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Investigations on insertion forces of double-tee joints into solid wood planks and wood-based boards

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Abstract: *Investigations on insertion forces of double-tee joints into solid wood planks and wood-based boards.* The article presents results of investigations on forces needed to force into solid wood planks and wood-based boards, without glue application, double-tee fasteners of '*joint nail*' type in two connecting variants: at an angle of 90° and 45°. The obtained values of assembling forces were described by diagrams for each of the applied sample material: pine, oak, chipboard and MDF. The performed investigations showed that the highest pressing-in force should be applied for oakwood. In the case of pinewood, these forces were by about 35% and for wood-based boards – by about 75% lower.

Keywords: joint nails, double-tee joints, wood-based board.

INTRODUCTION

Double-tee connections of joint nail type (http://www.jointnails.com) (Fig. 1) are employed, primarily, to join solid wood but also wood-based boards. It is an inseparable type of connection and in Poland it is applied, among others, in funeral industry.

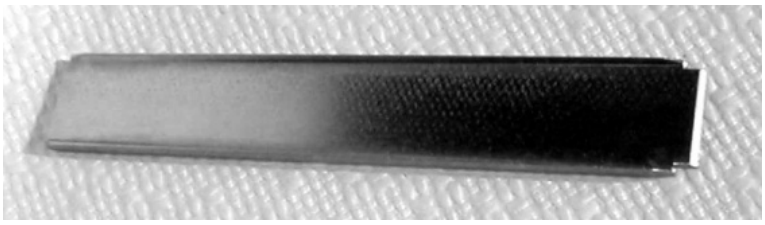


Figure 1. Double-tee joint nail connection (http://www.jointnails.com).

A properly made connection of two boards requires making a kerf in each of them which is 1-2 mm deeper than half of the width of the double-tee joint. This facilitates insertion and assembly of the connection for which a pneumatic hammer is frequently applied. A simultaneous application of glue (prior to hammering the joint nail in) makes the connection stable, strong and invisible. In the technology of the described connections, a so called 'initial tightening' takes place during assembly (Pohl at al., 2009) because the joint nail is characterised by 1:100 tapering resulting in tightening of the assembled planks and exerting an assembly clamp (Fig. 2).

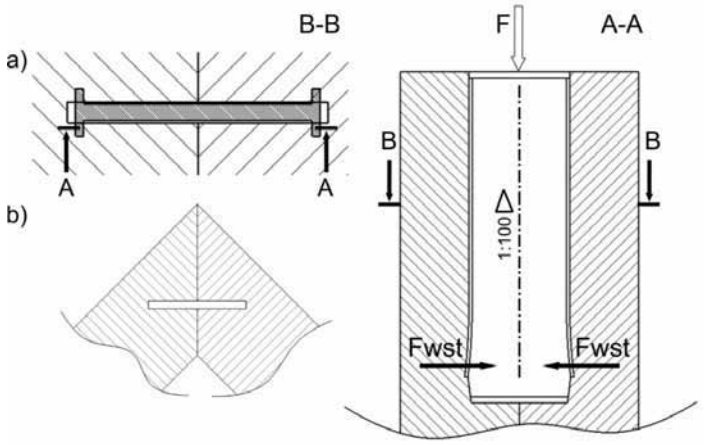


Figure 2. Mechanism of the development of the initial tightening: a) joint nail hammered into elements, b) kerf made in elements prior to assembly; F – hammering force of the joint nail, $F_{wst.}$ – force of the initial tightening [2]

RESEARCH OBJECTIVE

The aim of experiments was to determine forces necessary to assemble (insert) a double-tee connection of joint nail type in solid wood planks and wood-based boards. The forces are directly associated with the initial tightening mechanism during the assembling process caused by the tampering of the joint and are different for specific types of materials.

METHODOLOGY

Investigations were carried out on an angle joint presented in Figure 3. Each joint consists of the following elements: two boards and two double-tee connectors of joint nail type. Experiments were performed on samples prepared from the following materials: pine, oak, chipboard – PW and medium density fibreboard – MDF. The above-described trials were carried out for glueless joints.

