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Test Report

Applicant:	Tecfi S.p.A. S.S. Appia Km 193 81050 Pastorano (CE) ITALY
Order No. (MPA):	**902 0617 000/1**
Test Object:	**Initial Type Testing (ITT) of self-tapping screws for use in timber structures according to EN 14592:2008** **here: Testing of wood screws type "TT02", diameter d = 6 mm**
Date of Receipt of Test Item:	26. October 2010
Commencement of Test:	11. November 2010 – 27. January 2011
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Initial Type Testing (ITT) of self-tapping screws for use in timber structures according to EN 14592:2008

here: Testing of wood screws type "TT02", diameter d = 6,0 mm

1 Preface

With letter dated 15. October 2010, the company Tecfi S.p.A., 81050 Pastorano/Italy, commissioned MPA University of Stuttgart to conduct the Initial Type Testing (ITT) according to EN 14592:2008 of screws with the type designation "TT02". In total, load bearing tests with 3 different nominal diameters (d = 6 mm, d = 8 mm and d = 10 mm) of self-tapping screws with the type designation "TT02" were to be performed.

In this context, the company Tecfi S.p.A. submitted self-tapping screws with the type designation "TT02" to MPA University of Stuttgart for the purpose of testing. For each diameter to be tested two packages of screws with the maximum length produced were sent. The test material arrived at MPA University of Stuttgart on 26. October 2010.

The present report covers the load bearing tests carried out with self-tapping wood screws with the type designation "TT02", dimension d x L = 6,0 x 300 mm, and their results. The screws are intended to be used for fastening to wood.

2 Test material

2.1 Wood screws

The following wood screws were submitted by the customer for the purpose of testing:

- **Self-tapping wood screws type "TT02", diameter d = 6,0 mm, with countersunk head and partial thread made of carbon steel (cf. Figure 1, Annex 1):**

Date of receipt of samples:	26. October 2010
Sample size:	Approx. 100 wood screws; dimension d x L = 6,0 x 300 mm (= maximum screw length produced for this type of screw)

The exact product specifications of the screws submitted for testing purposes as well as the name and address of the manufacturing facility, as stated by the customer, are given in Table 8, Annex 12.

2.2 Solid wood and glued-laminated timber

For the tests conducted in order to determine the withdrawal parameter and the head pull-through parameter of the screws under consideration, solid soft wood was used (wood

species: spruce). The density of the soft wood met the requirements according to EN 28970, Method 2.

For the tests conducted in order to determine the torsional resistance („insertion moment“), glued-laminated timber of strength class GL 24 (wood species of lamellas: spruce) according to EN 14080 was used. According to the specifications given in EN 14592, Annex B, the density of the glued-laminated timber was in the range of 400 kg/m³ to 500 kg/m³.

3 Test procedure

3.1 Dimensions of the screws

The relevant dimensions governing the load bearing behaviour, in particular length, thread length, inner and outer thread diameter, etc., were measured according to specifications given in EN 14592, Section 5 and Table 4. The dimensions of the five screws type “TT02”, dimension d x L = 6,0 x 300 mm, were measured by using a shape projector with twentyfold magnification.

3.2 Tensile capacity

The determination of the tensile capacity f_{tens} was carried out on following EN 1383, Image 4. Ten screws were tested, whereby each screw was loaded up to rupture. During the tensile test, the screw head was fixed by a steel plate with an adapted bore hole. The speed of loading was adjusted in such a manner that failure occurred within a time span of approximately 10 seconds.

3.3 Yield moment

The yield moment M_y and the maximum bending angle α_{max} of the screws were determined according to EN 409. Each screw was bent only along its threaded part.

Ten tests were conducted by using a free length (cf. EN 409, Annex A) of l_2 = 2 d (d = outer diameter of the screws) in a specifically designed bending device.

3.4 Torsional strength

The determination of the torsional strength f_{tor} (= breaking torque) of the screws was carried out following EN ISO 10666. Ten screws were twisted until rupture occurred.

The tests were carried out in a torsion test machine with a stepless adjustable electro-mechanical drive. The test speed was regulated in such a manner that failure occurred within a time span of approximately 10 seconds. The torsional moment was measured by using an intermediary calibrated torque rod equipped with strain gauges.

