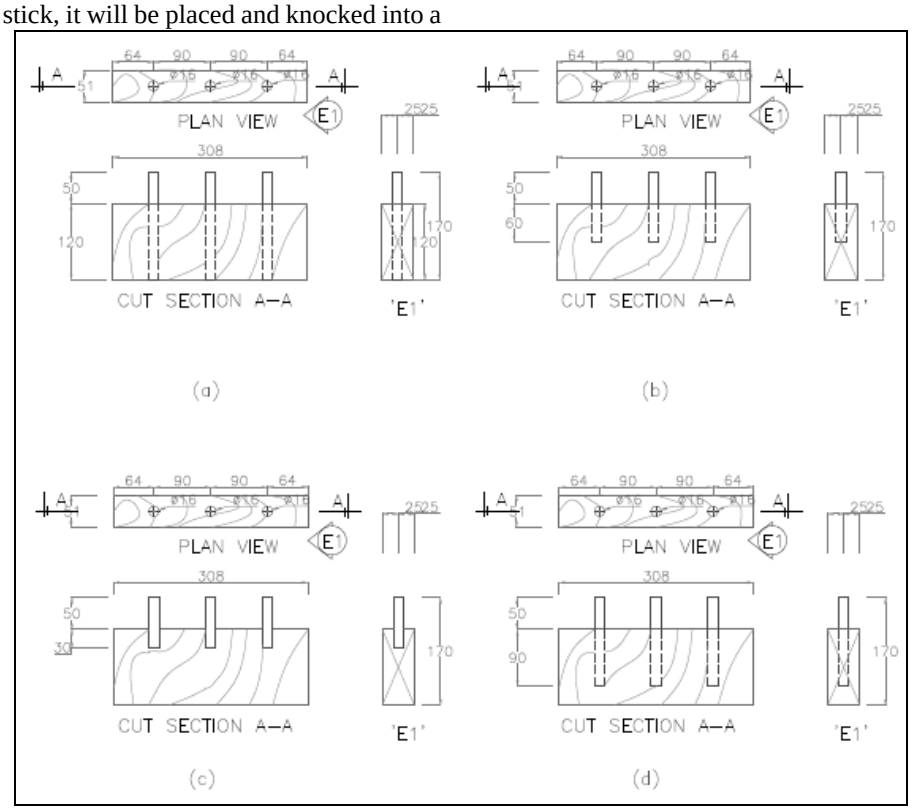

Figure 1: Sample Dimensions

Figure 2: Withdrawal Samples for Chengal Species

Figure 3: Shimadzu Testing Machine with 50 kN Capacity

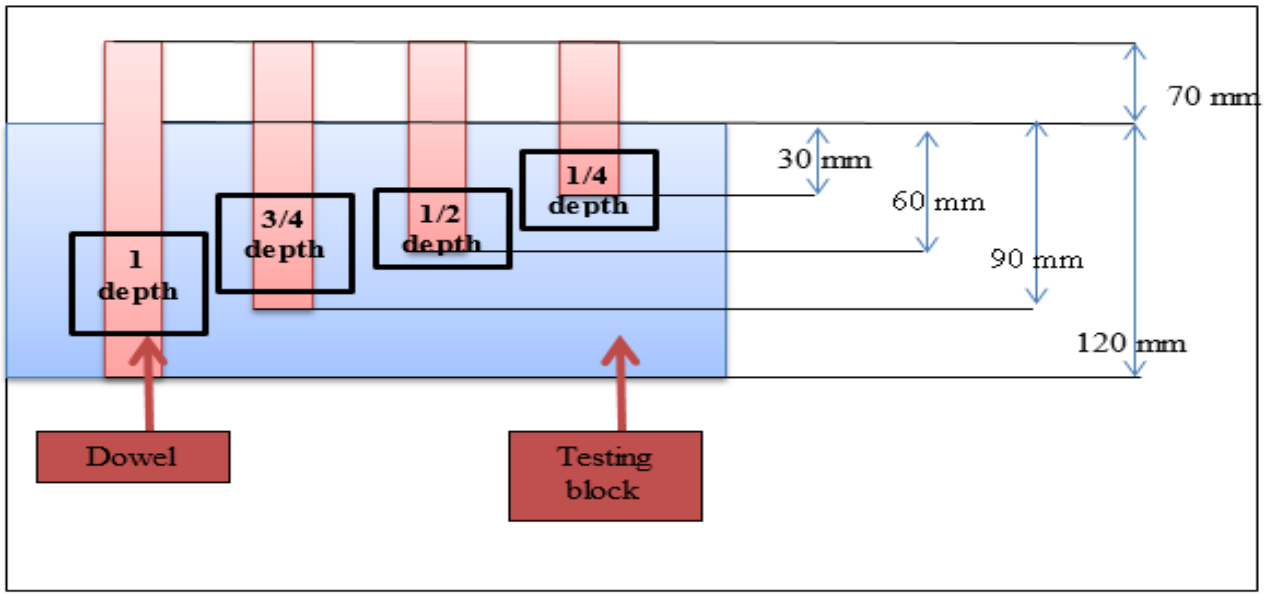

Figure 4: Embedment Depths Tested

Table 1 shows the summary of the material preparions for this study.

Table 1: Scope of Research

Embedment depth (mm)	Type of Fastener	Diameter (mm)	No of Specimens (Nos)
120	Dowel	16	30
90			30
60			30
30			30

IV. RESULTS AND DISCUSSION

the mean, standard and coefficient of variation results for each embedment depth of Chengal dowelled connection was shown in Table 2.

Table 2: Withdrawal Capacity For Chengal Dowelled Connection

NOS	WITHDRAWAL RESISTANCE (N)			
	30 mm	60 mm	90 mm	120 mm
MEAN	1274.531	1786.302	1709.688	1903.802
STD	643.6636	897.2461	919.8529	1419.302
COV (%)	50.50198	50.22924	53.8024	74.55093

A comparison of withdrawal capacity of Chengal was determined experimentally and presented in Figure 5. The average withdrawal capacity of Chengal dowelled connection with 30, 60 90 and 120 mm embedment tested was 1.27 kN (coefficient of variation [COV] 50.5%), 1.79 kN (COV 50.2%), 1.71 kN (COV 53.8%) and 1.90 kN (COV 74.55%) respectively.

