FOREST project

Physical and Mechanical Properties of Densified Veneer Wood for Structural Applications

Part 3.1

DENSIFIED VENEER WOOD REINFORCED JOINTS WITH DOWEL-TYPE FASTENERS LOADED IN TENSION

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Annex

DENSIFIED VENEER WOOD REINFORCED JOINTS WITH DOWEL-TYPE FASTENERS LOADED IN TENSION

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1 Introduction

The load-carrying capacity of joints with mechanical fasteners frequently determines the size of the members. By gluing a wood-based material like densified veneer wood (dvw) on the surface of the timber members, the member properties are improved and the spacings and distances of the fasteners can be reduced. The reinforcing material is able to distribute concentrated loads uniformly while the glueline transfers the shear stresses to the timber. Gluing of dvw to wood is easy to perform. Temperature cycling tests as well as delamination tests were carried out by JANSSEN 1988 to investigate the glueline quality. It was concluded that the glueline between dvw and wood, using recorcinol adhesives, is at least as good as gluelines of glued laminated timber.

This report presents the results of tests with densified veneer wood reinforced joints with dowel-type fasteners loaded in tension. The three member tests were performed with expanding tube fasteners and bolts.

The tube is a new type of fastener developed for structural use. The pre-drilled holes have a larger diameter than the tube itself. It is fastened and expanded in diameter by decreasing its length due to compression at both ends. The expansion of the diameter should be limited to prevent splitting of the timber. Washers are needed to fix the curled ends.

2 Tests

2.1 Test programme

With a total of 58 tests the load-carrying capacity and the load-deformation behaviour of locally reinforced three member joints was investigated taking into consideration the following influencing parameters.

- target thickness of the reinforcement
- quality of the veneers
- type of fastener
- diameter of the tube fastener
- end distance of the fastener

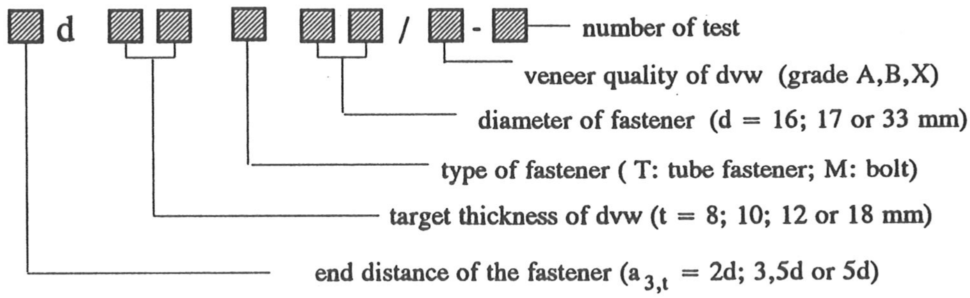
The test programme is given in **Table 1.** Four or five tests were made in each test-series.

Table 1: Test programme

end distance	tube fastener d = 33 mm		tube fastener d = 17 mm			hexagon bolt M 16
	t = 12 mm	t = 18 mm	t = 8 mm	t = 10 mm	t = 12 mm	t = 10 mm
2 d	2,0d12T33	2,0d18T33	-	2,0d10T17	2,0d12T17	-
3,5 d	3,5d12T33	3,5d18T33	3,5d08T17	3,5d10T17	3,5d12T17	3,5d10M16
5 d	5,0d12T33	5,0d18T33	5,0d08T17	-	-	5,0d10M16

The diameters of the tube fasteners in **Table 1** are diameters before expanding the tubes.

The notation of the individual tests is as follows:



2.2 Test material

The investigations were focused on glued laminated timber and dvw made of beech. The densities of the European whitewood lamellae, where the fasteners were placed, are given in **Annex 1 and 2**. The histogram of density is shown in **Fig.1**. The mean density at a temperature of 20°C and a relative humidity of 0,65 was 436 kg/m³ with a standard deviation of 42,8 kg/m³.

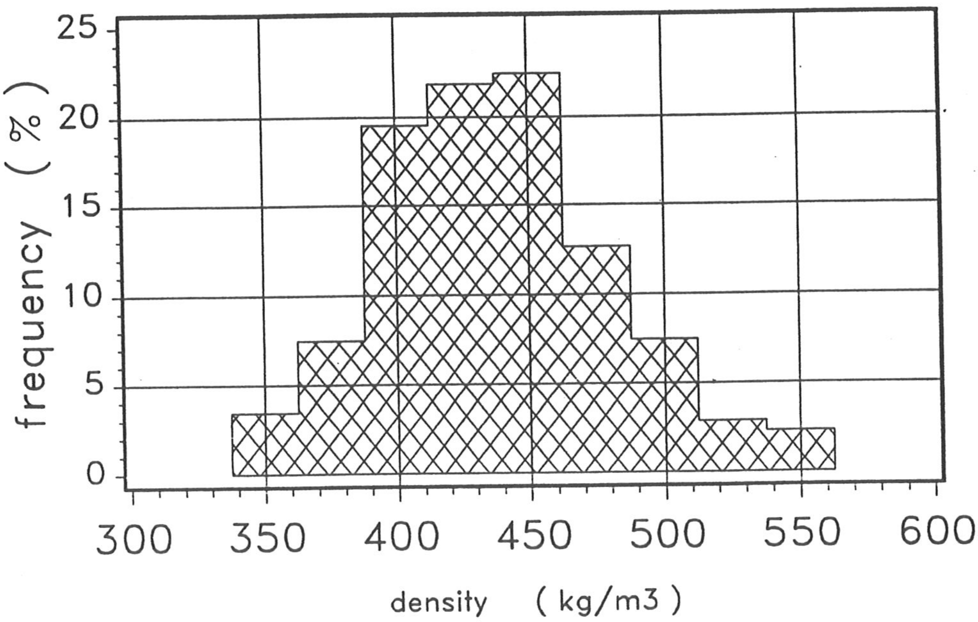


Figure 1: Density histogram of the European whitewood lamellae

The mean density of the measured dvw panels (n = 40) was 1114 kg/m³ with a standard deviation of 36,3 kg/m³. The minimum value was 1050 kg/m³, the maximum value was 1207 kg/m³.

2.3 Test method and results

All test specimens, as shown in **Fig. 2**, were loaded in grain direction of the glued laminated timber. The dvw-panel were loaded at an angle of 0°/90° between load and grain direction of the face ply. The veneers of some panels were not balanced, so the load-grain angle on one side was 0° and on the other side 90°. The dimensions of the specimens are given in **Table 2**. The pre-bored holes in the timber members for the bolted joints were equal to the nominal diameter of the bolt (Hexagon bolt M16-Property class 8.8-ISO 898-1). The joints with tube fasteners were manufactured at Delft University of Technology. The expanded diameter of the tube fasteners were 18 mm respectively 35 mm. **Fig. 3** shows the test set-up.

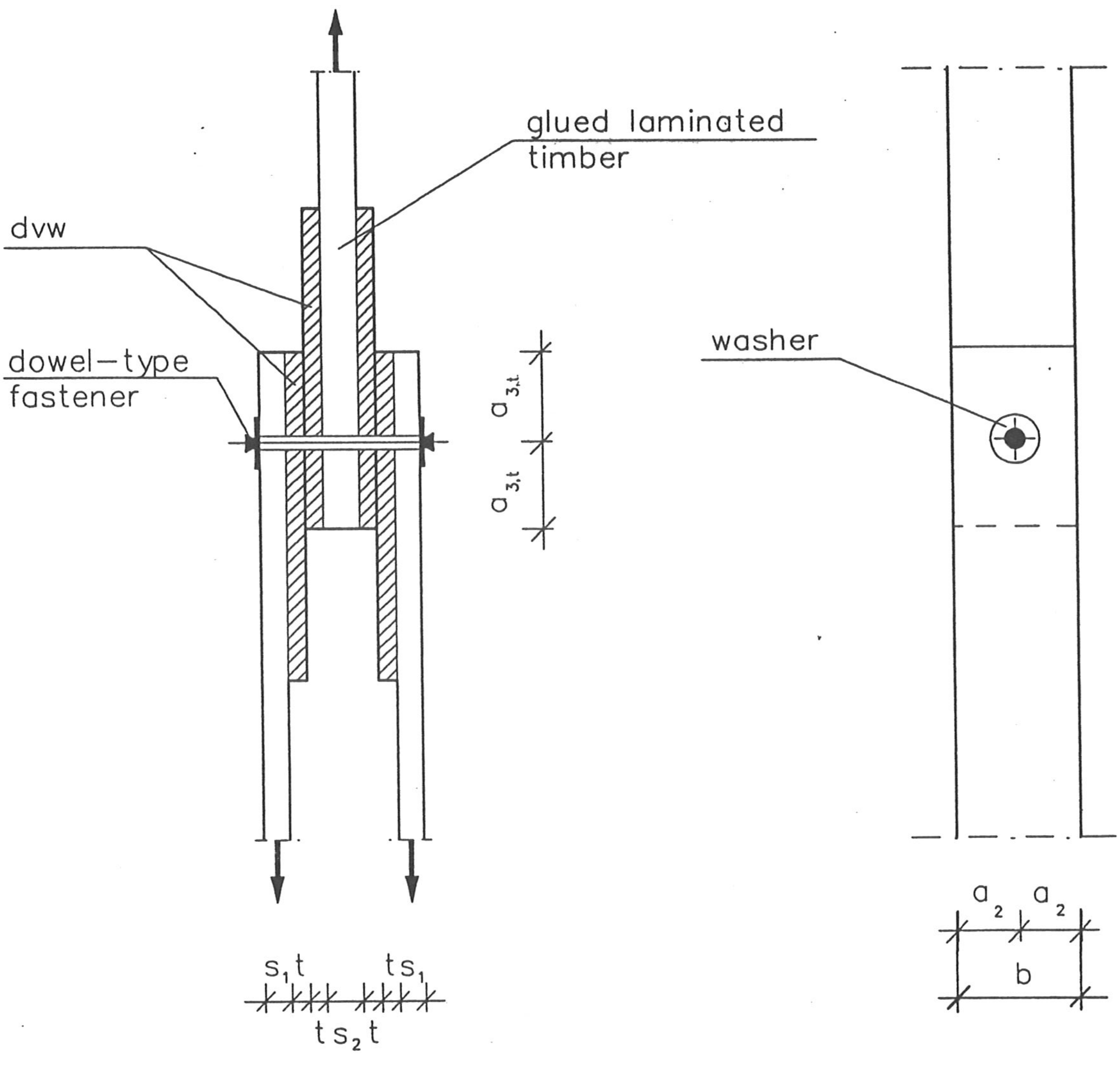


Figure 2: Test specimen loaded in tension

Table 2: Dimensions of the specimens

type of fastener	d (mm)	s_1 (mm)	s_2 (mm)	b (mm)	a_2 (mm)	$a_{3,t}$ = 2d (mm)	$a_{3,t}$ = 3,5d (mm)	$a_{3,t}$ = 5d (mm)
tube	17	25	40	100	50	35	60	90
	33	30	50	160	80	70	125	175
bolt	16	25	40	100	50	-	60	80

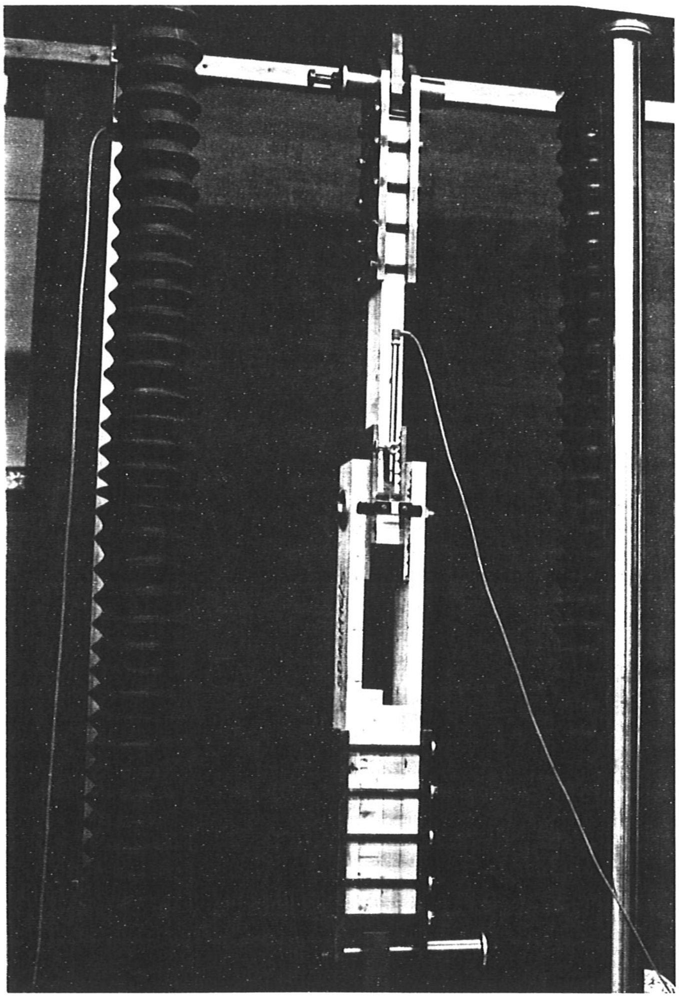


Figure 3: Test set-up and specimen loaded in tension

The test procedure used was in line with EN 26891.

