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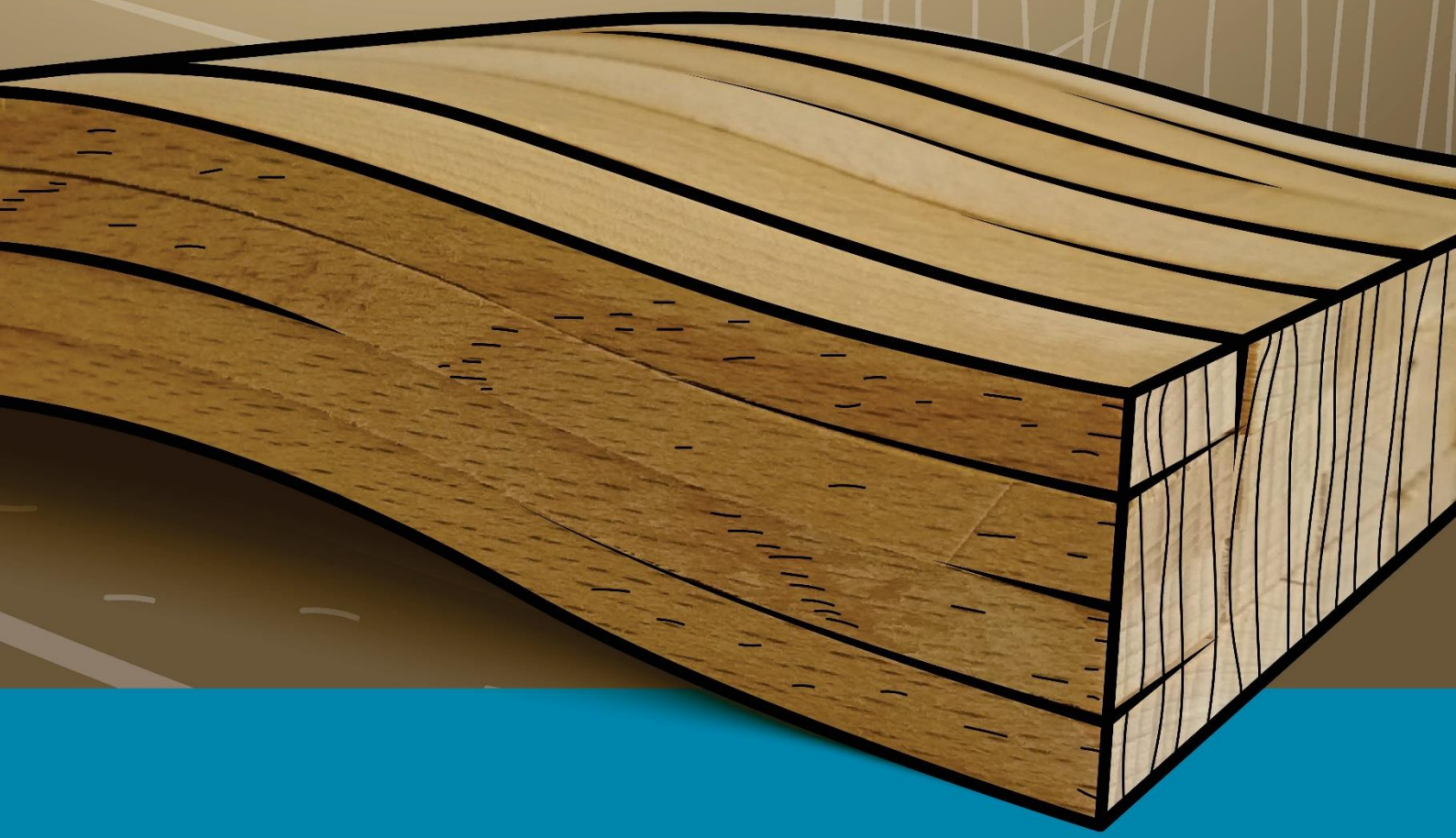

WOOD KPLUS

Mendel University in Brno

10TH HARDWOOD CONFERENCE PROCEEDINGS

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Performance comparison of domino pin and domino connector fastened corner joints