3.5 Torsional resistance

Ten screws were drilled in glued-laminated timber in order to determine the characteristic torsional resistance $R_{tor,k}$ (= insertion moment). The drill-in tests were conducted following EN 14592, Annex B, by using a mobile torque and a rotation angle measuring instrument, type Schatz Inspect+.

The cross section of the glued-laminated timber specimens used for the drill-in tests were (height H x width B) H x B = 400 mm x 140 mm.

The scheme of the drill-in tests in order to determine the torsional resistance is sketched in Figure 2, Annex 1. All screws have been screwed-in perpendicular to the width of the glued-laminated timber specimen without any previous pre-drilling while using a suitable electric driven screw driller. The annual growth rings of the lamellas were orientated perpendicular to the screw-in direction.

For each screw-in test, a torque-rotation angle graph was recorded. The torsional resistance, respectively, was determined from the recorded graphs as maximum value by the time, the screw head barely did not yet touch the glued-laminated timber surface (cf. Figure 2, Annex 1).

3.6 Withdrawal parameter

The pull-out tests according to EN 1382 conducted in order to determine the characteristic withdrawal parameter $f_{ax,k}$ from solid soft wood were performed using ten screws.

The scheme of the pull-out tests is shown in Figure 3, Annex 2. Also given are the screw-in depth s_g as well as the dimensions of the solid wood specimens.

According to EN 1382, Section 6.3.1, in total five tests with annual growth rings running parallel and five tests with annual growth rings running perpendicular to the screw-in direction (cf. Figure 3, Annex 2) were conducted. In both cases, the angle between the screw axis and the direction of the wood fibres was 90°. All screws have been screwed-in without any previous pre-drilling.

All tests were conducted at a constant displacement rate of 5 mm/min until maximum load was reached.

3.7 Head pull-through parameter

The head pull-through tests according to EN 1382 were conducted in order to determine the characteristic head pull-through parameter $f_{head,k}$ with respect to solid soft wood (sample size: ten screws).

The scheme of the head pull-through tests is shown in Figure 4, Annex 3. Each screw was fixed in the wood in a pre-drilled hole; the pre-drill diameter corresponded to the outer thread diameter d of the screw. Furthermore, a counterbore was put in the wood specimen so that the counter sunk head was evenly fitting to the surface of the wood (cf. Figure 4, Annex 3).

The measurements of the solid wood test specimens were (height H x width B) H x B = 40 mm x 160 mm. Five tests each were conducted with annual growth rings oriented parallel and perpendicular to the screw-in direction of the screws (cf. Figure 4, Annex 3).

All tests were conducted at a constant displacement rate of 5 mm/min until maximum load was reached.

4 Test Results

4.1 General remarks

For the test results obtained, the following statistical quantities were calculated:

x_{mean} : mean value

s : standard deviation

COV : coefficient of variation

x_k : characteristic value (5%- or 95%-fractile)

The characteristic values were calculated according to EN 14358 assuming a minimum standard deviation s_y = 0,05 for the logarithmized data in such cases where the coefficient of variation of the original data was smaller than 5 %.

The test results (single values) obtained with screws type “TT02” and the related statistical quantities discussed above are reported subsequently.

4.2 Dimensions

The results of the revised dimensions are given in Table 1, Annex 4. Also given are the nominal values (based on the drawings submitted by the company Tecfi S.p.A.) along with the respective tolerance limits (minimum and maximum values) calculated on the basis of the permissible limit deviations according to EN 14592, Section 5.

Remark: Concerning the length and the nominal diameter (= outer thread diameter), the tolerance limits have been calculated according to EN 14592, Sections 5.2 and 5.3, allowing a maximum deviation of ± 2,5 % of the given nominal dimension. For all further dimensions (e.g. thread length, inner thread, shank and head diameter, etc.), the calculation of the tolerances was performed according to EN 14592, Section 5.4, allowing a maximum deviation of ± 5 % of the respective given nominal value.