The load-deformation curves of all tests are given in **Annex 3 - 16.** Most curves showed an elastic behaviour up to a certain proportional limit followed by a plastic deformation. In tests with an end distance of 2d only, a brittle failure was observed. The individual results of each test are given in **Table 3 - 5 (see Annex 17 - 19).**

From the load-deformation curves the slip and slip modulus can be determined in accordance with EN 26891 as follows:

maximum load per fastener	max F	
maximum slip	max v	
initial slip	v_i	$= v_{04}$
modified initial slip	$v_{i,mod}$	$= \frac{4}{3} \cdot (v_{04} - v_{01})$
joint settlement	v_s	$= v_i - v_{i,mod}$
elastic slip	v_e	$= \frac{2}{3} \cdot (v_{14} + v_{24} - v_{11} - v_{21})$
slip at $0,6 \cdot F_{max}$	$v_{0,6}$	
slip at $0,8 \cdot F_{max}$	$v_{0,8}$	
modified slip at $0,6 \cdot F_{max}$	$v_{0,6,mod}$	$= v_{0,6} - v_{24} + v_{i,mod}$
modified slip at $0,8 \cdot F_{max}$	$v_{0,8,mod}$	$= v_{0,8} - v_{24} + v_{i,mod}$
initial slip modulus per shear plane	k_i	$= \frac{0,4 \cdot F_{est}}{v_i}$
slip modulus per shear plane	k_s	$= \frac{0,4 \cdot F_{est}}{v_{i,mod}}$

The slip measurements v_{01}, v_{11}, v_{04}, v_{14} und v_{24} are deformations at loading points given in EN 26891 and F_{est} is the estimated maximum load. The failure modes are also listed in this **Table 3-5**. The failure modes are illustrated in **Fig. 4 - 9.**

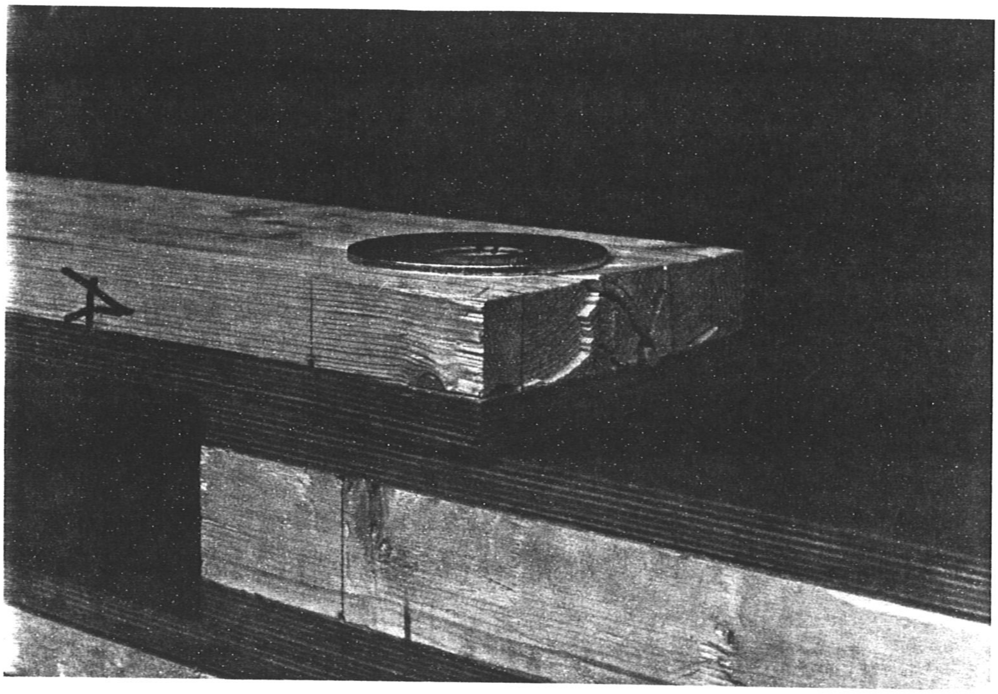


Figure 4: Splitting (SP) of dvw and shear block failure (SB) of wood

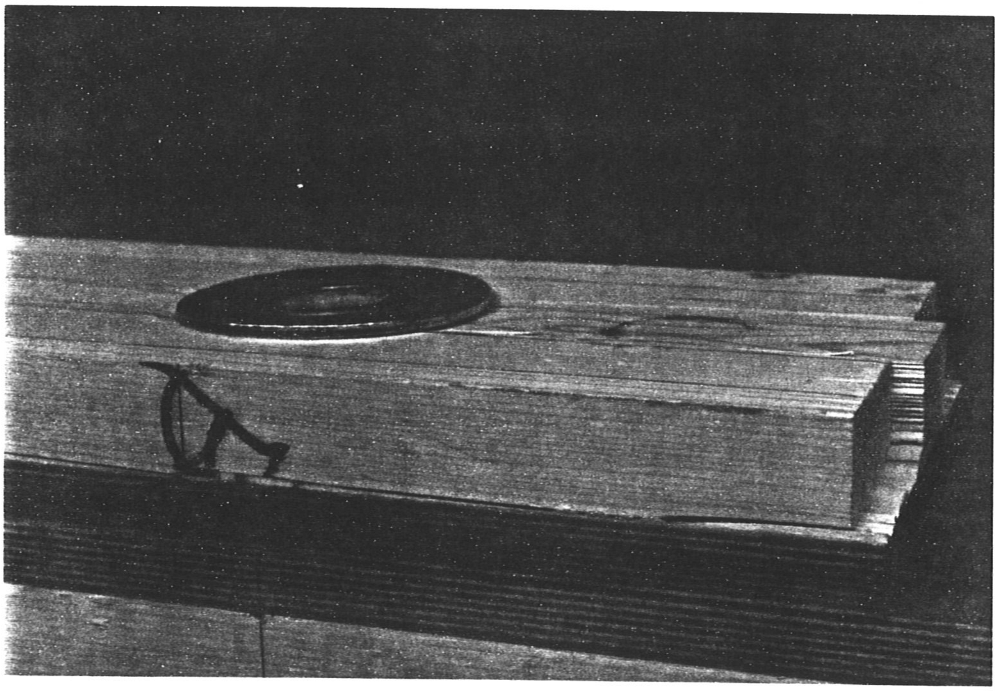


Figure 5: Tension failure (T) of dvw and shear block failure (SB) of wood

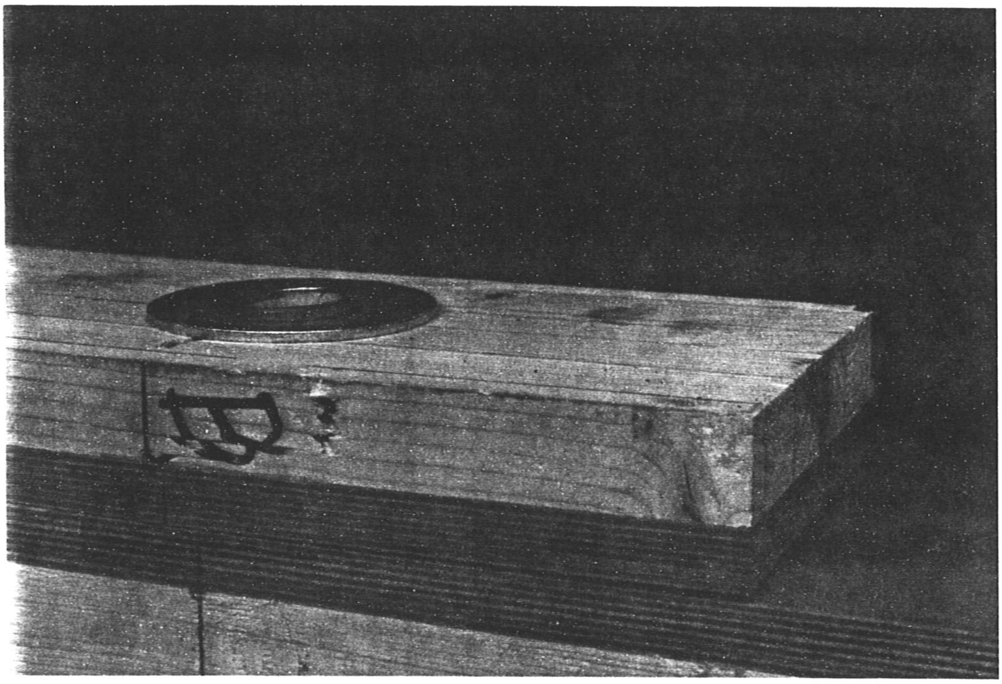


Figure 6: Tension failure (T) of dvw and wood

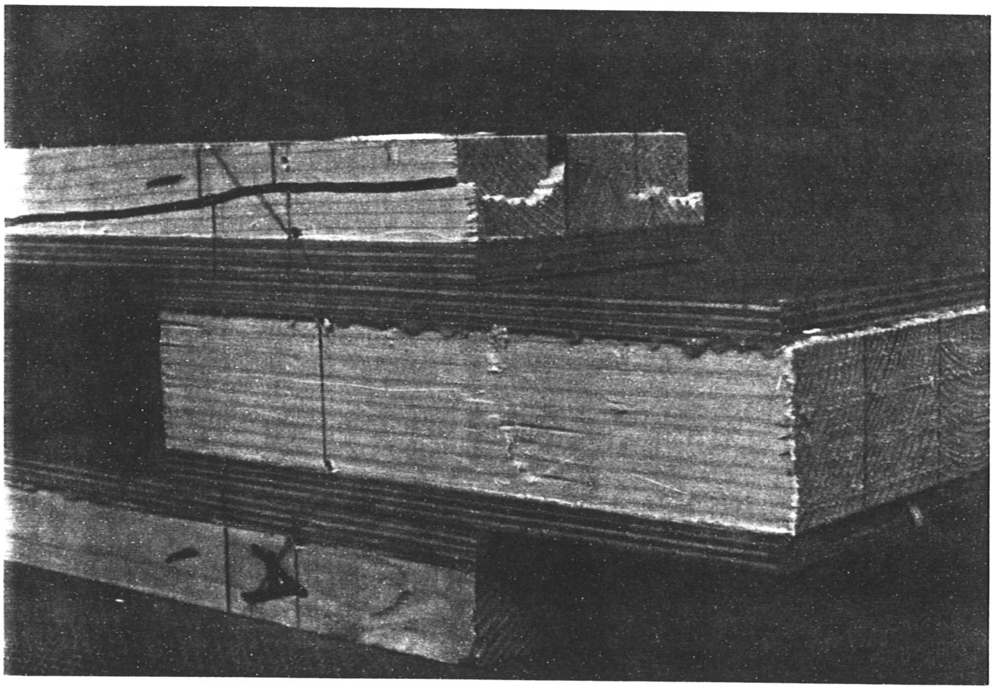


Figure 7: Shear failure (S) of wood

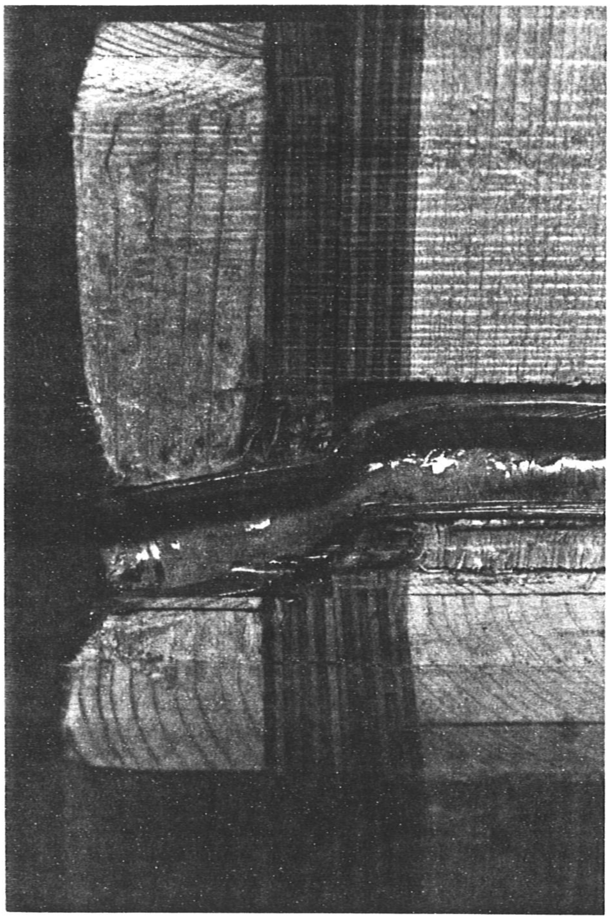


Figure 8:
Embedding failure (E) of
dvw and wood (Tube fastener)

