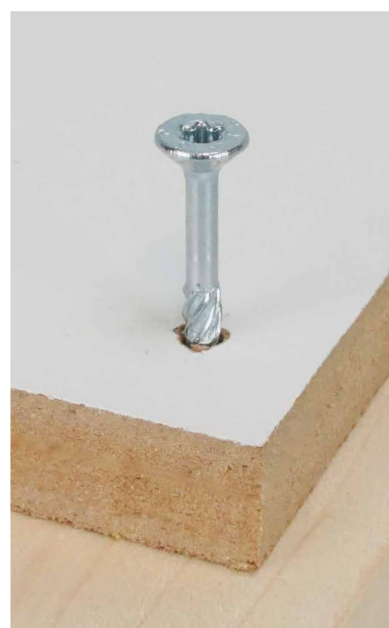


Experimental evaluation of minimum distances and spacing of screws in carpentry and furniture materials

TECHNICAL REPORT



PRP2222 – TECHNICAL REPORT

Experimental evaluation of minimum distances and spacing of screws in carpentry and furniture materials

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**Revision List:**

Rev.	Date	Contents of modification
00	09/2025	First issue
01	01/2026	Layout modifications and additions in accordance with the comments proposed by TL and PLM
02	07/2026	Removal of the comparison with the benchmark

COMPILED	VERIFIED	APPROVED
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SUMMARY

Purpose and objective of the project (PRP2222).....	5
Test setup.....	6
Tested materials.....	8
Tested screws.....	11
<i>Wide face</i> insertion – Ø3.5x50 screws.....	14
Melamin-faced board.....	14
MDF.....	15
Melamine-faced MDF	16
Plywood.....	17
<i>Wide face</i> insertion – Ø4.0x50 screws.....	18
Melamin-faced board.....	18
MDF.....	19
Melamine-faced MDF	20
Plywood.....	21
Spruce.....	22
<i>Wide face</i> – Ø4.5x50 screws	23
Melamin-faced board.....	23
MDF.....	24
Melamine-faced MDF	25
Plywood.....	26
<i>Wide face</i> insertion – Preliminary remarks	27
<i>Narrow face</i> insertion – Ø4.0x50 screws	29
Melamine-faced board.....	29
MDF/Melamine-faced MDF	31
Plywood.....	31
Spruce.....	32
<i>Narrow face</i> insertion – Preliminary remarks.....	33
Concluding remarks	34
Annex 1	36
<i>Wide face</i> insertion – Ø3.5x50 screws.....	36
<i>Wide face</i> insertion – Ø4.0x50 screws.....	52
<i>Wide face</i> insertion – Ø4.5x50 screws.....	69

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Purpose and objective of the project (PRP2222)

The aim of this project is to evaluate the behaviour of small-diameter and short-length screws used in the carpentry sector. In particular, in order to determine whether the screw installation can be considered suitable, the results obtained were analysed with reference to the following aspects:

- Compatibility of the screw with the substrate material;
- Mode and extent of damage to the substrate surface, with particular attention to the presence and assessment of any cracking phenomena;
- Possibility of installing the screws at reduced distances, adopting spacing and minimum edge distances smaller than those prescribed by Eurocode 5 (for details of the distances considered, please refer to the following chapter).

If all the above requirements are satisfied, the screw under examination may be considered suitable for use with the considered substrate and thickness.

To this end, an extensive experimental campaign was carried out, during which the screws were tested through insertion and installation into samples obtained from panels among the most commonly used as finishing materials in the carpentry and furniture sectors.

In the final evaluation of the connector performance in the various materials, the following parameters were considered:

- **Screw type:** partial-thread screws (SNK/HBS) and full-thread screws (HTS-H/HTS)
- **Screw diameter** (3.5 mm; 4 mm; 4.5 mm);
- **Panel material**
- **Panel thickness**
- **Installation orientation:** *wide face* or *narrow face* of the panel.

Test setup

In order to analyse the installation performance, the screws were installed using minimum distances and spacing significantly smaller than the limits prescribed by Eurocode 5, with the aim of reproducing real application conditions.

- For each diameter, specimens were produced using the same installation pattern, varying the distances according to the screw diameter.
- To evaluate the impact on finishes and the behaviour of the material, the screws were installed both until the head was fully seated and by limiting the insertion length to the threaded portion only, in order to observe how the thread interacts with the surface.

As a criterion for defining the minimum distances, a value equal to:

$$2 \times d_1 \text{ (where } d_1 \text{ is the nominal diameter of the screw)}$$

was adopted both as the edge distance and as the spacing between screws. In particular, the influence of the variation of each of these distances was analysed independently, without considering them as simultaneous conditions. This assumption was kept constant for all tested cases (installation on the wide face), since no significant issues emerged during installation.

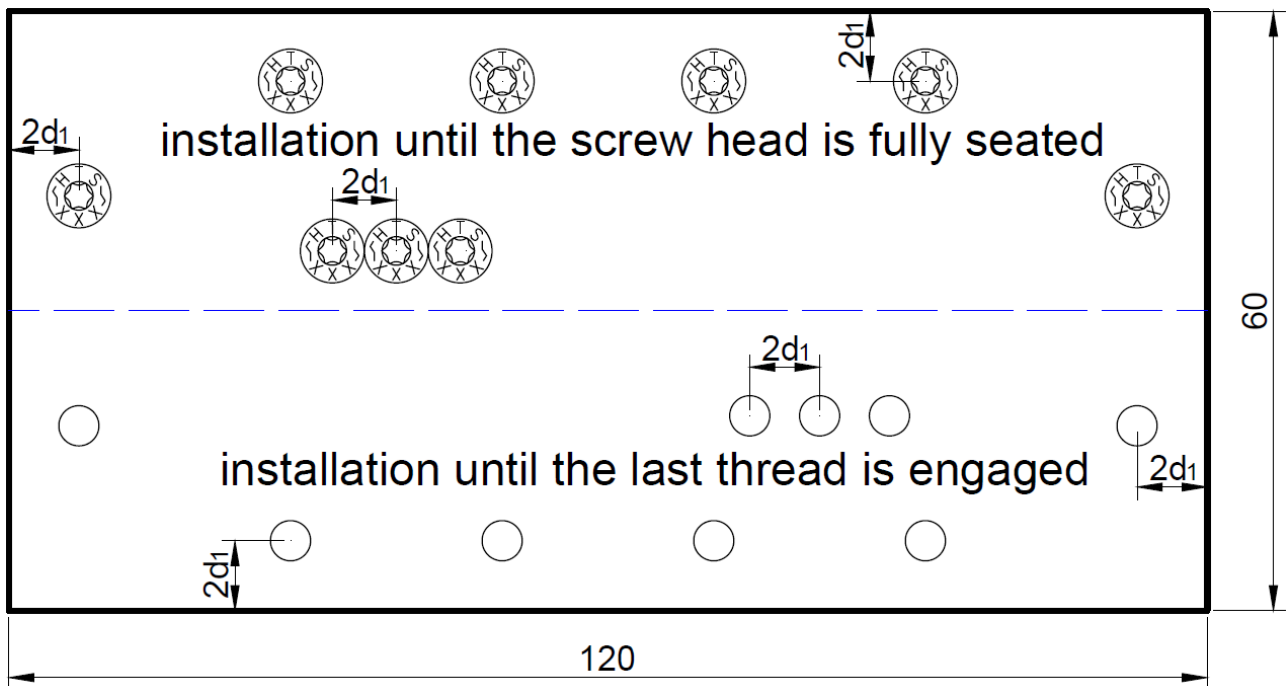
With regard to the installation of screws on the narrow face (within the panel thickness), several tests were carried out for each material in order to identify the minimum edge distances and screw spacing that could be adopted. In all cases, an initial minimum distance — both between screws and from the edge — equal to $2 \times d_1$ was adopted, verifying that the installation did not cause damage to the material; whenever this occurred, the distances were progressively increased until suitable values for the examined specimen were identified.

It should be noted that, in the case of the narrow face, the screws were installed only up to the smooth shank portion of the connector.

The dimensions of each specimen are equal to 120 mm × 60 mm. In order to facilitate the installation of the screws into the tested materials, the specimens were positioned on spruce wood supports, used exclusively for the execution of the test.

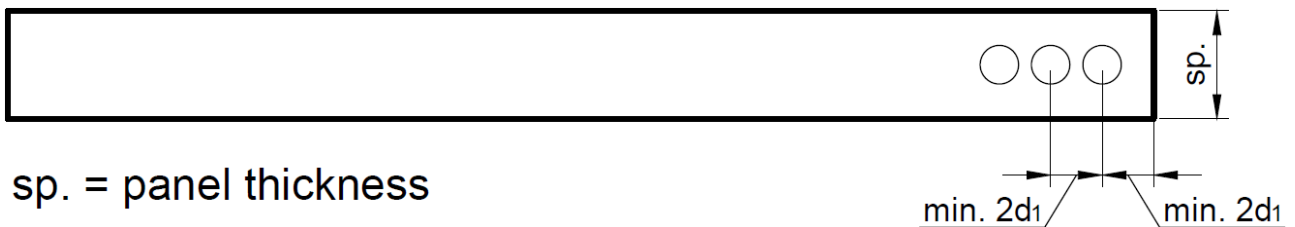
Wide face insertion

The test setup used for the execution of the tests on the *wide face* is shown below.



Narrow face insertion

The test setup used for the execution of the tests on the *narrow face* is shown below.



sp. = panel thickness

Tested materials

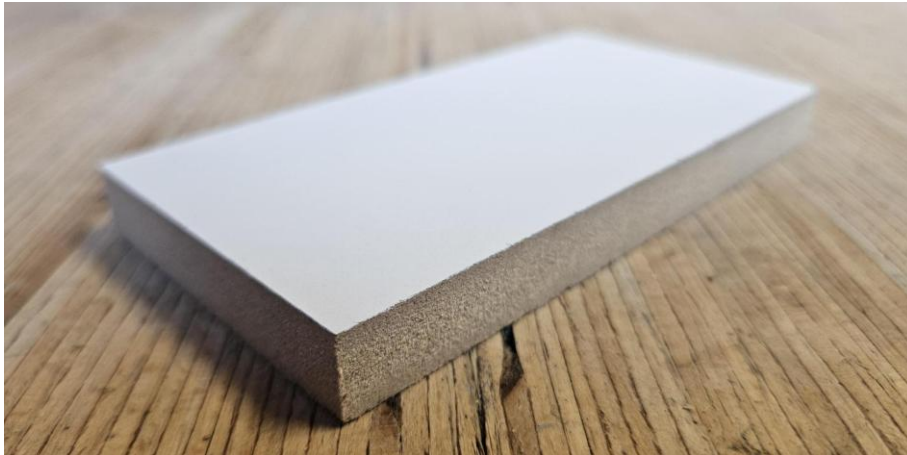
Melamin-faced board



Tested thicknesses: 13 mm and 16 mm.

Characteristics: particleboard panel coated with decorative paper impregnated with melamine resins. It is an economical solution widely used for flat-pack furniture and modern furnishings. It offers good resistance to scratches and stains, but is less valuable from both an aesthetic and structural point of view.

MDF (Medium-density fibreboard)



Tested thicknesses: 12 mm and 16 mm

Characteristics: medium-density fiberboard (MDF) panel. It has a smooth and compact surface, making it well suited for painting or lacquering. It is easy to machine and finish, but has poor resistance to moisture.

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Melamine-faced MDF panel

Tested thicknesses: 16 mm and 19 mm.

Characteristics: MDF coated with decorative papers or plastic films (e.g. melamine or PVC). It combines the density and machinability of MDF with the practicality of a pre-finished decorative surface. It is widely used for cabinet doors and modern furniture.

Plywood

Tested thicknesses: 12 mm and 15 mm.

Characteristics: Panel made of thin layers of wood veneers bonded together with alternating grain directions. It offers high mechanical strength, good dimensional stability, and durability. It is more expensive than particleboard and MDF and is used for high-quality furniture and load-bearing structures.

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Spruce

Tested thicknesses: 15 mm and 19 mm.

Characteristics: Soft solid wood, light in colour, easily machinable and lightweight. It is widely used for structural applications, rustic or traditional furniture. It has good mechanical strength but low surface hardness.

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Tested screws

Full-thread screw HTS/HTS-H

Dimensions and geometric characteristics:

Diameter [mm]	Length [mm]	Thread type	Thread pitch [mm]	Tip	Milling
3,5	50	Total – symmetric	1,80	3 Thorns	No
4	50	Total – symmetric	2,00	3 Thorns	No
4,5	50	Total – symmetric	2,20	3 Thorns	No



Partial-thread screw HBS/SNK

Dimensions and geometric characteristics:

Diameter [mm]	Length [mm]	Thread type	Thread pitch [mm]	Tip	Milling
3,5	50	Partial - asymmetric	2,15	3 Thorns	Sì
4	50	Partial - asymmetric	2,35	3 Thorns	Sì
4,5	50	Partial - asymmetric	2,55	3 Thorns	Sì



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Di seguito si riporta un riassunto dei test effettuati, differenziando per materiale del pannello, Thickness e vite utilizzata:

Panel material	Panel thickness	Screw type	Screw dimensions [diameter x length]	WIDE FACE INSERTION N° test performed	NARROW FACE INSERTION N° test performed
Melamin-faced board	13 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	3	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	3	5
			Ø4,5 x 50	1	0
	16 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	3	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	3	5
			Ø4,5 x 50	1	0
MDF	12 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
	16 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
Melamine-faced MDF	12 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
	19 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0

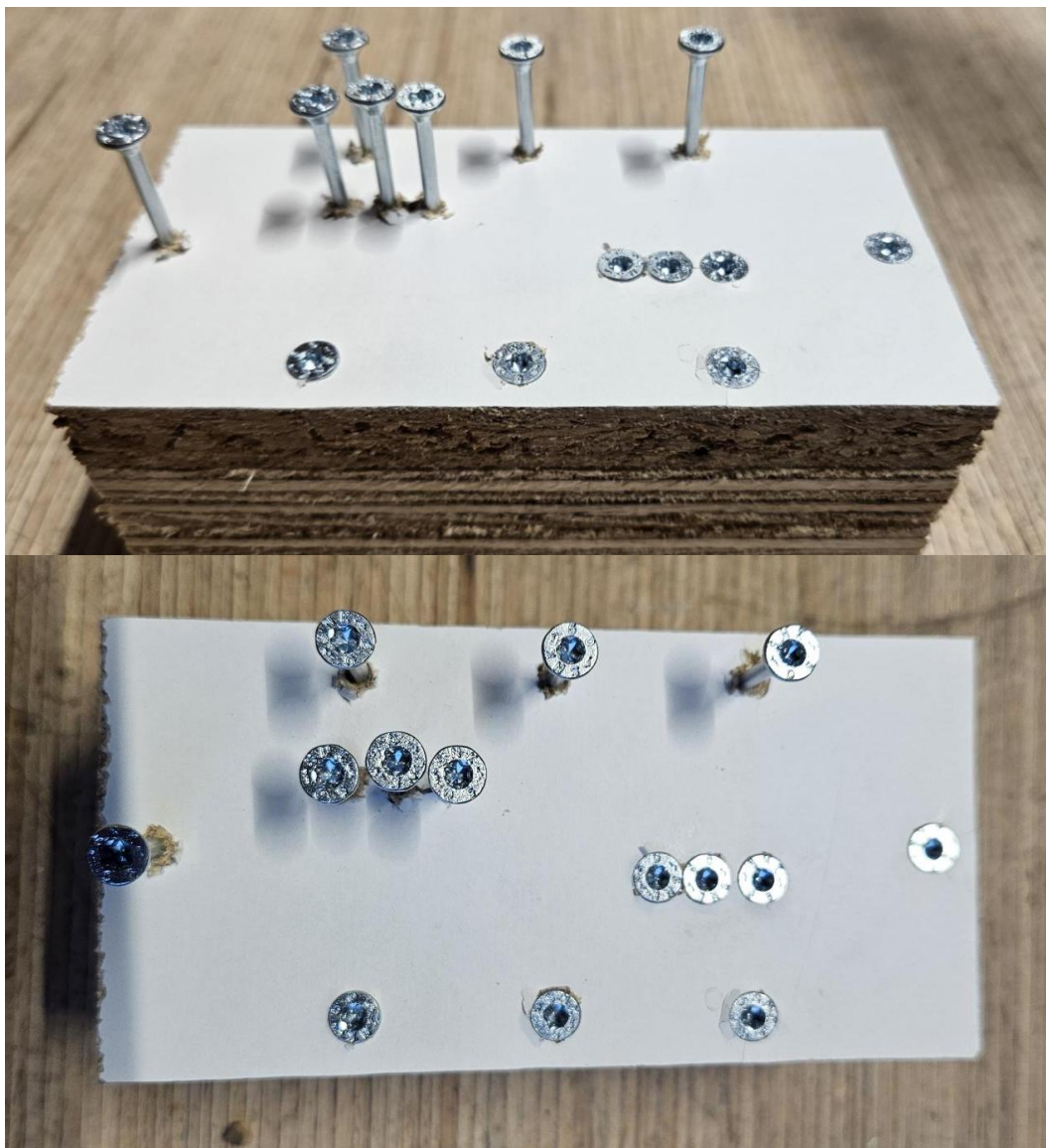
Panel material	Panel thickness	Screw type	Screw dimensions	WIDE FACE INSERTION	NARROW FACE INSERTION
Plywood	12 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
	15 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
Spruce	15 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
	19 mm	HBS SNK	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0
		HTS HTS-HT	Ø3,5 x 50	1	0
			Ø4,0 x 50	1	5
			Ø4,5 x 50	1	0

The following section shows the test results in the form of images of the specimens produced. Given the high number of tests carried out, only the most significant images for each material/thickness are shown; for the complete set of tests, please refer to **Annex 1** at the end of the document.

Wide face insertion – Ø3.5x50 screws

Melamin-faced board

13 mm thickness – SNK3550

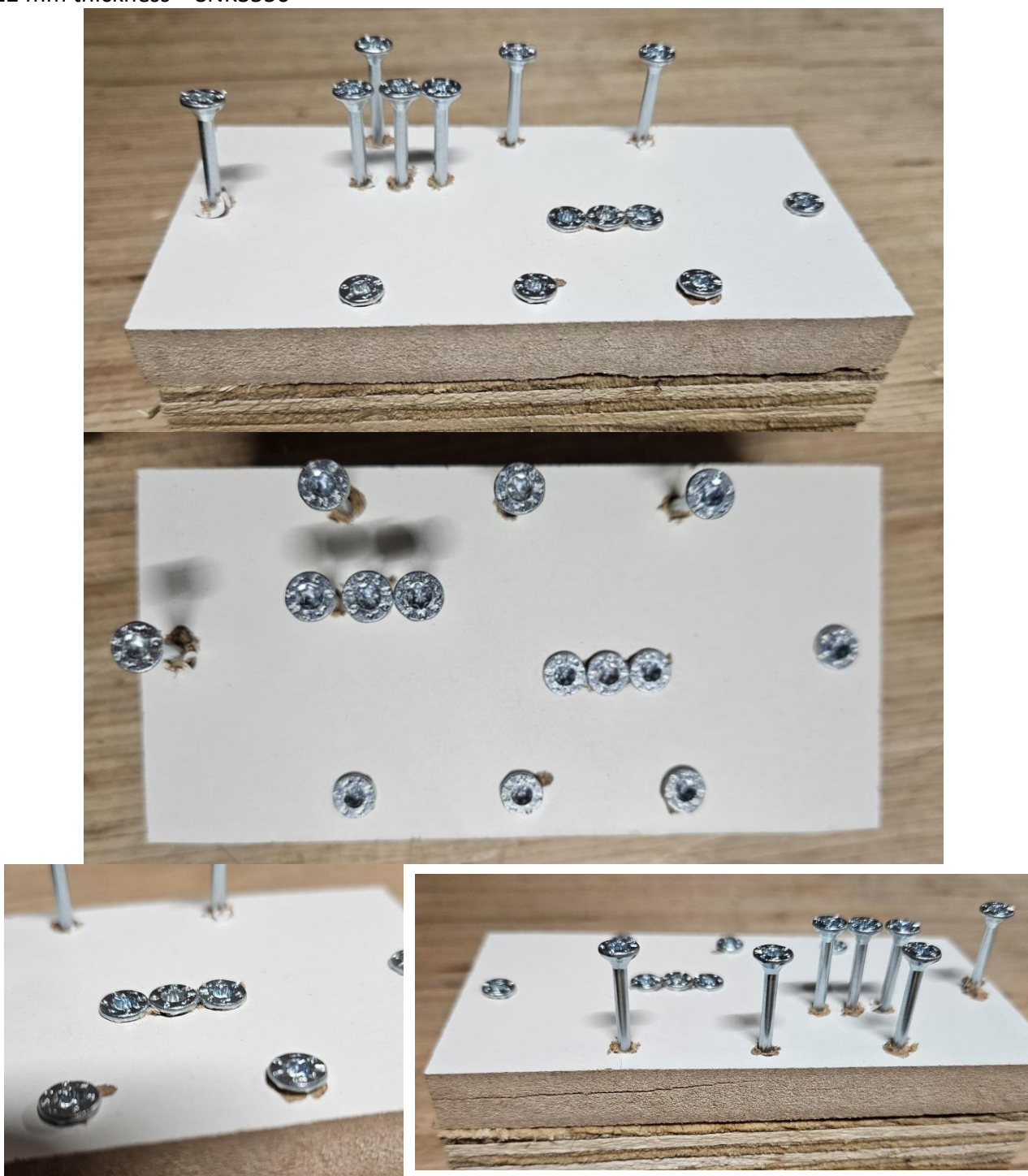


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MDF

12 mm thickness – SNK3550



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Melamine-faced MDF

12 mm thickness – SNK4550



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Plywood

12 mm thickness – SNK3550



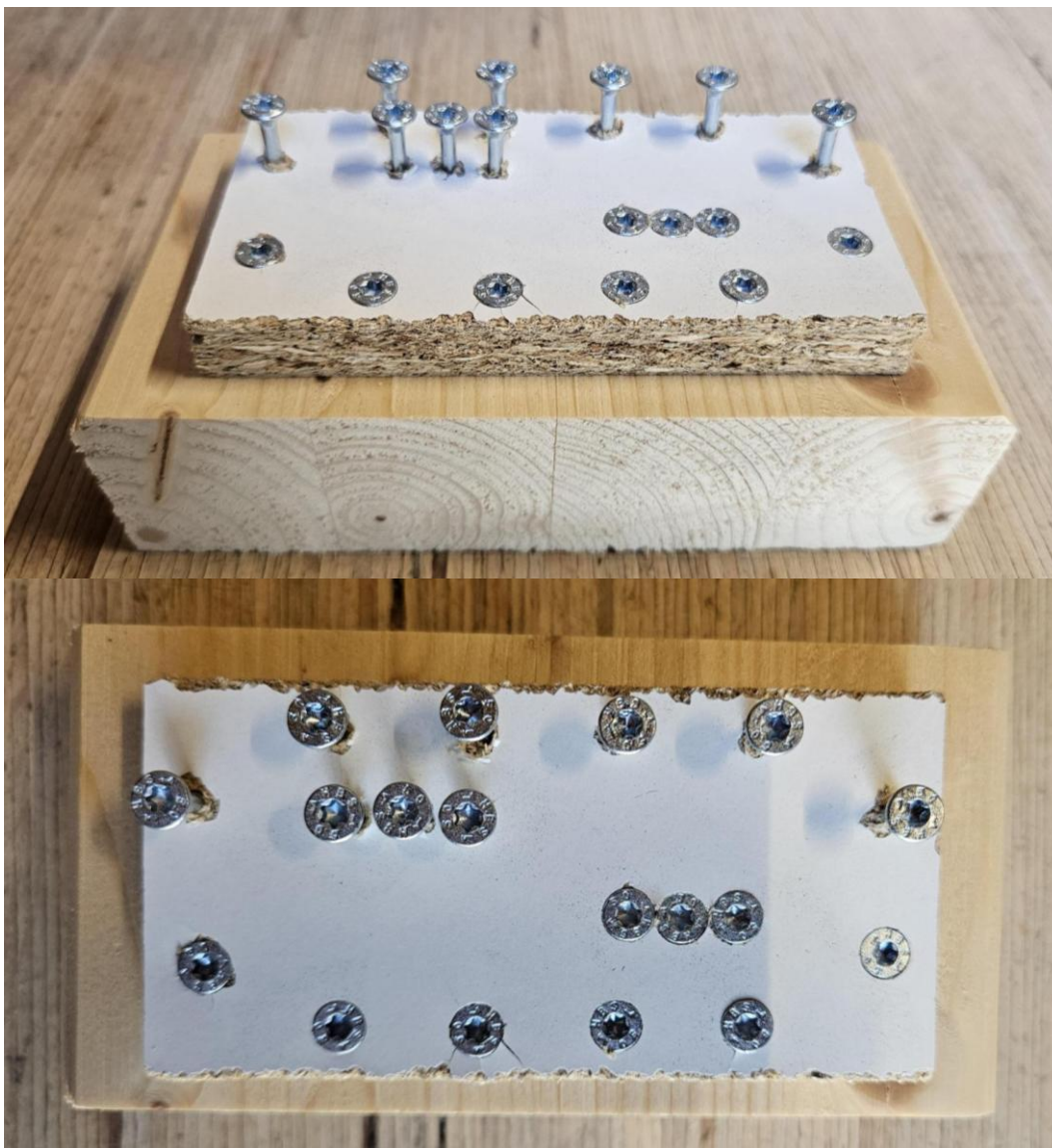
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Wide face insertion – Ø4.0x50 screws

