GRISPE

Guidelines and **R**ecommendations for **I**ntegrating **S**pecific **P**rofiled steel sheets in the **E**urocodes (**GRISPE**)

Test report

Main Part

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Guidelines and Recommendations for Integrating Specific Profiled Steels sheets in the Eurocodes (GRISPE)

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D 3.3 Test report	***Due date: 30th April 2015*** ***Completion date: 30th April 2015***

Content

1 Preliminary remarks

Versuchsanstalt für Stahl, Holz und Steine of the Karlsruhe Institute of Technology (KIT) investigated the load-bearing capacity of steel trapezoidal sheeting with and without perforation and with single holes for the research project "Guidelines and Recommendations for Integrating Specific Profiled Steels sheets in the Eurocodes (GRISPE)" co-funded under the Research Fund for Coal and Steel. The trapezoidal steel sheeting profiles were produced by Joris Ide (France). The test program was specified in the deliverable D3.2 "Test program definition".

2 Object of testing

The tested trapezoidal sheeting profiles from Joris Ide consist of steel sheeting according to EN 10346:2009, which are formed to profiles with the following section heights and overall widths by roll-forming:

Type of profile	Steel grade according to EN 10346:2009	Height [mm]	Width [mm]	Thickness [mm]
PML 73	S320GD	73	780	0.75 and 1.00
PML 56	S320GD	56	900	0.75 and 1.00

Table 1: Section heights and overall widths of the different tested profiles

The nominal cross-section geometry of the tested profiles is given in annex A.1 to A.2. The profile PML 73 was tested without perforation, with flange perforation, with web perforation and with total perforation. The single holes of the perforation were arranged square. In addition the profiles PML 73 and PML 56 were tested with a single hole (circular or square) in the middle of the span in the upper flange.

3 Scope of testing

The test performances for determination of the resistance values for bending, shear and web crippling were done according to EN 1993-1-3:2010. The tests performed are listed in table 2 as follows. In addition tensile tests according to EN 6892-1:2009 on perforated sheets and plate flexion tests were performed. Furthermore the profile geometry was measured.

Profile	Type of test	Type of perfora-tion/Type of hole	Thickness [mm]	Span [mm]	Number of tests
PML 73 (profile 4) Delivery 3	Single span test with down-ward load	without flange web total	0.75 and 1.00	3300	18
PML 73 (profile 4) Delivery 3	Internal support test with downward load with b_u = 60 mm and b_u = 160 mm	without flange web total		500	28
				1100	24
				1700	28
PML 73 (profile 4) Delivery 1	Internal support test with downward load with b_u = 60 mm and b_u = 160 mm	without flange*) web*) total*)		500	32
				1100	32
				1700	32
PML 73 (profile 4) Delivery 3	End support test with down-ward load	without flange web total		700	14
PML 73 (profile 4) Delivery 1	End support test with down-ward load	without flange*) web*) total*)		700	16
PML 73 (profile 4) Delivery 1	Single span test with down-ward load for profiles with a single hole in the upper flange in the middle of the span	without	0.75 and 1.00	3300	4
		circular d = 120 mm			4
		circular d = 105 mm			4
		circular d = 90 mm			4
		square d = 120 mm			4
		square d = 105 mm			4
		square d = 90 mm			4
PML 56 (profile 5) Delivery 2	Single span test with down-ward load for profiles with a single hole in the upper flange in the middle of the span	without	0.75 and 1.00	3300	4
		circular d = 100 mm			4
		circular d = 65 mm			4
		square d = 100 mm			4
		square d = 65 mm			4

*) perforation: triangle arrangement

Table 2: Tests performed

4 Test performance and results

4.1 General remarks

The test specimens were delivered August 13th (delivery 1) and October 24th (delivery 2) 2014 and January 14th (delivery 3) 2015. The tests were performed using calibrated testing machines of the Versuchsanstalt für Stahl, Holz und Steine of the Karlsruhe Institute of Technology (KIT). The specimens are all described by the following system:

