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krafton® bridge deck plank 500.55

Mechanical Properties

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1. Summary

In this report the mechanical properties of the pultruded glass fibre reinforced krafton® 500.55 bridge deck plank are reported. The mechanical properties of the bridge deck plank have been determined by means of testing. The tests were executed by TüV Rheinland (former TNO Quality services) and reported in report 11609R-E09.0246 dated 01.09.2011.

The properties are summarized in Table 1.

From Issue 3 onwards, "brake tests" have also been executed by krafton®. These have been reported.

In Issue 5 the bending stress ($\sigma_{b,char}$), bending strength (M_b), shear stress (τ_{kar}) and shear strength (D) have been recalculated based on the test performed on 26-02-2016 by SKZ and the characteristic shear force ($D_{char,200}$) due to a point load at 200 x 200 recalculated, based on the tests performed by krafton® on 21-12-2018.

		Unit	krafton® 500.55
Dimensions	(b x h)	mm	500 x 55
Cross section	(A)	mm^2	6,238
Shear surface	(A_s)	mm^2	2,503
Moment of inertia	(I)	mm^4	2,705,284
Section modulus	(W)	mm^3	82,078
Weight	(G)	kg/m^2	22.4
Modulus of elasticity	(E_{av})	N/mm^2	31,443
Flexural strength	($\sigma_{b,char}$)	N/mm^2	366
Shear strength	(τ_{char})	N/mm^2	52.2
Profile properties			
Flexural stiffness	(EI)	Nmm^2/mm	170.1×10^6
Flexural strength	(M_b)	Nmm/mm	60,081
Shear strength	(D)	N/mm	261
Compressive strength	($N_{\perp,char}$)	N/mm/rib	563
Characteristic shear force due to point load on 200 x 200	($D_{char,200}$)	N	123,317
Characteristic braking force with 1 mounting block	($RE_{char,1}$)	N	7,425
Characteristic braking force with 2 mounting blocks	($RE_{char,2}$)	N	19,499
Characteristic braking force with 4 mounting blocks	($RE_{char,4}$)	N	44,953

Table 1

2. Product description

Pultruded, glass fibre reinforced polyester bridge deck plank.

Figure 1 shows the cross-section of the plank. The global dimensions are 500 x 55 x 5 mm. The thickness of the vertical ribs is 4 mm.

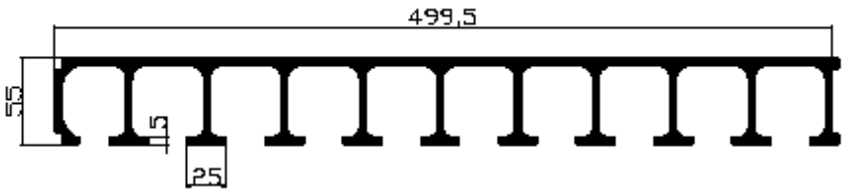

Figure 1

2.1. Geometric properties

Width	b	:	500	mm
Height	h	:	55	mm
Number of ribs	n	:	11	pcs
Distance between the ribs	d	:	50	mm
Surface	A	:	6,238	mm^2
Shear area	As	:	2,503	mm^2
Moment of inertia	I	:	2,705,284	mm^4
Section modulus	W	:	82,078	mm^3
Weight of plank	G	:	22.4	kg/m^2

3. Test

3.1. Test description

5 tests were carried out, namely:

- Determination of flexural stiffness and flexural strength according to EN ISO 14125.
- Determination of shear strength by means of a 3-point bending test with a stamp, right next to the support.
- Determination of compressive strength perpendicular to the bridge deck according to ISO 604
- Determination of permissible shear force as a result of a point load at 200 mm x 200 mm, according to the wheel print of an unintended vehicle according to EN1991-2 NB - Traffic loads on bridges.
- Determination of permissible horizontal braking force on a typical joint
    - Plank connected with 1 mounting block
    - Plank connected with 2 mounting blocks
    - Plank connected with 4 mounting blocks

3.2. Test results

According to EN1990:2002 appendix D, the characteristic strength value is calculated from the average strength value minus k_n times the standard deviation. The values for k_n are used according to table D1 in EN1990:2002. The characteristic stiffness value is equal to the average measured stiffness value.