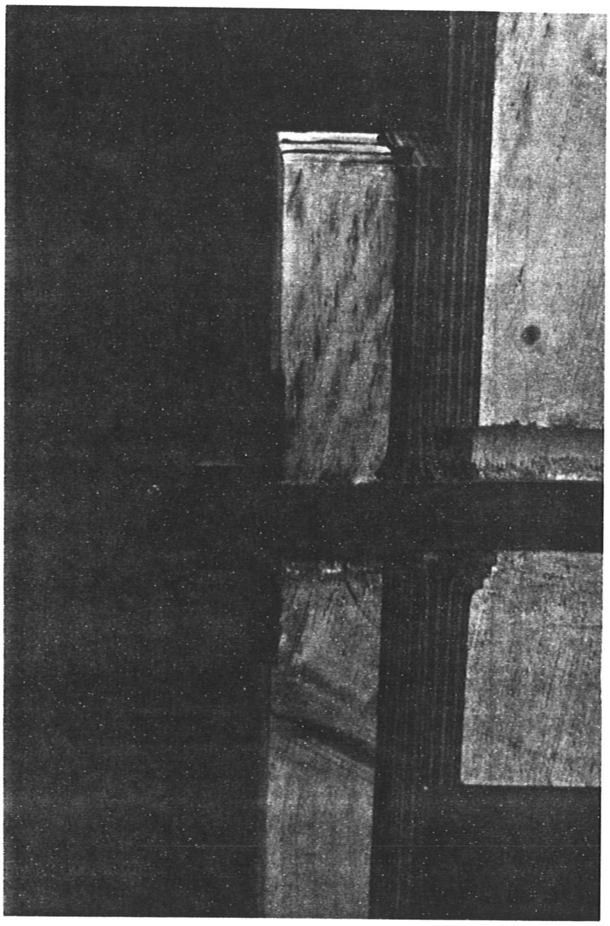


Figure 9:
Embedding failure (E) of
dvw and wood (Hexagon bolt)

3 Conclusions

The mean values and the coefficients of variation of the test results are summarized in Table 6.

Table 6: Test results of dvw reinforced joints with tube fasteners and bolts loaded in tension (Mean values)

Test serie	t (mm)	d (mm)	$a_{3,t}$	max F (kN)	max v (mm)	k_i (kN/mm)	C.V. (k_i) (%)	k_s (kN/mm)	C.V. (k_s) (%)
2,0d10T17	10		2 d	46,3	3,13	13,5	22,8	12,8	19,7
2,0d12T17	12		2 d	51,4	4,40	11,1	10,8	9,25	7,41
3,5d08T17	8	17	3,5 d	58,8	15,0	16,9	16,3	15,0	15,9
3,5d10T17	10		3,5 d	67,1	14,7	15,5	19,6	13,7	23,1
3,5d12T17	12		3,5 d	71,7	13,2	16,7	20,9	15,8	22,2
5,0d08T17	8		5 d	57,3	15,0	16,9	19,5	13,6	19,0
2,0d12T33	12		2 d	116,3	3,25	84,7	15,7	68,2	17,1
2,0d18T33	18		2 d	139,4	7,90	70,9	12,8	57,0	10,2
3,5d12T33	12	33	3,5 d	159,6	13,2	87,9	13,4	71,2	14,8
3,5d18T33	18		3,5 d	155,7	11,2	78,5	18,9	63,7	19,6
5,0d12T33	12		5 d	163,7	14,5	88,5	8,12	70,4	6,91
5,0d18T33	18		5 d	161,4	12,4	84,3	6,23	66,9	5,63
3,5d10M16	10	16	3,5 d	78,8	13,3	20,8	9,14	19,7	13,4
5,0d10M16	10		5 d	84,2	14,8	22,4	4,24	21,4	3,78

C.V. = coefficient of variation

From the test data the following may be argued:

- *Influence of end distance of the fastener*

  For small end distances ($a_{3,t}$ = 2d) a brittle failure was observed. For end distances up to 3,5d the maximum load with similar joint configuration is approximately the same. The ratio max $F_{3,5d}$ /max $F_{5d.}$ ranges between 0,94 and 1,03 (mean value 0,98).

- *Influence of veneer quality*

The influence of veneer quality is negligible. The grades are based on an acoustic-ultrasonic selection (Leijten 1992) of visual graded veneers. The load-carrying capacities of locally reinforced joints with panels made of high graded veneers (A and X) are approximately 5% higher than those of joints with panels made of low graded veneer (B).

- *Influence of the type of fastener*

The mean maximum load of the tested reinforced joints with ordinary hexagon bolts (Property class 8.8 - ISO 898-1) compared to tube-fastened joints is ≈17 % higher (in case of similar joint configuration). Both types of joints have a different load-deformation curve (see **Fig. 10**). Bolted joints are stiffer and have a nearly ideal elastic-plastic load-deformation behaviour.

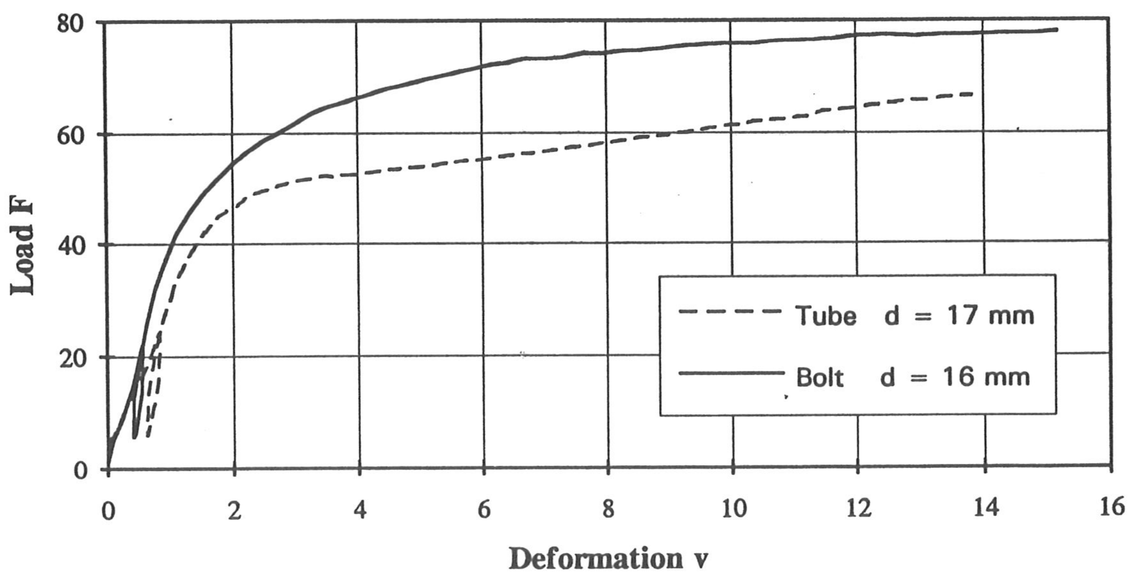


Figure 10: Comparison of typical load-deformation curves between bolted (3,5d10M16) and tube-fastened (3,5d10T17) joints

The fastener diameter and the thicknesses of timber and dvw must be considered in a model for calculating the lateral load-carrying capacities of these joints.

4 References

JANSSEN, H.F.M. 1988 : Durability of the glued connection between wood and Lignostone. Delft / The Netherlands: Faculty of Civil Engineering, University of Technolgy. - Stevin Research Report 25-88-101/14-LV-7

LEIJTEN, A.J.M. 1992 : Grading of veneer and tension tests parallel to the grain. Delft / The Netherlands: Dep. of Civil Engineering, University of Technolgy. - Stevin Research Report 25.4-92-10/C/HE-30

Annex

Densities of the timber members

(Tube fastener d = 17 mm)

Test	Density (kg/m³)			Mean density of test series (kg/m³)
	Middle member	Side member 1	Side member 2	
2,0d10T17/A-1	423	393	425	
2,0d10T17/A-2	422	395	389	
2,0d10T17/A-3	498	399	427	
2,0d10T17/A-4	443	434	495	428
2,0d12T17/B-1	440	468	386	
2,0d12T17/B-2	441	410	431	
2,0d12T17/B-3	442	408	476	
2,0d12T17/B-4	425	460	451	436
3,5d08T17/X-1	410	405	400	
3,5d08T17/X-2	388	449	397	
3,5d08T17/X-3	436	417	475	
3,5d08T17/X-4	489	455	394	426
3,5d10T17/A-1	497	416	446	
3,5d10T17/A-2	417	516	445	
3,5d10T17/A-3	403	417	415	
3,5d10T17/A-4	413	405	421	434
3,5d12T17/B-1	434	480	463	
3,5d12T17/B-2	441	484	387	
3,5d12T17/B-3	435	436	380	
3,5d12T17/B-4	437	545	403	443
5,0d08T17/X-1	477	406	418	
5,0d08T17/X-2	493	407	421	
5,0d08T17/X-3	445	532	473	
5,0d08T17/X-4	413	455	513	454

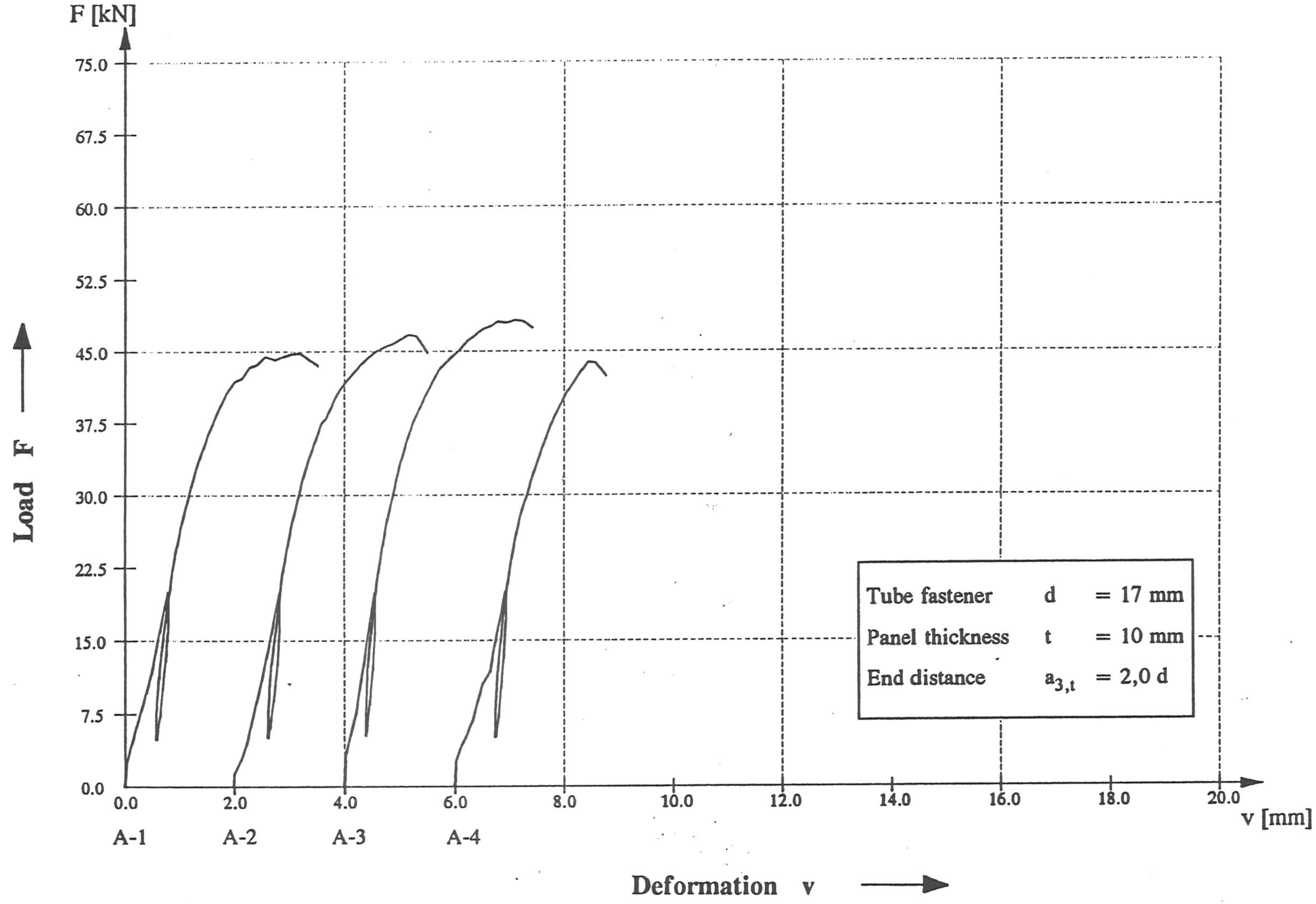
Densities of the timber members

(Tube fastener d = 33 mm)