Experimental planks and boards were made on a special numerically controlled woodworking machine which guaranteed repeatability of kerf milling 1.3 mm wide. The adopted dimensions of the assembled elements were as follows: 200x200x18 mm (Fig. 3). The manufacturer recommends such choice of the connecting element that it should constitute ¼ of the board length per one connector (the gap between joint nails constitutes ½ of the length of connecting edges) and, therefore, two 2'' (50 mm) joint nails were applied.

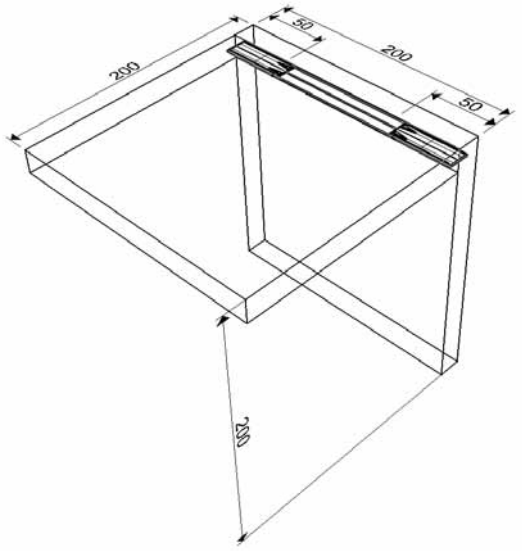


Figure 3. Spatial model of the sample used in experiments.

Investigations on forces necessary to insert the joint were carried out on a Zwick 1445 type testing machine equipped in appropriate experimental paraphernalia (Sydor 2005). The assembly of joint nails perpendicularly to the side of boards was performed on the testing machine.

The first 10-15 mm of the joint nail was inserted into the board kerf manually and then a pressure force *F* was applied until the joint nail was driven completely into the board. The results of this operation are presented in diagrams of the dependence force *F [N]* on displacement *s [mm]*.

Experiments were carried out in two variants of the joint (Fig. 4):

- Variant a) – straight boards (without cuts - angle 90^o),
- Variant b) – skew boards (with cuts at the angle of 45^o).

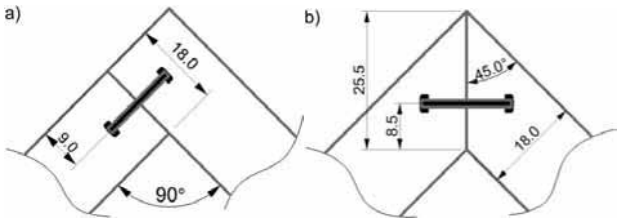


Figure 4. Variants of the experimental joints: (a) straight boards (b) skew boards.

The total of 20 replications for each experimental variant was performed and then mean values and standard deviations as well as ranges of errors at 95% level of confidence were calculated.

RESEARCH RESULTS

Figure 5 presents example results obtained for 20 MDF board samples with straight connection (variant a).

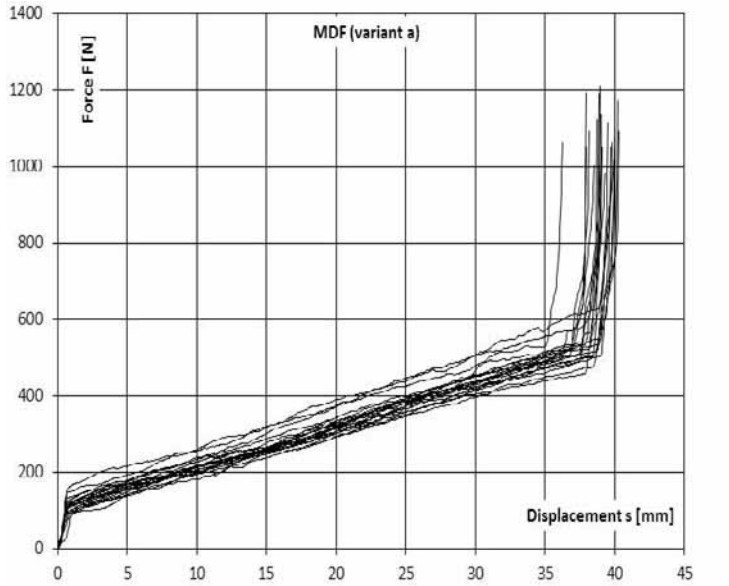
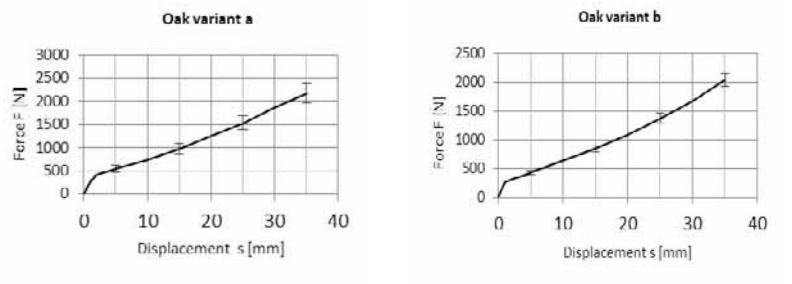