3.2.1. Flexural modulus

The flexural modulus is determined by determining the slope of the force-displacement curve. The slope is determined by taking two points on the graph and drawing a line between them. The points are chosen in the linear part of the curve. The E-modulus is calculated with the following formula:

$$\Delta y = \frac{\Delta F \times \ell^3}{48 \times E_b I} \qquad \rightarrow \qquad E_b = \frac{\Delta F \times \ell^3}{48 \times I \times \Delta y}$$

Wherein:

Δy	=	Displacement [mm]
ΔF	=	Force [N]
ℓ	=	Span [mm]
E_b	=	Flexural modulus [N/mm^2]
I	=	Moment of inertia [mm^4]

Sample no.	ℓ [mm]	F [N]	y [mm]	E_b [N/mm²]
2	880	80,000	13.5	31,100
3	1,100	80,000	23.4	35,040
4	1,200	79,824	36.8	28,860
5	1,200	80,000	33.7	31,590
6	1,200	80,000	34.6	30,770
			Average value [$E_{b,av}$]	31,443
			Standard deviation [s]	2,188

Table 2

3.2.2. Flexural strength

The test values ($F_{failure}$) are used to determine the flexural strength (σ_b) using the following formula:

$$\sigma_b = \frac{F_{failure} \times l}{4 \times W}$$

Wherein: ℓ = Span see Table 1

W = Section modulus 82,078 mm³

Sample no.	ℓ [mm]	$F_{failure}$ [N]	$\sigma_{b,min}$ [N/mm²]
1	1,400	91,810	391
2	1,400	92,880	396
3	1,400	101,390	432
4	1,400	91,030	388
5	1,400	92,080	393
6	1,400	99,380	424
		Average [$\sigma_{b,av}$]	404
		Standard deviation [s]	17
		Characteristic value [$\sigma_{b,char}$]	366

Table 3

The characteristic value is determined from the average value minus 2.18 x the standard deviation.

3.2.3. Shear strength

The test values ($F_{failure}$) are used to determine the shear strength (τ) by the following formula:

$$\tau = \frac{F_{failure} \times (L - a)}{L \times A_s}$$

The test was executed on a test bench with a measuring range of 250 kN. The test sample has a length of 3080 mm and has been tested at a span of L=1400mm. The pressure punch forms a line load on the product with a diameter of 30 mm. The distance between the punch and the support was a = 65 mm.

Sample no.	$F_{failure}$ [N]	τ [N/mm²]
1	144,000	54.9
2	139,000	53.0
3	148,000	56.4
4	142,000	54.1
5	145,000	55.2
6	126,000	48.0
	Average value [τ_{av}]	54.7
	Standard deviation [s]	1.1
	Characteristic value [τ_{char}]	52.2

Table 4

The characteristic value is determined from the average value minus 2.18 x the standard deviation.

3.2.4. Shear strength for a concentrated load at 200 x 200 mm

The test results ($F_{failure}$) are used to determine the shear strength (D_{200}) by means of the following formula:

$$D_{200} = \frac{F_{failure} \times (l - l_0)}{l}$$

This only applies to a load on 200 x 200 mm. The value ℓ_0 is equal to half the length of the point load surface, plus the distance between the support and the edge of the point load.

Sample no.	ℓ [mm]	ℓ_0 [mm]	$F_{failure}$ [N]	D_{200} [N/mm]
1	1,000	200	137,580	123,822
2	1,000	200	144,500	130,050
3	1,000	200	146,550	131,895
4	1,000	200	145,760	131,184
5	1,000	200	146,320	131,688
6	1,000	200	142,390	128,151
Average value [$D_{av,200}$]				129,465
Standard deviation [s]				2,820
Characteristic value [$D_{char,200}$]				123,317

Table 5

The characteristic value is determined from the average value minus 2.18 x the standard deviation.

3.2.5. Compressive strength under a concentrated load

The compressive strength has been tested with a pressure punch of 100 x 50 mm. The measured force (Fmax) is divided by the number of supporting ribs and the length of the punch (50 mm). The resulting force per mm of rib can be used to evaluate any point load.