Melamin-faced board

13 mm thickness – HBS450

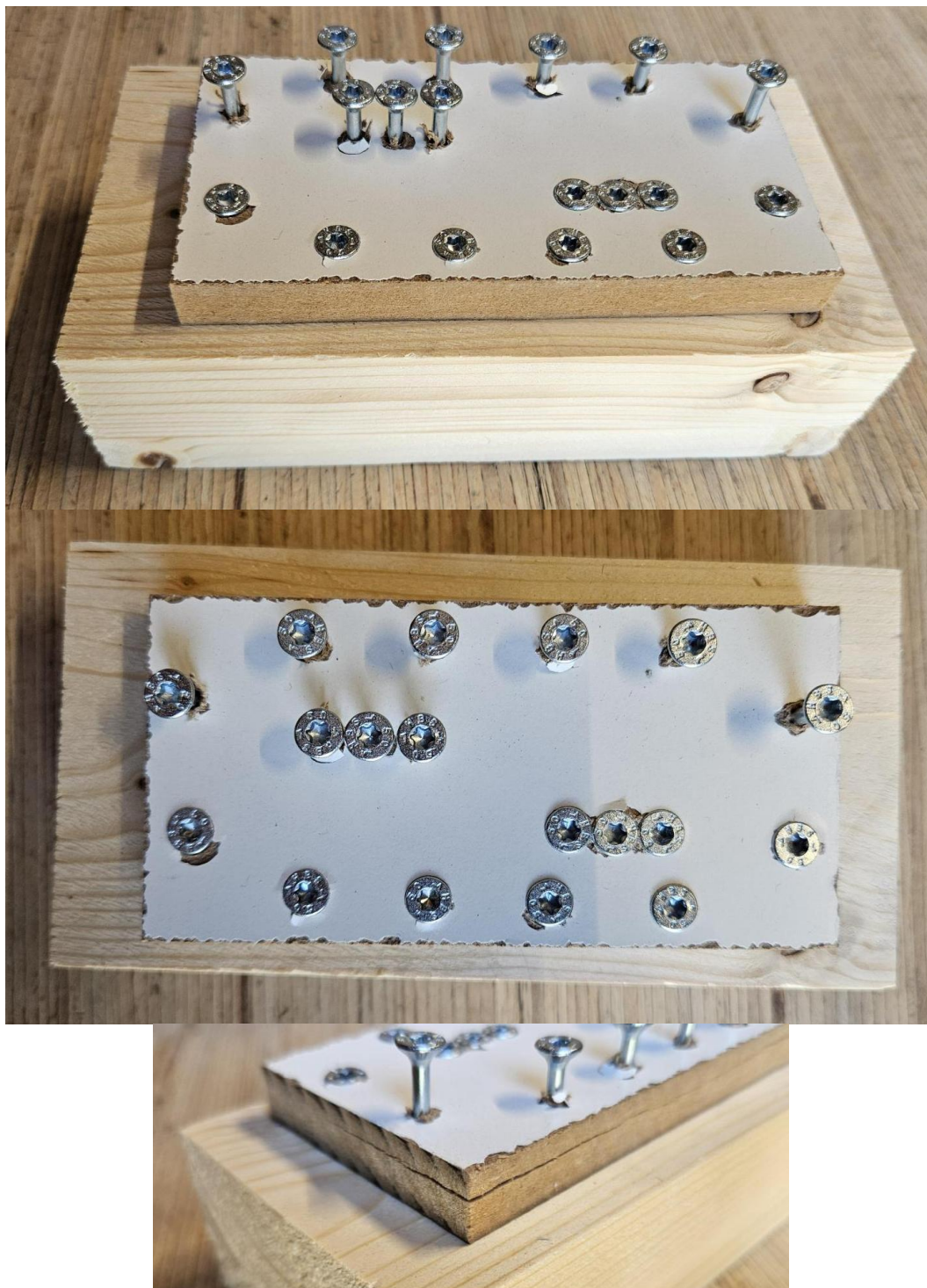


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MDF

12 mm thickness – HBS

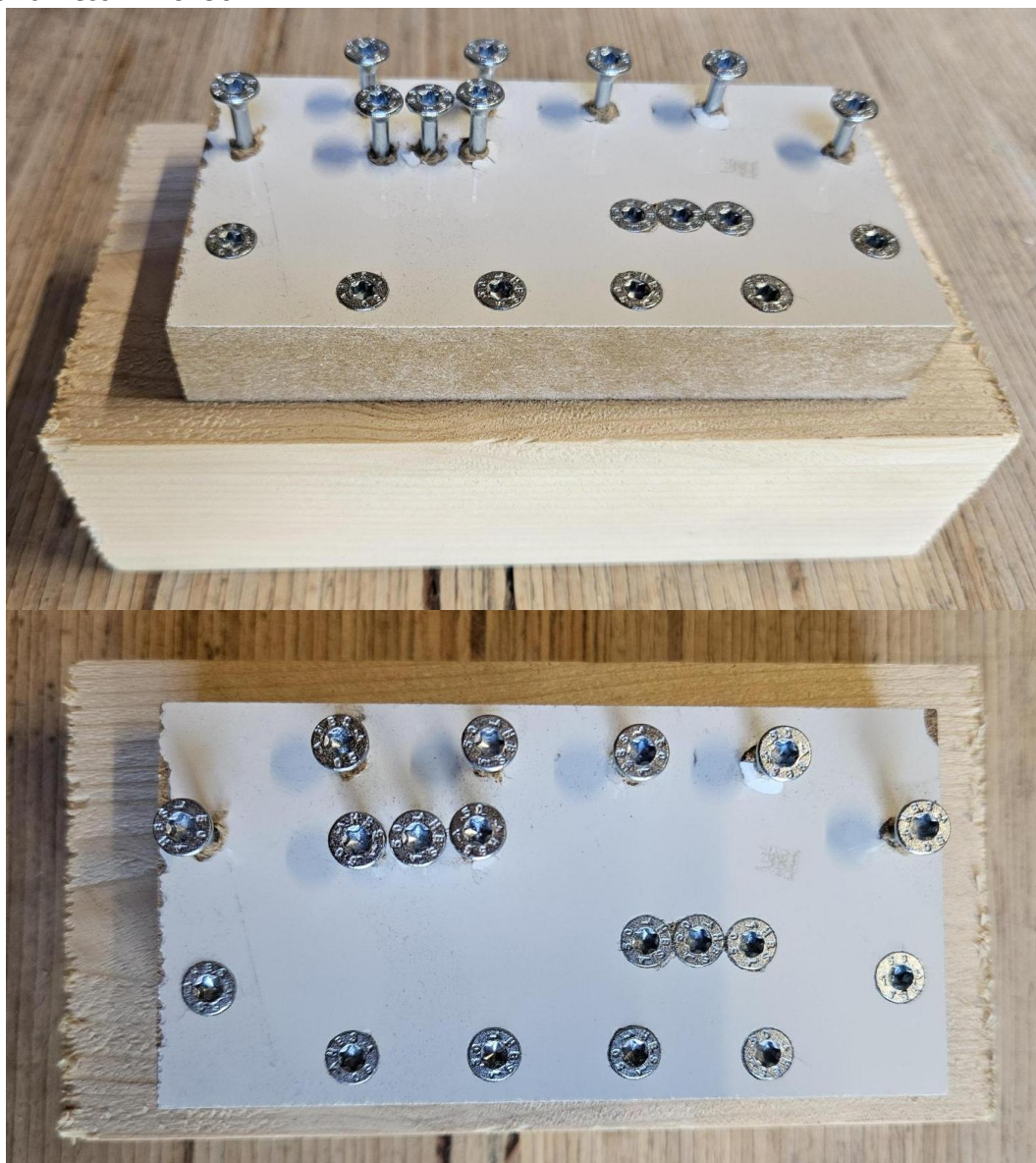


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Melamine-faced MDF

19 mm thickness - HBS450

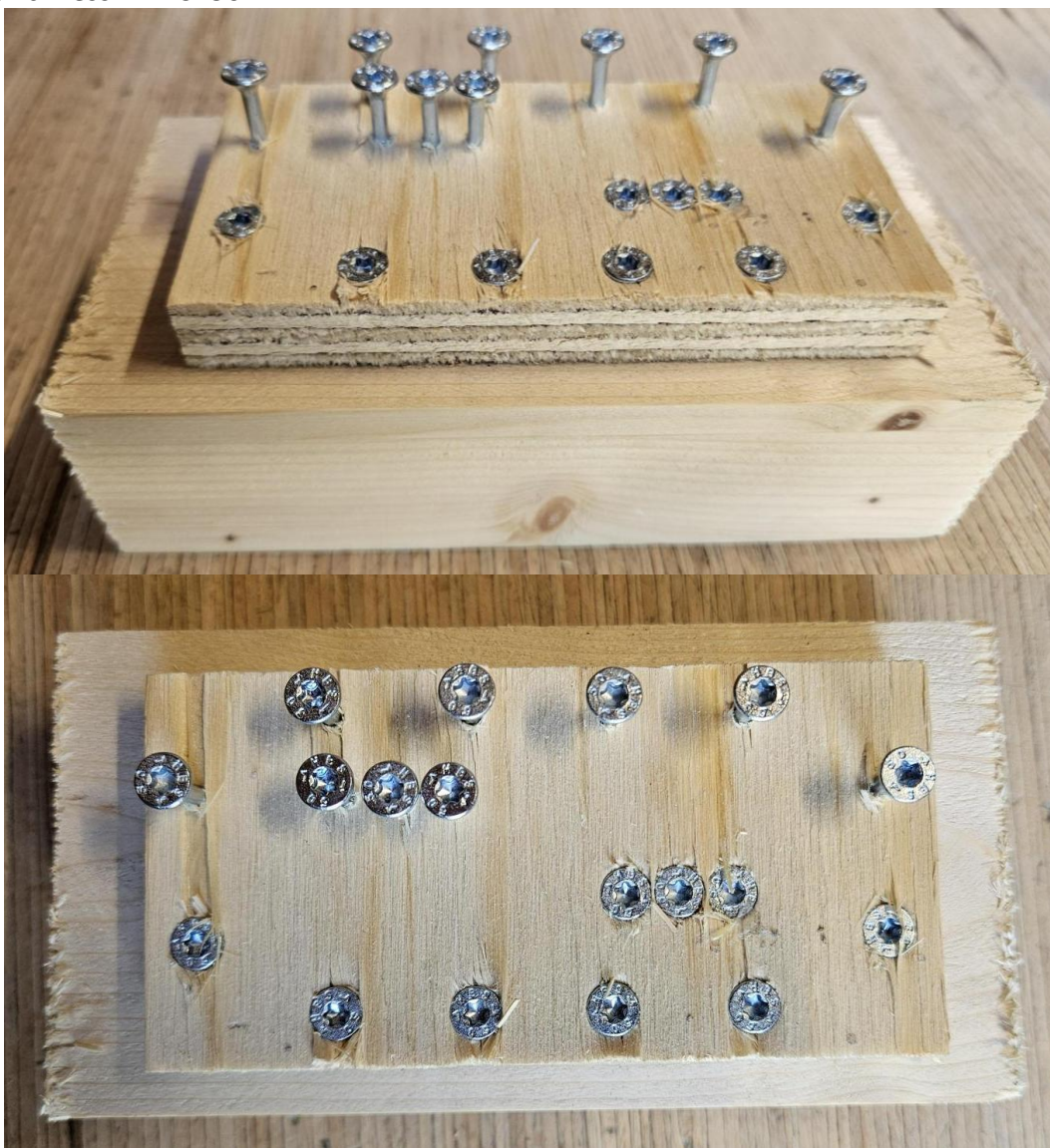


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Plywood

15 mm thickness – HBS450

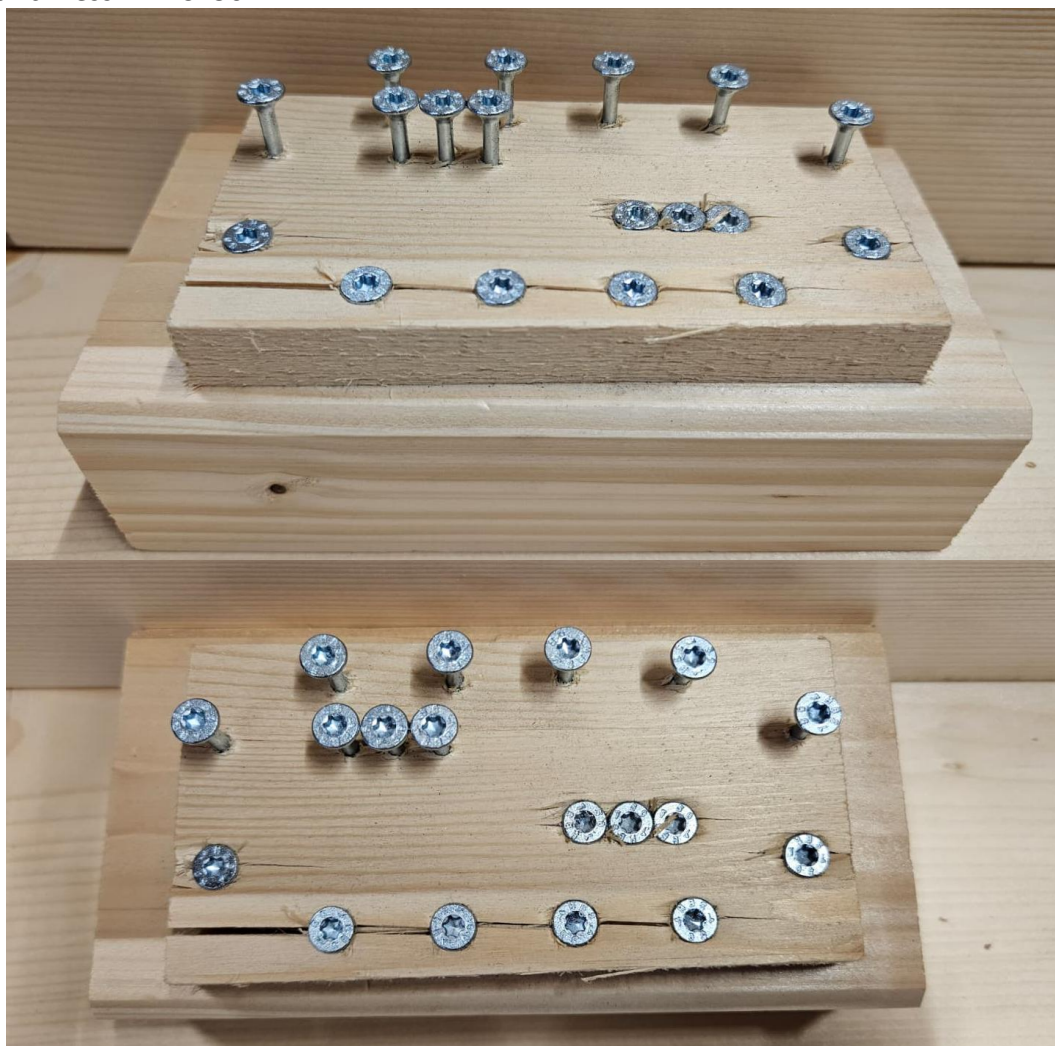


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Spruce

15 mm thickness – HBS450



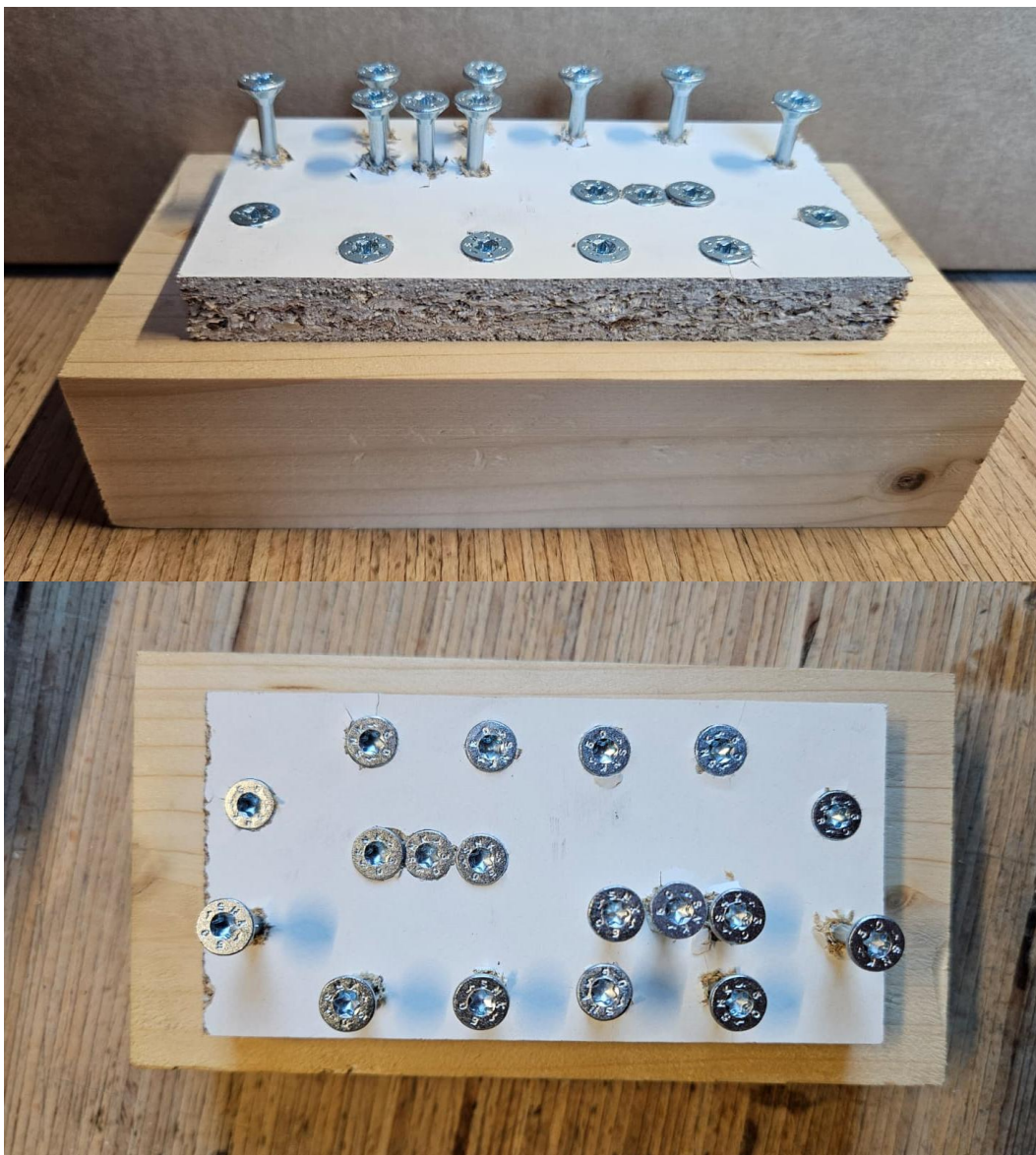
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Wide face – Ø4.5x50 screws