Test	Density (kg/m³)			Mean density of test series (kg/m³)
	Middle member	Side member 1	Side member 2	
2,0d12T33/B-1	390	392	481	
2,0d12T33/B-2	473	536	463	
2,0d12T33/A-3	494	509	474	
2,0d12T33/A-4	457	461	507	469
2,0d18T33/A-1	474	440	442	
2,0d18T33/B-2	430	440	439	
2,0d18T33/A-3	494	420	440	
2,0d18T33/B-4	414	476	497	449
3,5d12T33/B-1	483	449	479	
3,5d12T33/B-2	440	490	503	
3,5d12T33/A-3	462	491	415	
3,5d12T33/A-4	477	416	418	460
3,5d18T33/B-1	453	478	424	
3,5d18T33/B-2	374	429	376	
3,5d18T33/A-3	464	456	446	
3,5d18T33/B-4	448	471	393	434
5,0d12T33/B-1	443	428	440	
5,0d12T33/B-2	414	430	453	
5,0d12T33/A-3	432	411	449	
5,0d12T33/A-4	415	465	445	435
5,0d18T33/B-1	449	361	390	
5,0d18T33/B-2	434	405	517	
5,0d18T33/B-3	431	469	431	
5,0d18T33/B-4	412	445	435	431

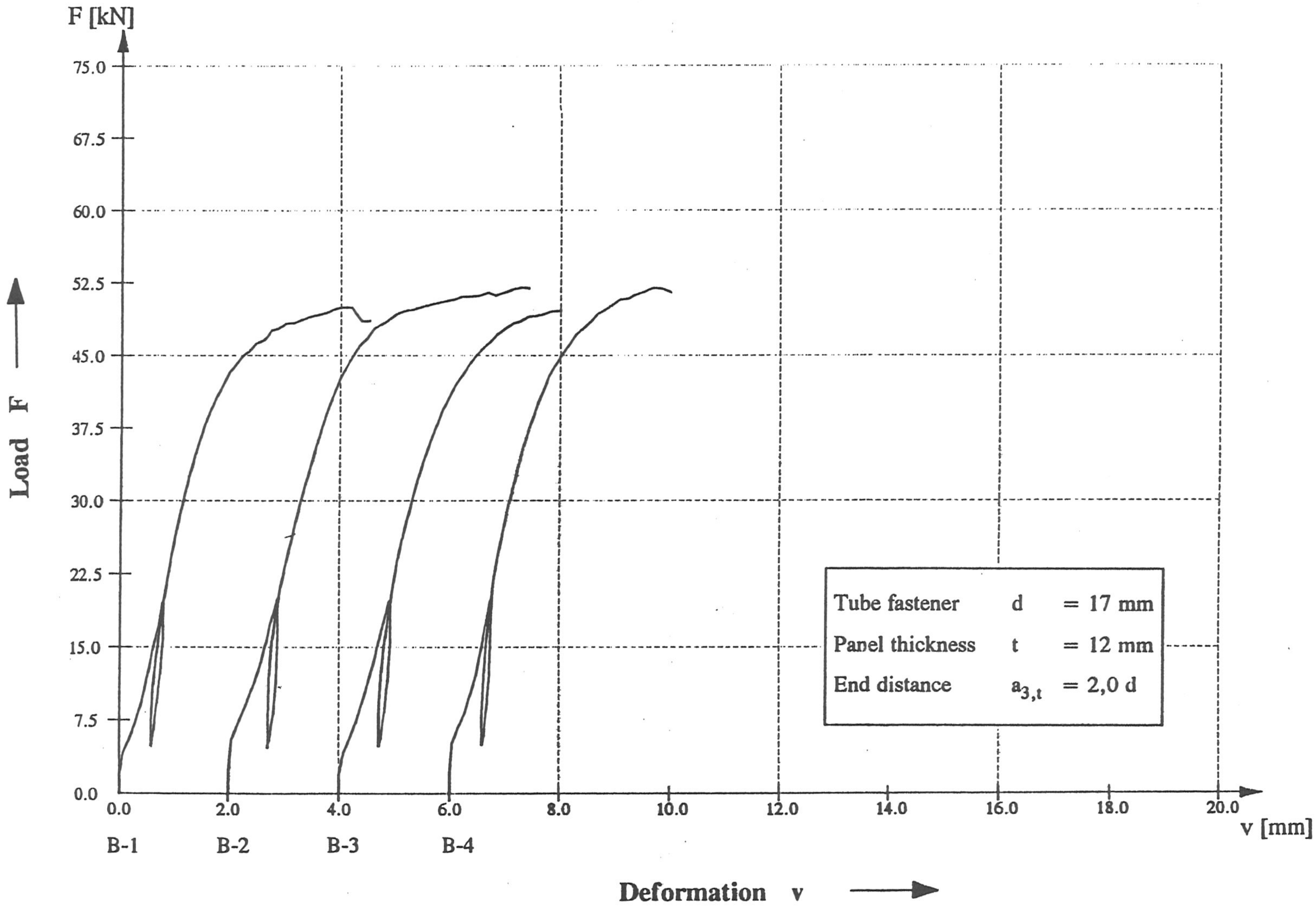
(Hexagon bolt M 16)

Test	Density (kg/m³)			Mean density of test series (kg/m³)
	Middle member	Side member 1	Side member 2	
3,5d10M16/A-1	383	349	363	
3,5d10M16/A-2	363	383	378	
3,5d10M16/A-3	554	361	412	
3,5d10M16/B-4	446	383	402	
3,5d10M16/B-5	412	363	395	396
5,0d10M16/A-1	402	554	480	
5,0d10M16/A-2	395	446	361	
5,0d10M16/B-3	446	412	402	
5,0d10M16/A-4	363	349	554	
5,0d10M16/B-5	349	446	395	423



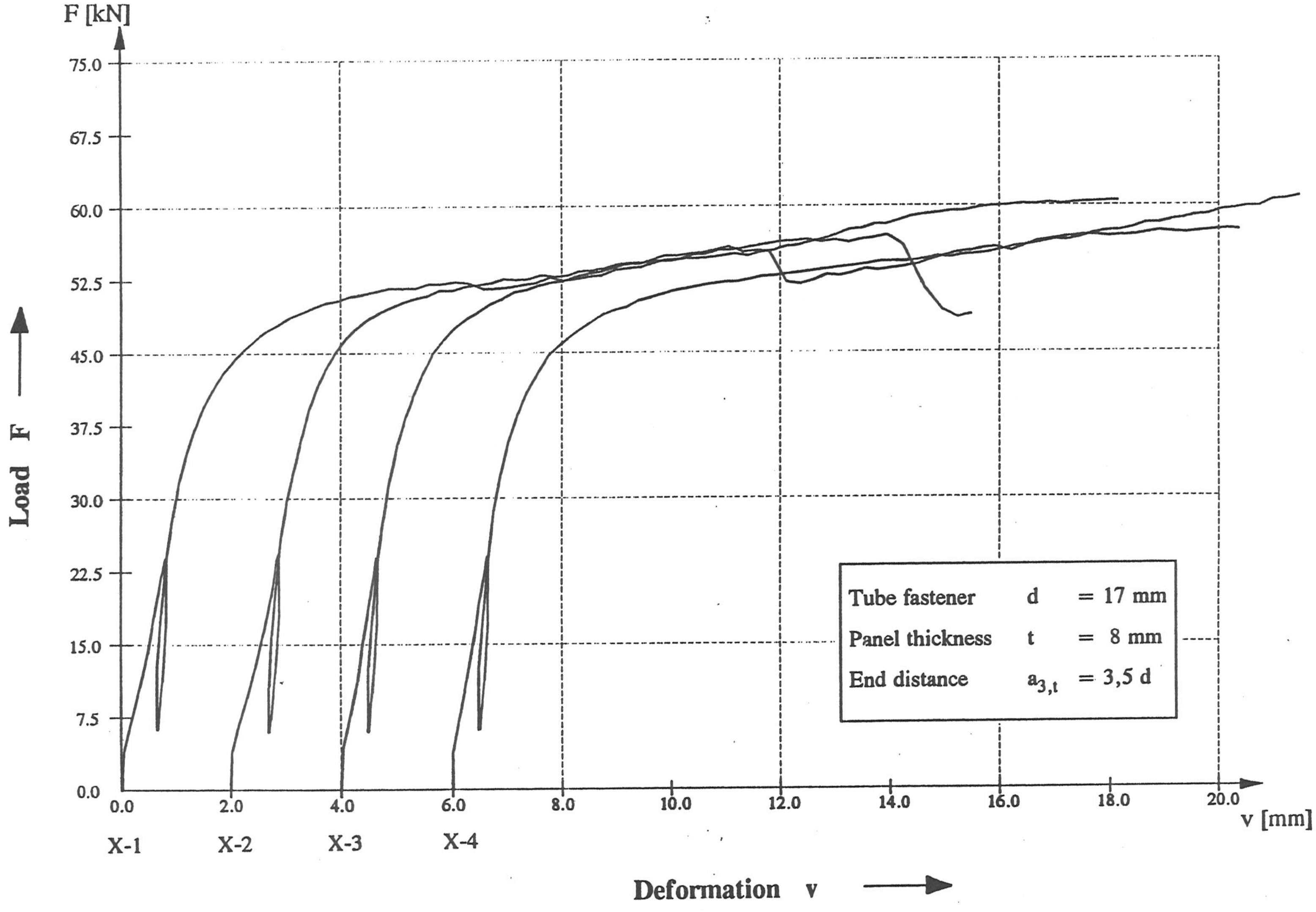
Load-deformation curves (Test serie 2,0d10T17)

Annex 3

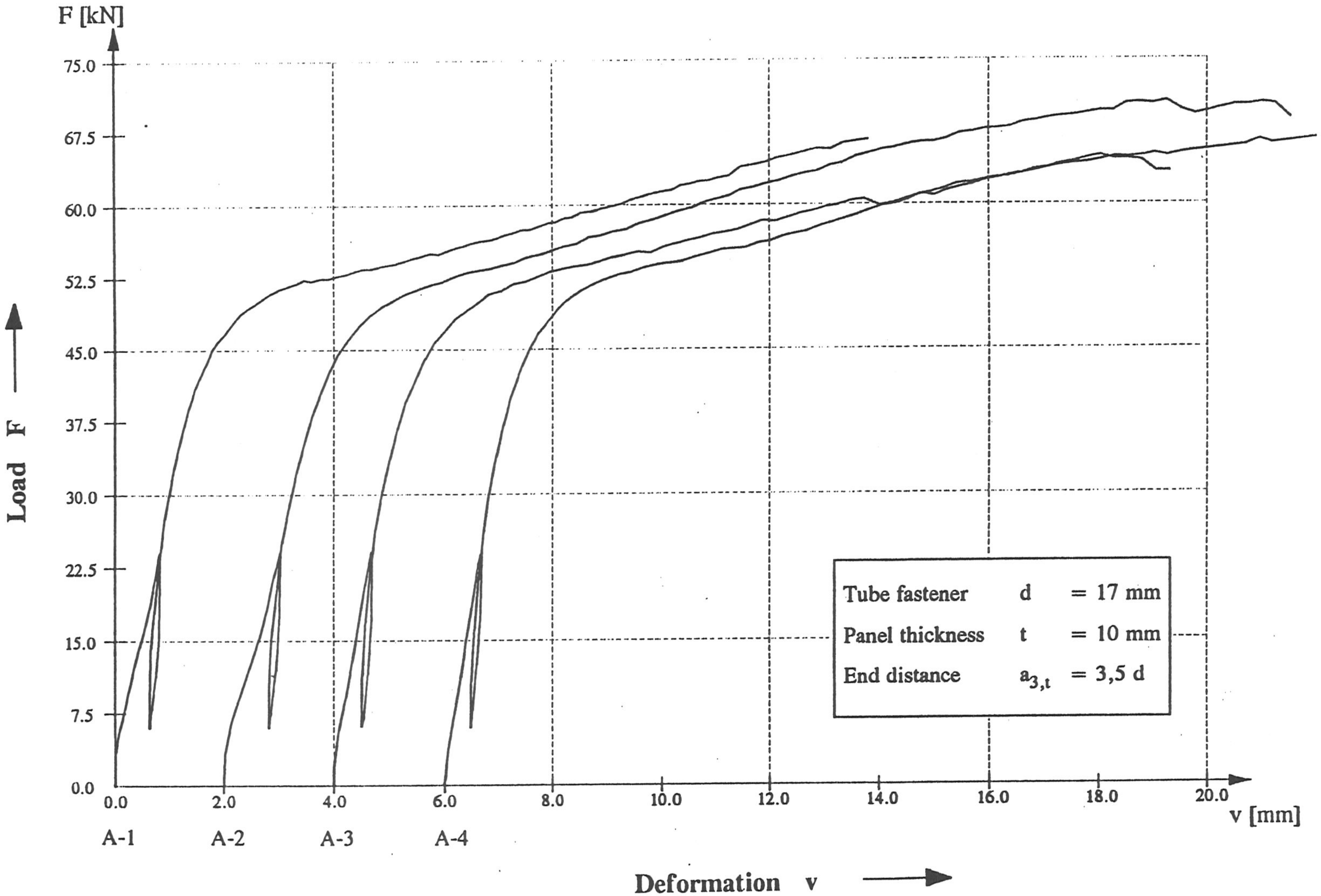


Load-deformation curves (Test serie 2,0d12T17)