4.3 Tensile capacity

The obtained tensile capacities f_{tens}, determined by tensile tests according to EN 1383, are given in Table 2, Annex 5.

The characteristic tensile capacity was obtained as $f_{tens,k}$ = 12524 N ≈ 12500 N.

4.4 Yield moment

According to EN 14592, Section 6.3.4.2, the yield moment of screws in general has to be determined at a bending angle of $\alpha_1 = 45/d^{0,7}$ degrees (d = outer thread diameter). In any case, all bending tests have been continued up to a maximum bending angle of $\alpha_{max} = 45°$ in order to make sure that the screws had no cracks when the bending angle of at least $\alpha_2 = (45/d^{0,7} + 10)$ degrees was reached.

The moment-angle graphs of the bending tests according to EN 409 are pictured in Figure 5, Annex 6. As becomes evident from the graphs, all screws reached the required bending angle according to EN 14592, Section 6.3.4.2, in the amount of $\alpha_2 = (45/d^{0,7} + 10)$ degrees undamaged and without any visible cracks.

Table 3, Annex 7, summarizes the test results of the bending tests conducted according to EN 409 (yield moment and maximum bending angle).

The characteristic yield moment was obtained as $M_{y,k} = 8{,}9$ Nm.

4.5 Torsional strength

Table 4, Annex 8, summarizes the test results of the torsional strength f_{tor} (= breaking torque) of the screws, obtained in torsional tests according to EN ISO 10666.

The characteristic torsional strength was obtained as $f_{tor,k} = 10{,}1$ Nm.

4.6 Torsional resistance

Table 5, Annex 9, summarizes the test results of the screw-in tests conducted according to EN 14592, Annex B, up to a maximum screw-in depth of l_{max} (screw head barely sticking out of the wood surface).

The measured values for the torsional resistance R_{tor} (= insertion moment) were normalized to a density of 450 kg/m³ (correction factor $k_\rho = 450 / \rho$).

The characteristic torsional resistance was obtained as $R_{tor,k} = 6{,}3$ Nm.

4.7 Withdrawal parameter

The results of the withdrawal tests with respect to solid soft wood specimen according to EN 1382 are given in Table 6, Annex 10. For each test conducted, the obtained maximum load $R_{ax,\rho}$, the normalized load R_{ax} (normalization to a characteristic wood density of $\rho_k = 350$ kg/m³, correction factor $k_\rho = \rho_k / \rho = 350 / \rho$) and the hereof deduced withdrawal parameter f_{ax} are listed in the table, respectively.

The withdrawal parameter was calculated according to EN 1382:

$f_{ax} = R_{ax} / (d \cdot s_g)$

with

R_{ax} maximum load of the withdrawal test (normalized with regard to the density),
d outer thread diameter of the screw,
s_g screw-in depth of the screw in the solid wood.

The characteristic withdrawal parameter was obtained as $f_{ax,k}$ = 12,9 N/mm².

4.8 Head pull-through parameter

The results of the head pull-through tests conducted according to EN 1382 are given in Table 7, Annex 11. For each test conducted, the obtained maximum load $R_{head,\rho}$, the normalized loads R_{head} (normalization to a characteristic wood density of ρ_k = 350 kg/m³, correction factor $k_\rho = \rho_k / \rho = 350 / \rho$) and the hereof deduced head pull-through parameter f_{head} are listed in the table, respectively.

The head pull-through parameter was calculated according to EN 1383:

$f_{head} = R_{head} / (d_h^2)$

with

R_{head} maximum load of the head pull-through test (adjusted with regard to the density),
d_h head diameter of the screw.

The characteristic head pull-through parameter was obtained as $f_{head,k}$ = 11,2 N/mm².

5 Summary of the essential results and expertise

5.1 General

The company Tecfi S.p.A., 81050 Pastorano/Italy, commissioned MPA University of Stuttgart to perform the Initial Type Testing (ITT) according to EN 14592:2008 on self-tapping wood screws type „TT02“ with a diameter of d = 6,0 mm. The tests conducted comprised the determination of the essential dimensions of the screws as well as the determination of the mechanical properties tensile capacity, torsional strength and yield moment in conjunction with the related bending angle. Furthermore, screw-in tests in glued-laminated timber, pull-out tests from solid wood and head pull-through tests through solid wood have been conducted.