Melamin-faced board

13 mm thickness – SNK4550

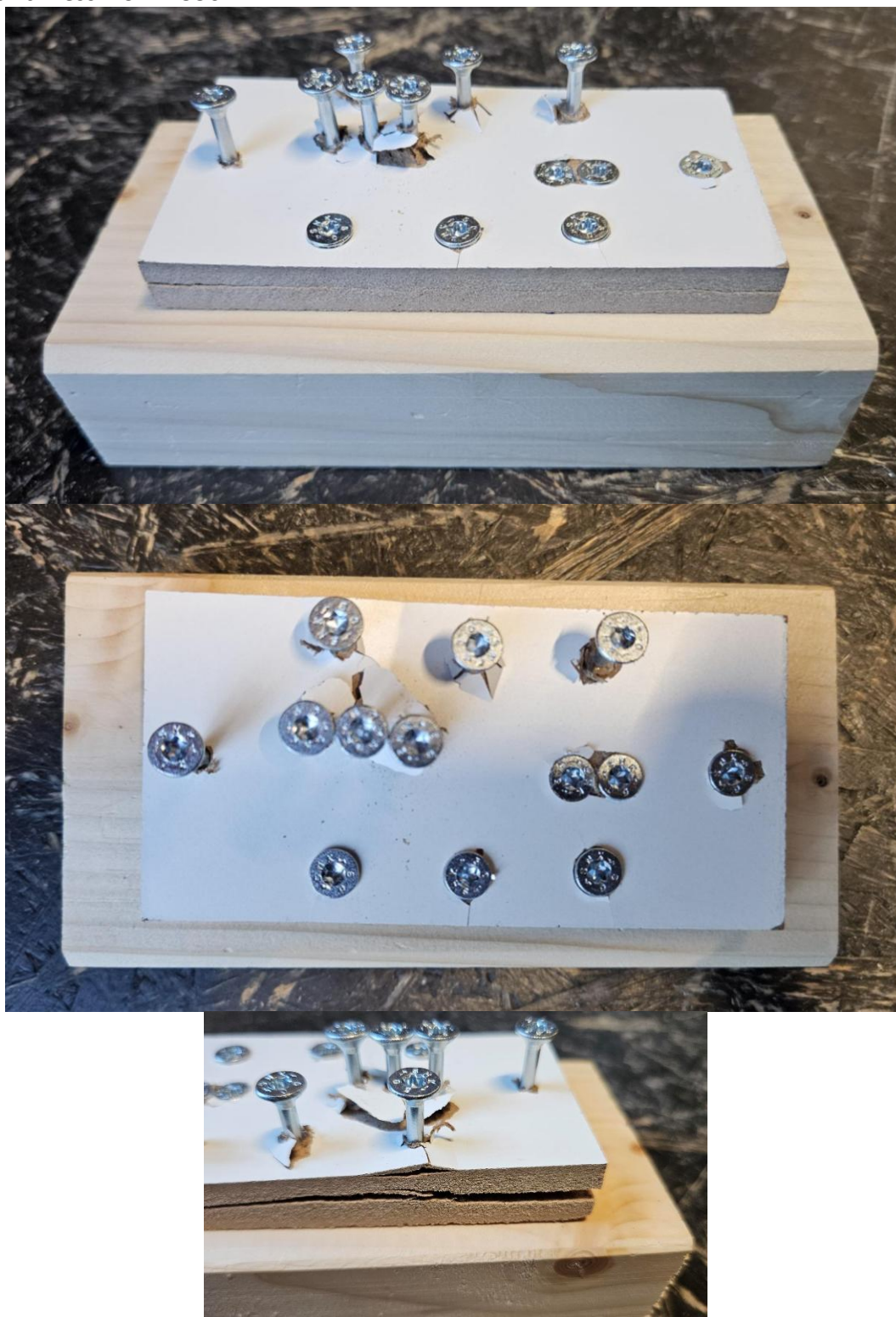


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MDF

12 mm thickness – SNK4550

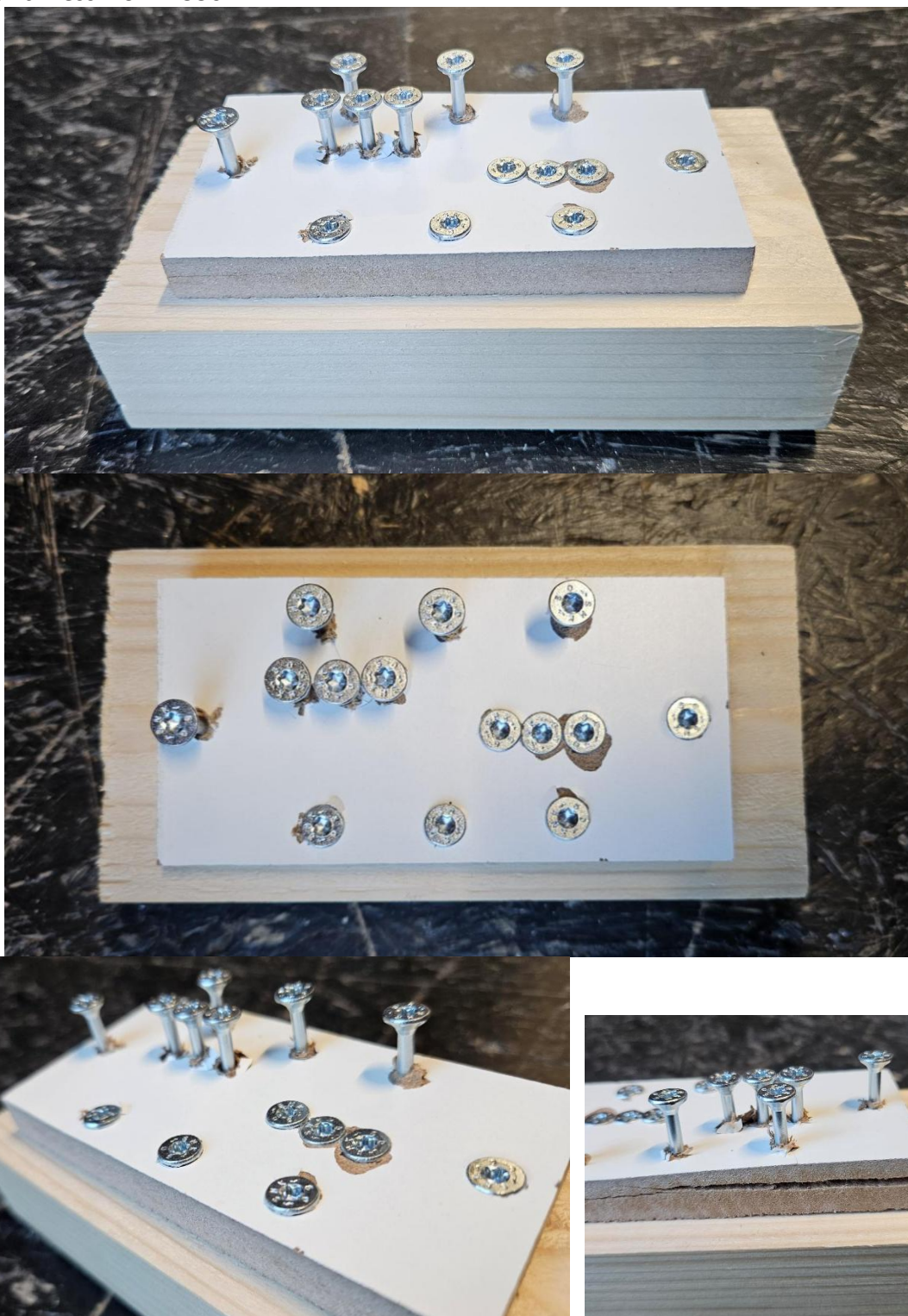


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Melamine-faced MDF

12 mm thickness – SNK4550



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Plywood

12 mm thickness – SNK4550



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Wide face insertion – Preliminary remarks

Qualitative considerations following the wide face tests are reported below, differentiated according to the substrate material.

Melamine-faced board

The surface finish is highly sensitive to drilling and tends to crack when the screw head comes into contact with the surface. Furthermore, due to the very slippery surface, it is not easy to keep the screw perfectly perpendicular to the panel surface.[CL8.1][AR8.2][AR8.3] This behaviour was observed for both screw families (HBS/SNK and HTS/HTS-HT) and for all tested diameters (Ø3.5 | Ø4.0 | Ø4.5).

However, it is still possible to install the screws with reduced minimum distances (edge distances and spacing) without compromising the substrate finish.

Plywood

Overall, the material performs fairly well, as screws can be installed easily, even very close to the edges or to one another.

MDF

The surface finish is damaged if the screw is driven in too quickly. In addition, due to the slippery surface, it is not easy to keep the screw perfectly perpendicular to the panel surface. For both tested thread types and for all considered diameters, significant surface cracking was observed, especially in the connector groups installed with a spacing equal to $2 \times d1$. Moreover, since MDF tends to separate through its thickness when stressed, large cracks formed along the specimen narrow face. In any case, these cracks are “hidden” once the screw head is fully seated against the surface..

Melamine-faced MDF

Similarly to MDF panels, the surface finish tends to be significantly damaged, especially if the screw is driven in too quickly. However, it is less slippery than standard MDF.

Spruce

The installation of screws in the wide face often leads to crack formation, which propagates when additional connectors are installed parallel to the grain direction of the panel (minimum distances are governed by EC5).

The following section presents a summary table of the minimum tested (and recommended) distances in the wide face configuration, applicable to all tested diameters:

Material	Melamine-faced board		Plywood		MDF		Melamine-faced MDF		Spruce	
Thickness	s = 13 mm	s = 16 mm	s = 12 mm	s = 15 mm	s = 15 mm	s = 19 mm	s = 15 mm	s = 19 mm	s = 12 mm	s = 19 mm
Edge distance	min. 2d	min. 2d	min. 2d	min. 2d	min. 2d	min. 2d	min. 2d	min. 2d	X	X
Screw spacing	min. 2d	min. 2d	min. 2d	min. 2d	min. 2d ¹	min. 2d ¹	min. 2d ¹	min. 2d ¹	X	X

¹ In this case, it is possible to install the screws. The surface may show some damage, which is nevertheless considered acceptable.

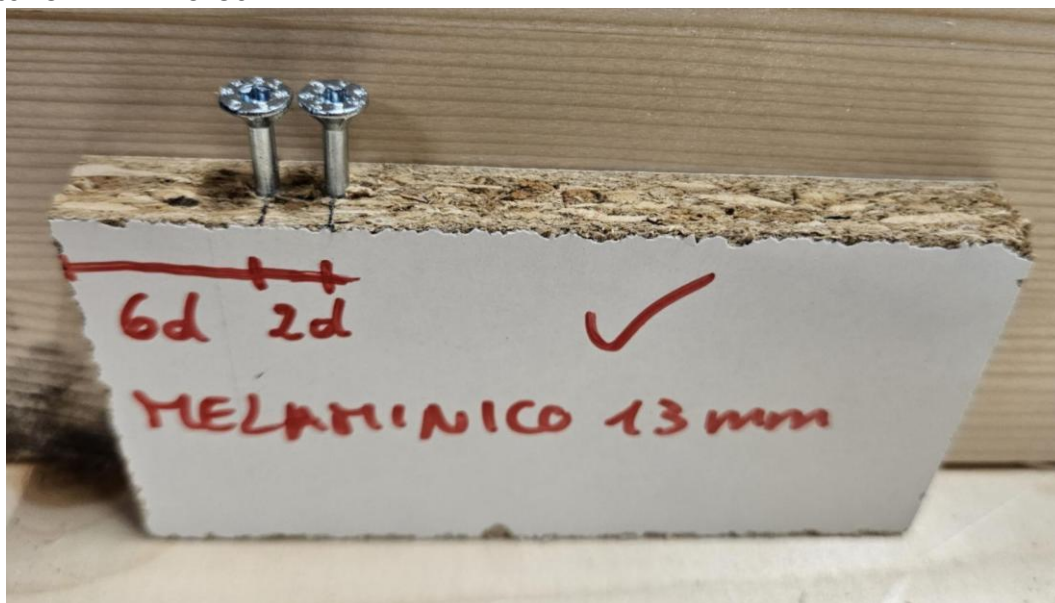
X = Test not passed: the screw cannot be installed in the material/thickness.

Narrow face insertion – Ø4.0x50 screws

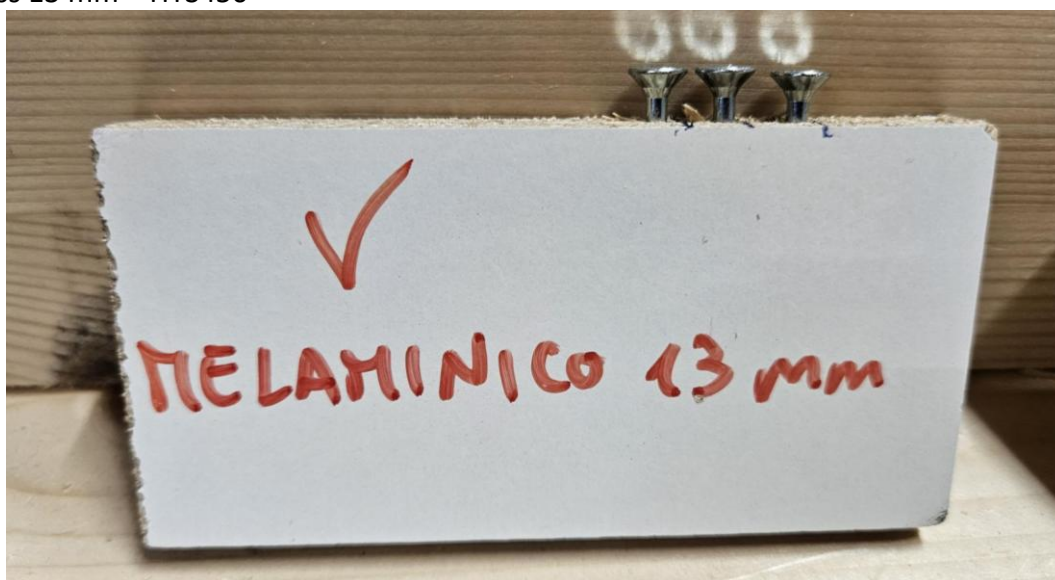
For this test configuration, only screws with a diameter of 4 mm were analysed.

Melamine-faced board

Thickness 13 mm – HBS450

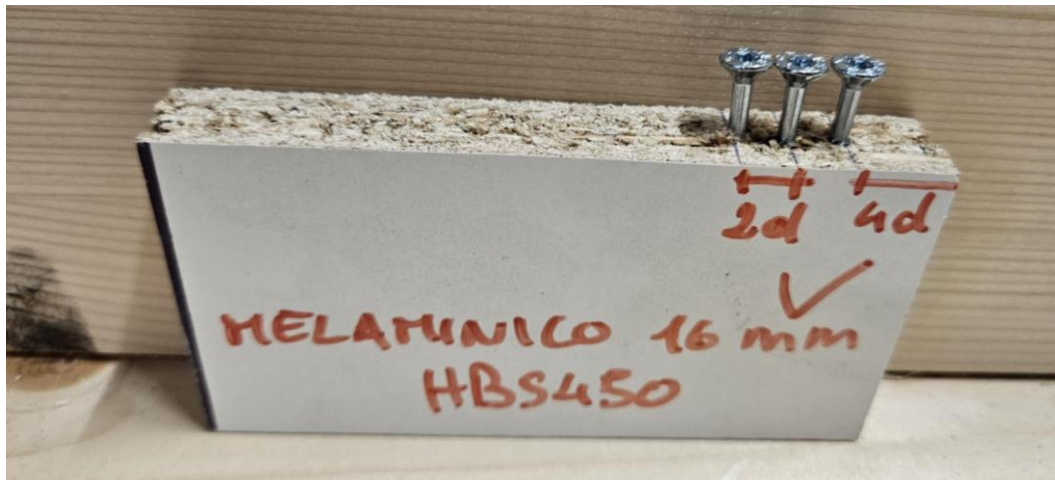


Thickness 13 mm – HTS450

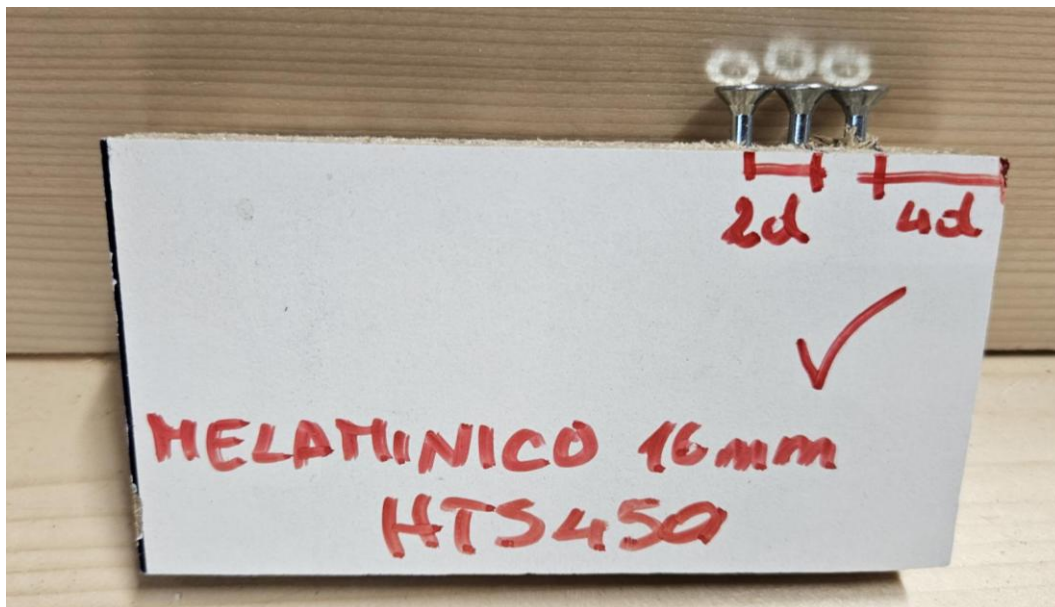


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Thickness 16 mm – HBS450



Thickness 13 mm – HTS450



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MDF/Melamine-faced MDF

Thickness 19 mm – HBS450



Plywood

Thickness 15 mm – HBS450



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Spruce

Thickness 15 mm – HBS450



Thickness 19 mm – HBS450



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Narrow face insertion – Preliminary remarks

Below are the qualitative considerations following the wide face tests, differentiated according to the substrate material.

Melamine-faced board

Screws can be installed by increasing the initially assumed minimum distances ($2 \times d_1$), without crack formation.

Plywood

For panels with a thickness of 12 mm, the considered screw diameter is too large, leading to panel deformation (buckling); therefore, a reduced thickness should be adopted. For a thickness of 15 mm, screw installation was straightforward and no cracking was observed.

MDF / Melamine-faced MDF

Installation in the thickness of the panel is not feasible, as the material—characterised by low cohesion—exhibits cracking phenomena regardless of the screw position, i.e., at any edge distance. Furthermore, the presence of multiple connectors leads to further propagation and widening of the cracks that form.

Spruce

In this case, screws could be installed without particular issues, slightly increasing the initially assumed minimum distances (both edge distances and spacing).

A summary table of the minimum tested (and recommended) distances in the *narrow face* configuration is reported below.

Material	Melamine-faced board		Plywood		MDF		Melamine-faced MDF		Spruce	
Thickness	s = 13 mm	s = 16 mm	s = 12 mm	s = 15 mm	s = 15 mm	s = 19 mm	s = 15 mm	s = 19 mm	s = 12 mm	s = 19 mm
Edge distance	min. 6d	min. 5d	X	min. 3d	X	X	X	X	min. 3d	min. 2d
Screw spacing	min. 2d	min. 2d	X	min. 2d	X	X	X	X	min. 3d	min. 2d

X = Test not passed: the screw cannot be installed in the material/thickness.

Concluding remarks

The final evaluations were carried out based on the previously defined parameters. The main observations are reported below, divided by panel material type.

- **Melamine-faced board:** The melamine-faced board proved to be a particularly delicate material, especially in terms of surface finish. Crack formation during installation (wide face) was strongly influenced both by the quality/cohesion of the melamine adhesive layer and by the screw driving speed. No significant differences were observed between full-threaded and partial-threaded screws. With regard to minimum edge distances, thinner panels tended to deform more and were more sensitive to screw insertion. However, by increasing these distances, it is still possible to install the screws without causing excessive panel deformation.
- **MDF/Melamine-faced MDF:** MDF panels showed marked surface degradation, particularly when screws were installed with a spacing equal to 2 times the diameter. Significant cracking was also observed when insertion stopped in correspondence with the smooth shank portion of the screw.
 - o HBS/SNK installation → a longer setting time was observed compared to full-threaded screws. In almost all cases, it was not possible to drive the screw head flush with the panel surface, as the smooth shank embedded in the material did not provide sufficient pull-out capacity.
 - o HTS/HTS-H installation → installation was faster, but with more evident damage to the surface finish compared to HBS/SNK.
- **Plywood:** Plywood did not show any particular critical issues. In some cases, damage to the surface veneer layer was observed, likely due to the high number of screws installed in a limited area. Also in this material, HTS/HTS-H screws resulted in shorter installation times.
- **Spruce:** Spruce proved to be poorly suited for wide face installations with reduced spacing, as it is strongly influenced by the minimum distance requirements defined by Eurocode 5. In almost all tested configurations, cracking occurred. No issues were observed, instead, in narrow face installations.

As screw diameter increases, a general reduction in performance was observed. With smaller diameters, improvements were found in terms of:

- reduced setting time;
- less damage to the surface finish;
- lower force required to initiate screw insertion.

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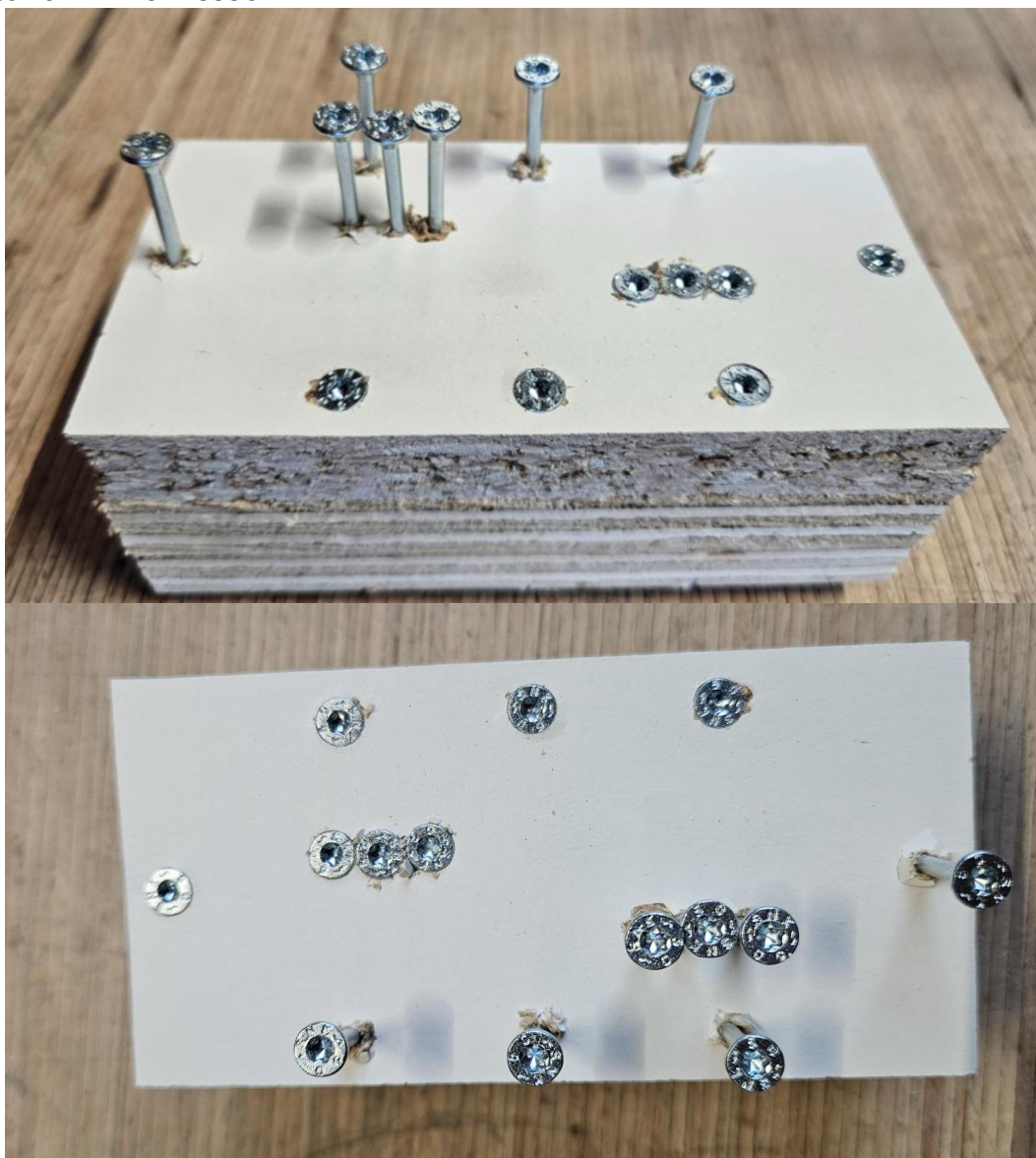
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Annex 1