Annex 4

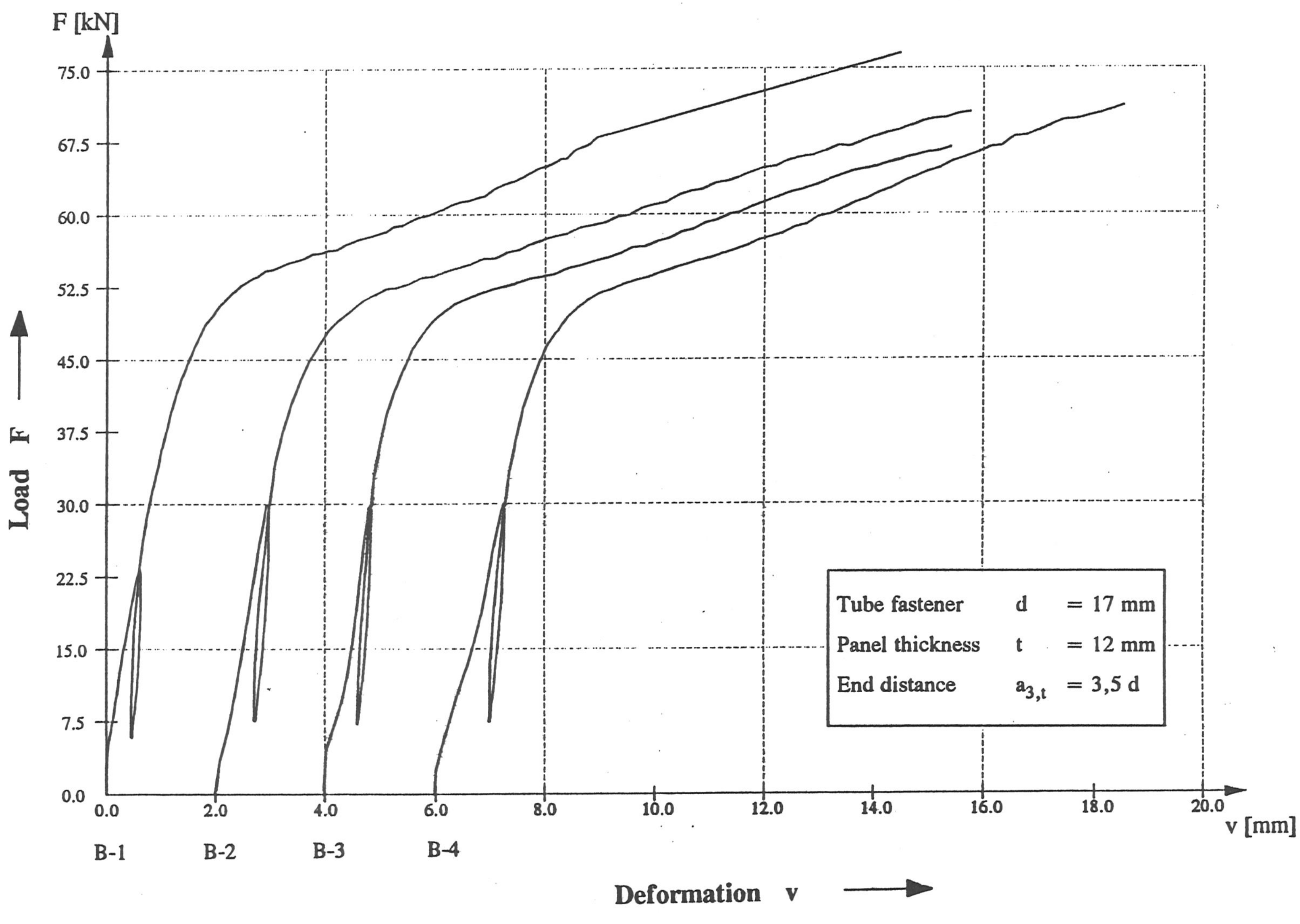


Load-deformation curves (Test serie 3,5d08T17)



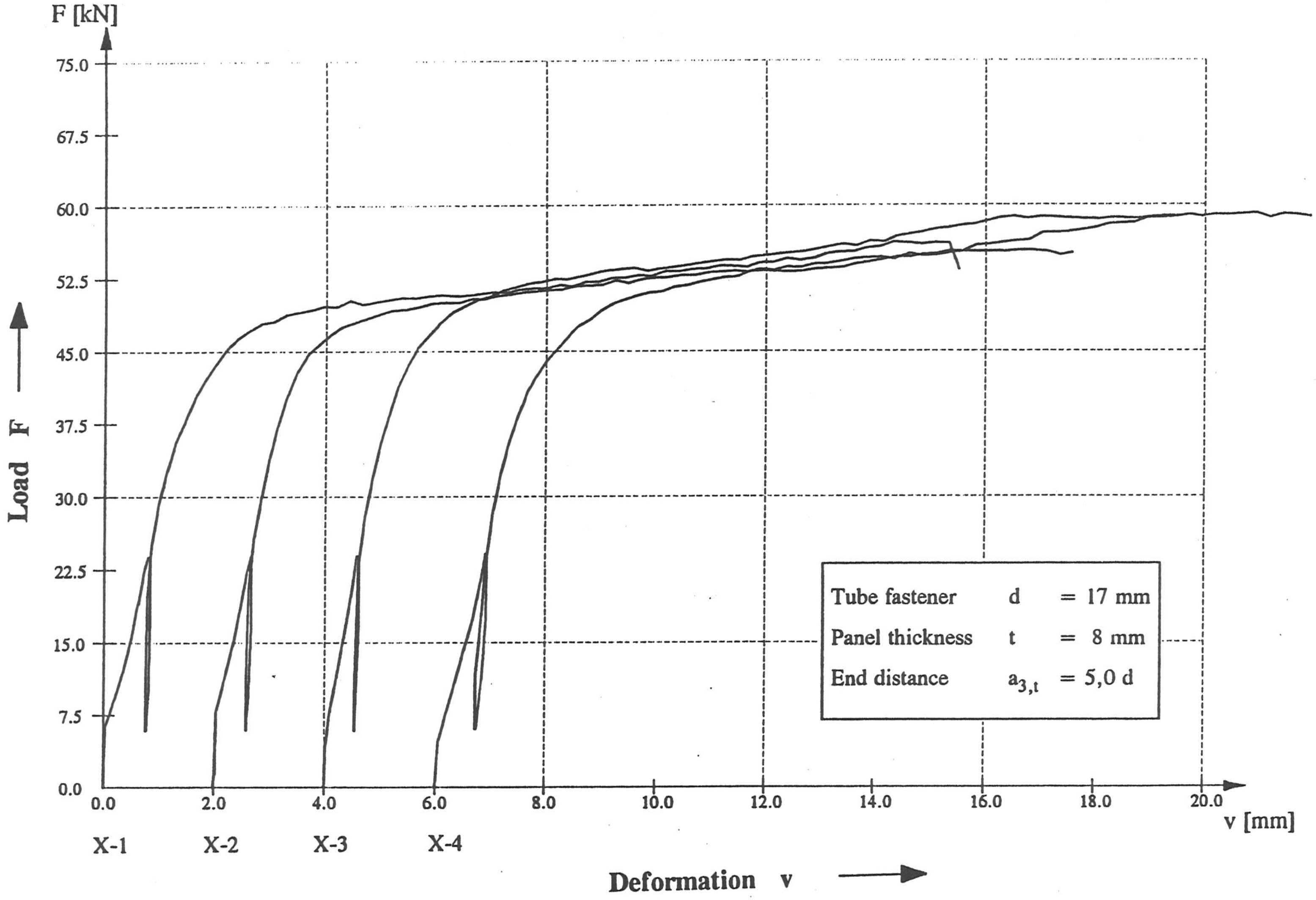
Load-deformation curves (Test serie 3,5d10T17)

Annex 6

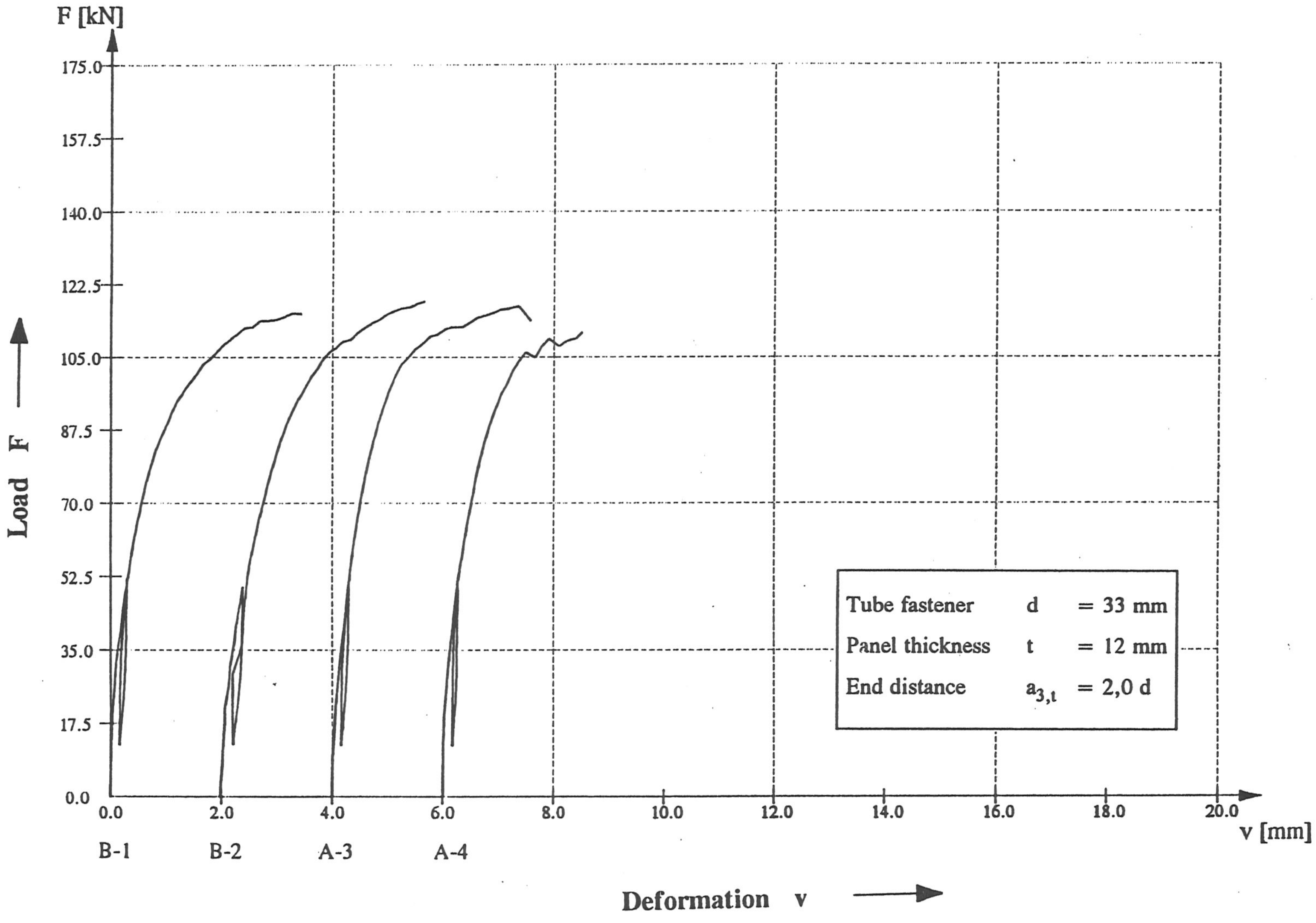


Load-deformation curves (Test serie 3,5d12T17)