Figure 5. Results of examination of the insertion force of double-tee fasteners into MDF board without cutting (variant a)

The performed analysis comprised the range of forcing in the joint nails to the depth of 35 mm because, as it was explained earlier, the first 10-15 mm of the assembly of the double-tee connector was carried out manually to insert the fastener into the kerf correctly.

On the basis of the research results, the mean curve of dependence force F – displacement s was calculated and, in selected points, ranges of standard errors for 95% confidence level were presented. The curves obtained in this way are presented in Fig. 6 in forms of F - s diagrams.



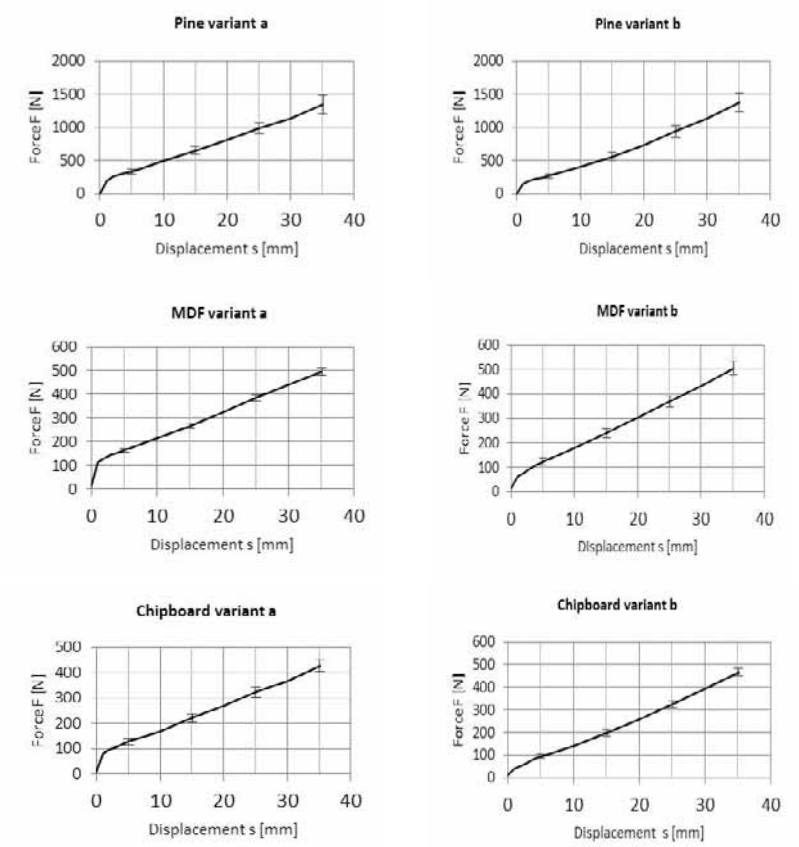


Figure 6. Results of investigations of the insertion force of joint nail type fasteners (with confidence intervals 95%) in oak, pine, chipboard and MDF boards for straight and skew connections.

Figure 7 collates research results of insertion forces for both types of joints (variants a and b) for all the examined materials.