System:	XXXX – XXXX – XXX – XX	
First block:	Type of test	
(two to four char.)	PF	= single span, positive flexion
	IS6	= internal support, b_u = 60 mm
	IS16	= internal support, b_u =160 mm
	ES	= end support
Second block:	Profile number	
(one to four char.)	4	= PML 73 without perforation
	4f	= PML 73 with flange perforation
	4w	= PML 73 with web perforation
	4t	= PML 73 with total perforation
	4Hc1	= PML 73 with single circular hole d = 120 mm
	4Hc2	= PML 73 with single circular hole d = 105 mm
	4Hc3	= PML 73 with single circular hole d = 90 mm
	4Hs1	= PML 73 with single square hole d = 120 mm
	4Hs2	= PML 73 with single square hole d = 105 mm
	4Hs3	= PML 73 with single square hole d = 90 mm
	5H1	= PML 56 without single hole
	5Hc1	= PML 56 with single circular hole d = 100 mm
	5Hc2	= PML 56 with single circular hole d = 65 mm
	5Hs1	= PML 56 with single square hole d = 100 mm
	5Hs2	= PML 56 with single square hole d = 65 mm
Third block (three char.):	Sheet thickness	
	075	= 0.75 mm
	100	= 1.00 mm
Fourth block:	Test number (running) and type of span (only for IS tests)	
(one or two char.)	1	= span l = 500 mm
	2	= span l = 1100 mm
	4	= span l = 1700 mm

4.2 Single span tests

For the determination of the characteristic values of the mid-span moment resistance, single span tests for load case “gravity loading” (positive flexion) were performed with uniformly distributed load simulated by four line loads. The tests performed are shown in table 2. The overhang of each profile was 100 mm. The load was introduced into the small flanges via transverse steel sections and timber blocks. The profiles were prevented from spreading by transverse ties. At the end supports timber blocks were used to avoid web crippling. The deflections were measured continuously in mid-span and at the end supports by each two trip wire displacement sensors. At mid span, the deflections were measured under the bottom flanges of edge ribs and at the end support at the upper flanges, see figure B.1 in annex B. The structure of the specimens and the static systems are given in annex B. The load was applied deflection-controlled with a speed of 30 mm/min. The load was measured continuously using a load cell with a maximum capacity of 50 kN. The displacement and the load measured were visualized as load-deflection curve.

In all single span tests a non-linear load-deflection behaviour appeared until the failure load was reached. In all tests failure occurred by buckling of the upper flange in the middle of the span near the load applying traverse.

The results including preload of the single span tests are listed in the following tables. Annex B shows the experimental setup, photos from the tests and the load deflection-curve.

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
PF-4-075-1	3300	0.748	0,59	10.36
PF-4-075-2		0.749		10.29
PF-4-075-3		0.745		10.45
PF-4-100-1		0.966		15.36
PF-4-100-2		0.960		15.08
PF-4-100-3		0.964		15.24
PF-4f-075-1		0.751		9.67
PF-4f-075-2		0.753		9.80
PF-4f-100-1		0.966		13.86
PF-4f-100-2		0.966		13.97
PF-4w-075-1		0.748		9.69
PF-4w-075-2		0.755		9.76
PF-4w-100-1		0.966		13.98
PF-4w-100-2		0.962		13.82
PF-4t-075-1		0.752		6.38
PF-4t-075-2		0.747		6.56
PF-4t-100-1		0.960		9.65
PF-4t-100-2		0.967		9.67

Table 4: Results of single span tests (delivery 3)