All tests have been conducted with screws of the dimension d x L = 6,0 x 300 mm (= maximum screw length produced).

The calculation of the respective characteristic values was carried out according to EN 14358.

5.2 Dimensions

The recorded actual dimensions of the inspected screw type “TT02” (cf. Table 1, Annex 4; tested dimension d x L = 6,0 x 300 mm) were consistently within the tolerance limits according to EN 14592, Sections 5.2 to 5.4, with regard to the nominal values (cf. Figure 1, Annex 1) provided by the manufacturer.

Furthermore, the requirements according to EN 14592, Section 6.3.3, were fulfilled:

- Nominal diameter d (= outer thread diameter) within the range of 2,4 mm ≤ d ≤ 24 mm,
- Inner thread diameter d_1 of the screws within the range of 60 % to 90 % of the outer thread diameter d (0,6 d ≤ d_1 ≤ 0,9 d),
- Thread length L_t at least 6 times the outer thread diameter (L_t ≥ 6 d).

5.3 Summary of the test results obtained when determining the mechanical properties tensile capacity, yield moment and torsional strength of the screws

The Summaries 1 to 3 give an overview of the statistical quantities (mean value, standard deviation, coefficient of variation and characteristic value) obtained when determining the mechanical properties tensile capacity f_{tens}, yield moment M_y and torsional strength f_{tor} (= breaking torque) of the screws.

screw type	tested dimension	tensile capacity f_{tens}			
		mean value	standard deviation	coefficient of variation	characteristic value
	d x L	$f_{tens,mean}$	s	COV	$f_{tens,k}$
	[mm x mm]	[N]	[N]	[%]	[N]
Tecfi "TT02", carbon steel (zinc plated)	6,0 x 300	13913	265	1,9	12524

Summary 1: Overview of the statistical values (mean value, standard deviation, coefficient of variation and characteristic value) of the test results regarding the tensile capacity f_{tens} of wood screws type “TT02” (carbon steel; tested dimension: d x L = 6,0 x 300 mm)

screw type	tested dimension	yield moment M_y			
		mean value	standard deviation	coefficient of variation	characteristic value
	d x L	$M_{y,mean}$	s	COV	$M_{y,k}$
	[mm x mm]	[Nm]	[Nm]	[%]	[Nm]
Tecfi "TT02", carbon steel (zinc plated)	6,0 x 300	9,9	0,1	1,3	8,9

Summary 2: Overview of the statistical values (mean value, standard deviation, coefficient of variation and characteristic value) of the test results regarding the yield moment M_y of wood screws type “TT02” (carbon steel; tested dimension: d x L = 6,0 x 300 mm)

According to EN 14592, Section 6.3.4.2, screws designated for the use in load bearing timber structures must not have any cracks up to a bending angle of $\alpha_{lim} = (45/d^{0,7} + 10)$ degrees. This requirement was fulfilled by all tested screws type „TT02“.

screw type	tested dimension	torsional strength f_{tor}			
		mean value	standard deviation	coefficient of variation	characteristic value
	d x L	$f_{tor,mean}$	s	COV	$f_{tor,k}$
	[mm x mm]	[Nm]	[Nm]	[%]	[Nm]
Tecfi "TT02", carbon steel (zinc plated)	6,0 x 300	11,2	0,2	1,6	10,1

Summary 3: Overview of the statistical values (mean value, standard deviation, coefficient of variation and characteristic value) of the test results regarding the torsional strength f_{tor} (= breaking torque) of wood screws type “TT02” (carbon steel; tested dimension: d x L = 6,0 x 300 mm)

5.4 Summary of the test results obtained when determining the torsional resistance of the screws

Summary 4 gives an overview of the statistical quantities (mean value, standard deviation, coefficient of variation and characteristic value) obtained when determining the torsional resistance R_{tor} (= insertion moment) by means of screw-in tests. Also given are the characteristic torsional strength $f_{tor,k}$ (cf. Summary 3) and the characteristic torsional ratio $f_{tor,k}$ / $R_{tor,k}$ (= ratio between torsional strength and torsional resistance).