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ABSTRACT

A wide variety of fasteners have been developed and used to make ready-to-assemble furniture. These fasteners must withstand different periods of time. There are many different types of wood joints. The choice of joint type and its strength properties are one of the most important factors of a longtime good performance. In this study, research was conducted on Domino fasteners in wood furniture joints. The Domino is a loose mortise and tenon joining pin, with rounded edges, oval cross sections, and grooved surfaces, that create strong hidden joints, manufactured by the German company Festool, in 2006, supplied in 14 different sizes. Over the time further to the so called Domino pins (or bisquits) Domino connectors were also developed, fitting the same size holes. Although frequently used in practice, the performance of theese type connectors is rather underevaluated in the scientific literature. In this study, comparison of strength and elasticity of Domino pin and Domino connector fixed corner joints was evaluated in order to make recommandation which offers stronger connection.

INTRODUCTION

Structural joints are extremely important during furniture design. Structural rigidity and strength is known as a critical part of the design [4]. Wood fasteners are used to join individual pieces in a perfectly and functionally satisfactory piece such as a furniture component, furniture or overall structure [7]. In joint elements, internal forces are mostly distributed between compressive contact and an element due to external stress [16], [2].The areas where the elements are in contact with each other must be carefully bonded so that internal forces can be transmitted evenly across the surface [9]. Positioning of the joints is often known as a limiting factor in the design process [8], [12], [15]. There is a difference between glued (permanent) and non-glued (temporary and removable) joints. Connection and mounting means should be selected according to the connection type. Glued joints reduce vibration in the material compared to other joints and positively affect the strength of the structure [13].

The Domino is a loose mortise and tenon joining tool manufactured by the German company Festool. In 2006, the company Festool introduced a reliable Domino joiner system that creates strong hidden joints. This is a special type of joint using a loose tenon, or Domino pin, and mortises into which the Domino pin is inserted and glued. This is a joining element with rounded edges, oval cross sections, and grooved surfaces. It is supplied in 14 different sizes. The Domino can be purchased in pieces or in the form of a rod that the customer can shorten as needed. The domino joint can be glued to the wood material by means of glue or domino connectors.

These unique tools are the perfect blend of dowel joiner and biscuit joiner. Each system has its own advantages. Round dowels are some of the most important fasteners used in furniture assembly; It is known as one of the preferred connecting elements for frames and shelves. However, because round dowels do not allow misalignment, exact positioning is often required on benchtop or semi-stationary machines. Biscuit dowels are usually placed on the writing line using hand-held machines. Since the biscuit dowels are shorter than the guided grooves, a slight protrusion is not a problem since the joint can be moved while the dowel is inserted. However, this requires additional alignment when gluing. However, the domino join system is a mixture of both. It is an important component in wood joining.

After the adhesive is applied, the Domino adheres to the sides of the hole more tightly because of the swelling properties of wood, which makes the glued joint even stronger. The grooves on the Domino pin support even glue distribution [12], [5].

Another method of joining is joins using Domino connectors. The reason for using a connector is to aim for a more robust joint. Thus, it can be assumed that the joins are more powerful. The domino joints are suitable both for panel joints and frame and rack joints. The simple placement of the domino dowel allows for the economical production of individual parts and small batches, for chairs, tables and shelving. In this research, corner joining samples prepared using beech wood were combined using domino dowels and connector joining elements; The strength and elastic properties of domino joints and their relationship to cyclic load and creep are studied.

Derikvand et al. [3], tested structural connections using wood-based materials. They worked with a furniture manufacturer on a suitable method for testing screw connections and an improved method for evaluating a structure connected by such a connection. The results showed that the strength of the screw joints depends on the contact surface and shear forces that form on these surfaces. There were other important parameters such as the diameter and pitch of the screw thread. This method provides an objective assessment of the quality of the structure and the selection of the best joint for the designed furniture [3], [14].