Wide face insertion – Ø3.5x50 screws

Melamine-faced board

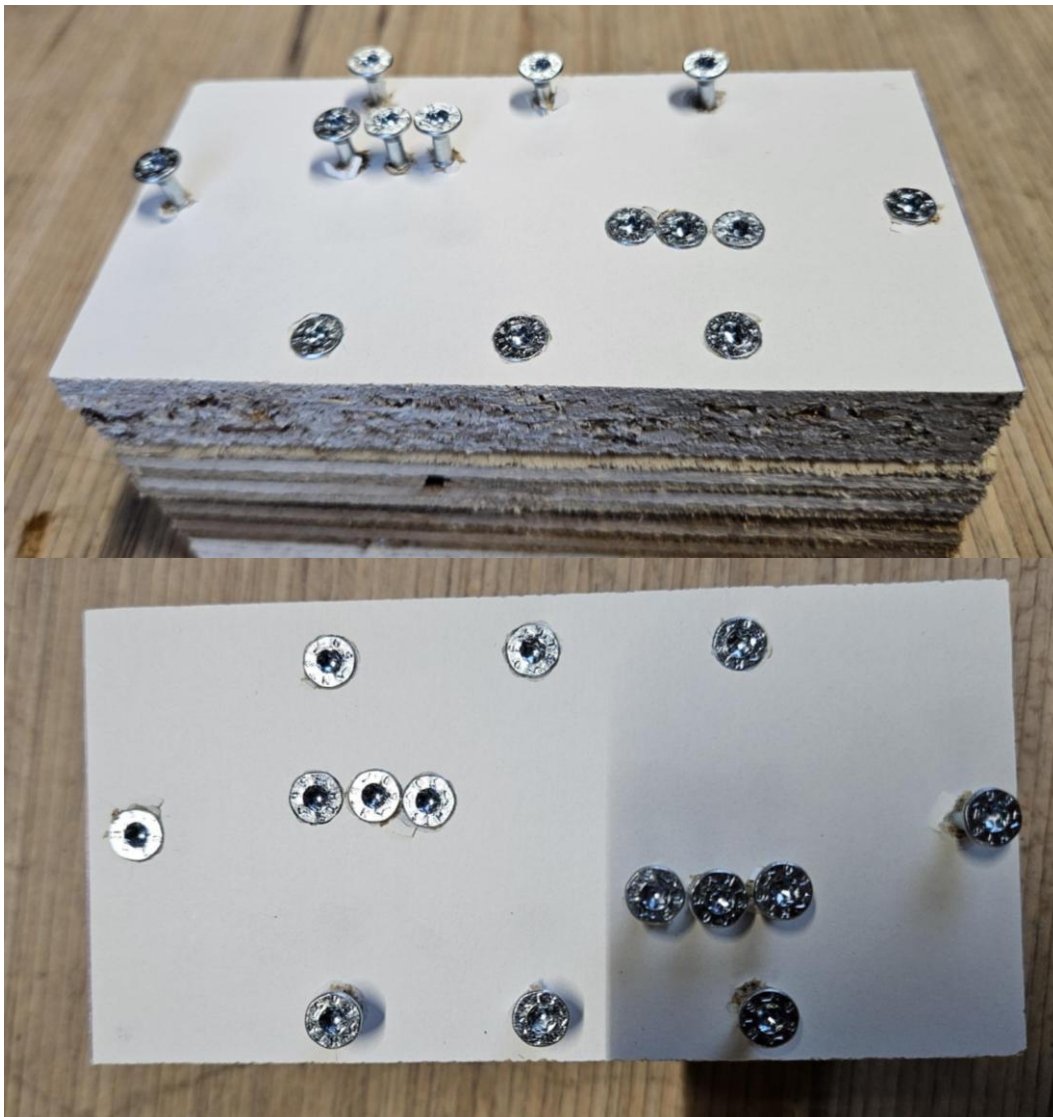
Thickness 16 mm – SNK3550



ROTHO BLAAS SRL

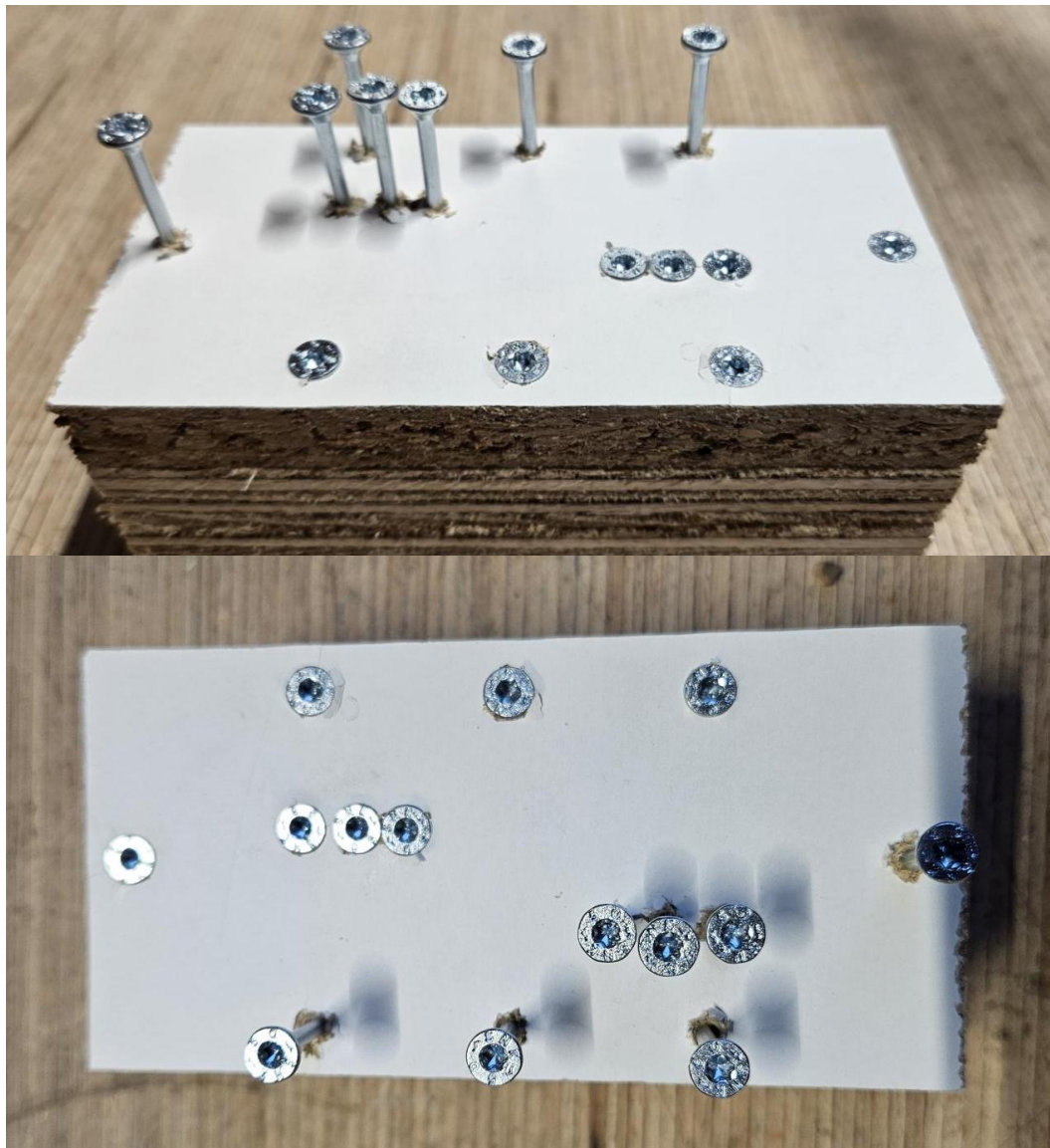
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Thickness 16 mm – HTS3550

**ROTHO BLAAS SRL**

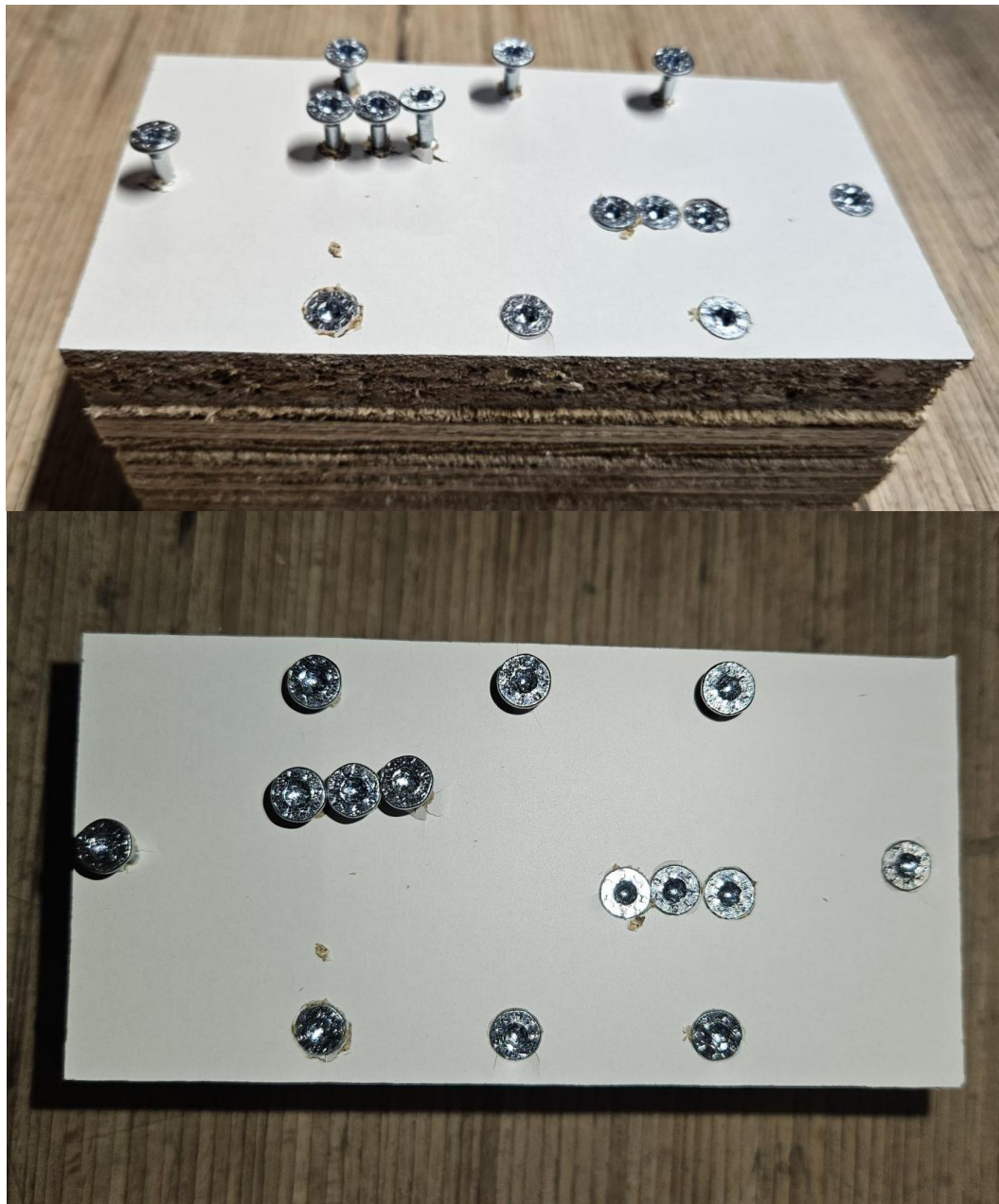
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Thickness 13 mm – SNK3550

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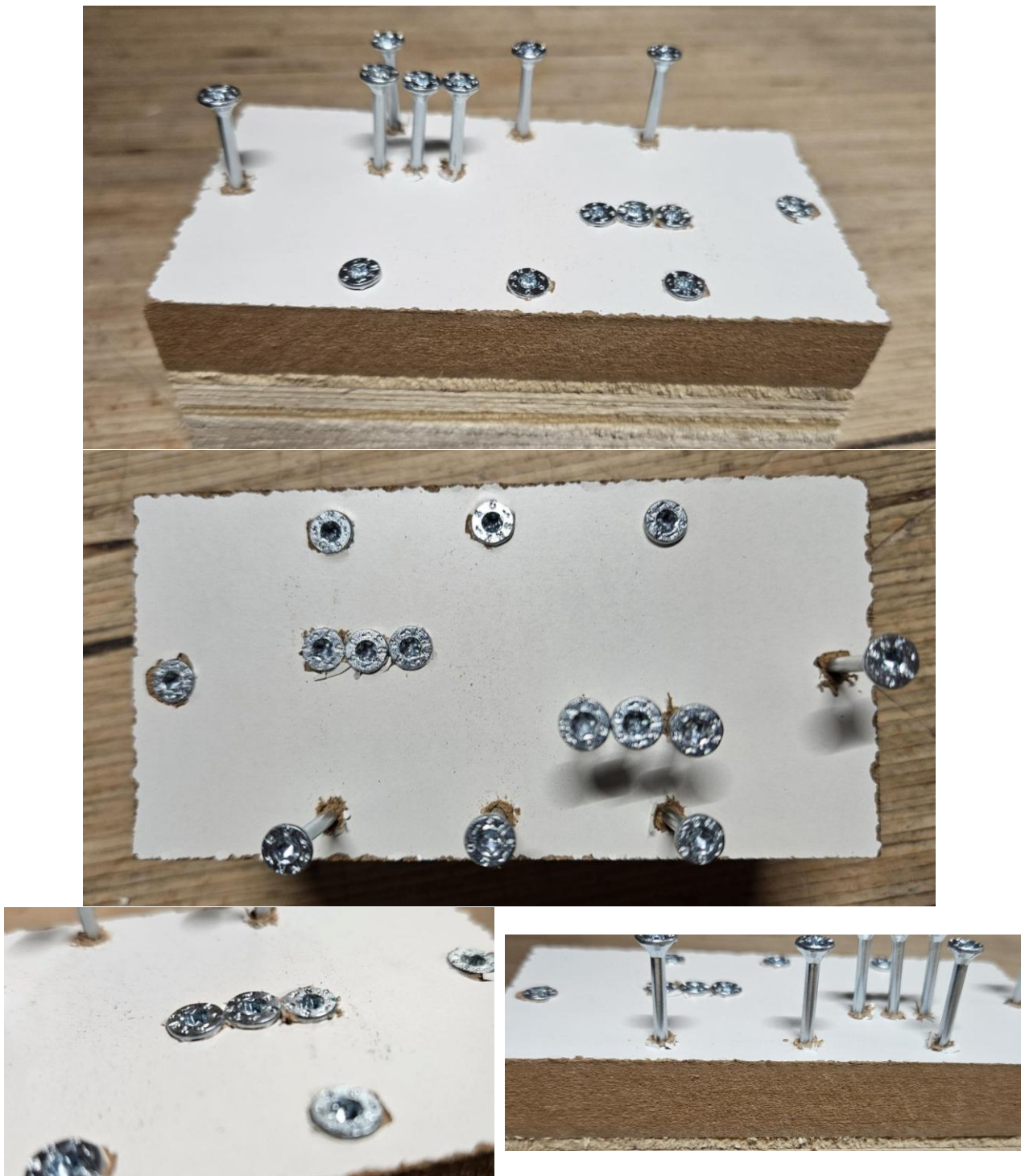
Thickness 13 mm – HTS4550

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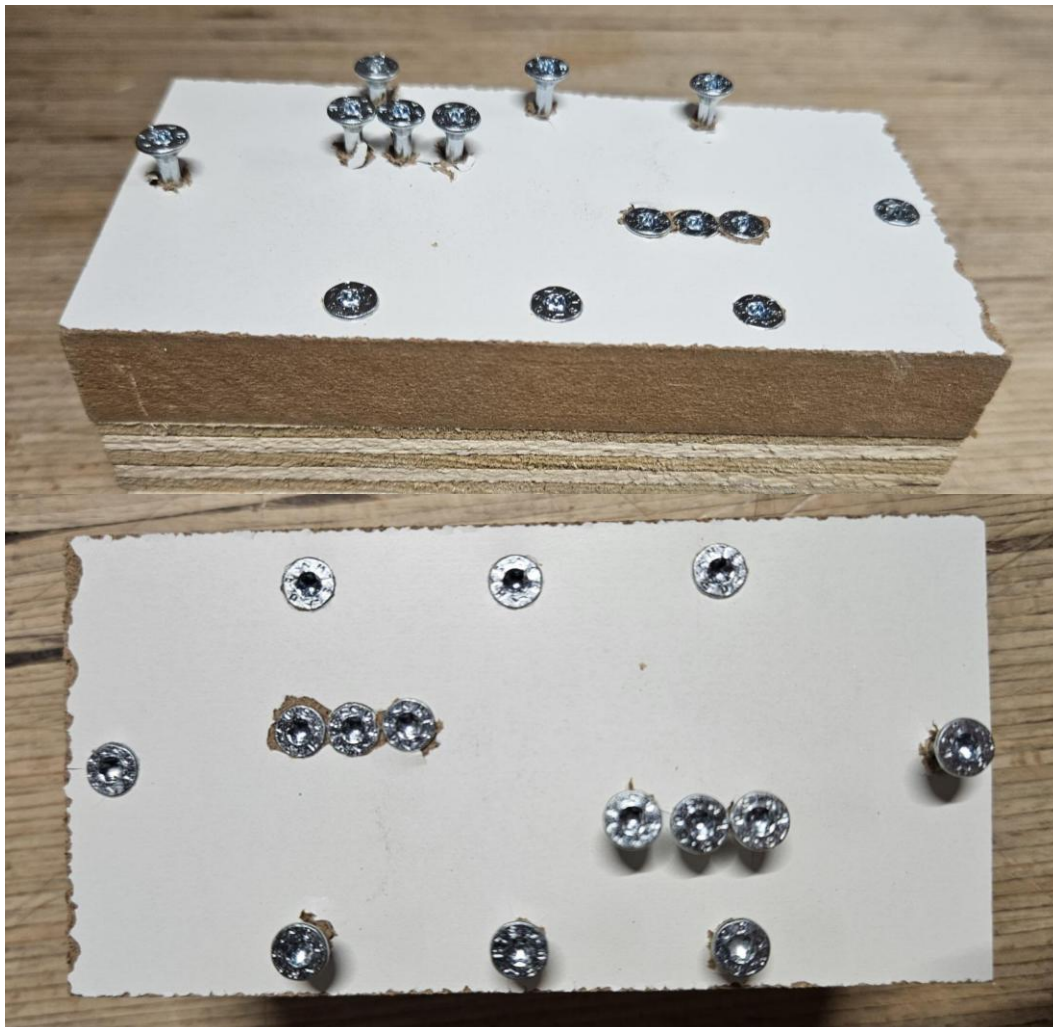
MDF

Thickness 16 mm – SNK3550

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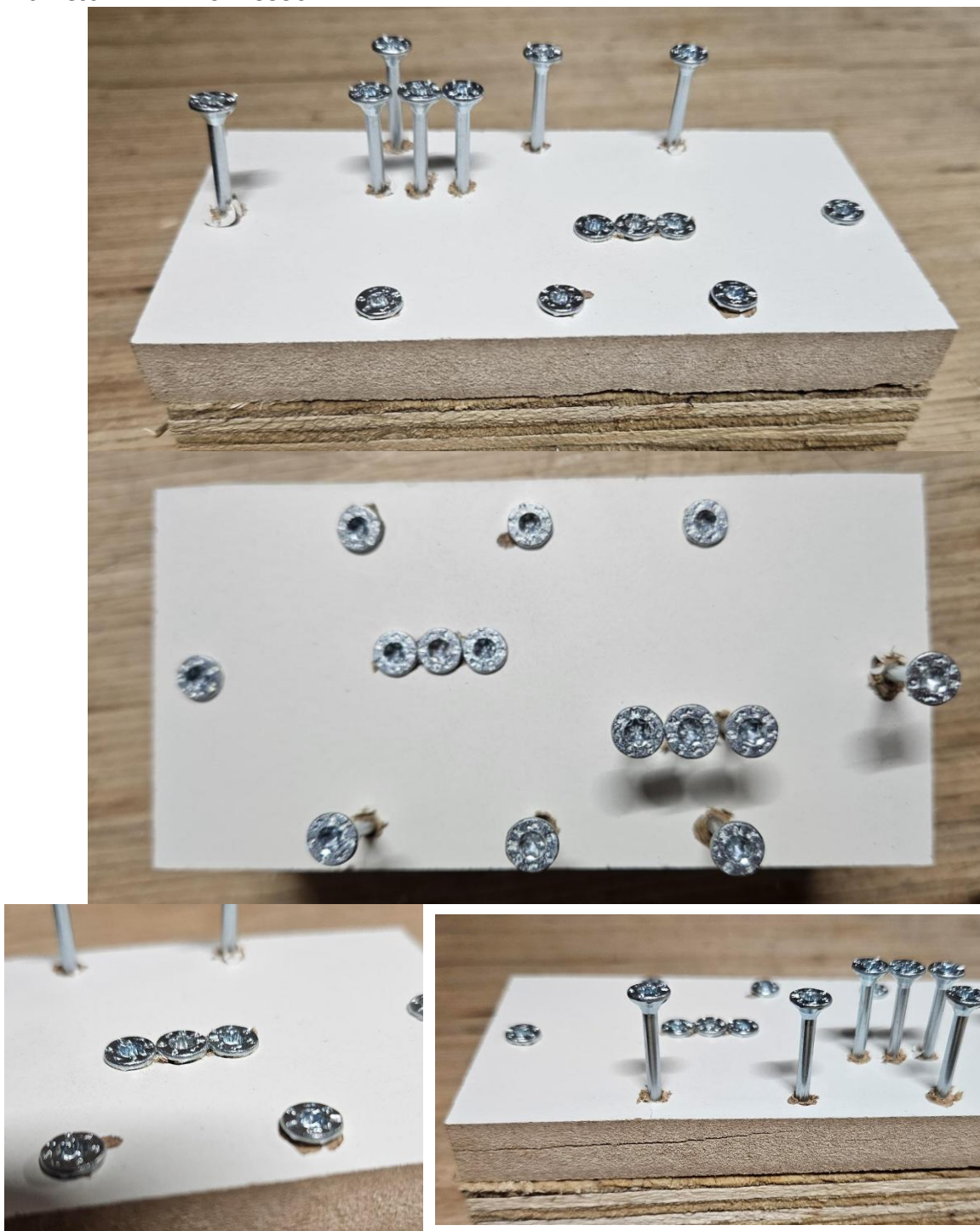
Thickness 16 mm – HTS3550



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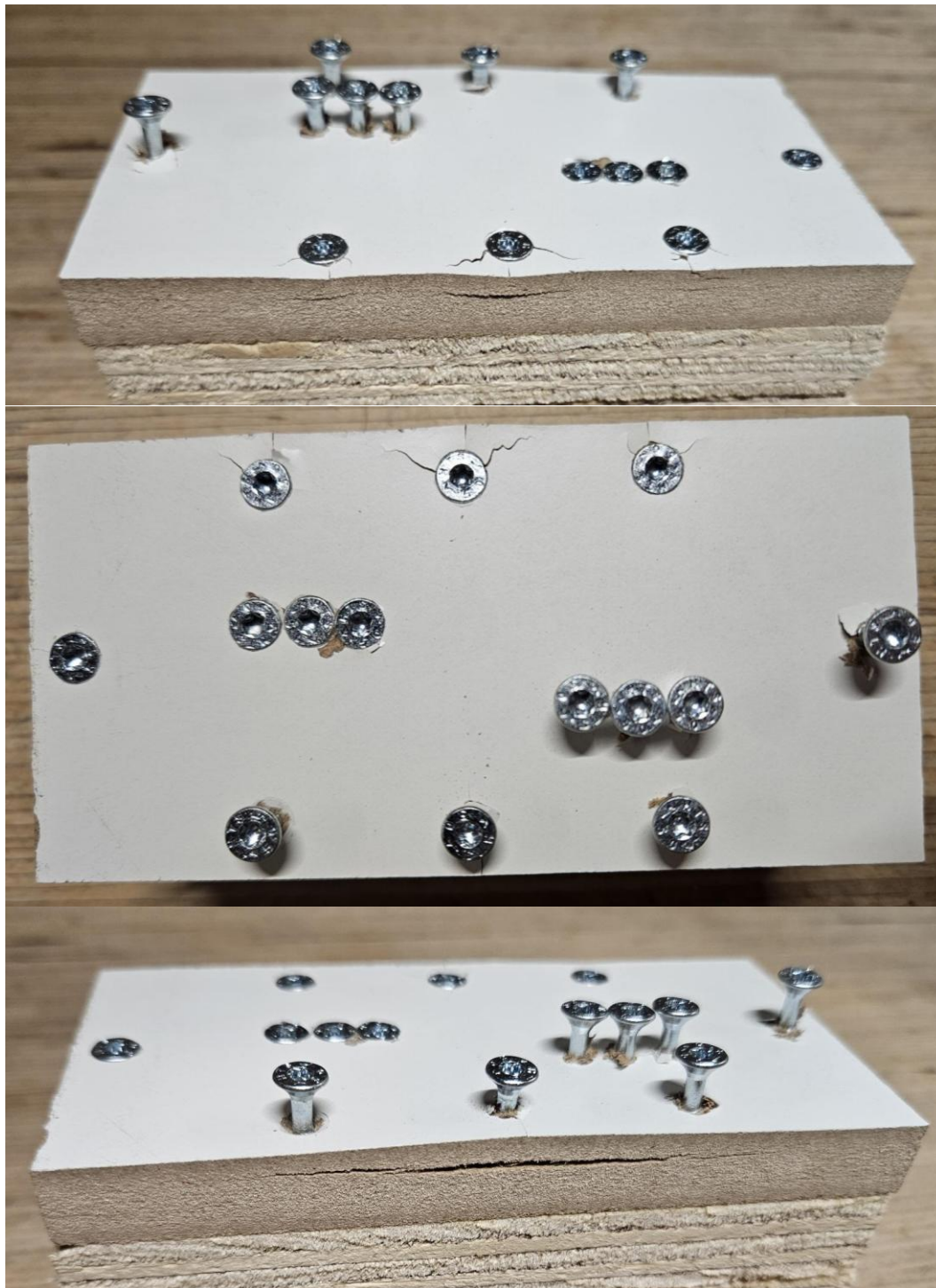
Thickness 12 mm – SNK3550