Test	Span [mm]	Measured hole diameter [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
PF-4-075-1	3300	-	0.727	0,57	9.08
PF-4-075-2		-	0.742		9.31
PF-4Hc1-075-1		121.7	0.724		7.93
PF-4Hc1-075-2		121.2	0.730		7.62
PF-4Hc2-075-1		106.4	0.731		8.50
PF-4Hc2-075-2		106.5	0.727		8.41
PF-4Hc3-075-1		92.2	0.735		8.48
PF-4Hc3-075-2		91.4	0.727		8.60
PF-4Hs1-075-1		121.7	0.736		7.74
PF-4Hs1-075-2		121.6	0.737		7.76
PF-4Hs2-075-1		106.3	0.741		8.37
PF-4Hs2-075-2		106.4	0.734		8.22
PF-4Hs3-075-1		91.7	0.726		8.63
PF-4Hs3-075-2		90.7	0.739		8,58
PF-4-100-1	3300	-	0.989	0,57	14.94
PF-4-100-2		-	0.983		14.90
PF-4Hc1-100-1		121.9	0.983		12.85
PF-4Hc1-100-2		122.0	0.981		13.06
PF-4Hc2-100-1		106.6	0.980		14.03
PF-4Hc2-100-2		106.0	0.982		14.05
PF-4Hc3-100-1		92.0	0.982		14.16
PF-4Hc3-100-2		91.0	0.980		13.95
PF-4Hs1-100-1		121.6	0.986		12.73
PF-4Hs1-100-2		121.6	0.984		12.68
PF-4Hs2-100-1		106.6	0.983		13.29
PF-4Hs2-100-2		106.5	0.985		13.36
PF-4Hs3-100-1		91.2	0.982		14.36
PF-4Hs3-100-2		93.1	0.980		14.26

Table 5: Results of single span tests (delivery 1)

Test	Span [mm]	Measured hole diameter [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
PF-5H1-075-1	3300	-	0.736	0,57	6.71
PF-5H1-075-2		-	0.730		6.68
PF-5Hc1-075-1		103.0	0.734		6.05
PF-5Hc1-075-2		103.3	0.736		6.29
PF-5Hc2-075-1		66.5	0.733		6.39
PF-5Hc2-075-2		66.7	0.730		6.40
PF-5Hs1-075-1		101.6	0.731		6.32
PF-5Hs1-075-2		101.5	0.736		6.16
PF-5Hs2-075-1		66.8	0.735		6.23
PF-5Hs2-075-2		66.6	0.733		6.26
PF-5H1-100-1		-	0.976		10.90
PF-5H1-100-2		-	0.978		10.71
PF-5Hc1-100-1		100.8	0.968		10.33
PF-5Hc1-100-2		101.0	0.977		10.31
PF-5Hc2-100-1		65.9	0.966		10.37
PF-5Hc2-100-2		65.6	0.958		10.38
PF-5Hs1-100-1		102.5	0.968		10.15
PF-5Hs1-100-2		101.3	0.967		10.30
PF-5Hs2-100-1		65.7	0.967		10.22
PF-5Hs2-100-2		66.3	0.969		10.28

Table 6: Results of single span tests (delivery 2)

4.3 Internal support tests

Instead of extensive investigations of the intermediate support area of continuous beams, internal support tests for load case “gravity loading” (intermediate support downward load) were performed. The tests performed are shown in table 2. Loading was applied in mid-span via a transverse steel plate with a width of b_u = 60 mm or b_u = 160 mm. The profiles were prevented from spreading by transverse ties. At the supports the profiles were pivoted on trapezoidal timber blocks. The deflections were measured continuously in mid-span and near the end supports by each two trip wire displacement sensors. At mid span and at end support, the deflections were measured under bottom flanges of edge ribs, see figure C.1 in annex C. The structure of the specimens and the static system are given in annex C.

The load was applied deflection-controlled with a speed of 3 mm/min to 5 mm/min, the speed was increased to 10 mm/min after the maximum load was reached. The load was measured continuously using a calibrated load cell. In all internal support tests (intermediate support downward load) an approximately linear elastic load-bearing behaviour appeared until failure load was reached. Failure occurred by deformation of the webs (web-crippling). The results including preload of the internal support tests are listed in the following table. Annex C shows the test setup, photos of the tests and the load deflection-curves.