Sample no.	F_{max} [N]	$N_{\perp}$ [N/mm]
1	86,871	869
2	78,770	788
3	86,435	864
4	73,940	739
5	64,505	645
	Average value [$N_{\perp,av}$]	781
	Standard deviation [s]	93
	Characteristic value [$N_{\perp,char}$]	563

Table 6

The characteristic value is determined from the average value minus 2.18 x the standard deviation.

3.2.6. Horizontal shear joint with 1 block per plank

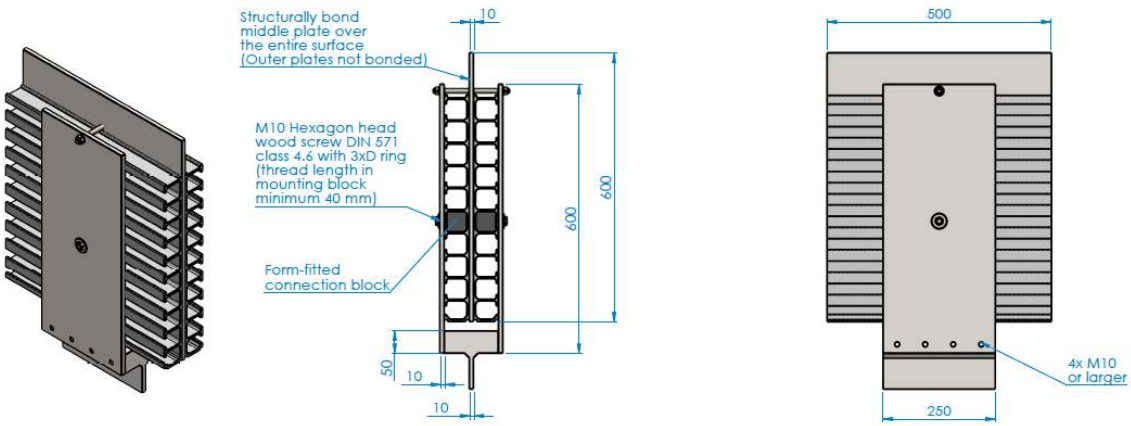

Figure 2 Test setup 1 connection block

The test is performed on 2 planks at the same time to obtain a symmetrical force transmission. So two specimens are tested per test. The force on each connection is half of the measured breaking force.

Sample no.	F_{max} [N]	RE_1 [N]
1	19,900	9,950
2	22,900	11,450
3	24,300	12,150
4	17,800	8,900
5	17,800	8,900
	Average value [$RE_{1,av}$]	10,270
	Standard deviation [s]	1,482
	Characteristic value [$RE_{1,char}$]	7,425

Table 7

The characteristic value is determined from the average value minus 2.18 x the standard deviation. (cf EN1990 Annex D - based on 10 tests and Vx unknown)