Gaff et al.[14], discusses the effect of selected parameters, such as the type of stress (tensile and compressive), size of the Domino joiner (one-half and one-third thickness), wood species (beech (Fagus sylvatica L.) and spruce (Picea abies L.)), and adhesive type (polyvinyl acetate and polyurethane), on the joint stiffness. The influence of the annual rings was also monitored. According to this study, the elastic stiffness of the joint is significantly affected by the tree species, the stress type and the thickness of the Domino pin; After comparing the types of joints, it was found that Domino joints are the only types of joints in which the half-thickness joint does not increase the stiffness of the joint.and while the stiffness is roughly constant for the Spruce wood specimens, there is a significant decrease in the beech wood specimens, and this is probably because of the Domino pin geometry and size of the mortises in the rails and stile, where the half-thickness mortises caused the joint to weaken. Half thickness was an unnecessary "luxury" for spruce wood specimens and absolutely not suitable for beech wood specimens. The effect of the adhesive on joint stiffness has not been proven to be significant. Joints bonded with PVAc glue are known to have only about 9% higher hardness. The glue type, milling quality, thickness of the glued joint and quality of the work were also important factors; It was concluded that the use of one-third thick beech Domino joint bonded with PVAc glue is considered ideal, and the use of half-thickness beech and spruce Domino joints glued with PUR glue is especially appropriate under tensile stress.

Aman et al. [1]., compared loose tenon and tenon joints with traditional tenon and tenon joints using test specimens made from cherry, oak, and maple. Experiments have shown that the strength of the joint with a loose tenon and tenon is within the strength range of a pin joint and a conventional tenon and tenon joint. The article states that the loose tenon system could be cheaper and more efficient. The usage and primary processing costs of the material are lower. Also, using two parts machined in the same way for a Domino pin also reduces production time.

The main purpose of this research is to examine the strength and elastic properties of Domino dowels and connectors; and comparing these two fasteners. This information can then be used in practice by furniture manufacturers and designers to simplify the design and production process.

EXPERIMENTAL

Materials

In this study, corner joints 20 samples were used in total. Examples used: these are corner connection samples combined with 10 connectors and corner connection samples combined with 10 domino dowels. The pasted samples were then conditioned at 20°C and 65% relative humidity until a constant mass was obtained.

Table 1: Test samples and joining details

Specimens	Corner Joint	Domino	Connector
10	10	+	-
10	10	-	+

Beech wood is widely used in the production of chairs, armchairs, tables, office furniture, chairs, and school furniture in places where resistance to load and deformation is required [10]. This tree species is easily accessible today. At the same time, it can be polished very well and the texture of expensive, scarce valuable trees on the market can be modified with lacquer and paint. Likewise, this wood species takes its place as a preferred type in the market due to its resistance, hardness and suitability of bending properties and easy processing [11].

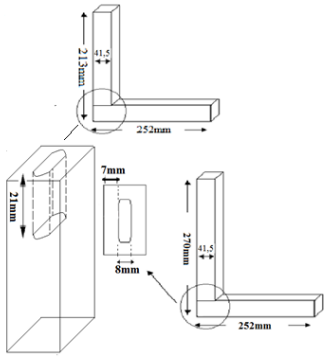

Figure 1: Image of samples corner joints

First, the samples were cut to measure 213x252mm.Then holes were drilled in these samples in a 8 mm diameter Festool Domino XL machine. 10 corner joint samples were prepared using glue and domino joints; The remaining 10 corner joint samples were combined using connectors and sent to the test device.

Figure 2: Examples of corner joints combined using connectors and dominoes

The Domino is a loose mortise and tenon joining tool manufactured by the German company Festool. These unique tools are the perfect blend of dowel joiner and biscuit joiner. Each system has its advantages. Round dowels, the traditional solution for frames and racks. Round dowels are among some of the most important

jointing elements used in furniture assembly. However, because round dowels do not allow for misalignment, exact positioning is usually required with bench-mounting or semi-stationary machines. Biscuit dowels are positioned on the scribe line, usually using handheld machines. Because biscuit dowels are shorter than the routed grooves, a slight offset does not pose a problem when the dowel is inserted as the joint can be moved. However, this does require additional alignment when gluing. However, the domino joining system is a mixture of both joins. It is an important component in the wood joining process.
After the adhesive is applied, the Domino adheres to the sides of the hole more tightly because of the swelling properties of wood, which makes the glued joint even stronger. The grooves on the Domino pin support even glue [12], [5]. Another method of joining is joins using Domino connectors. The reason for using a connector is to aim for a more robust joint. Thus, it can be assumed that the joins are more powerful. During the preparation of the samples, in the corner joints samples made with domino joints, wooden material and domino joining were made using glue. The glue is applied both to the surface of the domino joining element and to the holes drilled by machine. No glue was used during the connections made with the connector.
The domino jointing system is suitable both for panel joints and frame and rack joints. The simple placement of the domino dowel allows for the economical production of individual parts and small batches, for chairs, tables and shelving.
The Festool Domino XL machine we used during the test is used to drill the desired holes in the wood material. The appropriate height and depth are also set by the milling machine depending on the dimensions of the selected Domino pin [5]. This tool, cuts mortises in the manner of a biscuit joiner. A drill-like rotating cutter cuts a round-ended mortise. Each plunge creates a domino loose tenon, creating joints in stock from 22.2 millimeters (0.87 in) wide. There are five cutter sizes (4 mm, 5 mm, 6 mm, 8 mm and 10 mm) for six different Domino tenon sizes. Self-referencing pins allow the cutting of rows of evenly spaced mortises. Mortise width is adjustable in three increments with a knob, and cuts can be overlapped for long mortises. Fence tilts from 0-90 °, with stop positions at 0 °, 22.5 °, 45 °, 67.5 °, 90 °. A Domino pin combines the advantages of round and flat pins. It is an improved version that prevents twisting and is firmer.

