THE SAFE WORKING LOAD FOR TIMBER SAW STOOLS USED FOR SCAFFOLDING

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ABSTRACT

The Carpentry Section at Otago Polytechnic has previously used saw stools and scaffolding planks for low level scaffolding while building relocatable houses. However, there was a Health & Safety risk because the saw stools are not approved for this use. This paper presents a testing study evaluating the safe working load for timber saw stools used for scaffolding. A total of 30 tests with six load scenarios with different saw cut positions and five load scenarios having different saw cut depths were completed. The test results showed that a saw stool used for scaffolding is very capable of supporting all the imposed loads, with a conservative Factor of Safety (FOS) of 3.5. An inspection checklist and a User Guide Flow Chart have been developed for good practice. This project received support through a New Zealand Timber Design Society Scholarship.

KEYWORDS

Moment resisting joints, dowel-type connections, stiffness, component method.

1 INTRODUCTION

The Carpentry Section at Otago Polytechnic has previously used saw stools and scaffolding planks for low level scaffolding up to a maximum platform height of 1 meter while building relocatable houses. It was advised that this was a Health & Safety risk because the saw stools have not been approved for this use.

The Scaffolding, Access & Rigging New Zealand (SARNZ) Best Practice Guidelines for Scaffolding in New Zealand [1] specifies low level work as being under 5 meters, such as light duty activities including plastering, painting, general fit-out and finishing. There are no AS/NZS standards presently that advise on the safe loads for the use of timber stools for scaffolding.

This project was launched at the beginning of 2019 and received support through a New Zealand Timber Design Society Scholarship. The aim was to find out the safe working load for timber saw stools used for scaffolding. The proposed maximum load case is two saw stools 2750 mm apart, each supporting three proprietary scaffolding planks with each plank being rated for a maximum load of 140 kg [1].

A total of 30 tests with six load scenarios with different saw cut positions and five load scenarios having different saw cut depths have been completed using a Denison universal testing machine. The Denison machine is a 500 kN servo-hydraulic universal testing machine. The Denison was recently calibrated and found to be 99.25% to 99.9% accurate over the testing range. The Carpentry Section of Otago Polytechnic built a testing rig and tested three saw stools with it. The rig performed successfully up to a load of 21.5 kN before stool failure.

In addition to cut positions and depths which have been considered in the tests, both hand-made saw stools and machine-made saw stools were used for the testing, in order to determine if the construction method is a factor. Hand-made stools were constructed using primarily hand tools while the machine-made stools were constructed using power tools, but both types had the same dimensions and detailing. Knots in the timber planks were also considered in the research.

2 TESTING

2.1 Details of saw stool construction

All saw stools used in the testing were made from Pinus Radiata, which is an exotic softwood grown and used extensively in New Zealand. The timber was Ungraded, also known as “utility grade”. Carefully selected clear timber was chosen for the saw stools. All saw stools were made of the timber with straight parallel grain but not cross grain. Knots were allowed in the timber for making saw stools, but the position of a knot in the body of a saw stool may affect its load capacity. All saw stools were made by following drawings as shown in Figure 1. The design of the stools came from carpentry tutors at Otago Polytechnic from the 1970s and complied with old industry standards.

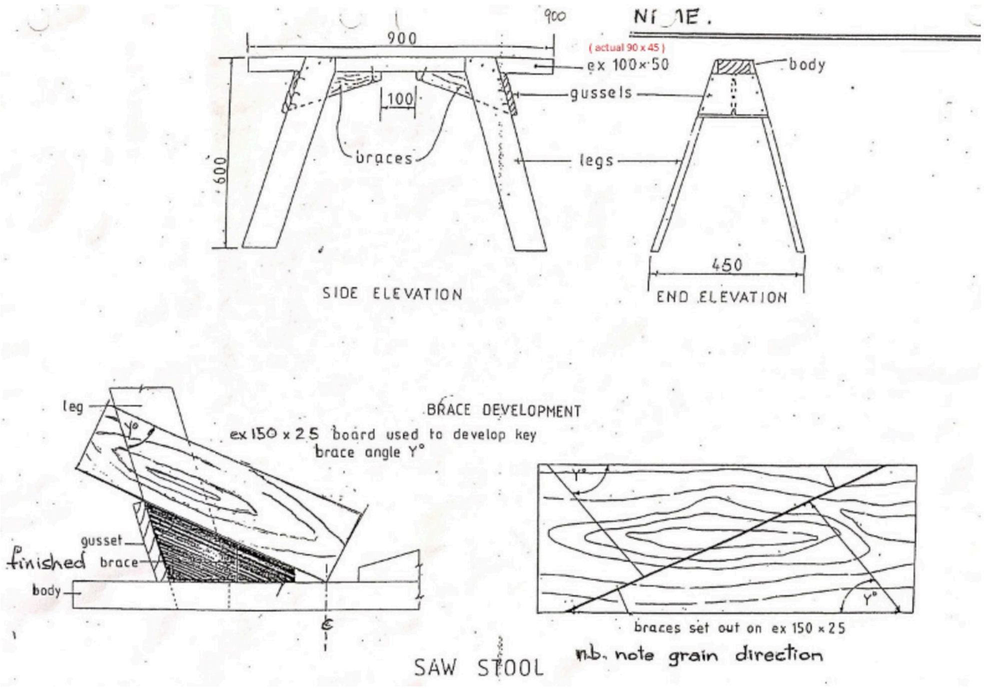

Figure 1: *Saw stool standard shape and sizes.*

2.2 Details of saw stool cuts

Because in practice saw stools always have cuts on them from use, six load cases of different saw cut positions and five load cases of different saw cut depths were considered for the testing. One or two cuts were put in each stool. In the stools with two cuts, the depth was always 5 mm, and in the stools with one cut, the depth ranged from 5 mm to 12 mm.