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-4-075-11	500	0.722	0.15	16.18
IS6-4-075-12		0.730		16.36
IS6-4-075-21	1100	0.735		9.87
IS6-4-075-22		0.739		9.93
IS6-4-075-41	1700	0.726		7.49
IS6-4-075-42		0.732		7.39
IS16-4-075-11	500	0.727		21.76
IS16-4-075-12		0.724		22.03
IS16-4-075-21	1100	0.732		13.29
IS16-4-075-22		0.737		13.74
IS16-4-075-41	1700	0.729		9.45
IS16-4-075-42		0.730		9.27
IS6-4-100-11	500	0.978		28.90
IS6-4-100-12		0.987		28.37
IS6-4-100-21	1100	0.981		16.75
IS6-4-100-22		0.986		16.57
IS6-4-100-41	1700	0.982		12.14
IS6-4-100-42		0.980		12.15
IS16-4-100-11	500	0.977		38.57
IS16-4-100-12		0.983		37.87
IS16-4-100-21	1100	0.990		22.08
IS16-4-100-22		0.986		21.66
IS16-4-100-41	1700	0.976		14.58
IS16-4-100-42		0.980		14.36

Table 7: Results of internal support tests for profiles without perforation (delivery 1)

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-4f-075-11	500	0.730	0.15	16.35
IS6-4f-075-12		0.724		16.14
IS6-4f-075-21	1100	0.737		9.71
IS6-4f-075-22		0.738		9.65
IS6-4f-075-41	1700	0.727		7.28
IS6-4f-075-42		0.728		7.30
IS16-4f-075-11	500	0.734		21.67
IS16-4f-075-12		0.732		21.62
IS16-4f-075-21	1100	0.735		13.10
IS16-4f-075-22		0.736		12.99
IS16-4f-075-41	1700	0.730		8.82
IS16-4f-075-42		0.723		8.85
IS6-4f-100-11	500	0.970		27.96
IS6-4f-100-12		0.979		28.06
IS6-4f-100-21	1100	0.978		16.08
IS6-4f-100-22		0.976		16.27
IS6-4f-100-41	1700	0.980		11.73
IS6-4f-100-42		0.981		11.75
IS16-4f-100-11	500	0.973		37.89
IS16-4f-100-12		0.976		38.20
IS16-4f-100-21	1100	0.982		20.86
IS16-4f-100-22		0.975		20.61
IS16-4f-100-41	1700	0.983		13.88
IS16-4f-100-42		0.978		13.95

Table 8: Results of internal support tests for profiles with perforation in the flanges (delivery 1)

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-4w-075-11	500	0.725	0.15	12.23*)
IS6-4w-075-12		0.729		13.05
IS6-4w-075-21	1100	0.740		8.39
IS6-4w-075-22		0.737		8.54
IS6-4w-075-41	1700	0.736		6.26
IS6-4w-075-42		0.733		6.26
IS16-4w-075-11	500	0.734		18.49*)
IS16-4w-075-12		0.730		18.32*)
IS16-4w-075-21	1100	0.730		10.82
IS16-4w-075-22		0.737		10.78
IS16-4w-075-41	1700	0.730		7.43
IS16-4w-075-42		0.728		7.40
IS6-4w-100-11	500	0.972		22.95
IS6-4w-100-12		0.978		22.77
IS6-4w-100-21	1100	0.987		14.25
IS6-4w-100-22		0.983		14.37
IS6-4w-100-41	1700	0.981		10.25
IS6-4w-100-42		0.982		10.31
IS16-4w-100-11	500	0.975		32.31
IS16-4w-100-12		0.985		32.43
IS16-4w-100-21	1100	0.988		18.43
IS16-4w-100-22		0.988		17.78
IS16-4w-100-41	1700	0.983		11.92
IS16-4w-100-42		0.985		12.09

*) rectangular timber blocks at the end supports

Table 9: Results of internal support tests for profiles with perforation in the webs (delivery 1)