Figure 3: Image of the Festool Domino XL Machine

Methods

Test Methods

The specific gravity values of the samples used during the study were calculated by considering ASTM Standard D 2395-93 Method A, volume measurement method. In addition, the moisture contents of the same samples were determined using ASTM Standard D 4442-92 MethodA. It is known that the factors affecting the durability of a material are the material used, the type of connection and the resistance of the fastener used. In the mechanical stresses that occur at the joints of the materials used, the forces try to both close and separate the vertical and horizontal components of the material. Therefore, the tensile test shown in the Figure was chosen as the method that represents the unfolding stresses at the junction of the material. In the clamping setup, the prepared corner joining samples were placed in the test machine as in Fig. 4 and then subjected to the compression test. A loading rate of 2 mm / min was used in all tests. Final fault load values and joint failure modes were recorded. All tests were carried out in a 10.000 N capacity universal testing machine at the Institute of Wood Based Products and Technologies, Sopron University. Loading was continued until separation occurred on the surface of the test samples. Maximum compressive strength

and tensile strength were determined as the force applied to each test specimen at the time of failure. The results of each sample were viewed by the computer to which the test device was connected.

Figure 4: Display of test samples on the test machine; corner joint sample with tensile test

RESULTS

In Table 2, the maximum displacement and maximum forces of the corner joining samples and the joints made with the connector and domino joining are evaluated; These two joining types and elements are compared. The results are presented graphically in Fig. 5; Fig. 7 shows the relationship between force and corner joint examples made with domino and terminal connectors.

Table2: Specimens of corner joints combined with connector and dowel

Corner Joint	**Connector**			**Domino Dowel**		
Specimens	**Max. displacm. at $F_{max.}$ (mm)**	**F_{max}, N**	**$M_{max,}$ Nm**	**Max. Displacm. at $F_{max.}$ (mm)**	**F_{max}, N**	**$M_{max,}$ Nm**
1	6.34	400.0	53.20	7.39	917.7	122.0
2	5.59	394.0	52.41	6.68	818.2	108.8
3	6.80	414.8	55.16	12.98	791.6	105.3
4	8.81	443.4	58.97	5.44	894.8	119.0
5	9.70	437.7	58.21	2.02	717.9	95.5
6	5.58	416.8	55.43	10.66	673.9	89.6
7	3.61	321.5	42.76	12.76	813.2	108.2
8	6.28	411.3	54.70	8.49	965.7	128.4
9	6.89	359.4	47.80	3.05	783.9	104.3
10	5.85	403.3	53.63	14.37	784.0	104.3