Annex 7

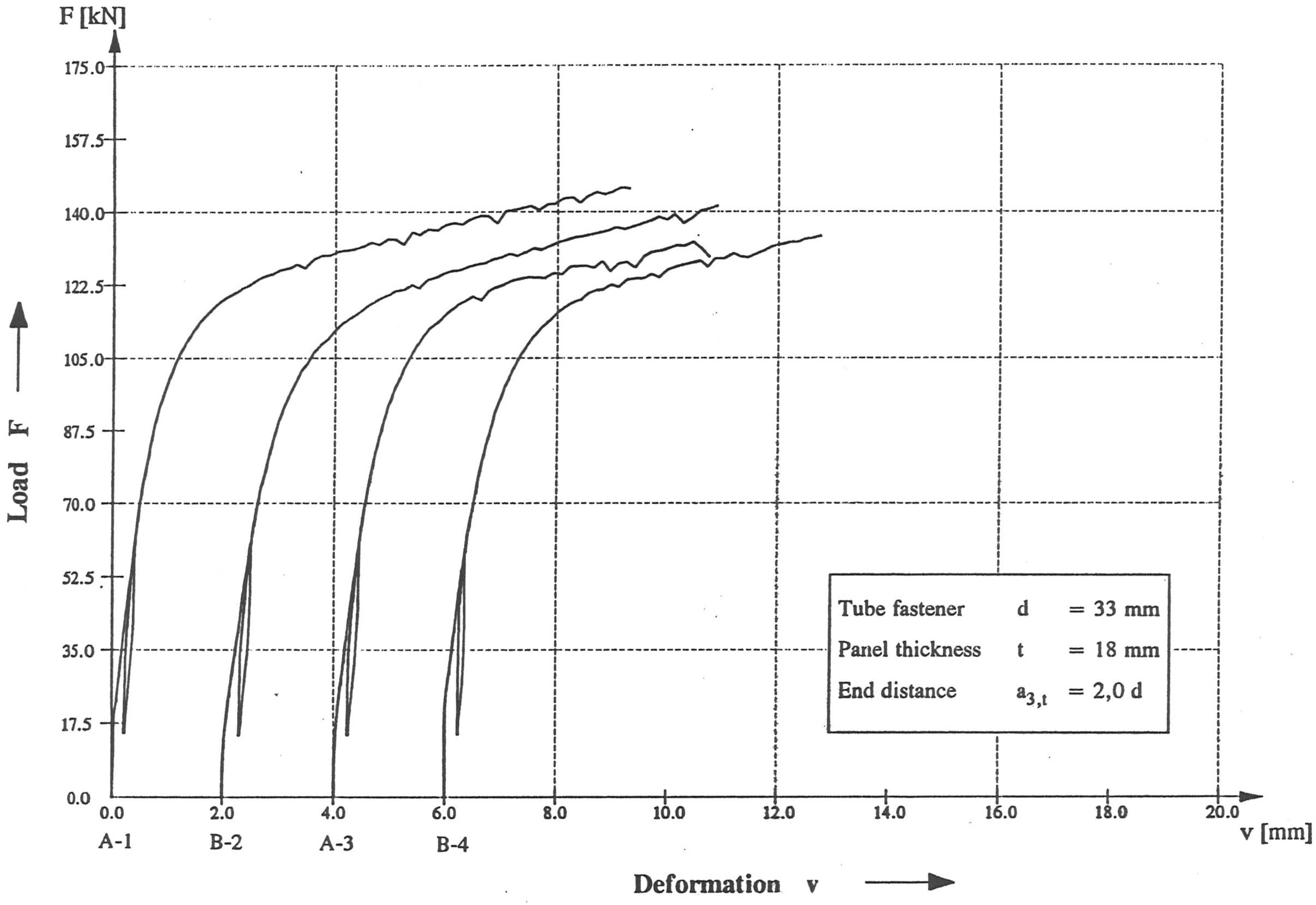


Load-deformation curves (Test serie 5,0d08T17)

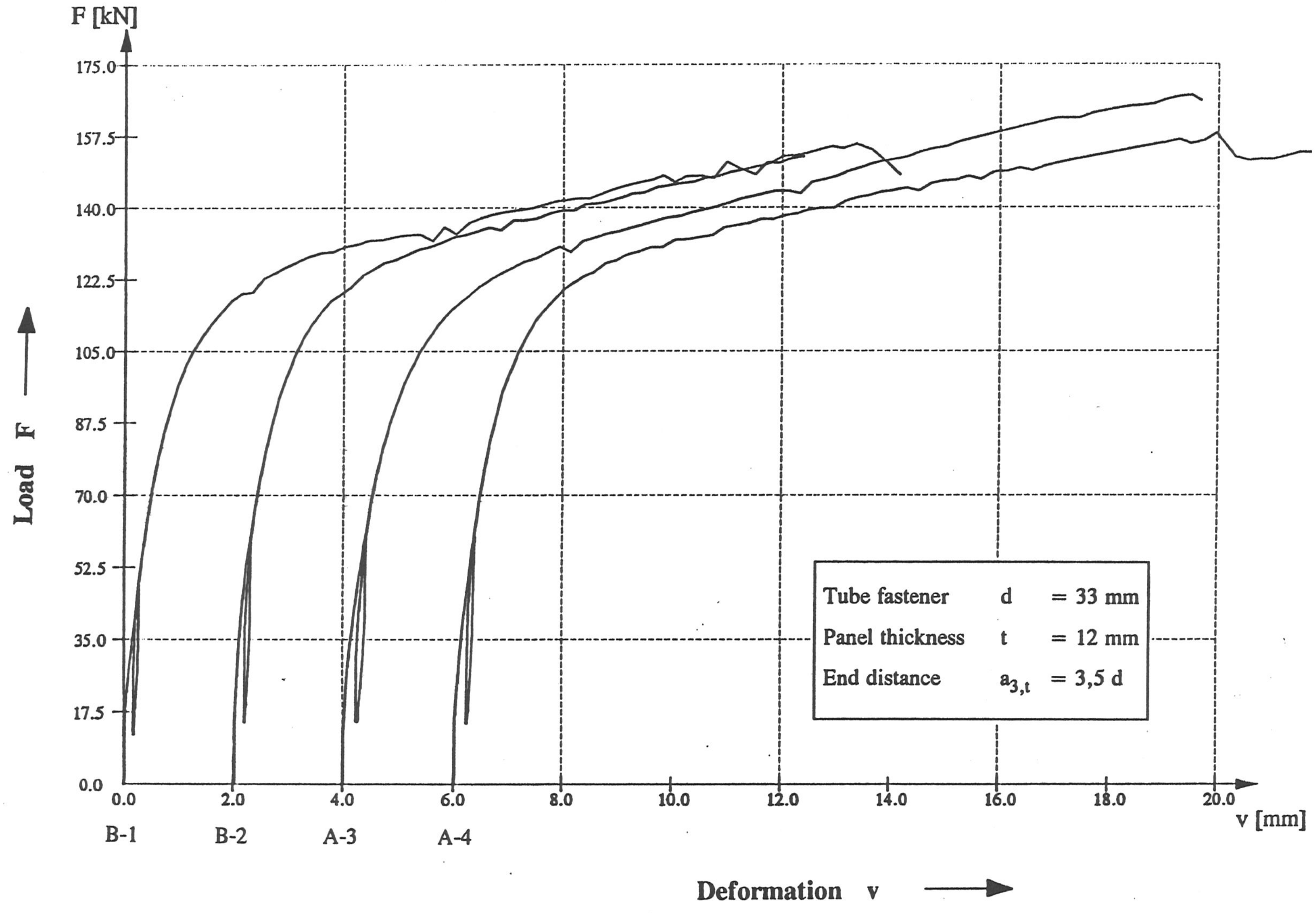


Load-deformation curves (Test serie 2,0d12T33)

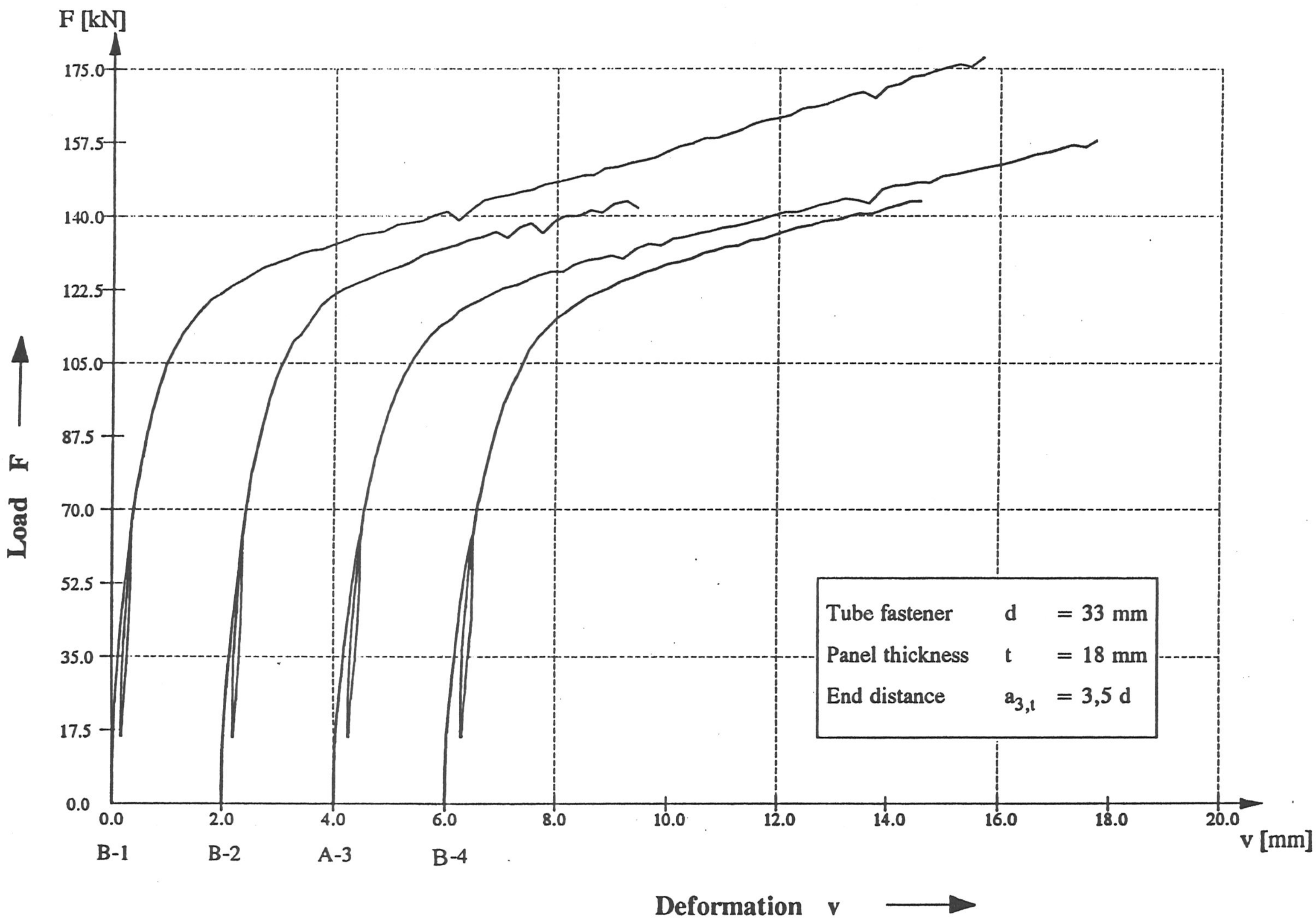
Annex 9



Load-deformation curves (Test serie 2,0d18T33)