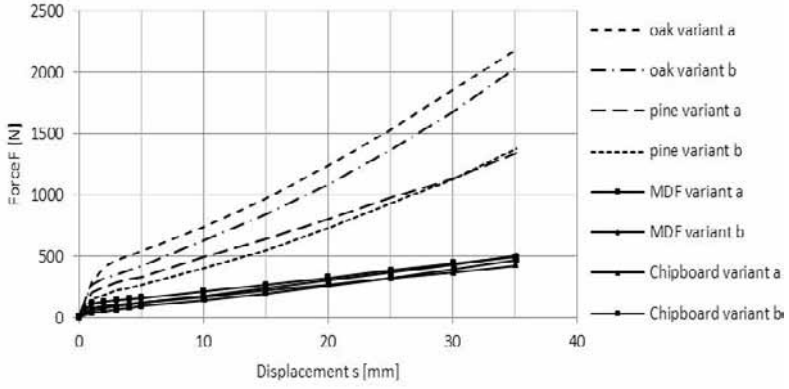


Figure 7. Cumulative research results of insertion forces of joint nail fasteners

Analysing Figures 6 and 7 it can be concluded that, as expected, the highest insertion forces occurred in oak samples and by about 35% smaller – in pine samples. Greater forces were required to insert fasteners in the case of straight joints (variant a) and slightly smaller – in the case of skew joints (variant b).

In the case of MDF and chipboards, the applied insertion forces were significantly smaller and amounted to about 25% of forces used in oak samples and were slightly higher for MDFs than for chipboards. In both of these materials, especially in the case of MDFs, a very small scatter of research results as well as lack of differences between variant a and b were observed. This is understandable bearing in mind the homogeneity of these boards.

CONCLUSIONS

The following conclusions were drawn on the basis of the obtained research results:

- The highest insertion force was required for oakwood, lower (by about 35%) for pinewood planks and the lowest (about 25% of the force required for oak) – for MDFs and chipboards,
- In the case of oakwood, a slightly higher insertion force was needed for straight joints (variant a) than for skew joints (variant b) (the observed difference – about 10%)
- The examined wood-based boards showed similar values of insertion forces and significant repeatability of results.
- For oak and pine woods, the course of dependence curves *force – displacement* was of exponential nature. The examined wood-based boards were characterised by a linear course of the dependence.

REFERENCES

1. B. BRANOWSKI i P. POHL: „Modelowanie półsztywnych węzłów konstrukcyjnych mebli", AR, Poznań, 2004.
2. P. POHL, K. RADZIKOWSKI, M. WOŁPIUK: „Połączenia kątowe drewna i płyt drewnopochodnych przy użyciu złącz dwuteowych", XXIV Sympozjon PKM Białystok-Białowieża, 2009.
3. M. SYDOR: „Właściwości konstrukcyjne półsztywnych kątowych połączeń płyt drewnopochodnych ze złączami", Politechnika Poznańska, typescript, Poznań, 2005.
4. G. WIELOCH, M. SYDOR, P. POHL: „Wyznaczenie optymalnych nośności i sztywności wybranych meblowych półsztywnych złącz kątowych", Politechnika Koszalińska, Zeszyty Naukowe Wydziału Mechanicznego nr 35, Prace XXII Ogólnopolskiej Konferencji Polioptymalizacja i Komputerowe Wspomaganie Projektowania, Mielno, 2004.
5. http://www.jointnails.com, 02.08.2010.

Streszczenie: *Badania nad siłami wciskania złącz dwuteowych w płytach drzewnych i drewnopochodnych.* W pracy przedstawiono wyniki badań sił wciskania łączników dwuteowych typu *joint nails*, bez użycia kleju, w płyty drzewne oraz drewnopochodne przy dwóch wariantach połączeń – pod kątem 90^0 i 45^0. Uzyskane wartości sił montażowych opisano wykresami dla każdego materiału próbki: sosny, dębu, płyty wiórowej i MDF. Badania wykazały, że największą siłę wciskającą należy stosować dla drewna dębu, dla drewna sosny siły te są o ok. 35% niższe, a dla płyt drewnopochodnych o ok. 75 % niższe.

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