screw type	tested dimension	torsional resistance R_{tor}				charact. torsional strength	charact. torsional ratio
		mean value	standard deviation	coeff. of variation	charact. value		
	d x L	$R_{tor,mean}$	s	COV	$R_{tor,k}$	$f_{tor,k}$	$f_{tor,k}$ / $R_{tor,k}$
	[mm x mm]	[Nm]	[Nm]	[%]	[Nm]	[Nm]	[-]
Tecfi "TT02", carbon steel (zinc plated)	6,0 x 300	4,9	0,6	12,2	6,3	10,1	1,60

Summary 4: Overview of the statistical values (mean value, standard deviation, coefficient of variation and characteristic value) obtained when determining the torsional resistance R_{tor} of wood screws type “TT02” (carbon steel; tested dimension: d x L = 6,0 x 300 mm); additionally, the associated characteristic torsional strength $f_{tor,k}$ and the characteristic torsional ratio $f_{tor,k}$ / $R_{tor,k}$ (= ratio between torsional strength and torsional resistance) are given

According to EN 14592, Section 6.3.4.6, for screws used in load bearing timber structures, a ratio of at least $f_{tor,k}$ / $R_{tor,k}$ ≥ 1,5 is mandatory. As shown in Summary 4, this requirement was fulfilled by the screw type „ TT02”, dimension d x L = 6,0 x 300 mm, under consideration.

5.5 Summary of the test results obtained when determining the withdrawal parameter and the head pull-through parameter of the screws

The Summaries 5 and 6 give an overview of the statistical quantities (mean value, standard deviation, coefficient of variation and characteristic value) obtained when determining the withdrawal parameter f_{ax} and the head pull-through parameter f_{head} of the screws. The underlying characteristic density of the wood was, for both mechanical properties, ρ_k = 350 kg/m³.

screw type	tested dimension	withdrawal parameter f_{ax}			
		mean value	standard deviation	coefficient of variation	characteristic value
	d x L	$f_{ax,mean}$	s	COV	$f_{ax,k}$
	[mm x mm]	[N/mm²]	[Nm]	[%]	[N/mm²]
Tecfi "TT02", carbon steel (zinc plated)	6,0 x 300	14,3	0,5	3,8	12,9

Summary 5: Overview of the statistical values (mean value, standard deviation, coefficient of variation and characteristic value) obtained when determining the withdrawal parameter f_{ax} of wood screws type “TT02” (carbon steel; tested dimension: d x L = 6,0 x 300 mm)

screw type	tested dimension	head pull-through parameter f_{head}			
		mean value	standard deviation	coefficient of variation	characteristic value
	d x L	$f_{head,mean}$	s	COV	$f_{head,k}$
	[mm x mm]	[N/mm²]	[Nm]	[%]	[N/mm²]
Tecfi "TT02", carbon steel (zinc plated)	6,0 x 300	13,4	1,3	9,6	11,2

Summary 6: Overview of the statistical values (mean value, standard deviation, coefficient of variation and characteristic value) obtained when determining the head pull-through parameter f_{head} of wood screws type “TT02” (carbon steel; tested dimension: d x L = 6,0 x 300 mm)

5.6 Conclusion

The tested self-tapping wood screws with type designation “TT02”, diameter d = 6,0 mm, have successfully passed the Initial Type Testing (ITT) according to EN 14592:2008.

The requirements given in EN 14592, Table 4, regarding the measurements of the tested screws (tolerance limits acc. to EN 14592, Section 5 and Section 6.3.3) as well as the ratio between the torsional strength and the torsional resistance ($f_{tor,k}$ / $R_{tor,k}$ ≥ 1,5) have been fulfilled.