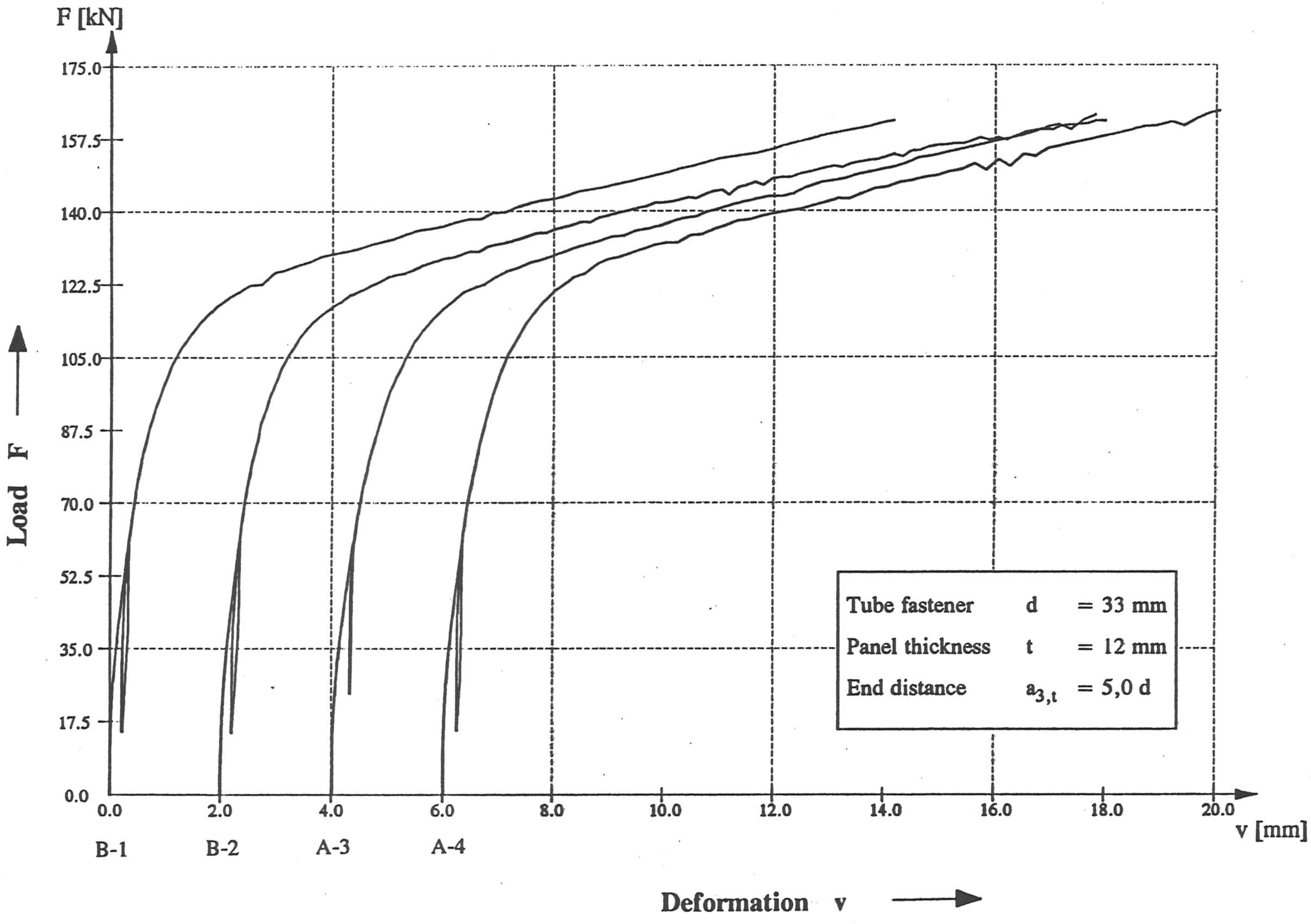


Load-deformation curves (Test serie 3,5d12T33)



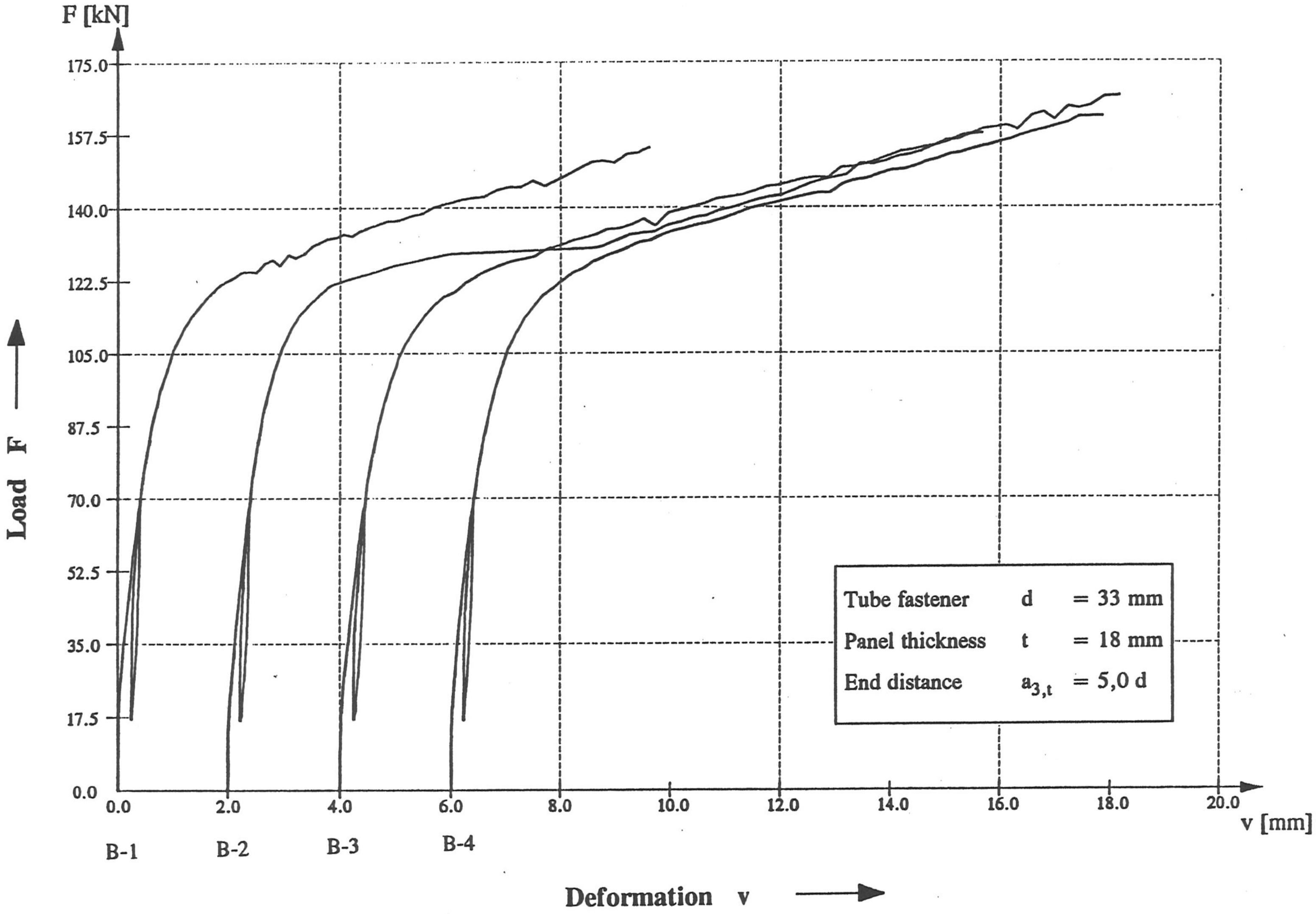
Load-deformation curves (Test serie 3,5d18T33)

Annex 12

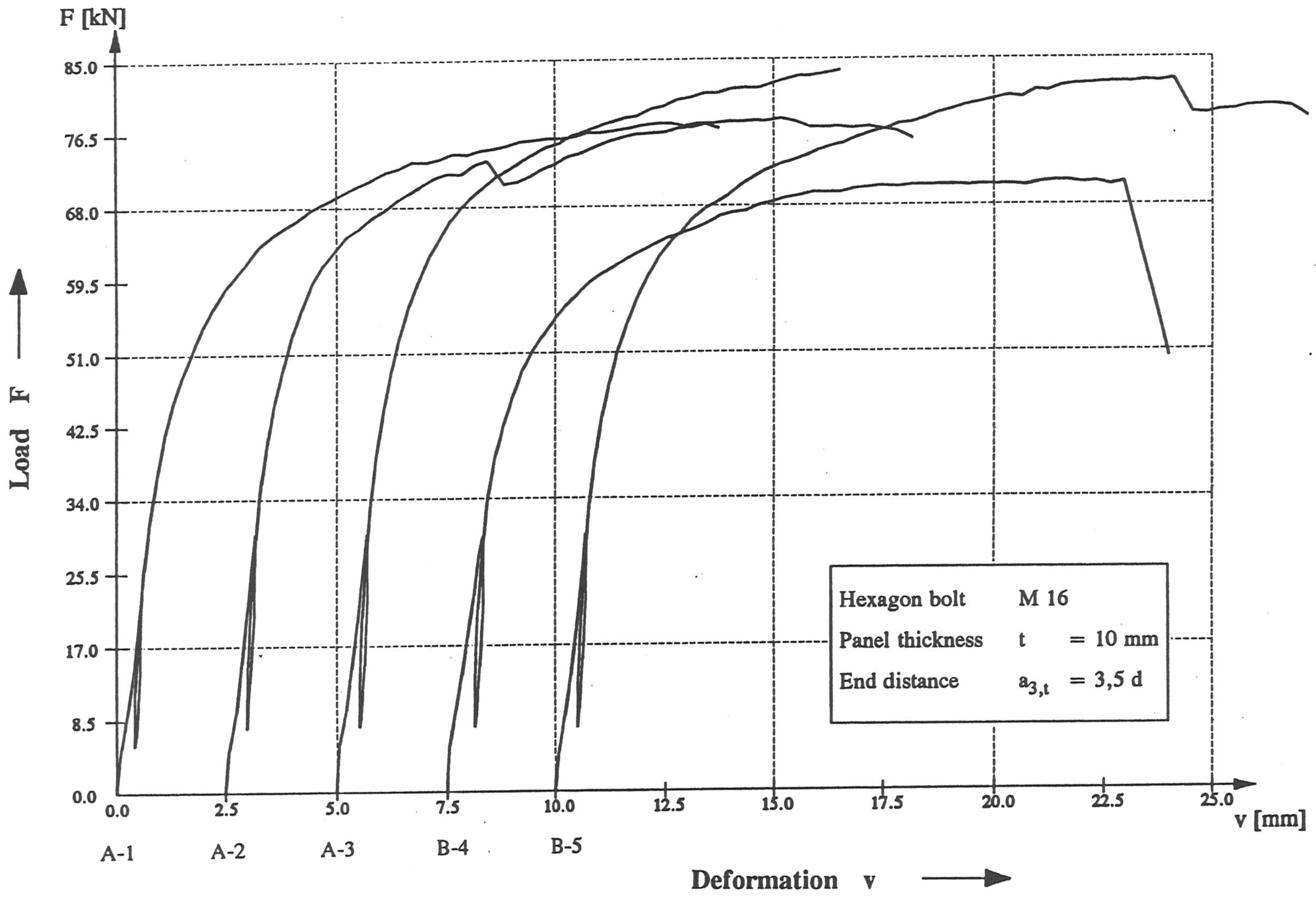


Load-deformation curves (Test serie 5,0d12T33)

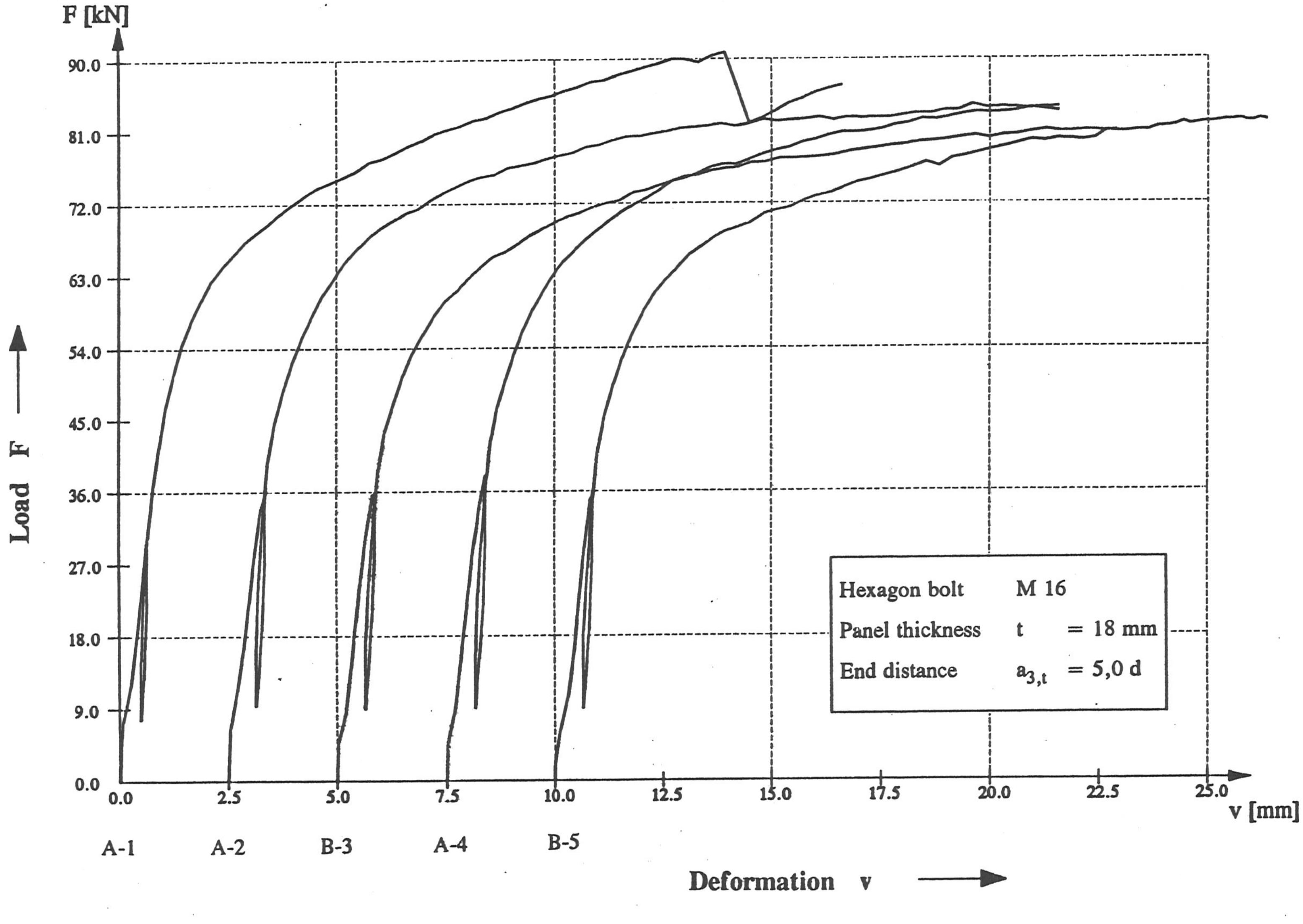
Annex 13



Load-deformation curves (Test serie 5,0d18T33)



