Loading tests of threaded inserts for determination of tensile and shear resistances

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Task **Loading tests of threaded inserts for determination of tensile and shear resistances**

1 Specimen

The customer sent to the laboratory of VTT Building and Transport two concrete slabs. During concrete construction 26 units of threaded inserts had been positioned in the slabs, which had the following measures:

Slab No. 1, 1920 * 1920 * 180 mm^3
Slab No. 2, 2400 * 2400 * 225 mm^3

Pouring of slabs had happened in horizontal position.

The slabs were equipped with following inserts:

Slab No. 1:
M24 * 120 No. 410R, 10 units
M24 * 120 No. 410n 3 units

Slab No. 2:
M24 * 150 No. 410R, 10 units
M24 * 150 No. 410n 3 units

Spacings of the inserts were $K \geq 4 * A$, however ≥ 400 mm and edge distances $E \geq 2 * A$, however ≥ 200 mm. Thicknesses of the concrete members were $H \geq 1.5 * A$, where A = embedment depth of insert.

2 Loading tests

Loading tests were carried out 30. - 31.8.2005.

The test arrangements are presented in Figures 1 and 2.

In general, the test rigs allowed the formation of an unrestricted rupture cone. For this reason the clear distance between the support reaction and an insert was at least $2 \cdot A$.

During all tests, the load was applied to the insert by a fixture representing the conditions found in practice.

During tension tests, the load was applied concentrically to the insert. To achieve this, hinges were incorporated between the loading device and an insert.

In shear tests, the load was applied parallel to the concrete surface.

The load was increased in such a way that the peak load occured after 1 to 3 minutes from commencement. Load and displacement were recorded continuously.

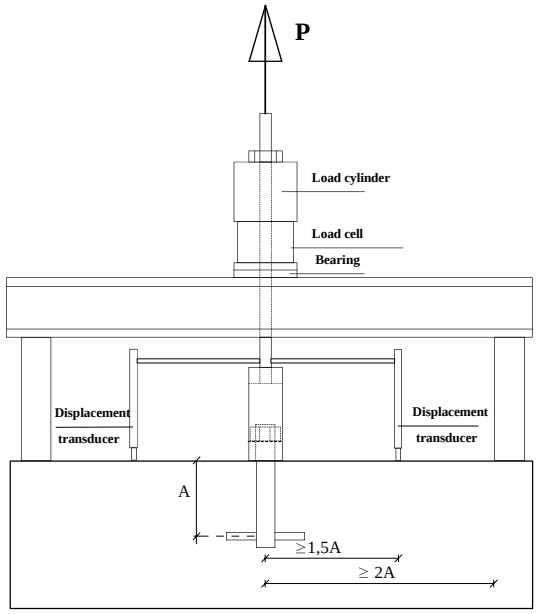


Figure 1. Arrangement of tension test.

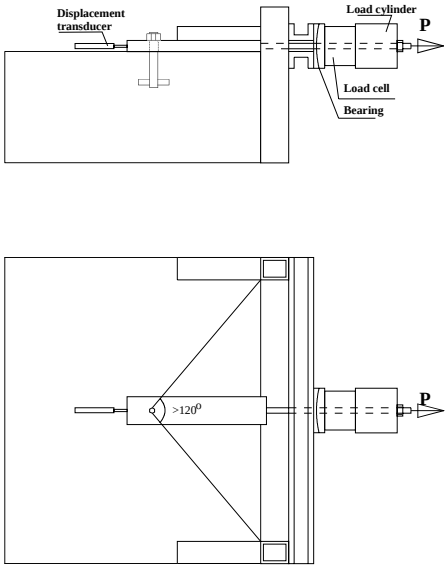


Figure 2. Arrangement of shear test.

3 Results

The results of the loading tests are given in the following Tables and Appendices:
- tension tests, Table 1,
- shear tests, Table 2,
- compressive strength of concrete, Table 3,
- characteristic tensile resistances, Table 4,
- characteristic shear resistances, Table 5,
- load-displacement curves, Appendix 2.

In the Tables P_{max} is the failure load of the test and P_L is the load corresponding to the displacement of 3 mm of an insert.

Table 1. Results of tension tests, concrete K25.