The high COV was found inconsistent due to human error. The wood dowel were man made which could contribute to it's inconsistency.

Figure 5 shows the effects of embedment depth of dowel withdrawal resistance. As shown in Figure 5 that the withdrawal resistance does not ascends consistently as the embedment increase. Dowelled connection with 90 mm embedment depth has lower withdrawal capacity than 30 mm.

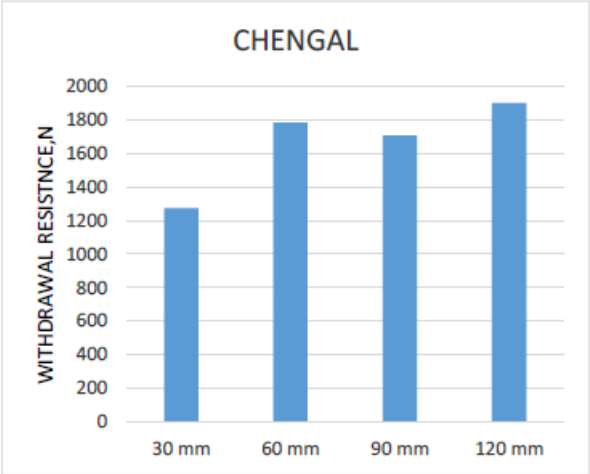

Figure 5: Withdrawal Values of Chengal Dowelled Connection

V. CONCLUSIONS AND RECOMMENDATIONS

This study examined the withdrawal capacity for Chengal dowelled connection with the effects of different dowel embedment depths. Depths tested in this study are 30, 60, 90 and 120 mm. This study generates data that proved the highest embedment depth reflected to higher withdrawal capacity. Nevertheless, the percentage different of withdrawal capacity between 120 mm and 60 mm embedment depth is only 6.3% which shows that double the embedment does not contributes to double its strength product.

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