Load-deformation curves (Test serie 3,5d10M16)



Load-deformation curves (Test serie 5,0d10M16)

Table 3: Results of the shear tests loaded in tension (Tube fastener d = 17 mm)

Test	t (mm)	d (mm)	$a_{3,t}$	max F (kN)	max v (mm)	v_i (mm)	$v_{i,mod}$ (mm)	v_s (mm)	v_e (mm)	$v_{06,mod}$ (mm)	$v_{08,mod}$ (mm)	k_i (kN/mm)	k_s (kN/mm)	Failure Mode
2,0d10T17/A-1	10	17	2 d	44,9	3,2	0,78	0,84	-0,06	0,32	1,06	1,51	12,87	11,90	SP(dvw) SB(wood)
2,0d10T17/A-2	10	17	2 d	47,4	3,3	0,82	0,77	0,05	0,23	1,04	1,52	12,24	12,90	SP(dvw) SB(wood)
2,0d10T17/A-3	10	17	2 d	48,6	3,3	0,56	0,61	-0,06	0,23	0,88	1,37	17,94	16,20	SP(dvw) SB(wood)
2,0d10T17/A-4	10	17	2 d	44,2	2,7	0,92	0,97	-0,06	0,26	1,17	1,63	10,91	10,20	SP(dvw) SB(wood)
2,0d12T17/B-1	12	17	2 d	50,3	4,3	0,99	1,15	-0,15	0,29	1,50	2,04	10,05	8,70	SP(dvw) SB(wood)
2,0d12T17/B-2	12	17	2 d	52,5	5,5	0,90	1,13	-0,23	0,26	1,57	2,15	11,14	8,80	SP(dvw) SB(wood)
2,0d12T17/B-3	12	17	2 d	50,1	4,0	0,95	1,07	-0,12	0,27	1,44	2,02	10,52	9,30	SP(dvw) SB(wood)
2,0d12T17/B-4	12	17	2 d	52,5	3,8	0,78	0,98	-0,20	0,23	1,35	1,92	12,80	10,20	SP(dvw) SB(wood)
3,5d08T17/X-1	8	17	3,5 d	57,3	14,9	0,81	0,89	-0,08	0,23	1,22	2,34	14,88	13,50	SP(dvw) SB(wood)
3,5d08T17/X-2	8	17	3,5 d	60,2	15,0	0,84	0,96	-0,12	0,27	1,37	2,52	14,21	12,40	E(dvw, wood)
3,5d08T17/X-3	8	17	3,5 d	57,3	15,0	0,63	0,70	-0,07	0,25	1,01	1,82	19,03	17,10	E(dvw, wood)
3,5d08T17/X-4	8	17	3,5 d	60,5	15,0	0,61	0,71	-0,10	0,23	1,11	2,68	19,56	16,90	E(dvw, wood)
3,5d10T17/A-1	10	17	3,5 d	67,2	13,8	0,83	0,97	-0,14	0,28	1,55	4,60	14,45	12,30	S(wood)
3,5d10T17/A-2	10	17	3,5 d	69,2	15,0	1,03	1,21	-0,18	0,30	1,98	6,00	11,65	9,90	E(dvw, wood)
3,5d10T17/A-3	10	17	3,5 d	65,5	15,0	0,67	0,76	-0,10	0,22	1,34	3,47	18,03	15,70	E(dvw, wood)
3,5d10T17/A-4	10	17	3,5 d	66,6	15,0	0,67	0,71	-0,04	0,27	1,26	3,58	17,79	16,80	E(dvw, wood)
3,5d12T17/B-1	12	17	3,5 d	76,8	14,5	0,63	0,76	-0,13	0,20	1,60	5,44	18,96	15,70	T(dvw) SB(wood)
3,5d12T17/B-2	12	17	3,5 d	70,8	13,8	0,93	0,90	0,03	0,35	1,42	5,45	16,07	16,60	T(dvw) SB(wood)
3,5d12T17/B-3	12	17	3,5 d	67,4	12,0	0,76	0,76	0,00	0,33	1,08	3,77	19,82	19,70	T(dvw) SB(wood)
3,5d12T17/B-4	12	17	3,5 d	71,6	12,6	1,24	1,33	-0,09	0,37	1,83	5,82	12,05	11,20	T(dvw) SB(wood)
5,0d08T17/X-1	8	17	5 d	56,1	15,0	0,80	1,02	-0,22	0,10	1,37	2,34	14,97	11,70	E(dvw, wood)
5,0d08T17/X-2	8	17	5 d	55,2	15,0	0,66	0,86	-0,20	0,12	1,15	1,82	18,06	13,90	E(dvw, wood)
5,0d08T17/X-3	8	17	5 d	58,8	15,0	0,57	0,70	-0,12	0,10	1,06	2,00	20,87	17,10	E(dvw, wood)
5,0d08T17/X-4	8	17	5 d	59,2	15,0	0,89	1,03	-0,14	0,27	1,41	2,63	13,52	11,60	E(dvw, wood)

Table 4: Results of the shear tests loaded in tension
(Tube fastener d = 33 mm)

Test	t (mm)	d (mm)	$a_{3,t}$	max F (kN)	max v (mm)	v_i (mm)	$v_{i,mod}$ (mm)	v_s (mm)	v_e (mm)	$v_{06,mod}$ (mm)	$v_{08,mod}$ (mm)	k_i (kN/mm)	k_s (kN/mm)	Failure Mode
2,0d12T33/B-1	12	33	2 d	116,2	3,4	0,29	0,36	-0,08	0,18	0,62	1,20	87,70	69,20	SP(dvw) SB(wood)
2,0d12T33/B-2	12	33	2 d	119,5	3,7	0,38	0,48	-0,10	0,28	0,79	1,41	66,07	52,40	SP(dvw) SB(wood)
2,0d12T33/A-3	12	33	2 d	118,4	3,4	0,29	0,35	-0,07	0,16	0,58	1,00	87,32	71,00	SP(dvw) SB(wood)
2,0d12T33/A-4	12	33	2 d	111,2	2,5	0,26	0,31	-0,05	0,12	0,50	0,89	97,69	80,40	SP(dvw) SB(wood)
2,0d18T33/A-1	18	33	2 d	146,8	9,3	0,40	0,48	-0,08	0,24	0,82	1,87	75,08	62,50	SP(dvw) SB(wood)
2,0d18T33/B-2	18	33	2 d	133,5	6,4	0,45	0,55	-0,10	0,25	0,79	1,49	66,34	54,70	SP(dvw) SB(wood)
2,0d18T33/A-3	18	33	2 d	142,1	8,9	0,49	0,60	-0,11	0,27	0,98	2,21	60,79	49,90	SP(dvw) SB(wood)
2,0d18T33/B-4	18	33	2 d	135,0	7,0	0,37	0,49	-0,12	0,25	0,77	1,53	81,30	60,98	SP(dvw) SB(wood)
3,5d12T33/B-1	12	33	3,5 d	156,6	13,4	0,37	0,46	-0,09	0,15	0,97	2,89	80,30	65,10	T(dvw) SB(wood)
3,5d12T33/B-2	12	33	3,5 d	153,8	10,4	0,29	0,35	-0,06	0,12	0,85	2,28	102,9	85,60	T(dvw) SB(wood)
3,5d12T33/A-3	12	33	3,5 d	169,2	15,0	0,39	0,48	-0,09	0,18	1,27	4,72	76,88	61,90	E(dvw, wood)
3,5d12T33/A-4	12	33	3,5 d	158,6	14,0	0,37	0,46	-0,09	0,15	0,97	2,89	80,30	65,10	SP(dvw) SB(wood)
3,5d18T33/B-1	18	33	3,5 d	145,2	7,3	0,37	0,46	-0,09	0,25	0,73	1,62	87,42	70,00	T(dvw) SB(wood)
3,5d18T33/B-2	18	33	3,5 d	158,4	13,7	0,47	0,57	-0,10	0,29	1,09	3,87	68,25	56,40	T(dvw) SB(wood)
3,5d18T33/A-3	18	33	3,5 d	175,0	15,0	0,34	0,41	-0,07	0,24	1,05	6,37	94,50	77,90	E(dvw, wood)
3,5d18T33/B-4	18	33	3,5 d	144,0	8,6	0,50	0,63	-0,13	0,28	0,97	2,06	63,76	50,60	T(dvw) SB(wood)
5,0d12T33/B-1	12	33	5 d	163,8	13,9	0,38	0,47	-0,09	3,99	1,17	4,32	77,92	63,30	T(dvw, wood)
5,0d12T33/B-2	12	33	5 d	165,1	14,1	0,33	0,42	-0,08	0,08	1,03	3,78	90,06	71,70	T(dvw) SB(wood)
5,0d12T33/A-3	12	33	5 d	167,0	15,0	0,32	0,40	-0,08	0,14	1,01	3,97	93,74	74,40	E(dvw, wood)
5,0d12T33/A-4	12	33	5 d	159,0	15,0	0,33	0,42	-0,09	0,18	0,95	3,83	92,10	72,10	E(dvw, wood)
5,0d18T33/B-1	18	33	5 d	155,2	9,6	0,39	0,49	-0,11	0,20	0,80	2,22	87,71	68,80	S(wood)
5,0d18T33/B-2	18	33	5 d	159,0	13,7	0,38	0,48	-0,10	0,18	0,80	3,06	88,72	70,20	T(dvw, wood)
5,0d18T33/B-3	18	33	5 d	168,3	14,2	0,44	0,55	-0,11	0,26	1,06	4,68	77,17	61,60	T(dvw) SB(wood)
5,0d18T33/B-4	18	33	5 d	163,0	11,9	0,41	0,51	-0,10	0,21	0,91	3,14	83,42	66,90	T(dvw, wood)

Table 5: Results of the shear tests loaded in tension (Hexagon bolt M16-Property class 8.8)

Test	t (mm)	d (mm)	$a_{3,t}$	max F (kN)	max v (mm)	v_i (mm)	$v_{i,mod}$ (mm)	v_s (mm)	v_e (mm)	$v_{06,mod}$ (mm)	$v_{08,mod}$ (mm)	k_i (kN/mm)	k_s (kN/mm)	Failure Mode
3,5d10M16/A-1	10	16	3,5 d	78,2	15,0	0,61	0,64	-0,04	0,15	1,47	3,15	19,75	18,65	E(dvw, wood)
3,5d10M16/A-2	10	16	3,5 d	77,7	10,9	0,67	0,67	0,00	0,27	1,15	2,28	22,52	22,39	SP(dvw) SB(wood)
3,5d10M16/A-3	10	16	3,5 d	84,0	11,5	0,68	0,73	-0,05	0,24	1,32	2,68	22,19	20,66	SP(dvw) SB(wood)
3,5d10M16/B-4	10	16	3,5 d	71,0	15,0	0,83	0,96	-0,12	0,23	1,40	2,88	17,96	15,68	E(dvw, wood)
3,5d10M16/B-5	10	16	3,5 d	83,0	14,1	0,70	0,71	-0,01	0,28	1,32	3,03	21,38	21,21	E(dvw, wood)
5,0d10M16/A-1	10	16	5 d	91,5	14,0	0,63	0,72	-0,09	0,21	1,52	4,24	23,82	20,89	E(dvw, wood)
5,0d10M16/A-2	10	16	5 d	83,5	15,0	0,79	0,89	-0,09	0,22	1,40	2,98	22,66	20,31	E(dvw, wood)
5,0d10M16/B-3	10	16	5 d	81,0	15,0	0,83	0,82	0,01	0,32	1,30	3,25	21,76	21,92	E(dvw, wood)
5,0d10M16/A-4	10	16	5 d	84,0	15,0	0,81	0,82	-0,02	0,33	1,26	3,01	22,30	21,85	E(dvw, wood)
5,0d10M16/B-5	10	16	5 d	81,4	15,0	0,84	0,81	0,04	0,26	1,28	3,04	21,35	22,28	E(dvw, wood)