Insert	P_{max} kN	P_L kN	Notes
M24 * 120 No. 410R			
1	79.1	-	1)
2	78.9	-	1)
3	75.3	-	1)
4	72.6	-	1)
5	73.7	-	1)
M24 * 120 No. 410			
1	71.4	-	1)
2	73.2	-	1)
3	75.6	-	1)
M24 * 150 No. 410R			
1	107.4	101.6	1) 2)
2	97.8	95.4	1) 2)
3	104.1	101.9	1) 2)
4	106.0	96.5	1) 2)
5	96.2	92.8	1) 2)

1) Concrete cone
2) Insert slips

Table 2. Results of shear tests, concrete K25.

Insert	P_{max} kN	P_L kN	Notes
M24 * 120 No. 410R			
1	87.8	87.2	1) 2)
2	89.3	-	1)
3	92.7	-	1)
4	83.4	79.4	1) 2)
5	84.5	-	1)
M24 * 150 No. 410R			
1	127.9	106.2	1) 2)
2	117.9	110.8	1) 2)
3	134.7	99.8	1) 2)
4	121.6	97.5	1) 2)
5	116.4	94.7	1) 2)
M24 * 150 No.410			
1	116.3	100.0	1) 2)
2	118.5	-	1)
3	127.6	107.0	1) 2)

1) Concrete cone
2) Insert slips

Table 3. Compressive strength of concrete (cube 150 * 150 * 150 mm^3).

Sample		Cylinder	
Slab No.	Date	Density kg/m^3	Strength MN/m^2
1 and 2	30.8.2005	2260	26.5
	"	2240	26.5
	"	2210	25.5
	"	2270	27.0
	"	2230	24.5
	"	2240	25.5

Table 4. Characteristic tensile resistances, concrete K25.

Insert	Concrete strength	Test Results			
		Mean value F_{cm} kN	Standard deviation s kN	Coefficient of variation δ_t	Characteristic resistance F_{ck} kN
M24 * 120 No. 410R	K25	75.92	2.97	0.04	71.02
M24 * 120 No. 410	K25	73.40 1)	2.11	0.03	-
M24 * 150 No. 410R	K25	102.3	5.01	0.05	94.03

1) Three test results

Table 5. Characteristic shear resistances, concrete K25.

Insert	Concrete strength	Test Results			
		Mean value F_{cm} kN	Standard deviation s kN	Coefficient of variation δ_t	Characteristic resistance F_{ck} kN
M24 * 120 No. 410R	K25	87.54	3.75	0.04	81.35
M24 * 150 No. 410R	K25	123.70	7.58	0.06	111.19
M24 * 150 No. 410	K25	120.8 1)	6.00	0.05	-

1) Three test results

Characteristic resistance has been calculated from the following Equation

$$\mathbf{F_{ck} = f_{cm} - 1.65 * s}$$

f_{cm} = mean value of test results
s = standard deviation of test results

$$\mathbf{s = \sqrt{\frac{\sum_{i=1}^{n} (f_{ci} - f_{cm})^2}{n-1}}}$$

f_{ci} = single failure load
n = amount of test results.

4 Threaded inserts as lifting devices of elements

According to the Finnish building code (RakMK B4: 2.6.1.5) the partial safety factor of the lifting device is four. In Table 6 will be presented allowable weights of elements with different values of lifting angles. The lifting angle means the angle between the vertical line and the lifting position.

When calculating the allowable weigth of an element for combined tension and shear loads the following Equations shall be satisfied:

$$\beta_N \leq 1$$
$$\beta_V \leq 1$$
$$\beta_N + \beta_V \leq 1.2,$$

where β_N and β_V ratio between design action and design resistance for tension and shear loading.

Table 6. Allowable lifting loads of threaded inserts (kN) (allowable weight of an element) with different values of lifting angles 0^o, 30^o, 60^o and allowable shear loads of threaded inserts (lifting angle 90^o), concrete K25.

Insert	Allowable weight of an element (kN)			
	Lifting angle			
	90^o (allowable shear force)	60^o	30^o	0^o (vertical lifting)
M24 * 120 No. 410R	20,4	8,5	14,2	17,8
M24 * 150 No. 410R	27,8	11,4	18,9	23,5

The values of Table 6 also apply to threaded inserts No. 410, No. 310R and No. 310.