The following characteristic values have been determined:

- characteristic tensional capacity acc. to EN 1383: $f_{tens,k}$ = 12500 N
- characteristic yield moment acc. to EN 409: $M_{y,k}$ = 8,9 Nm
- characteristic withdrawal parameter acc. to EN 1382 (characteristic wood density ρ_k = 350 kg/m³): $f_{ax,k}$ = 12,9 N/mm²
- charact. head pull-through parameter acc. to EN 1383 (characteristic wood density ρ_k = 350 kg/m³): $f_{ax,k}$ = 11,2 N/mm²
- characteristic torsional ratio acc. to EN ISO 10666 and EN 14592, annex B: $f_{tor,k}$ / $R_{tor,k}$ = 1,60

All tests referred to in the present report have been conducted with self-tapping screws type “TT02” with countersunk head and partial thread made of carbon steel; the dimension tested was d x L = 6,0 x 300 mm.

The determined characteristic values may also be used for screws of the type under consideration with a length L < 300 mm (with a thread length L_t < 80 mm, respectively). However, according to EN 14592, Section 6.3.3, the minimum required thread length for screws with a nominal diameter (= outer thread diameter) of d = 6,0 mm is $L_{t,min} = 6 \cdot d = 36$ mm.

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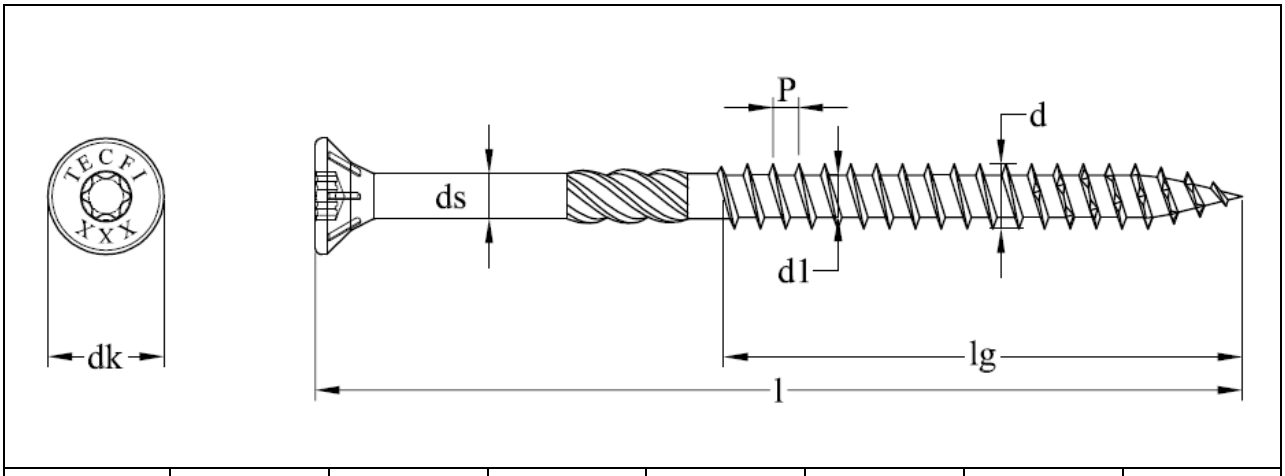

dimension	length	thread length	outer thread diameter	inner thread diameter	shank diameter	head diameter	thread pitch
d x L	L	L_g	d	d_1	d_s	d_k	P
[mm x mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
6,0 x 300	300,0	80,0	5,90	3,80	4,30	11,75	2,60

Figure 1: Shape and dimension of self-tapping screws type „TT02“ with countersunk head and partial thread made of carbon steel; tested dimension: d x L = 6,0 x 300 mm

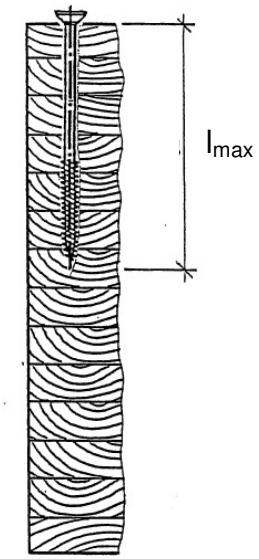

Figure 2: Scheme of the drill-in tests in order to determine the torsional resistance of self-tapping screws type „TT02” (carbon steel; tested dimension: d x L = 6,0 x 300 mm; maximum screw-in depth: l_{max} = 294 mm)

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