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Thickness 12 mm – HTS3550

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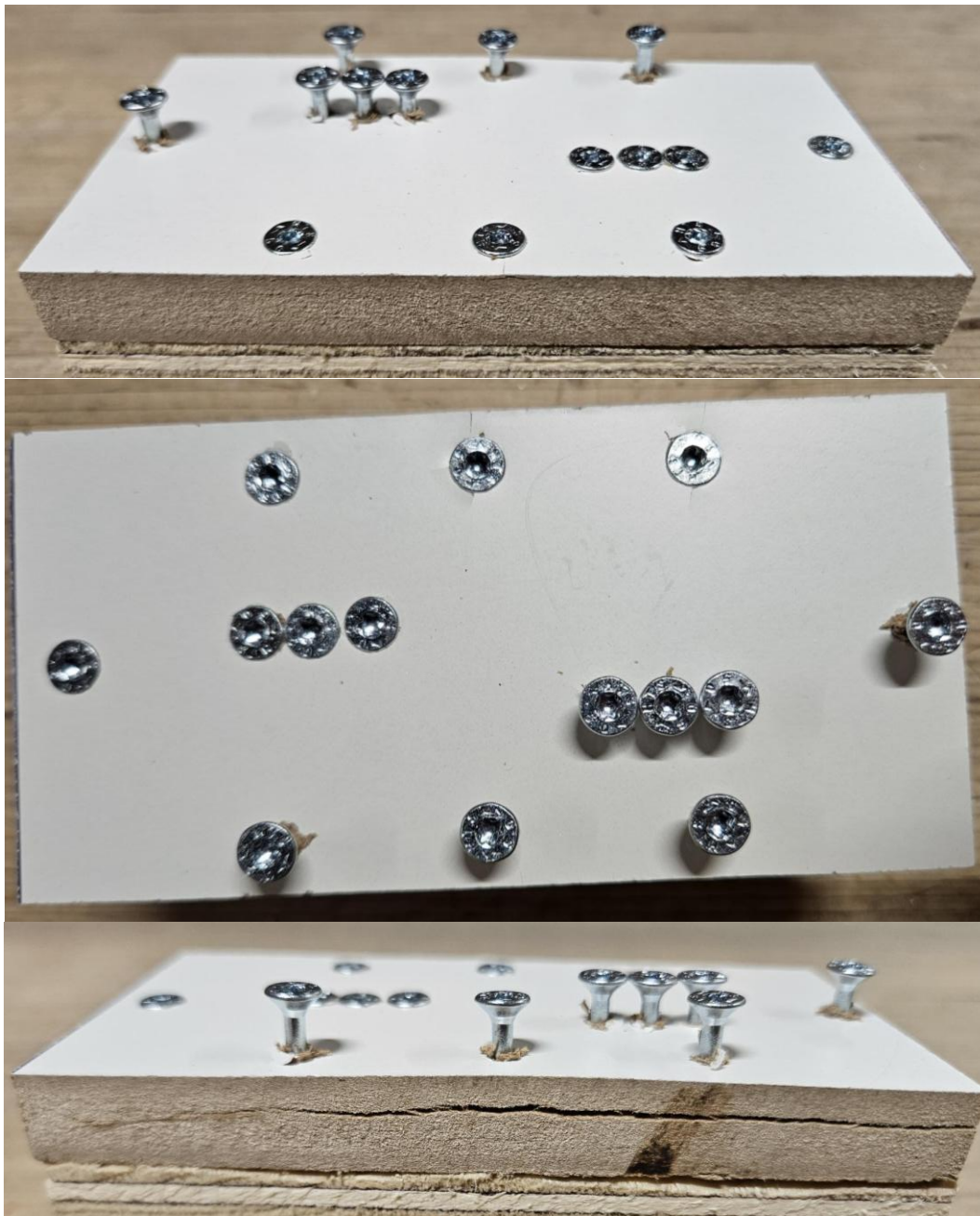
MELAMINE-FACED MDF

Thickness 12 mm – SNK4550

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Thickness 12 mm – HTS3550

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Thickness 19 mm – SNK3550

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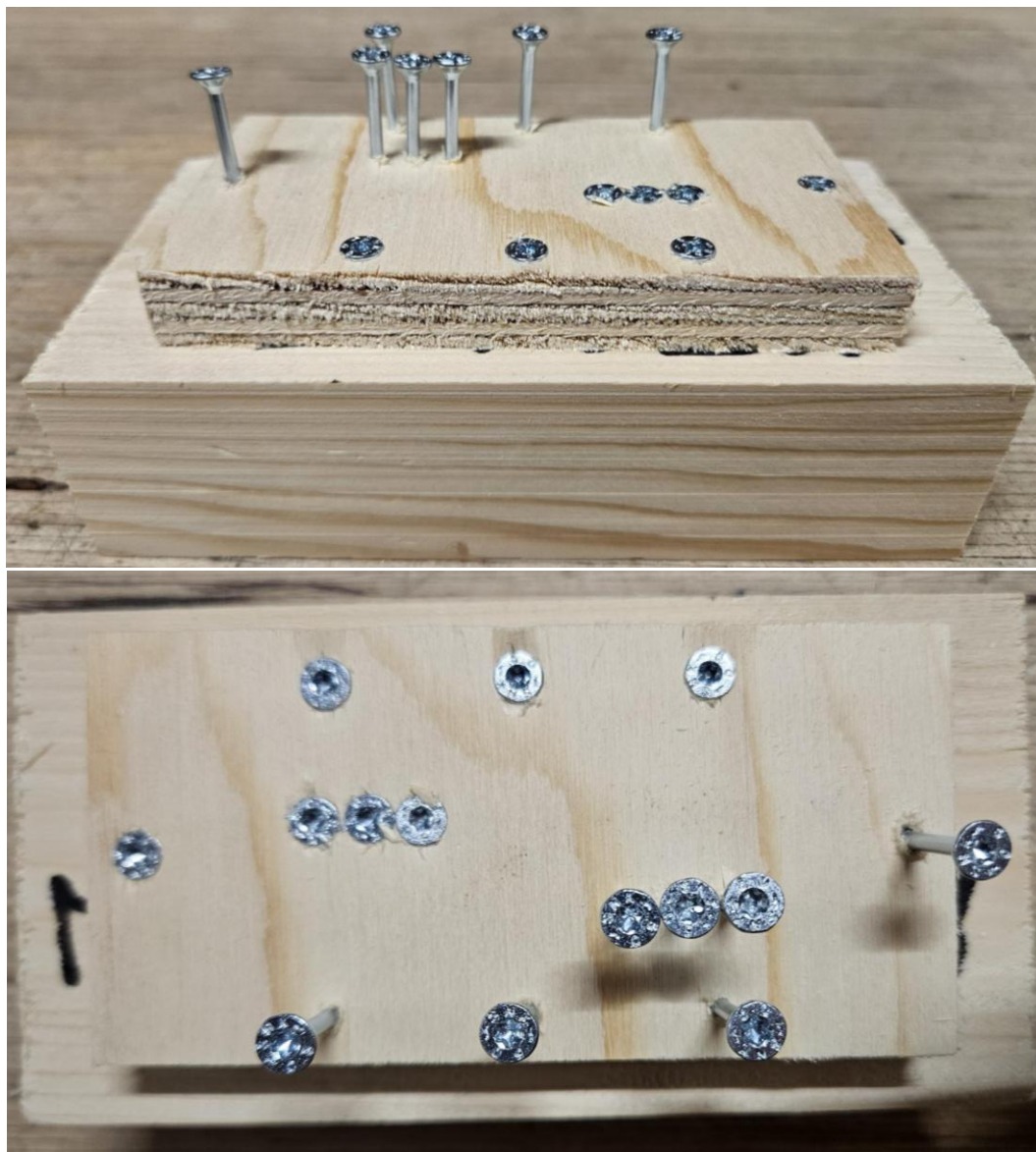
Thickness 19 mm – HTS4550

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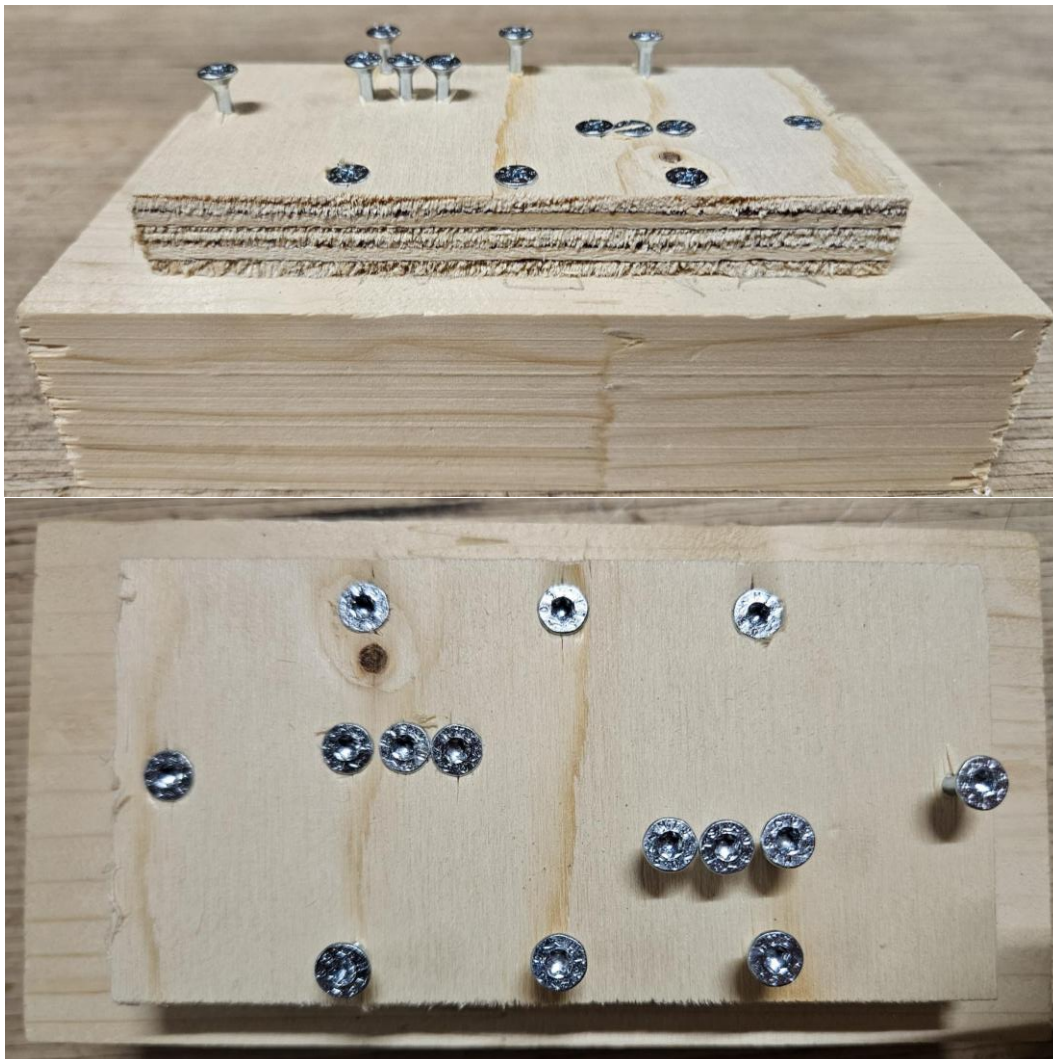
PLYWOOD

Thickness 15 mm – SNK3550

**ROTHO BLAAS SRL**

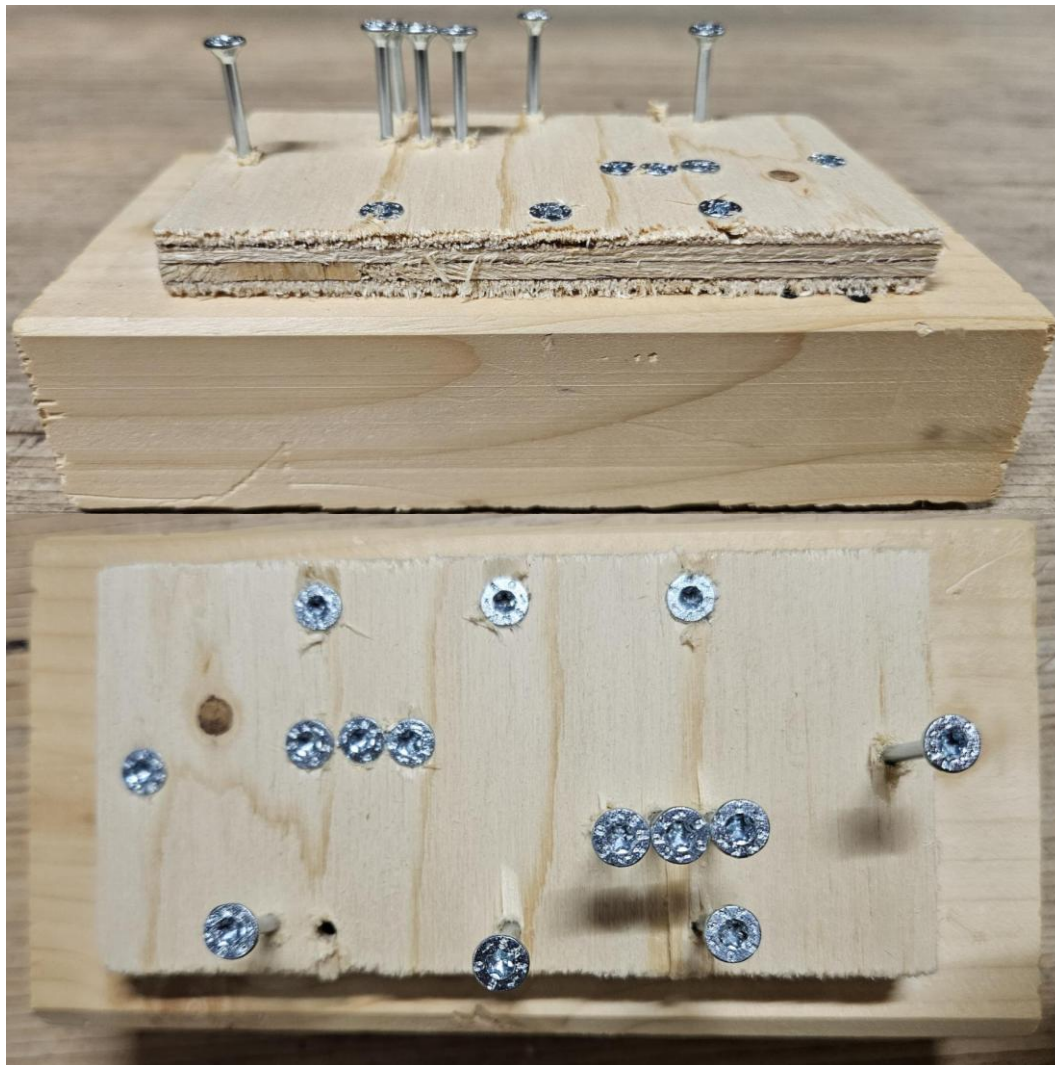
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Thickness 15 mm – HTS3550

**ROTHO BLAAS SRL**

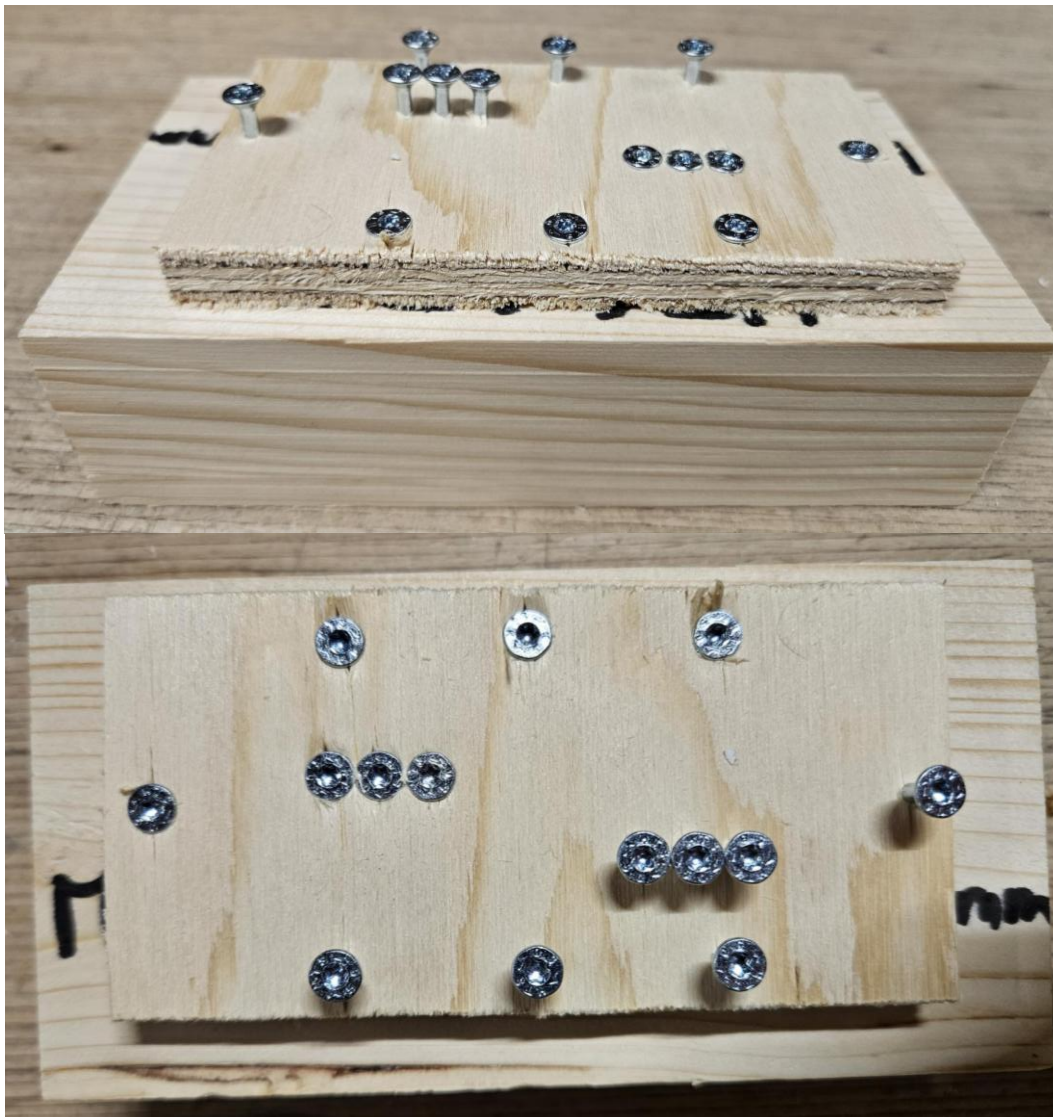
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Thickness 12 mm – SNK3550

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Thickness 12 mm – HTS3550

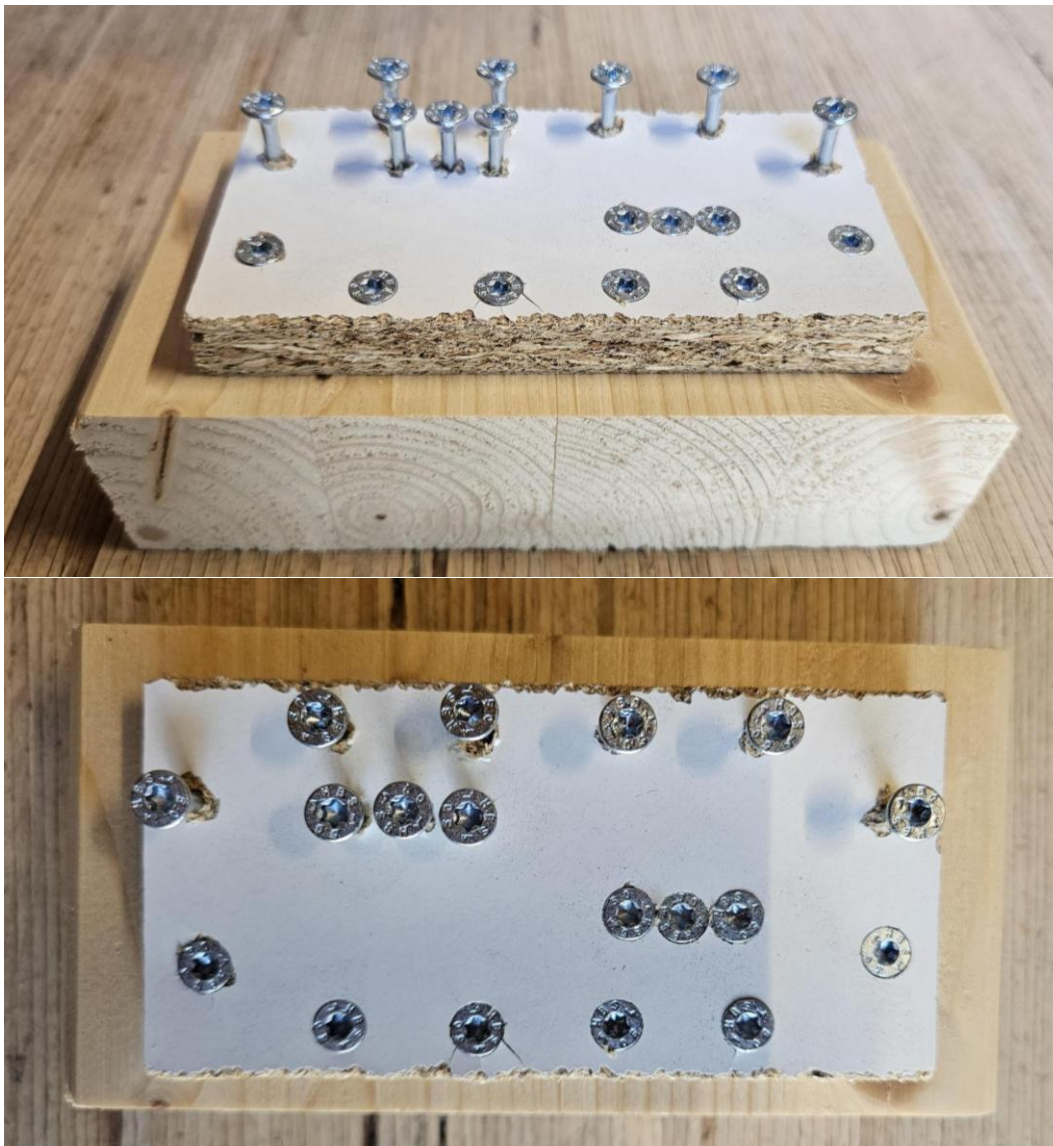
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Wide face insertion – Ø4.0x50 screws