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-4t-075-11	500	0.733	0.15	10.67*)
IS6-4t-075-12		0.738		10.34
IS6-4t-075-21	1100	0.733		6.70
IS6-4t-075-22		0.740		6.71
IS6-4t-075-41	1700	0.739		4.90
IS6-4t-075-42		0.732		4.87
IS16-4t-075-11	500	0.737		14.74*)
IS16-4t-075-12		0.726		14.70*)
IS16-4t-075-21	1100	0.739		8.71
IS16-4t-075-22		0.730		8.64
IS16-4t-075-41	1700	0.736		5.78
IS16-4t-075-42		0.735		5.81
IS6-4t-100-11	500	0.988		19.72
IS6-4t-100-12		0.990		19.34
IS6-4t-100-21	1100	0.984		11.31
IS6-4t-100-22		0.976		11.24
IS6-4t-100-41	1700	0.991		8.05
IS6-4t-100-42		0.990		8.09
IS16-4t-100-11	500	0.981		26.35
IS16-4t-100-12		0.982		26.47
IS16-4t-100-21	1100	0.995		14.07
IS16-4t-100-22		0.989		14.04
IS16-4t-100-41	1700	0.984		9.29
IS16-4t-100-42		0.983		9.41

*) rectangular timber blocks at the end supports

Table 10: Results of internal support tests for profiles with total perforation (delivery 1)

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-4-075-11	500	0.740	0.16	17.19
IS6-4-075-12		0.741		16.44
IS6-4-075-21	1100	0.741		10.74
IS6-4-075-22		0.738		10.77
IS6-4-075-41	1700	0.746		8.27
IS6-4-075-42		0.747		8.23
IS16-4-075-11	500	0.735		23.77
IS16-4-075-12		0.752		22.79
IS16-4-075-21	1100	0.737		14.90
IS16-4-075-22		0.740		14.59
IS16-4-075-41	1700	0.746		10.20
IS16-4-075-42		0.748		10.31
IS6-4-100-11	500	0.953		27.23
IS6-4-100-12		0.954		27.14
IS6-4-100-21	1100	0.950		16.05
IS6-4-100-22		0.950		16.01
IS6-4-100-41	1700	0.957		11.92
IS6-4-100-42		0.959		11.95
IS16-4-100-11	500	0.954		35.54
IS16-4-100-12		0.953		35.09
IS16-4-100-21	1100	0.949		21.26
IS16-4-100-22		0.950		21.24
IS16-4-100-41	1700	0.962		14.37
IS16-4-100-42		0.964		14.50

Table 11: Results of internal support tests for profiles without perforation (delivery 3)

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-4f-075-11	500	0.735	0.16	16.46
IS6-4f-075-41	1700	0.747		8.11
IS16-4f-075-11	500	0.732		23.56
IS16-4f-075-41	1700	0.753		9.70
IS6-4f-100-11	500	0.945		26.64
IS6-4f-100-41	1700	0.967		11.55
IS16-4f-100-11	500	0.952		36.04
IS16-4f-100-41	1700	0.959		14.00

Table 12: Results of internal support tests for profiles with perforation in the flanges (delivery 3)

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-4w-075-11	500	0.738	0.16	13.73
IS6-4w-075-12		0.740		13.65
IS6-4w-075-21	1100	0.741		9.40
IS6-4w-075-22		0.738		9.36
IS6-4w-075-41	1700	0.745		7.21
IS6-4w-075-42		0.743		7.23
IS16-4w-075-11	500	0.742		19.31
IS16-4w-075-12		0.741		18.43
IS16-4w-075-21	1100	0.740		12.50
IS16-4w-075-22		0.740		12.33
IS16-4w-075-41	1700	0.745		8.66
IS16-4w-075-42		0.748		8.66
IS6-4w-100-11	500	0.946		22.12
IS6-4w-100-12		0.950		21.87
IS6-4w-100-21	1100	0.948		14.29
IS6-4w-100-22		0.946		14.11
IS6-4w-100-41	1700	0.964		10.39
IS6-4w-100-42		0.963		10.34
IS16-4w-100-11	500	0.947		29.71
IS16-4w-100-12		0.955		29.87
IS16-4w-100-21	1100	0.947		17.89
IS16-4w-100-22		0.947		18.22
IS16-4w-100-41	1700	0.970		12.29
IS16-4w-100-42		0.964		12.41