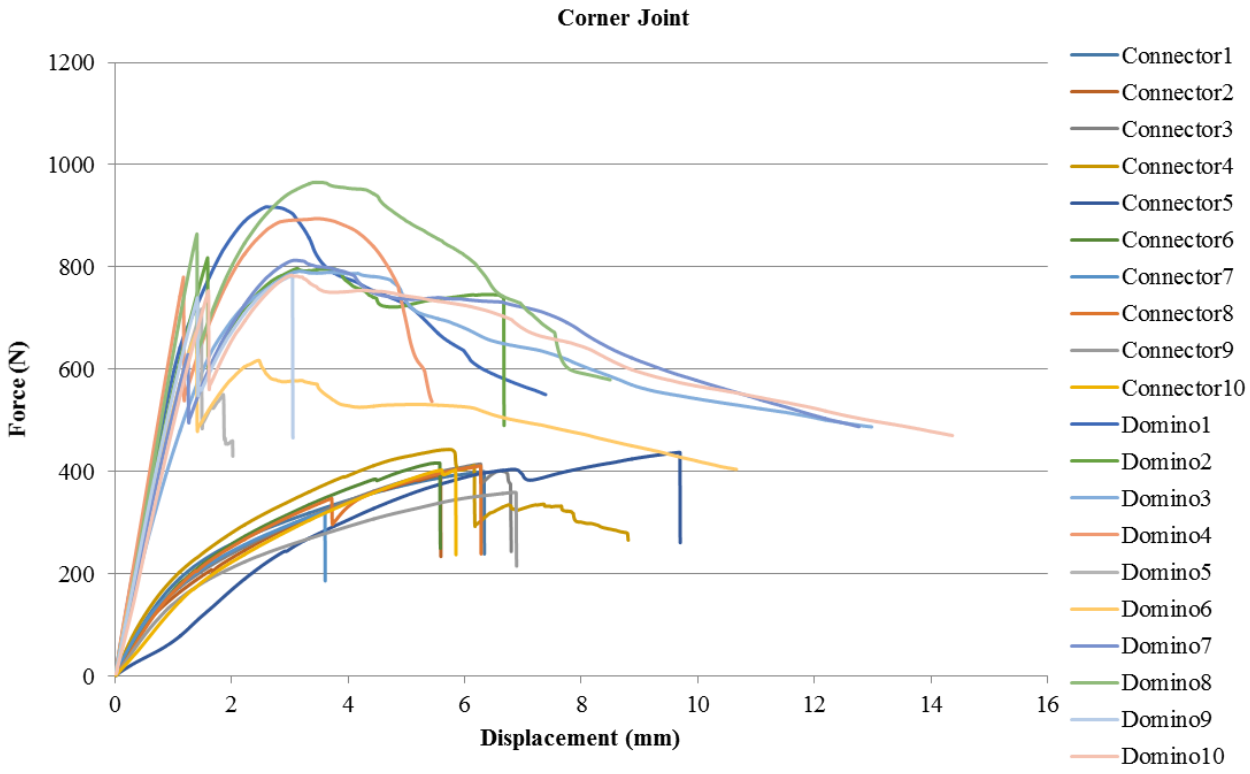

Figure 5: Force displacement plot of the connector and the domino joining element on the corner joint samples

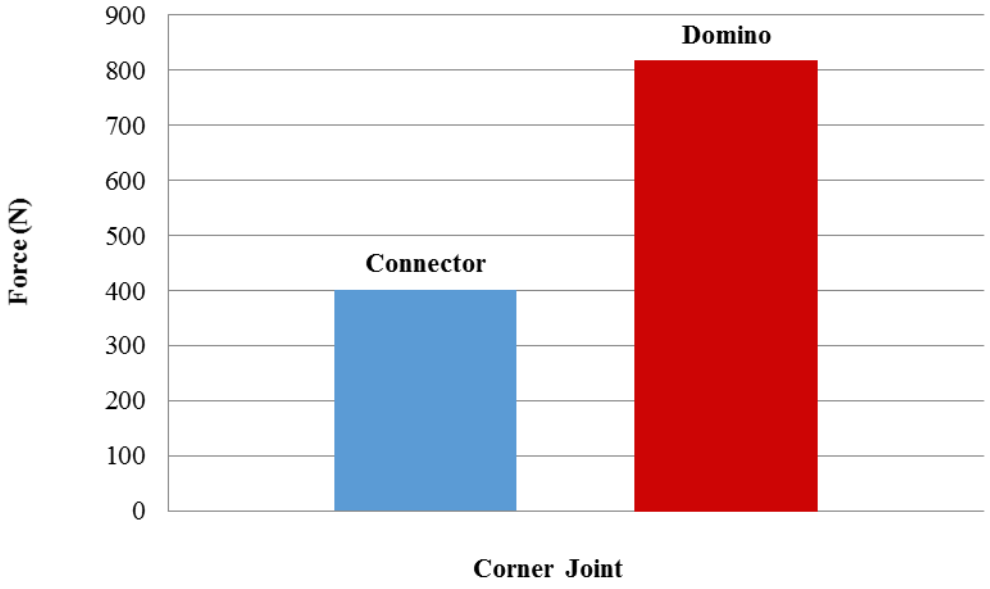

Figure 7: Relationship between force and the coner joint samples made with domino and connector connecting elements