Melamine-faced board

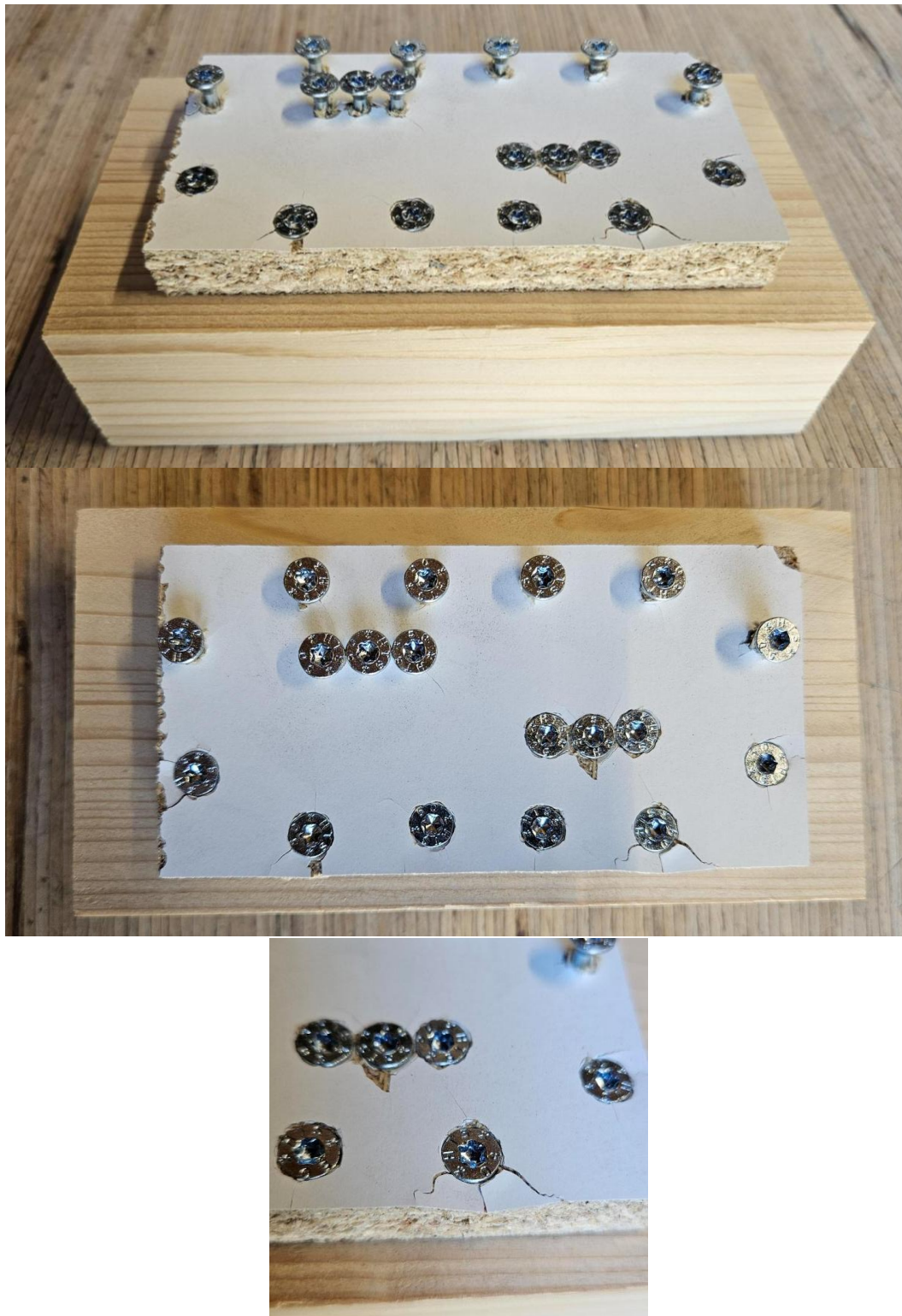
Thickness 13 mm – HBS450



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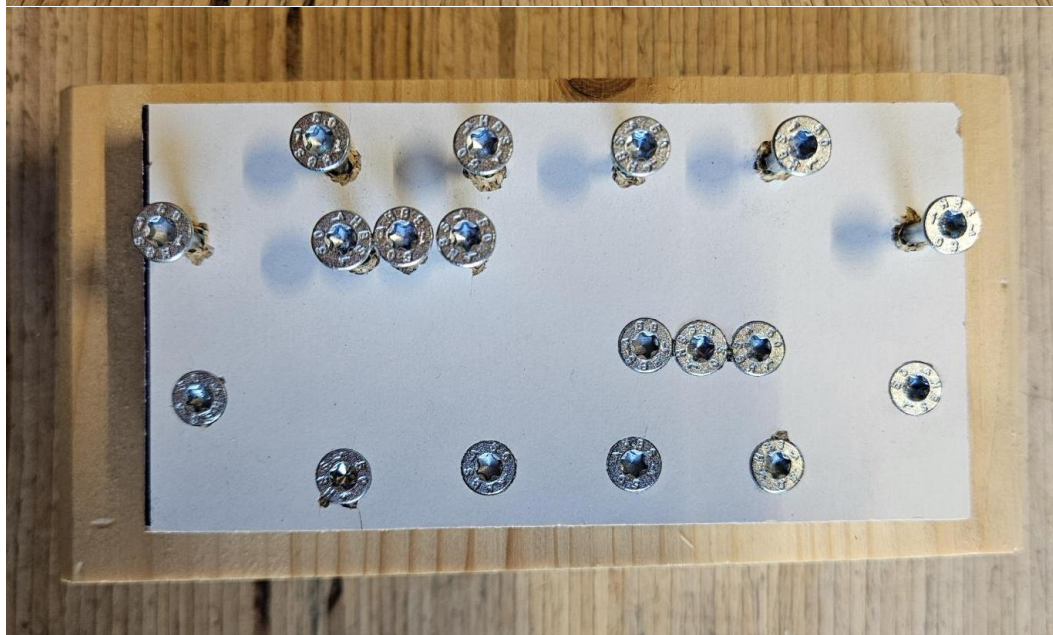
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Thickness 13 mm – HTS450

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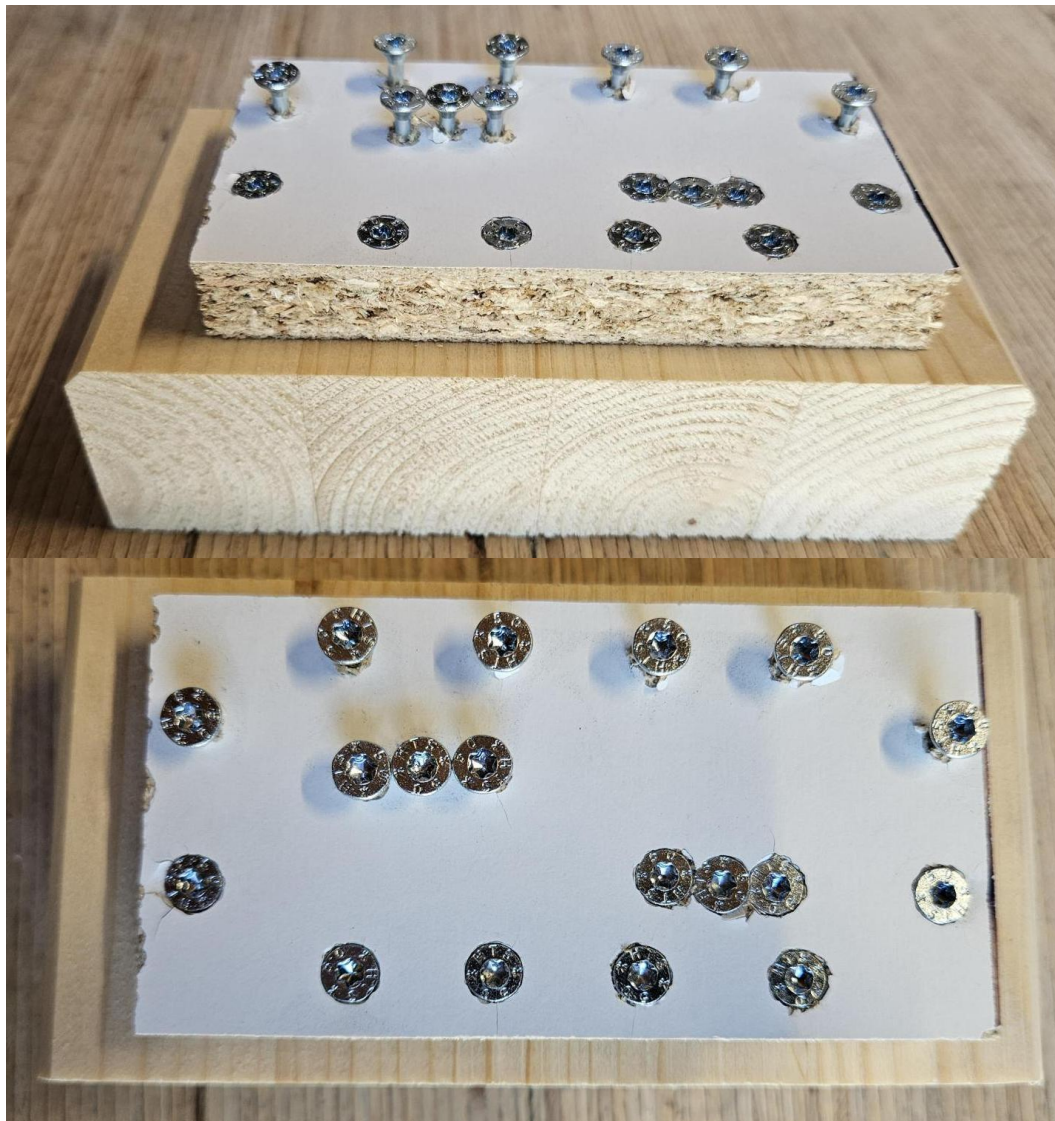
Thickness 16 mm – HBS450



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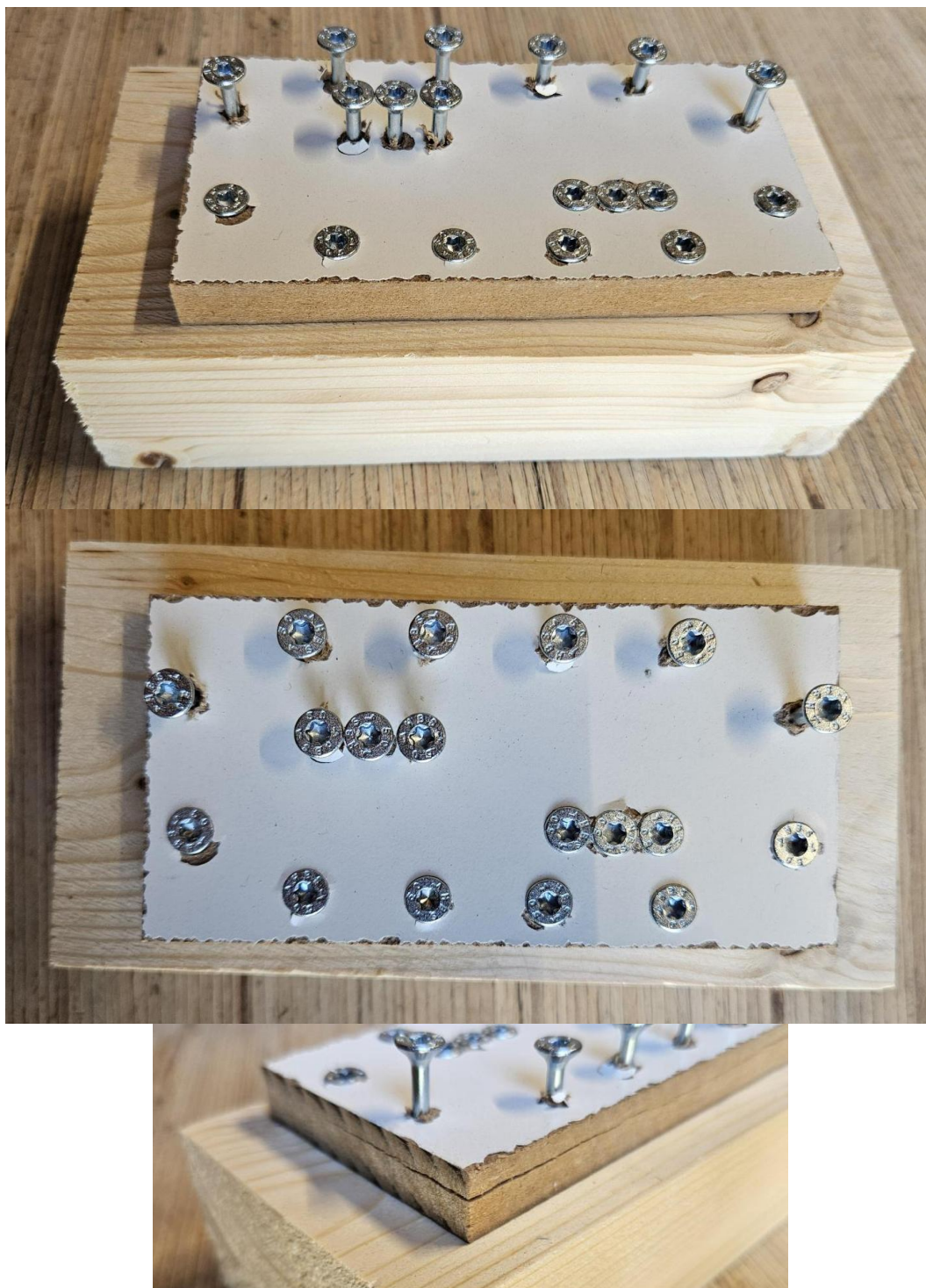
Thickness 16 mm – HTS450

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MDF

Thickness 12 mm – HBS

**ROTHO BLAAS SRL**

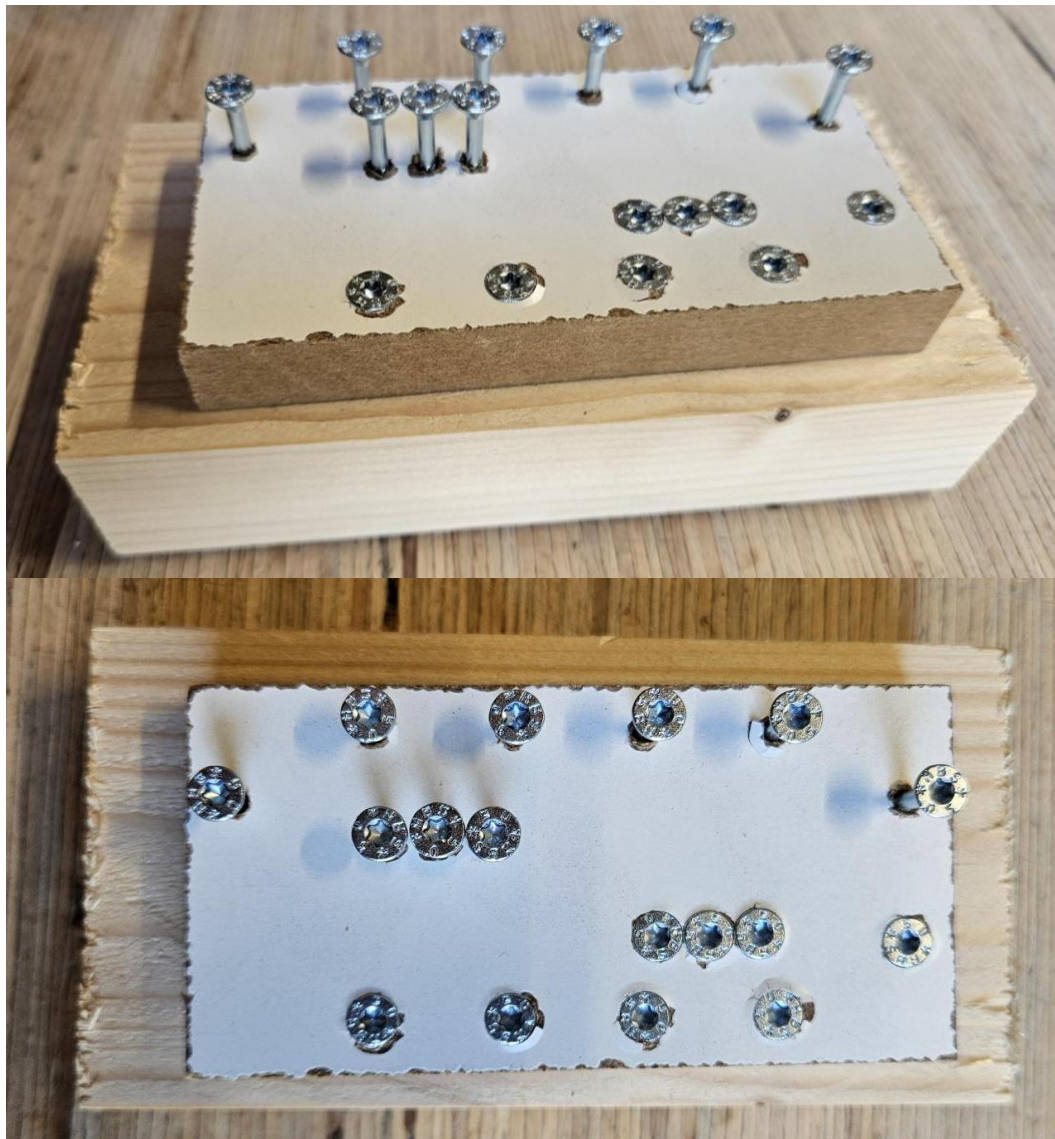
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Thickness 12 mm – HTS450

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Thickness 16 mm - HBS450

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Thickness 16 mm - HTS450

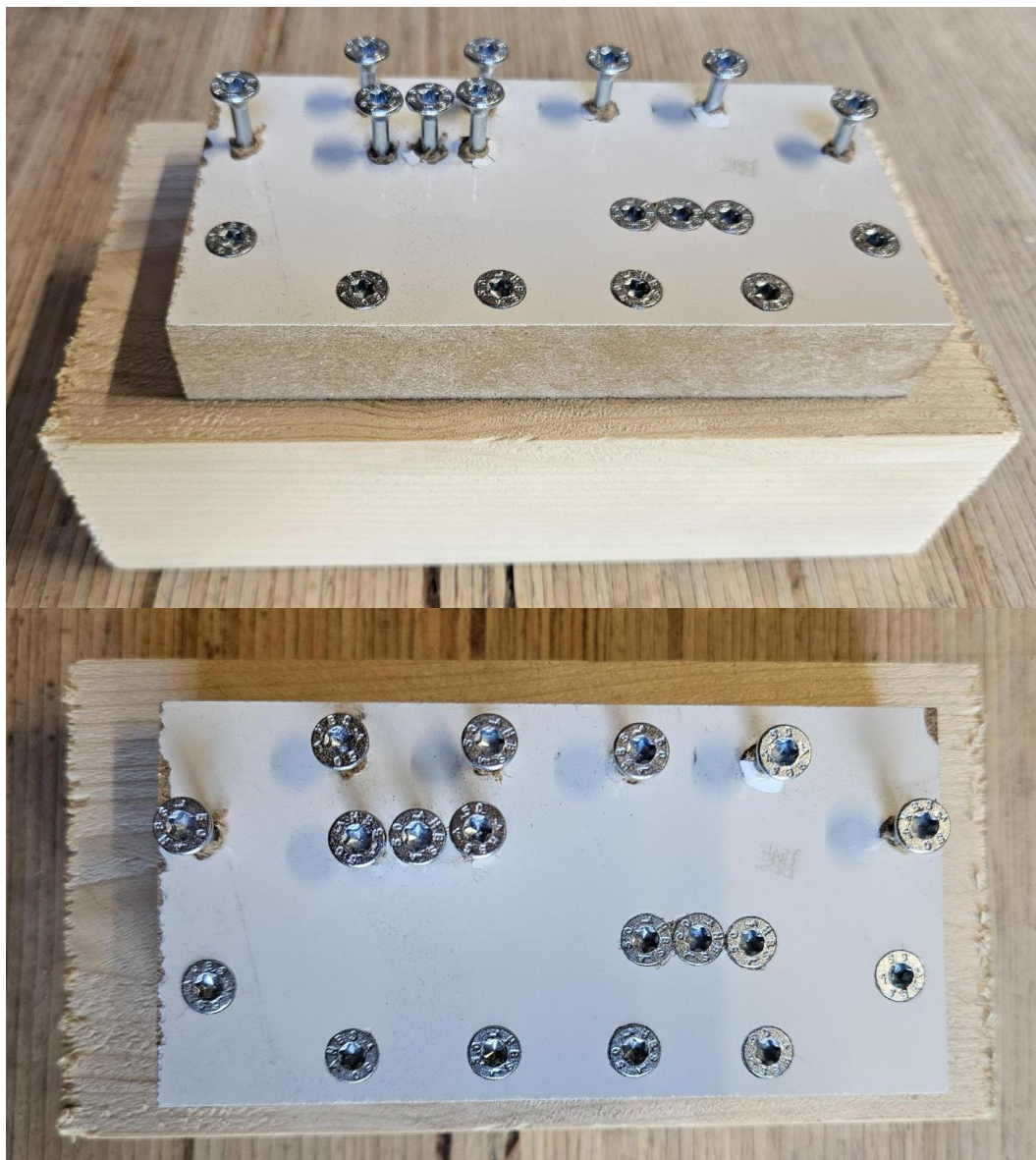


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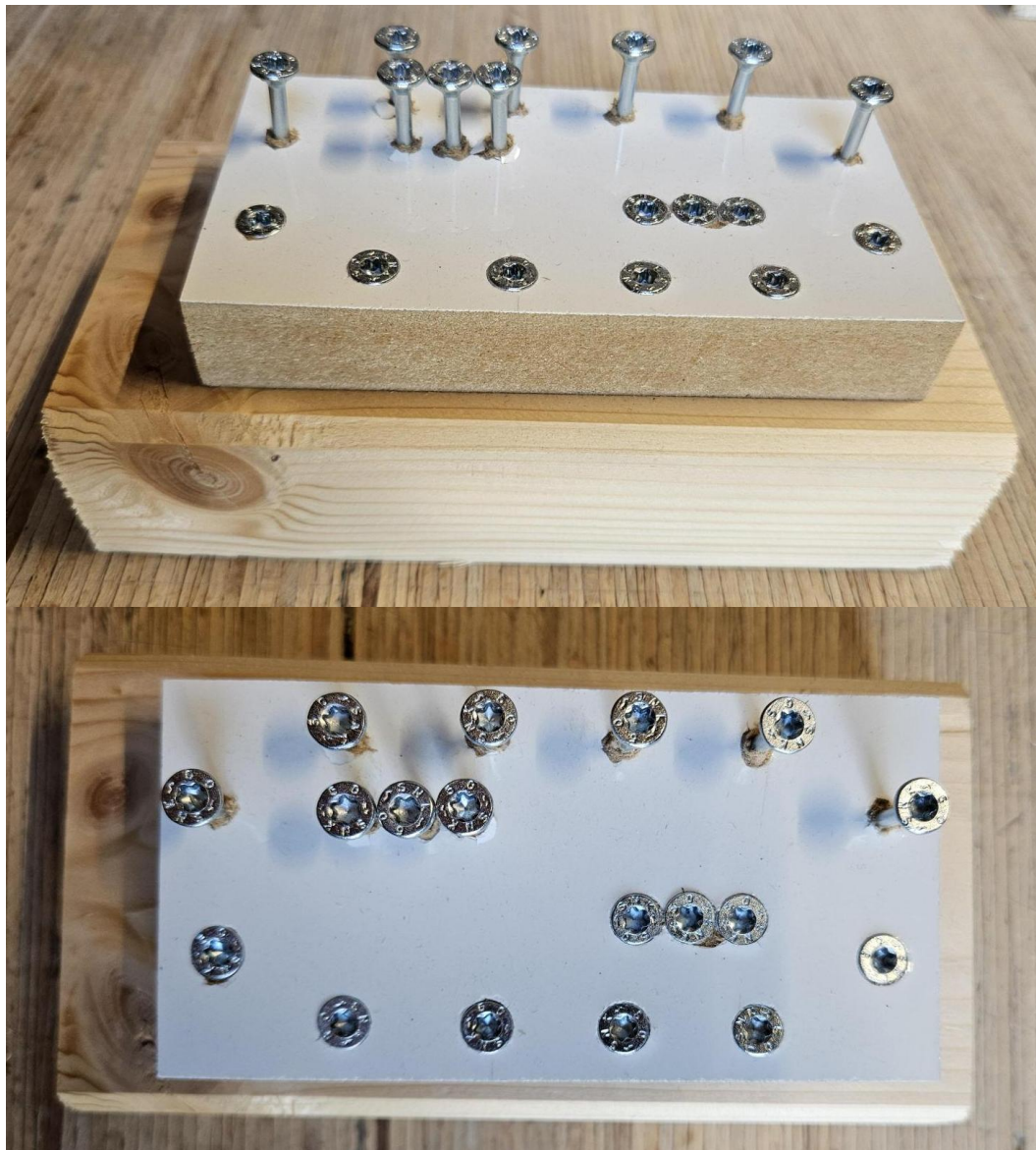
MELAMINE-FACED MDF