Table 13: Results of internal support tests for profiles with perforation in the webs (delivery 3)

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-4t-075-11	500	0.745	0.16	11.80
IS6-4t-075-12		0.735		11.95
IS6-4t-075-21	1100	0.739		7.30
IS6-4t-075-22		0.739		7.20
IS6-4t-075-41	1700	0.747		5.43
IS6-4t-075-42		0.743		5.51
IS16-4t-075-11	500	0.738		15.61
IS16-4t-075-12		0.733		15.70
IS16-4t-075-21	1100	0.735		9.68
IS16-4t-075-22		0.740		9.78
IS16-4t-075-41	1700	0.748		6.58
IS16-4t-075-42		0.748		6.66
IS6-4t-100-11	500	0.951		18.47
IS6-4t-100-12		0.954		18.26
IS6-4t-100-21	1100	0.988		10.95
IS6-4t-100-22		0.941		10.84
IS6-4t-100-41	1700	0.961		8.05
IS6-4t-100-42		0.962		8.03
IS16-4t-100-11	500	0.954		24.02
IS16-4t-100-12		0.980		24.00
IS16-4t-100-21	1100	0.948		14.02
IS16-4t-100-22		0.947		14.11
IS16-4t-100-41	1700	0.960		9.50
IS16-4t-100-42		0.963		9.52

Table 14: Results of internal support tests for profiles with total perforation (delivery 3)

4.4 End support tests

For the determination of the characteristic values of the end support resistance, end support tests for load case “gravity loading” were performed. The tests performed are shown in table 2. The load was applied via a transverse steel plate with a width of b = 300 mm and timber blocks attached to the bottom flanges of the profiles.

The profiles were prevented from spreading by transverse ties. At the tested end support a cutting edge (gradient of 1:20) is located. At the opposite end support timber blocks were used to avoid web crippling. The deflections were measured continuously at the transverse steel plate and at the end support with the cutting edge by two trip wire displacement sensors. At the end support the deflections were measured at the upper flanges, see figure D.1 in annex D. The structure of the specimens and the static systems are given in annex D. The load was applied deflection-controlled with a speed of 5 mm/min. The load was measured continuously using a calibrated load cell. Failure occurred by deformation of the webs (web-crippling) at the end supports followed by buckling of the upper flange below the load applying plate.

The results including preload of the end support tests are listed in the tables as follows. Annex D shows the test setup, photos from the tests and the load deflection-curves.

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
ES-4-075-1	700	0.738	0.54	29.94
ES-4-075-2		0.728		29.49
ES-4w-075-1		0.737		21.99
ES-4w-075-2		0.729		24.03
ES-4w-075-3		0.727		24.82
ES-4t-075-1		0.732		19.97
ES-4t-075-2		0.731		19.25
ES-4t-075-3		0.740		20.67
ES-4-100-1	700	0.985	0.54	47.39
ES-4-100-2		0.986		47.23
ES-4w-100-1		0.987		39.98
ES-4w-100-2		0.982		38.43
ES-4w-100-3		0.987		39.58
ES-4t-100-1		0.979		34.51
ES-4t-100-2		0.980		35.49
ES-4t-100-3		0.989		34.19

Table 15: Results of end support tests (delivery 1)