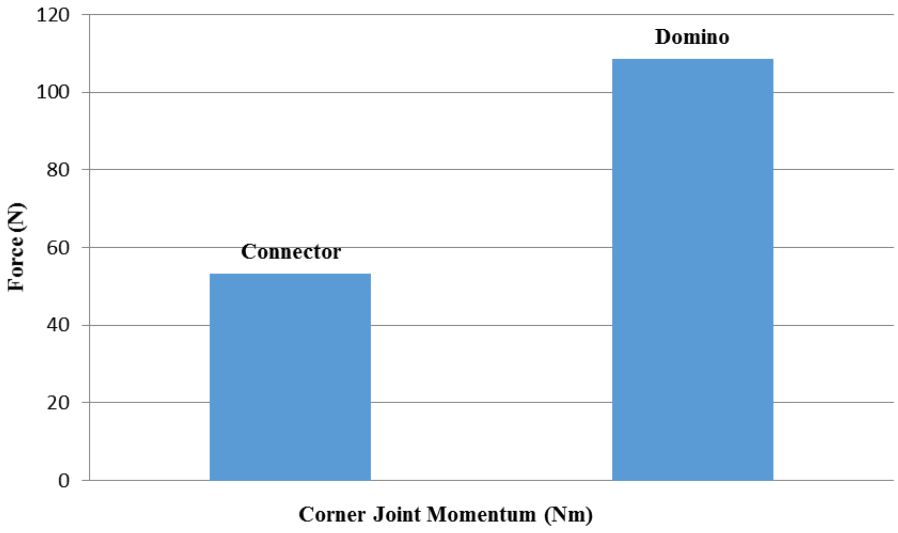

Figure 8: Force-momentum relationship on corner joining

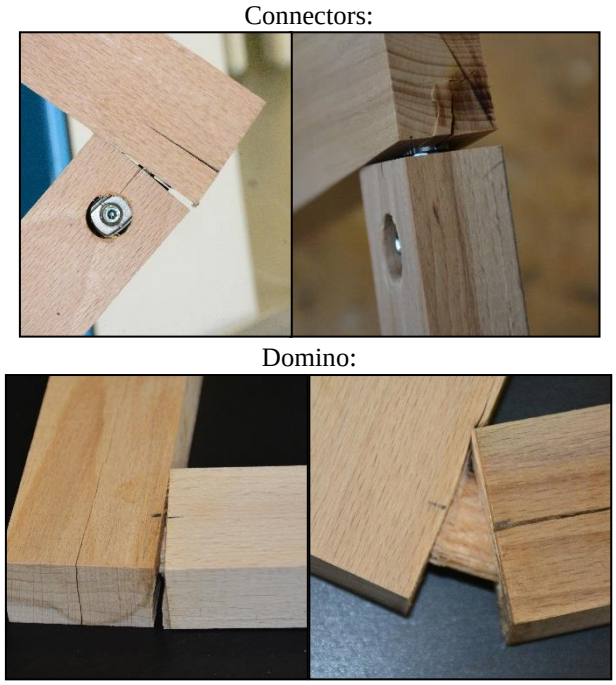

Figure 9: Failure modes registered for connectors and domino joints during the tests

As can be seen from the tables and graphs above, it has been revealed that the joints made using domino joints in corner joint samples show much more resistance than the joining using a connector. This is because, during the test, glue is applied to the surface of the domino joining element and the holes drilled by the Festool machine, resulting in a strong connection between the wood material and the joining element. As can be seen in the graphs: In most of the domino combinations, a graph that first increases linearly, then decreases and shows a linear increase again; With the connectors, a graph that first increases linearly and then decreases is obtained. Not using glue in joints made with connectors weakened the strength of the joining; The binary gear structure seen on the metal part of the connector has reduced the strength of the joint. For this reason, the joints made with the domino joining element have yielded very robust results. In line with the data obtained as a result of this study, the increase in demand and trust in this merge member, who started to make a new name in the sector; It is aimed to provide the prevalence of a strong connecting element as an alternative to other connecting elements.

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