Thickness 19 mm - HBS450

**ROTHO BLAAS SRL**

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Thickness 19 mm - SNK450

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Plywood

Thickness 12 mm – HBS450

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Thickness 12 mm – HTS450

**ROTHO BLAAS SRL**

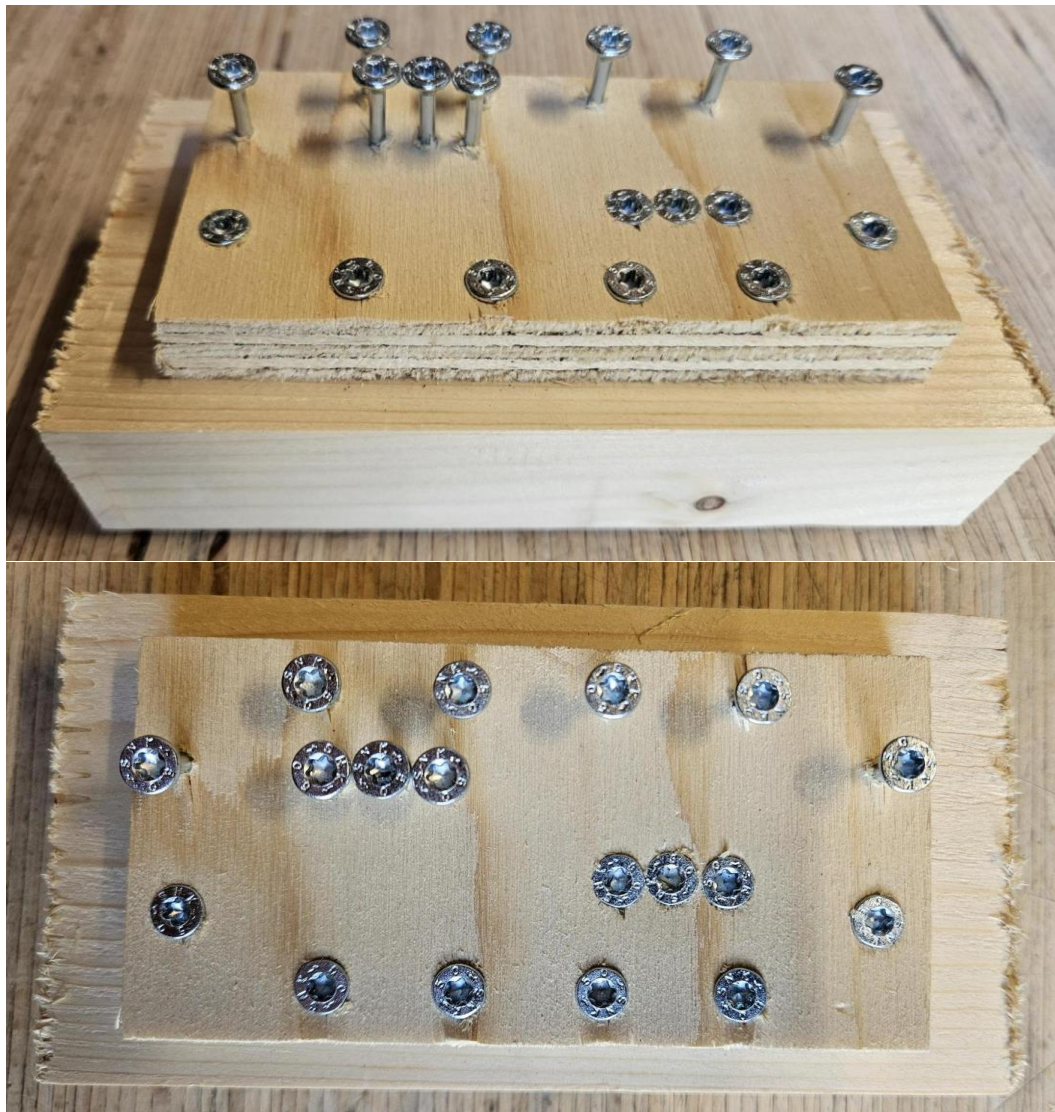
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Thickness 15 mm – HBS450

**ROTHO BLAAS SRL**

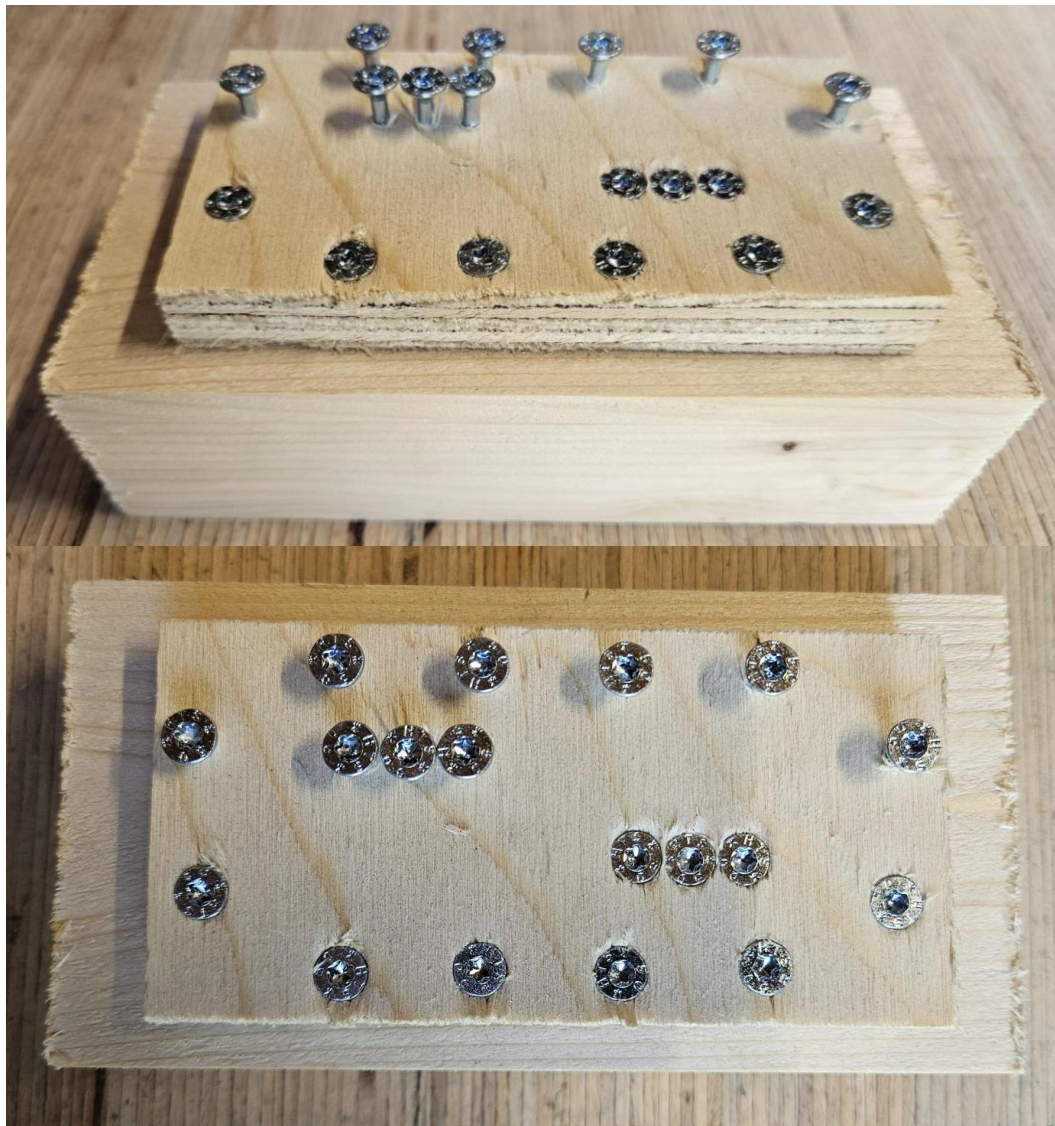
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Thickness 15 mm – SNK450

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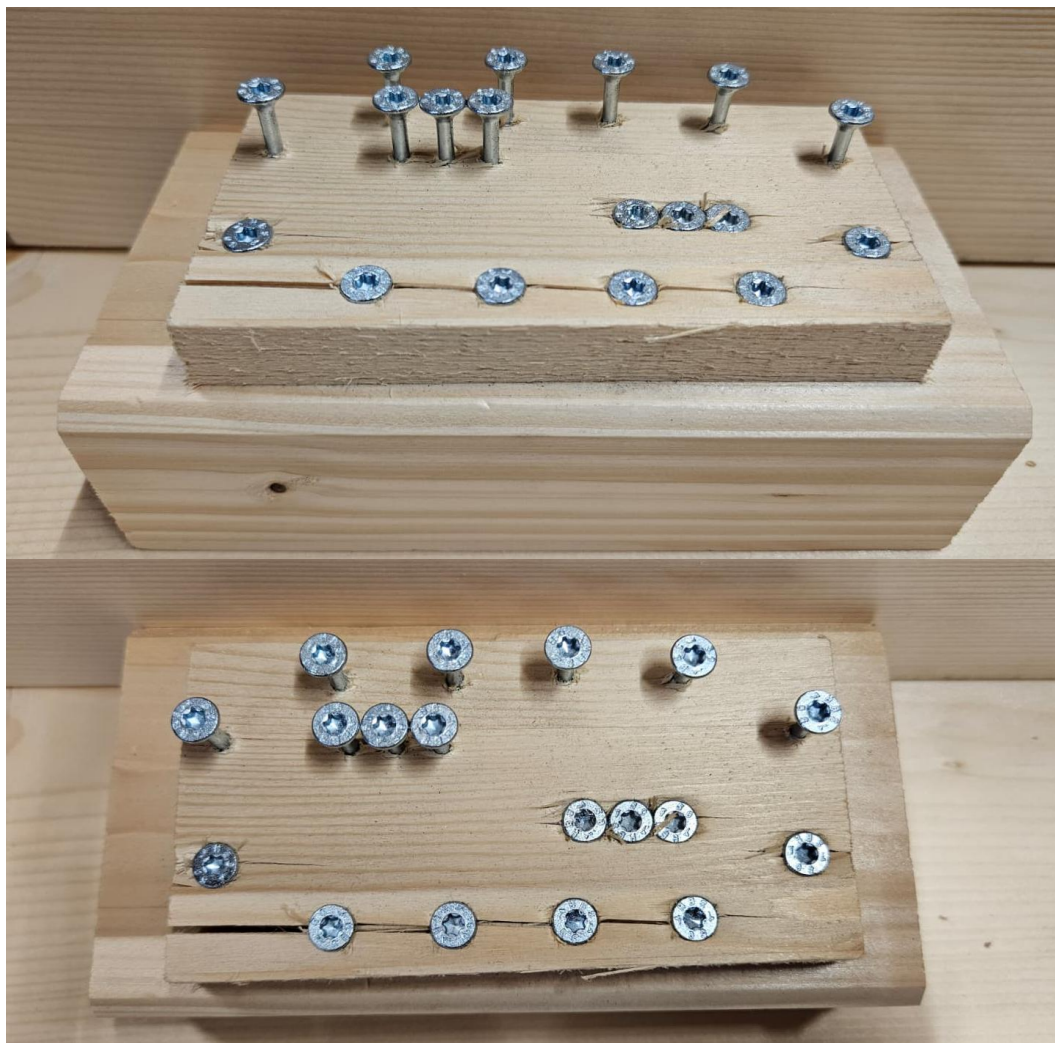
Thickness 15 mm – HTS450

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Spruce

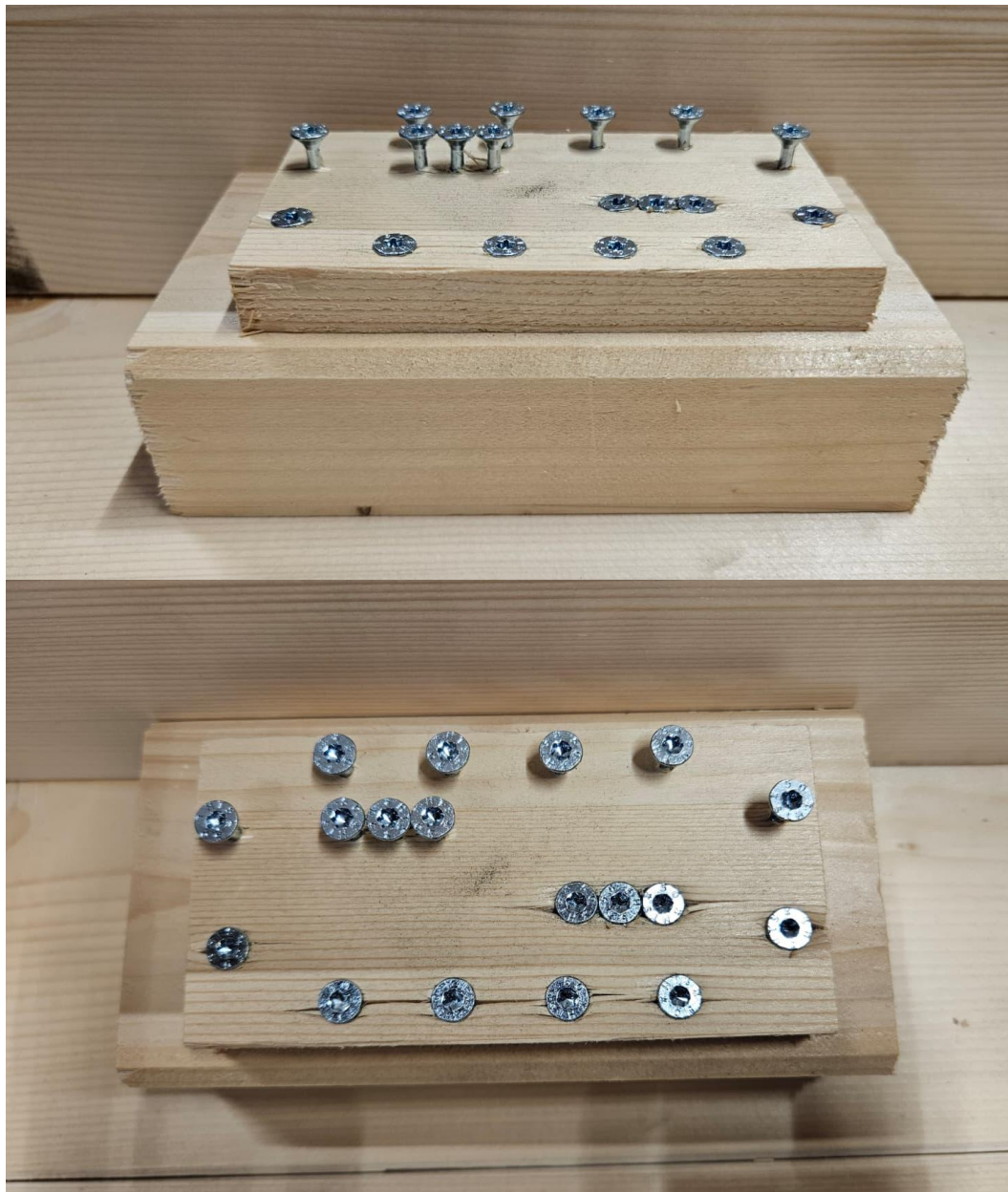
Thickness 15 mm – HBS450



ROTHO BLAAS SRL

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Thickness 15 mm – HTS450

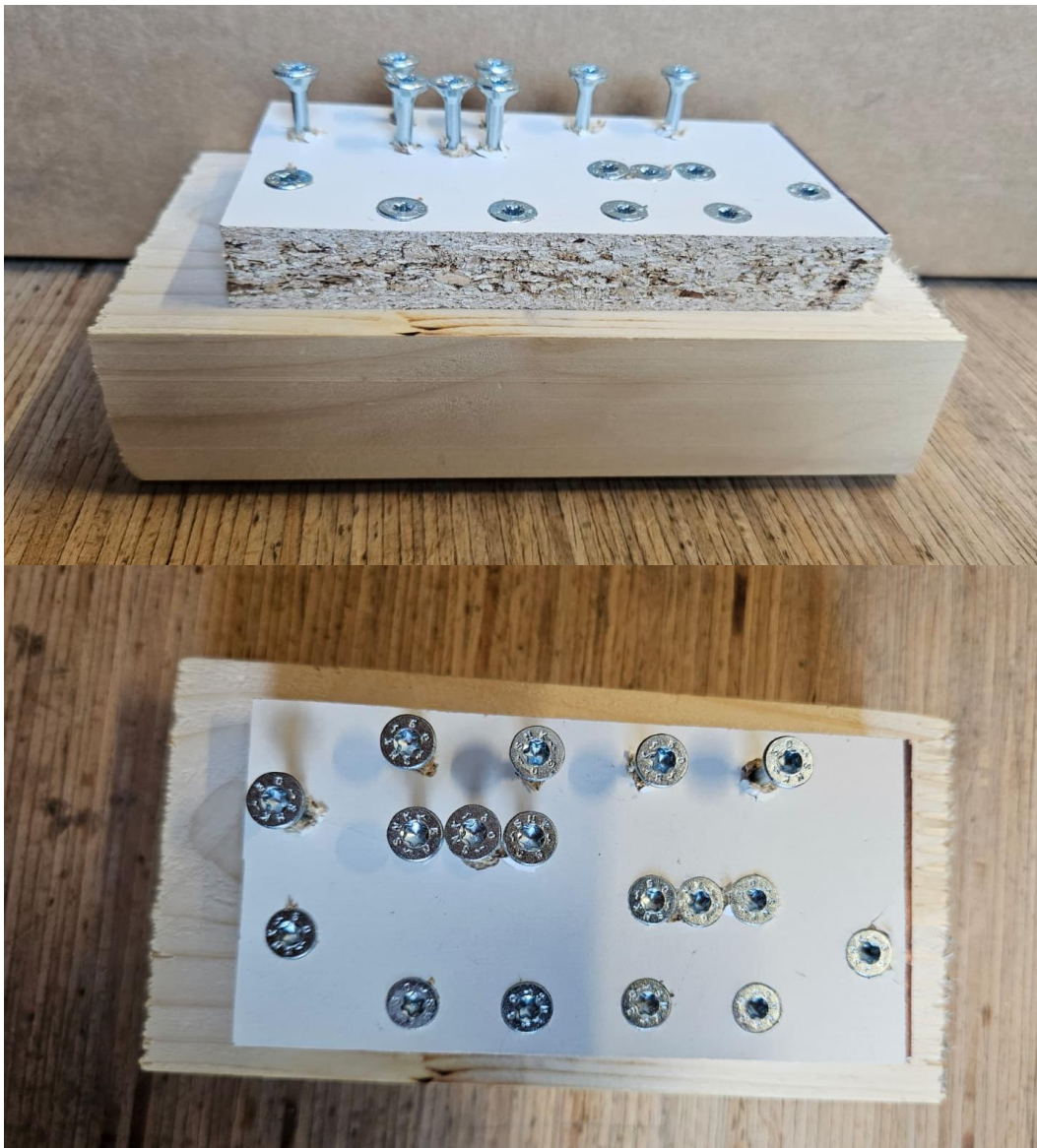
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Wide face insertion – Ø4.5x50 screws