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
ES-4-075-1	700	0.746	0.54	27.09
ES-4-075-2		0.744		26.67
ES-4f-075-1		0.750		26.54
ES-4w-075-1		0.745		20.63
ES-4w-075-2		0.748		20.02
ES-4t-075-1		0.745		16.63
ES-4t-075-2		0.745		17.00
ES-4-100-1	700	0.963	0.54	43.81
ES-4-100-2		0.964		43.48
ES-4f-100-1		0.962		42.04
ES-4w-100-1		0.962		30.56
ES-4w-100-2		0.961		30.36
ES-4t-100-1		0.955		26.23
ES-4t-100-2		0.960		26.40

Table 16: Results of end support tests (delivery 3)

4.5 Measurement of the profile geometry

The dimensions of the different profiles (PML 73 and PML 56) for both nominal thicknesses t_N = 0.75 mm and t_N = 1.00 mm were determined. The results are documented in annex G.

4.6 Material properties

For the determination of the material properties, 3 specimens per sheet , delivery date and per thickness were worked out for tensile tests according to EN 6892-1:2009 with the speci-men shape 2 according to EN 6892-1:2009 table B.1. The determination of the yield strength $R_{p0.2}$ and the tensile strength R_m was based upon the measured sheet thickness exclusive of zinc coating. The results of the tensile tests are given in table 17.

Profile/delivery	Nominal thickness t_N [mm]	Core thickness t_K [mm]	Yield strength $R_{p0,2}$ [N/mm²]	Tensile strength R_m [N/mm²]	Elongation at fracture $A_{L=80mm}$ [%]
PML 73 (profile 4) delivery 1 (to compare triangle perforated trapezoidal steel sheets)	0.75	0.698	355	391	30.1
		0.689	362	394	20.0
		0.697	354	390	30.6
	1.00	0.938	358	472	20.0
		0.936	367	488	20.0
		0.938	360	474	26.9
PML 73 (profile 4) delivery 1 (to compare holed trapezoidal steel sheets)	0.75	0.700	357	391	32.2
		0.701	355	391	31.7
		0.699	360	393	31.4
	1.00	0.945	360	463	27.5
		0.943	364	467	27.6
		0.947	361	467	27.3
PML 56 (profile 5) delivery 2 (to compare holed trapezoidal steel sheets)	0.75	0.697	355	393	30.4
		0.697	360	393	30.6
		0.700	358	391	30.8
	1.00	0.928	371	466	27.7
		0.932	371	467	27.4
		0.927	368	465	27.3
PML 73 (profile 4) delivery 3 (to compare square perforated trapezoidal steel sheets)	0.75	0.706	398	448	26.5
		0.711	393	447	25.9
		0.710	400	448	26.0
	1.00	0.926	379	470	26.4
		0.921	377	469	26.6
		0.926	376	468	26.6

Table 17: Results of tensile tests

For the determination of the material properties for perforated sheets, 3 specimens per type of perforation (fs = without perforation to compare with square arrangement, ft = without perforation to compare with triangular arrangement, s = perforation arranged in squares, t = perforation arranged in triangles) and per thickness were worked out for tensile tests according to EN 6892-1:2009 with the specimen shape 2 according to EN 6892-1:2009 table

B.1. The results of the tensile tests are given in table 18 and the stress-strain curves (based on the initial cross-sections) are given in annex E.