2.3 Test Procedure

The Denison machine is shown in Figure 2. Load was applied by part 1 moving down on to the saw stool. A saw stool stood on the rig (marked 2). The load was applied to a piece of a scaffolding plank (marked 5) and then to the saw stool (marked 6). When a saw stool failed, a failure load was read through part 4.

Figure 2: *Denison T42 B4 Machine at Otago Polytechnic.*

3 RESULTS AND DISCUSSION

3.1 Testing photos for different Load Scenarios

Table 1: Testing photos for different Load Scenarios

Load Scenario Series	Testing photos		
A			
B			
C			
D			
E			

F / H	
G	
H / F	The same as F / H
I	
J	
K	

3.2 Testing results for different Load Scenarios

A range of cuts of various depth and position were applied to brand new saw stools (Table 1). There were 10 load configurations for collecting data among 30 saw stools in this project. Of the 30 tests, 27 results were used in the data analysis (Table 2). Three testing results were considered invalid, because the first two tests did not include a scaffolding plank on the saw stools, which was not the real situation on how a load is applied to a saw stool. The third result was invalid because the rig was twisted during testing.

3.3 Analysis of results

3.3.1 Effect of saw cut depths

Thirteen tests were carried out with a single saw cut at the mid-span of the saw stool. Four different cut-depths were used: 5 mm, 7.5 mm, 10 mm, and 12 mm. The results indicated that the effect of cut depth was insignificant. The average failure load with the 5 mm cut was about the same as with the 10 mm cut.

3.3.2 Effect of saw cut positions

Eleven tests with five position combinations were

Table 2: Testing results for different Load Scenarios

Load Case Series	Testing Load (kN)
G	24.9
	28.4
	27.3
F / H	17.9
	12.2
	14.5
	19.8
I	28.8
	25.8
	30.6
	26.1
J	17.4
	16.9
	16
K	20
	18.7
A	23.5
	18.5
B	29.1
	19.7
C	17.9
	19.7
D	26.3
	24.2
E	25
	19.5
	30.2
Average Load (all)	**22.13**

done. There was no obvious relationship between positions and failure loads. It was also noticed that the average failure load with one cut was very similar to the average load with two cuts, 20.0 kN and 22.9 kN, respectively.

3.3.3 Effect of knots

There were eight saw stools with knots at different positions on different parts of the stools. The results are shown in Table 2. It became clear that a knot near the centre of the top plank of the saw stool could initiate a crack when the load was applied. In Table 2, Load Scenario F/H had a knot with a diameter of around 20 mm at the centre and a low failure load of 14.5 kN; Load Scenario J, which had a knot at a position close to the centre and another knot on the brace close to the screw, had a failure load (16.9 kN) that was lower than the total average load (22.1 kN). Knots at other positions not close to the centre, and on legs or braces or gussets had insignificant effects on the load performance. It is recommended that more testing about knots near the centre of saw stools be considered for future research.

3.4 FOS and User Guide Flow Chart

In this project, FOS refers to the required margin of safety for a saw stool used for scaffolding. As mentioned previously, the proposed maximum load configuration is for two saw stools 2750 mm apart, each supporting three scaffolding planks and each scaffolding plank carrying the maximum load of 140 kg, giving a working load, including the self-weight of the planks, of 3.38 kN. In this project, the lowest failure load of 12.2 kN has been used for the FOS calculations which means that all other tests have a larger FOS. As a result, FOS = 12.2 kN/3.38 kN = 3.6, which is rounded down to FOS = 3.5. This suggests that a saw stool used for scaffolding will be safe for a load up to 3.5 times the maximum working load. Therefore, a saw stool used for scaffolding is very capable of supporting all the imposed loads.

A flow chart of recommended questions that should be addressed when deciding on the safety of a wooden stool to be used as a scaffolding support has been developed and is available from the author and Otago Polytechnic.

4 CONCLUSIONS

Based on the testing conducted, the minimum Factor of Safety (FOS) for saw stools used as scaffolding can be taken as 3.5. This means that a saw stool used for scaffolding will be safe for a load up to 3.5 times the maximum working load.

The results will be discussed with a timber design engineer, and subsequently approval will be sought from Work & Safety for the use of this scaffolding method.

Environmental sustainability was also considered in this project. Except for failed sections of saw stools, most of the parts were reused in making new saw stools.

5 FUTURE RESEARCH

Testing the effects of screwed braces and glued braces on the load capacity of a saw stool is strongly recommended for future research. During the current project, it was found that more than 60% of the saw stools failed around the screws. There was a discussion about replacing the screwed braces with glued braces, which may increase the load capacity of a saw stool, but it was not possible to include this alternative connection within the current project.

Based on observations made during this project, additional research could include testing on saw stools of various ages, deeper depth cuts, multiple cuts at critical locations and with knots.

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REFERENCES

(1) Good Practice Guidelines-Scaffolding in New Zealand, WorkSafe New Zealand, November 2016