Melamine-faced board

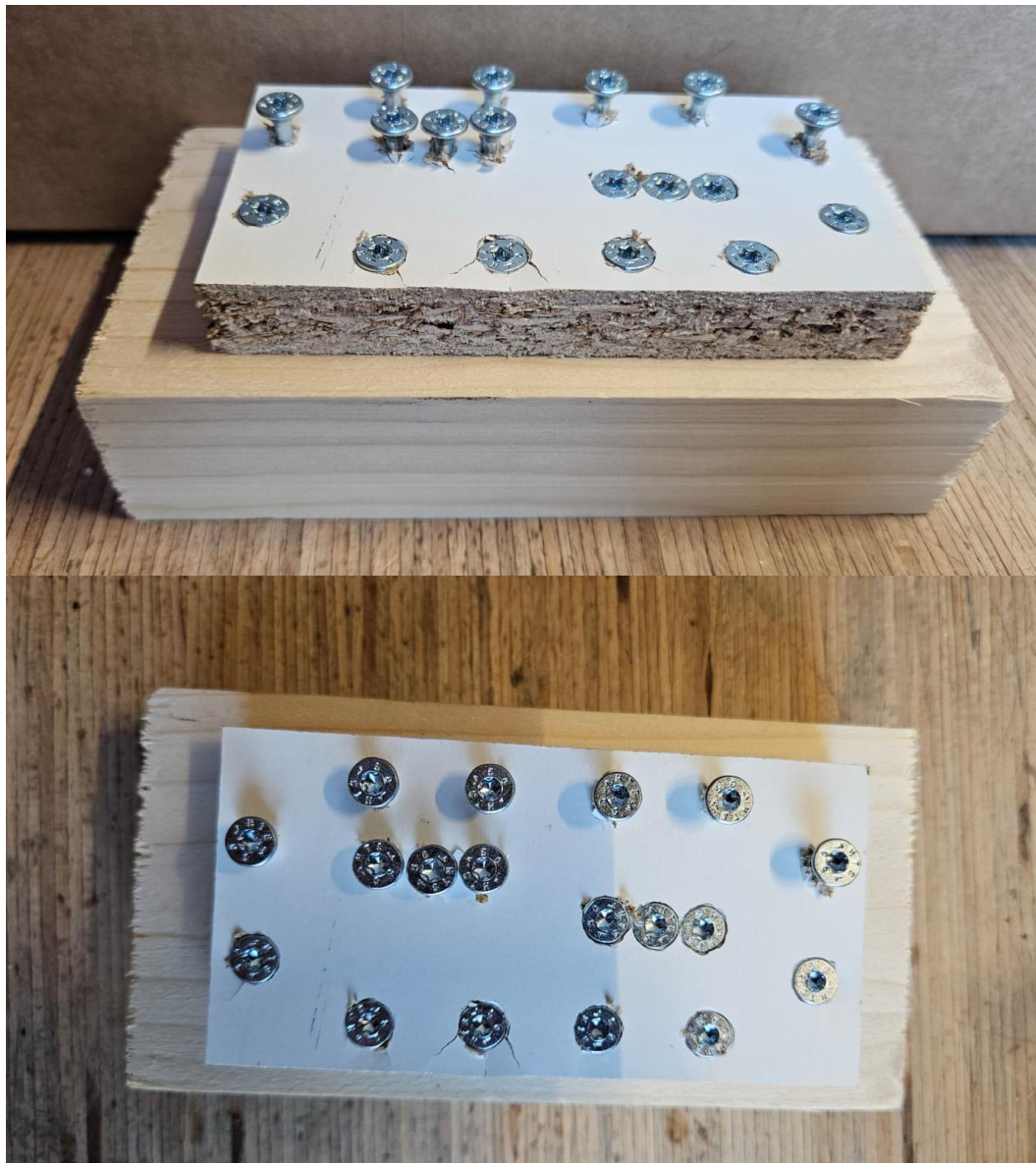
Thickness 16 mm – SNK4550



ROTHO BLAAS SRL

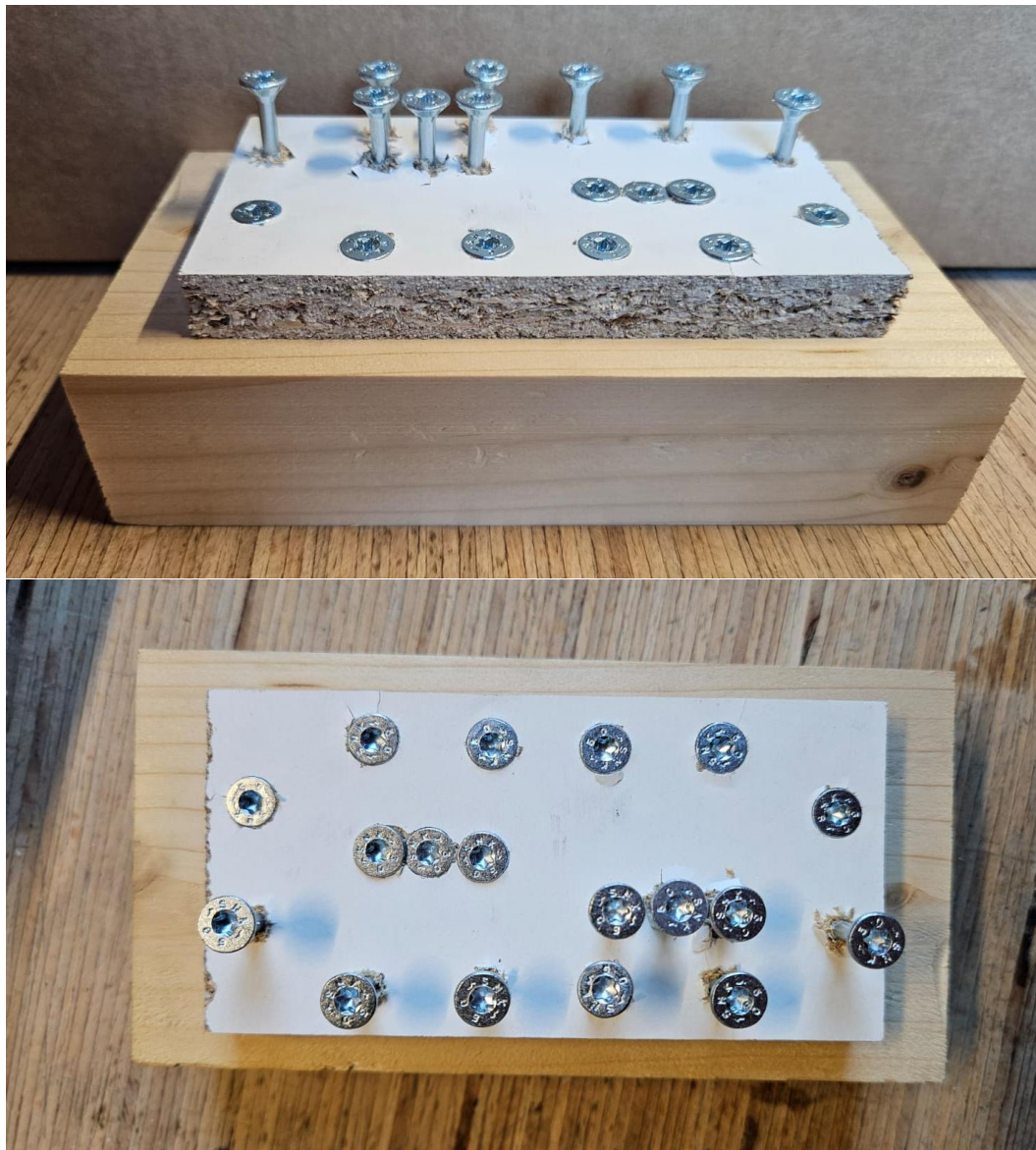
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Thickness 16 mm – HTS4550

**ROTHO BLAAS SRL**

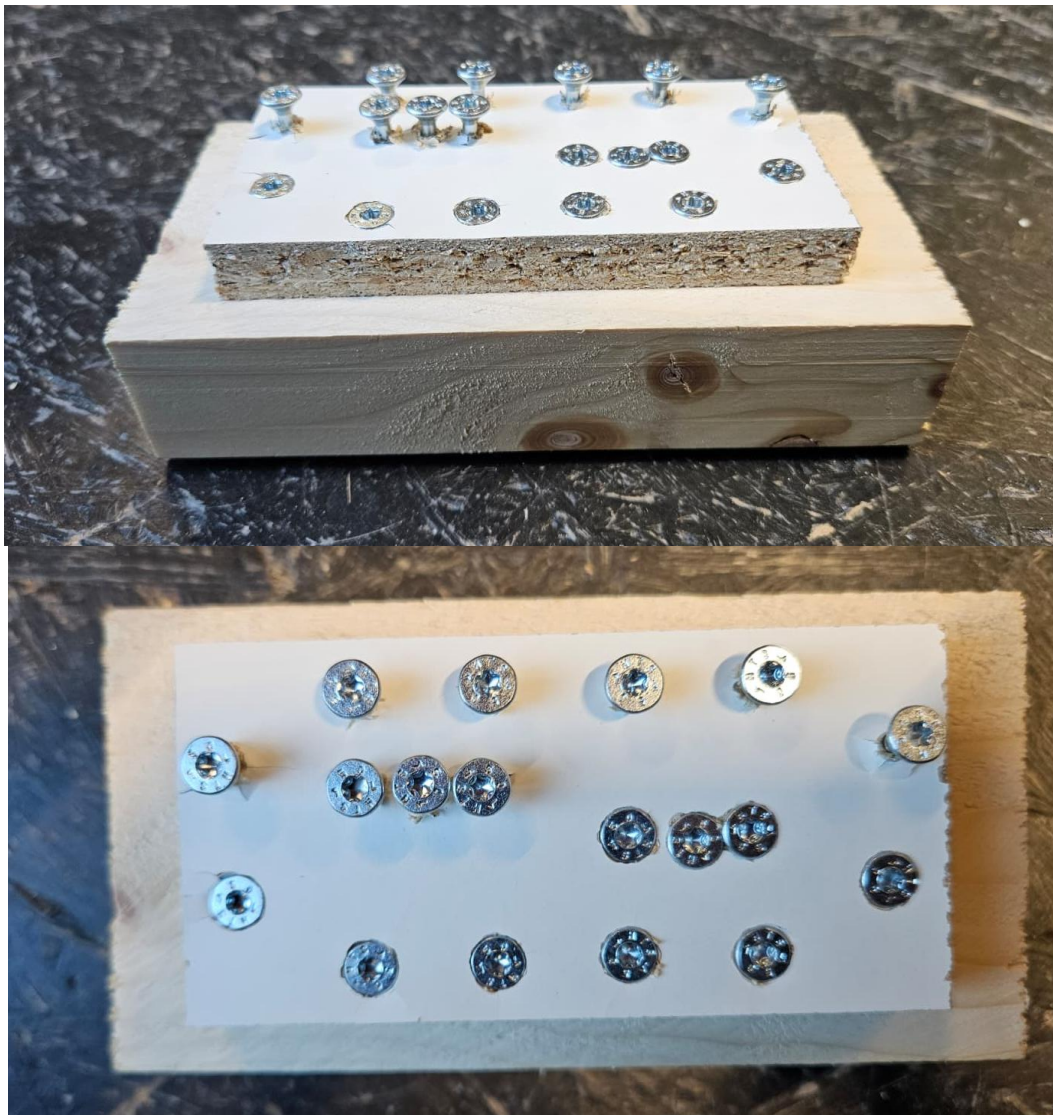
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Thickness 13 mm – SNK4550

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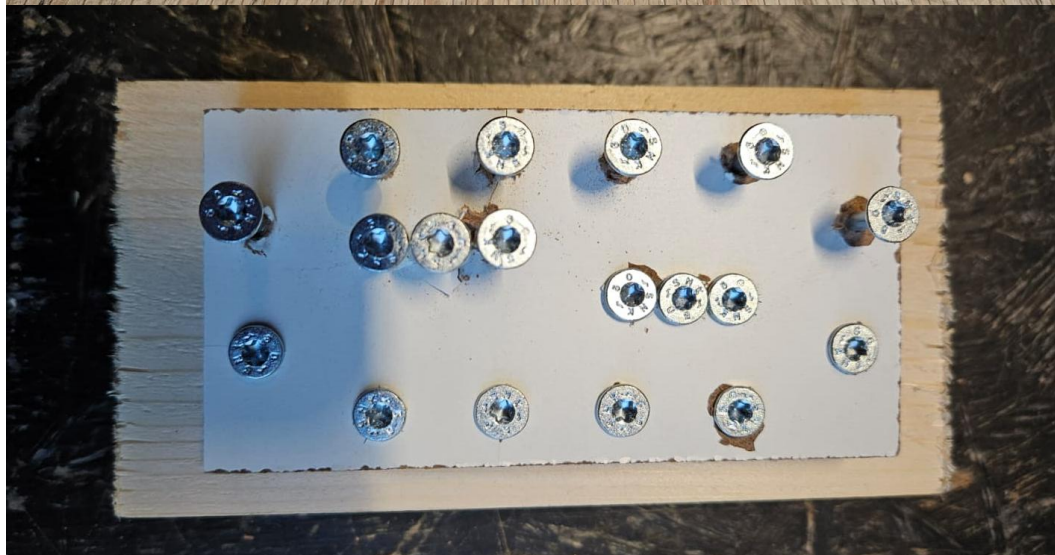
Thickness 13 mm – HTS4550

**ROTHO BLAAS SRL**

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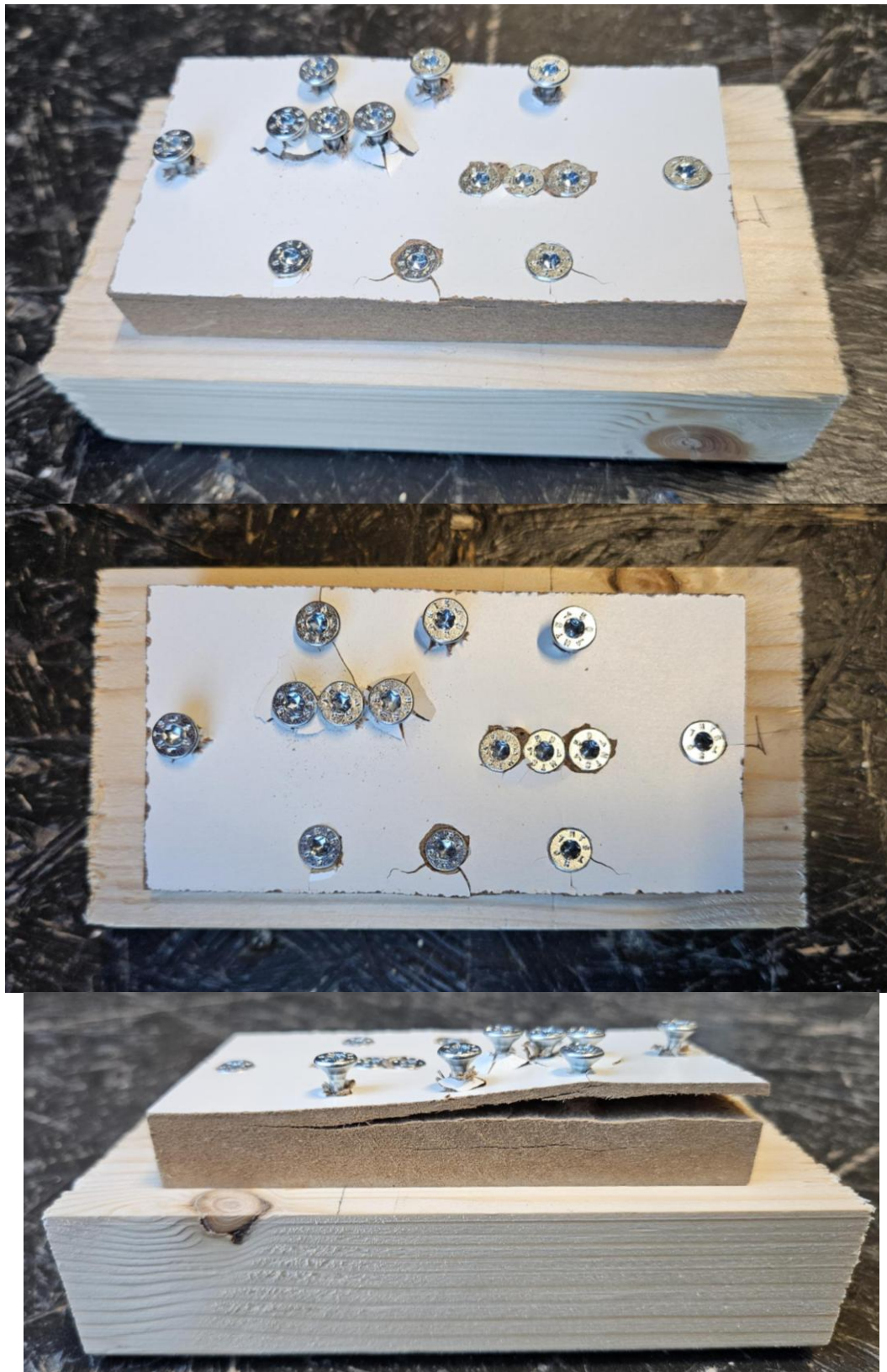
MDF

Thickness 16 mm – SNK4550

**ROTHO BLAAS SRL**

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Thickness 16 mm – HTS4550

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Thickness 12 mm – SNK4550



ROTHO BLAAS SRL

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Thickness 12 mm – HTS4550

**ROTHO BLAAS SRL**

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MELAMINE-FACED MDF

Thickness 12 mm – SNK4550

**ROTHO BLAAS SRL**

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Thickness 12 mm – HTS4550

**ROTHO BLAAS SRL**

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Thickness 19 mm – SNK4550

**ROTHO BLAAS SRL**

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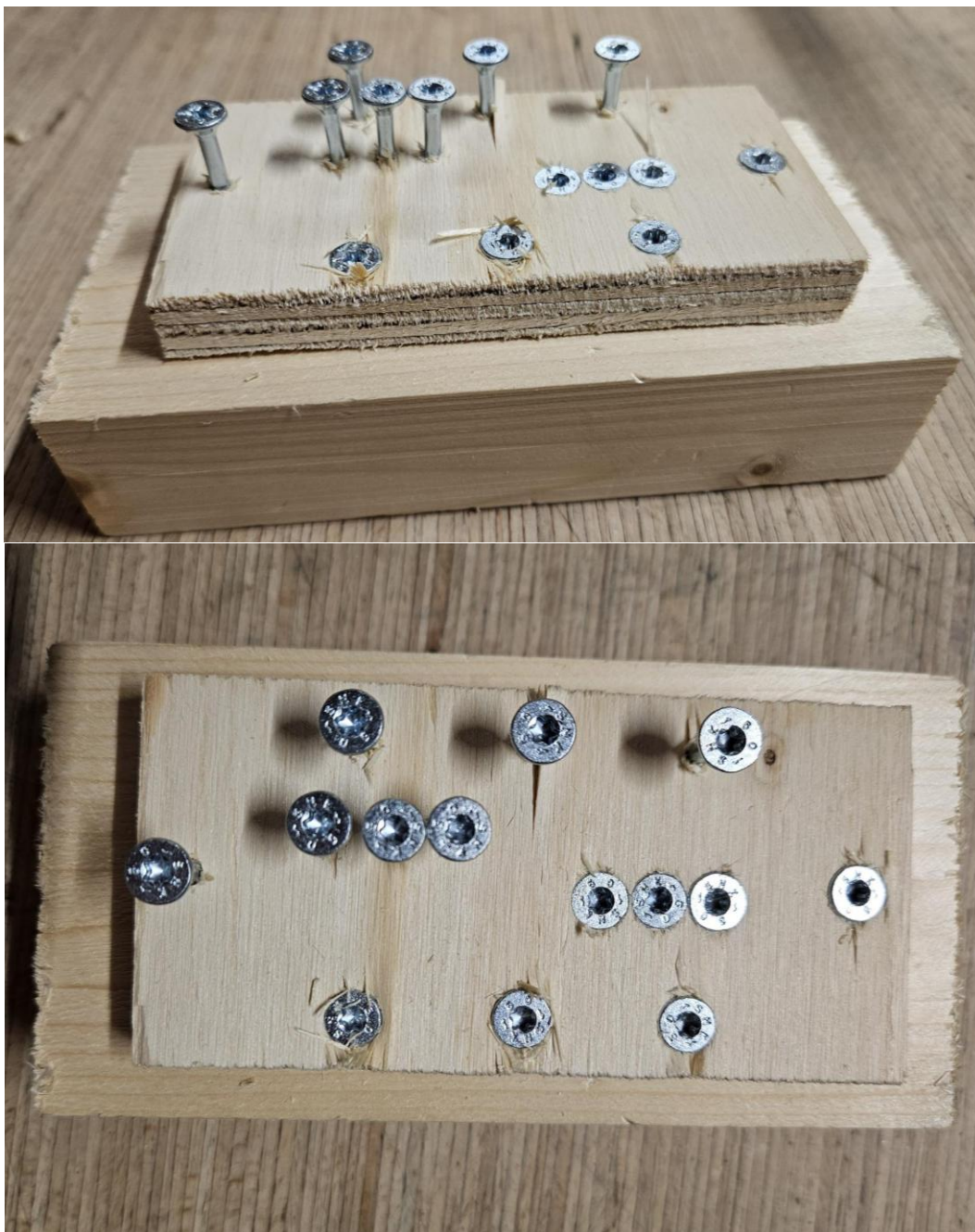
Thickness 19 mm – HTS4550

**ROTHO BLAAS SRL**

Via dell'Adige N.2/1 | I-39040, Cortaccia (BZ) | N. REA: BZ - 120599 | C.F e P.IVA IT 01433490214 | Cap. Soc.: EUR 52.000,00.
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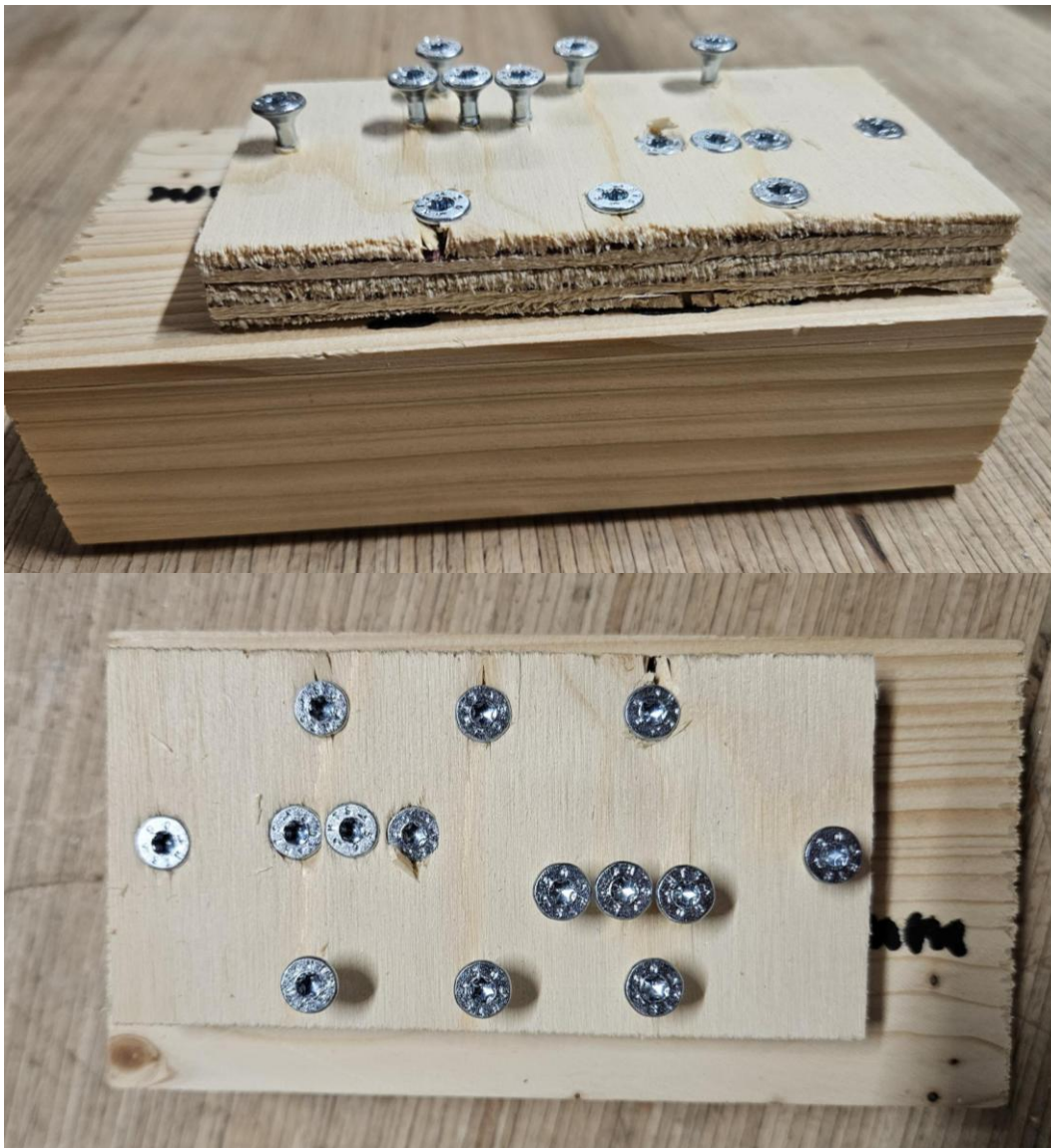
PLYWOOD

Thickness 15 mm – SNK4550

**ROTHO BLAAS SRL**

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Thickness 15 mm – HTS4550

**ROTHO BLAAS SRL**

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Thickness 12 mm – SNK4550

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Thickness 12 mm – HTS4550

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