3.2.7. Horizontal shear joint with 2 blocks per plank

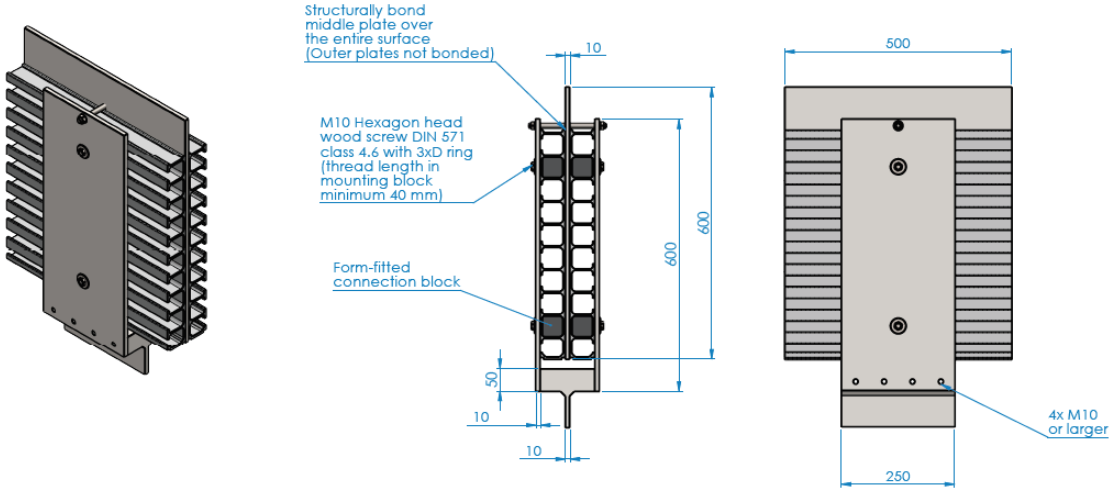

Figure 3 Test setup 2 connection blocks

The test is performed on 2 planks at the same time to obtain a symmetrical force transmission. So two specimens are tested per test. The force on each connection is half of the measured breaking force.

Sample no.	F_{max} [N]	RE_2 [N]
1	46,500	23,250
2	48,200	24,100
3	52,300	26,150
4	61,600	30,800
5	46,900	23,450
	Average value [$RE_{2,av}$]	25,550
	Standard deviation [s]	3,151
	Characteristic value [$RE_{2,char}$]	19,499

Table 8

The characteristic value is determined from the average value minus 2.18 x the standard deviation. (cf EN1990 Annex D - based on 10 tests and Vx unknown)

3.2.8. Horizontal shear joint with 4 blocks per plank

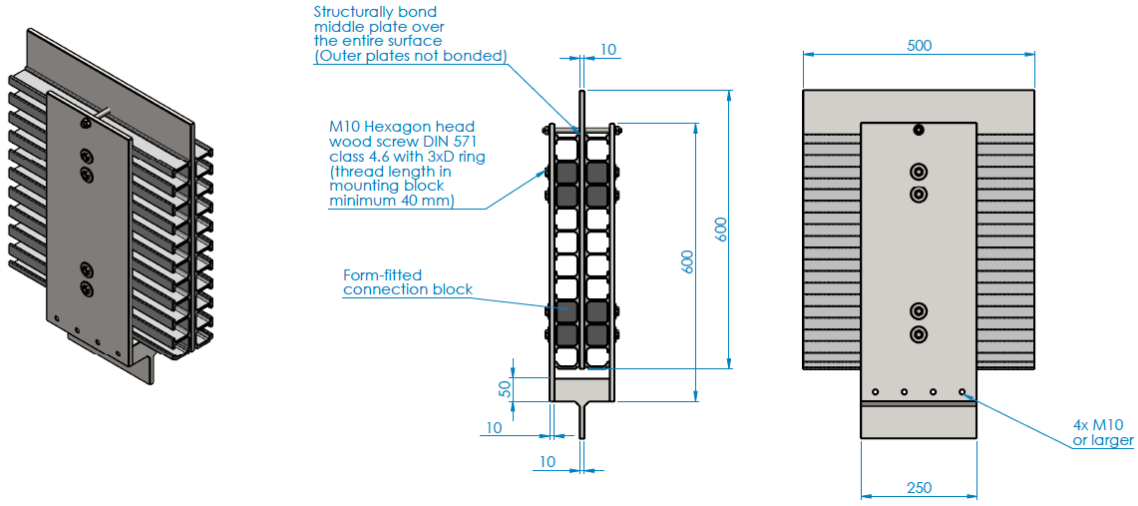

Figure 4 Test setup 4 connection blocks

The test is performed on 2 planks at the same time to obtain a symmetrical force transmission. So two specimens are tested per test. The force on each connection is half of the measured breaking force.

Sample no.	F_{max} [N]	RE_1 [N]
1	90,700	45,350
2	100,000*	50,000
3	100,000*	50,000
4	97,500	48,750
5	100,000*	50,000
	Average value [$RE_{4,av}$]	48,820
	Standard deviation [s]	2,014
	Characteristic value [$RE_{4,char}$]	44,953

Table 9

The characteristic value is determined from the average value minus 2.18 x the standard deviation. (cf EN1990 Annex D - based on 10 tests and Vx unknown)

* The test bench limit is reached at 100kN, full break not achieved, damage reported.