Test	Nominal thickness t_N [mm]	Width b_0 [mm]	e [mm]	d [mm]	Core thickness t_K [mm]	F_{max} [kN]	Yield strength $R_{p0,2}$ [N/mm²]	Tensile strength R_m [N/mm²]
TT-4fs-075-1	0.75	20.01	-	-	0.704	6.31	394	448
TT-4fs-075-2		20.00			0.705	6.32	399	448
TT-4fs-075-3		19.99			0.705	6.29	394	446
TT-4ft-075-1		20.01	-	-	0.706	7.09	387	502
TT-4ft-075-2		20.02			0.706	7.05	387	499
TT-4ft-075-3		20.02			0.705	7.08	388	502
TT-4s-075-1		20.03	11.21	4,98	0.703	3.42	206	243
TT-4s-075-2		20.04			0.701	3.43	207	244
TT-4s-075-3		20.04			0.701	3.40	205	242
TT-4t-075-1		20.01	12.49	4,98	0.707	4.31	233	305
TT-4t-075-2		20.02			0.706	3.97	228	281
TT-4t-075-3		20.02			0.706	3.59	229	254
TT-4t-075-4		20.03			0.706	3.59	229	254
TT-4fs-100-1	1.00	20.00	-	-	0.926	8.71	376	471
TT-4fs-100-2		20.01			0.926	8.68	375	468
TT-4fs-100-3		20.04			0.924	8.64	375	466
TT-4ft-100-1		20.01	-	-	0.925	8.57	390	463
TT-4ft-100-2		20.02			0.927	8.64	386	466
TT-4ft-100-3		20.01			0.925	8.64	390	467
TT-4s-100-1		20.03	11.22	4,98	0.917	4.61	208	251
TT-4s-100-2		20.02			0.919	4.70	208	255
TT-4s-100-3		20.03			0.920	4.71	207	256
TT-4t-100-1		20.02	12.50	4,99	0.927	4.57	227	246
TT-4t-100-2		20.02			0.925	4.60	217	249
TT-4t-100-3		20.01			0.926	3.95	217	247

Table 18: Results of tensile tests for perforated sheets

In addition 3-point bending tests on coupons (l =120 mm) with different perforation type (see above) were performed. The span was in all tests s = 108 mm. The results are given in table 19, the measured thicknesses and the load-displacement curves are given in annex F.

Test	Nominal thickness t_N [mm]	e [mm]	d [mm]	Width b_0 [mm]	Load F_0 [N]	Displacement w_0 [mm]
FT-4fs-075-1	0.75	-	-	45.89	20,03	1,70
FT-4fs-075-2				45.85	20,04	1,67
FT-4fs-075-3				45.89	20,03	1,69
FT-4ft-075-1		-	-	42.94	20,04	1,86
FT-4ft-075-2				42.88	20,03	1,88
FT-4ft-075-3				42.82	20,03	1,89
FT-4s-075-1		11.22	4.98	45.90	20,01	2,37
FT-4s-075-2				42.92	20,02	2,36
FT-4s-075-3				45289	20,01	2,35
FT-4t-075-1		12.48	4.98	42.56	20,03	2,31
FT-4t-075-2				42.53	20,03	2,55
FT-4t-075-3				42.51	20,02	2,55
FT-5fs-100-1	1.00	-	-	45.88	50,11	1,89
FT-5fs-100-2				45.87	50,08	1,93
FT-5fs-100-3				45.87	50,11	1,88
FT-5ft-100-1		-	-	43.17	50,10	2,03
FT-5ft-100-2				42.98	50,08	2,04
FT-5ft-100-3				43.38	50,09	2,09
FT-5s-100-1		11.22	4.98	45.88	50,04	2,71
FT-5s-100-2				45.87	50,06	2,67
FT-5s-100-3				44.89	50,04	2,75
FT-5t-100-1		12.51	4.99	44.58	50,06	2,80
FT-5t-100-2				44.69	50,06	2,44
FT-5t-100-3				44.65	50,06	2,70

Table 19: Results of 3-point bending tests

5 Summary

For the research project “Guidelines and Recommendations for Integrating Specific Profiled Steels sheets in the Eurocodes (GRISPE)” co-funded under the Research Fund for Coal and Steel the “Versuchsanstalt für Stahl, Holz und Steine” of the Karlsruhe Institute of Technology (KIT) made experimental investigations according to EN 1993-1-3:2010 on the load-bearing capacity of steel trapezoidal sheeting with and without perforation (triangle and square arrangement). Also tensile tests according to EN 6892.1:2009 and profile geometry measurements were accomplished.

In chapter 2 the trapezoidal sheeting are described with regard to application, geometry and material. Chapter 3 reflects the scope of testing. The description of the test set-up, the test performance and the documentation of the test results are given in chapter 4.