5 Threaded inserts as load bearing metal parts

In Table 7 will be presented design values of tensile and shear resistances for threaded inserts when these inserts are used as load bearing metal parts according to RakMK B4: 4.1.2.4. The design value of resistance must be greater than the design value of effect of actions.

The design values in Table 7 have been got by deviding the characteristic values by the factor which depends on failure mode. Because the reason of the failure was concrete failure the partial factor is 1.5 (reinforced concrete). Moreover, when the failure is brittle must be used still an other partial factor of 1.2.

Load-displacement curves needed in the serviceability limit state will be presented in Appendix 2.

Table 7. Design values of tensile and shear resistances for threaded inserts, concrete K25.

Insert	Design value of tensile resistance (kN)	Design value of shear resistance (kN)
M24 * 120 No. 410R	39,4	45,2
M24 * 150 No. 410R	52,2	61,7

The values of Table 7 also apply to threaded inserts No. 410, No. 310R and No. 310.

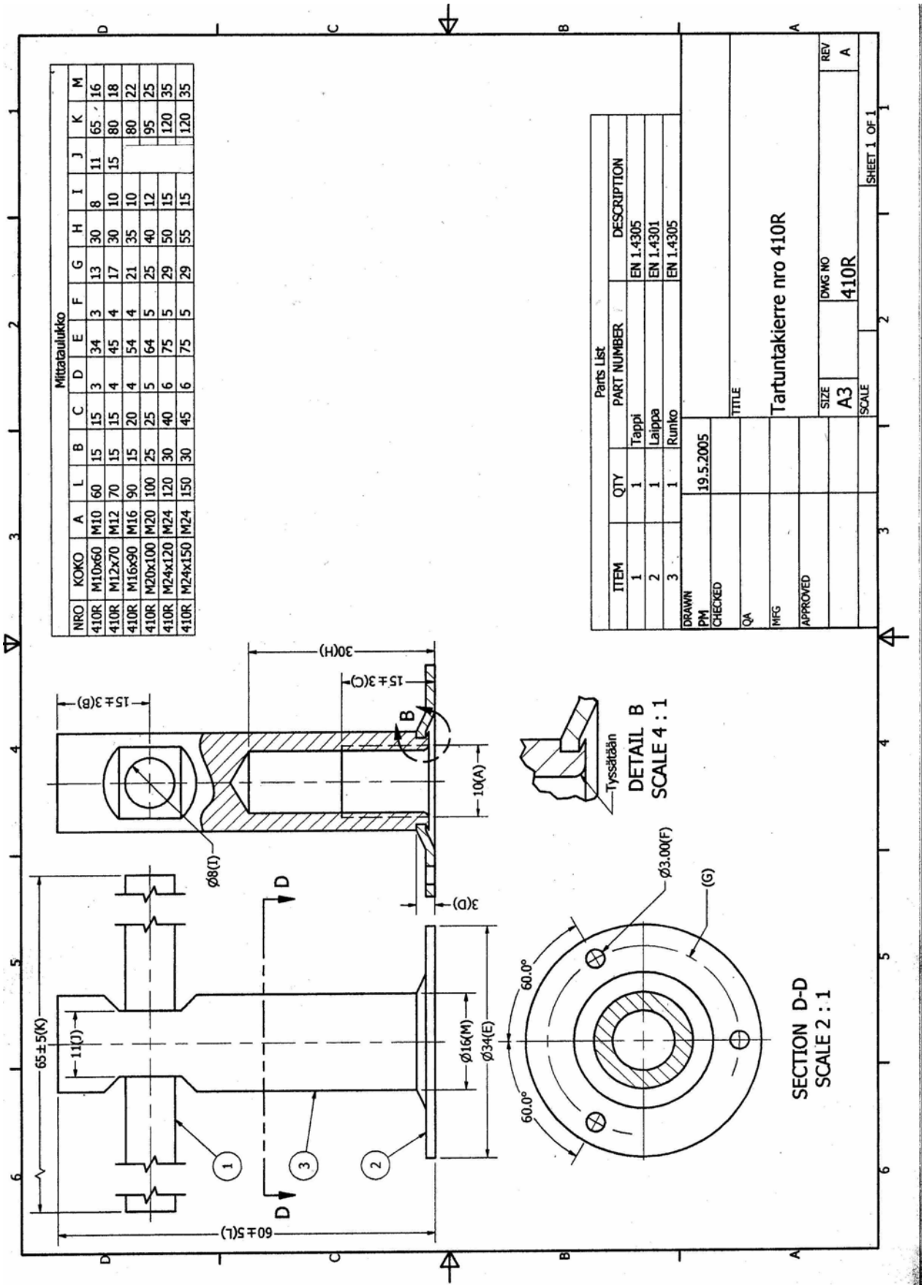
Espoo, 9th September 2005

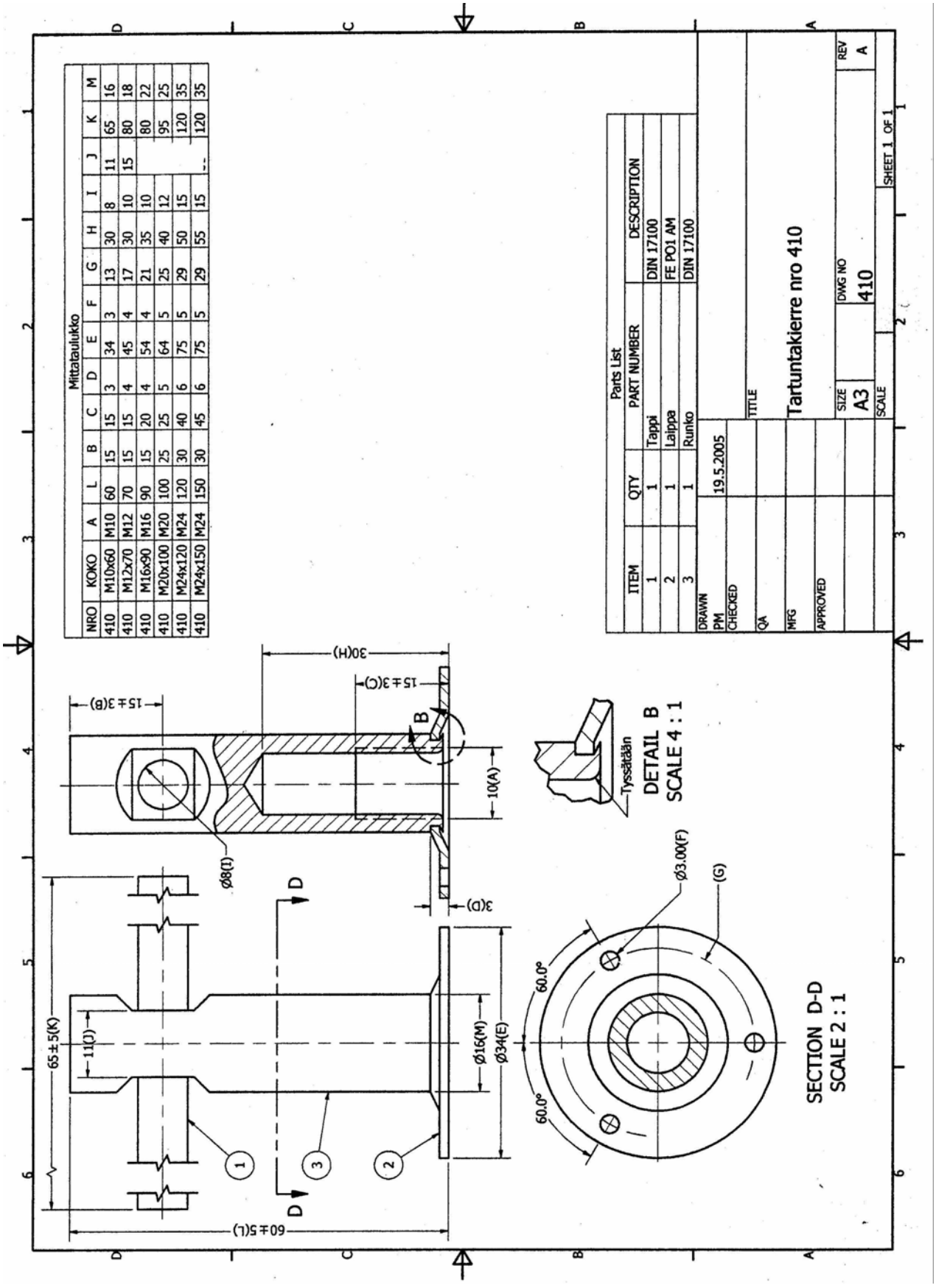
Pekka Salmi
Group Manager

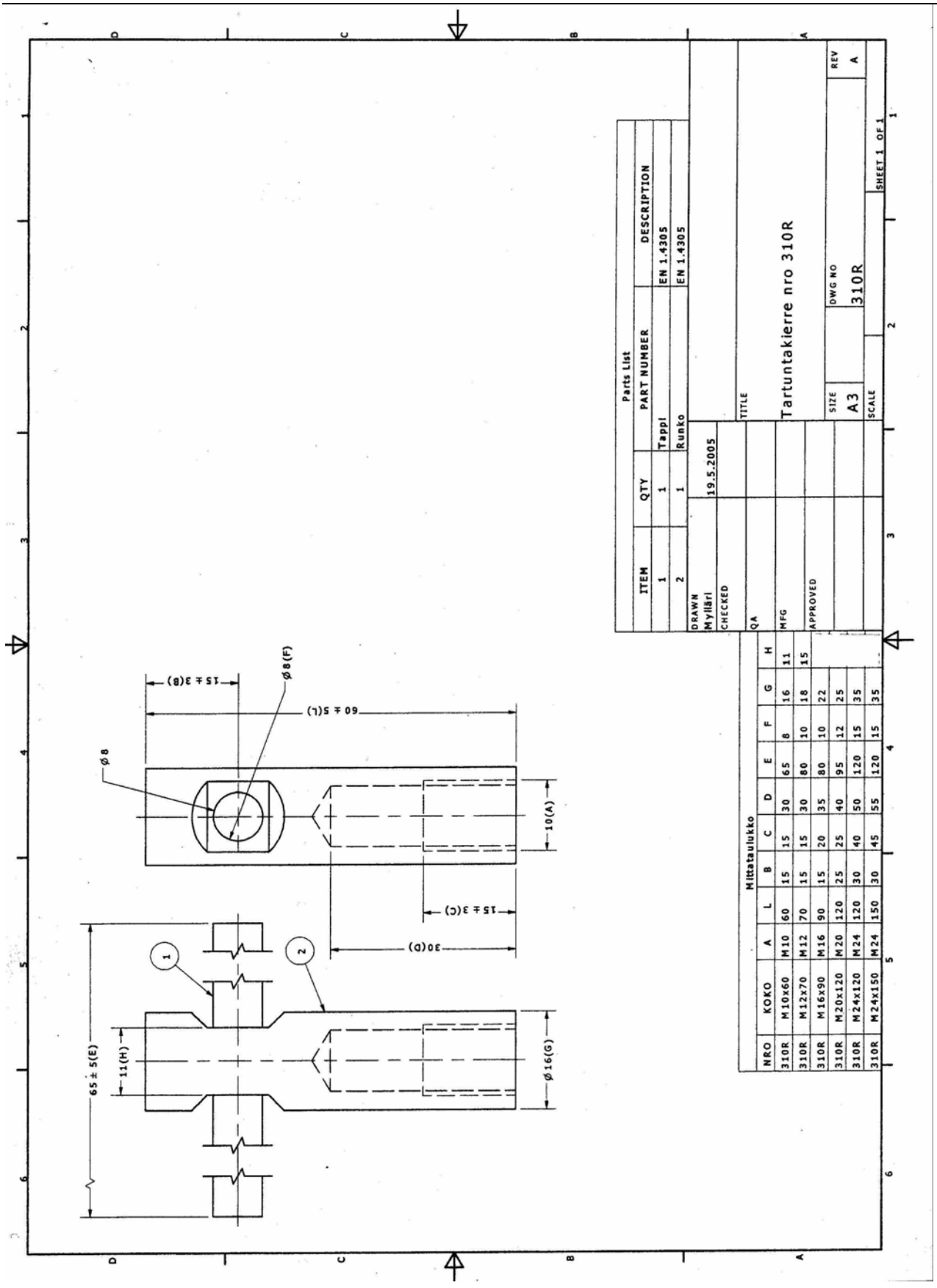
Heikki Lintunen
Research Engineer

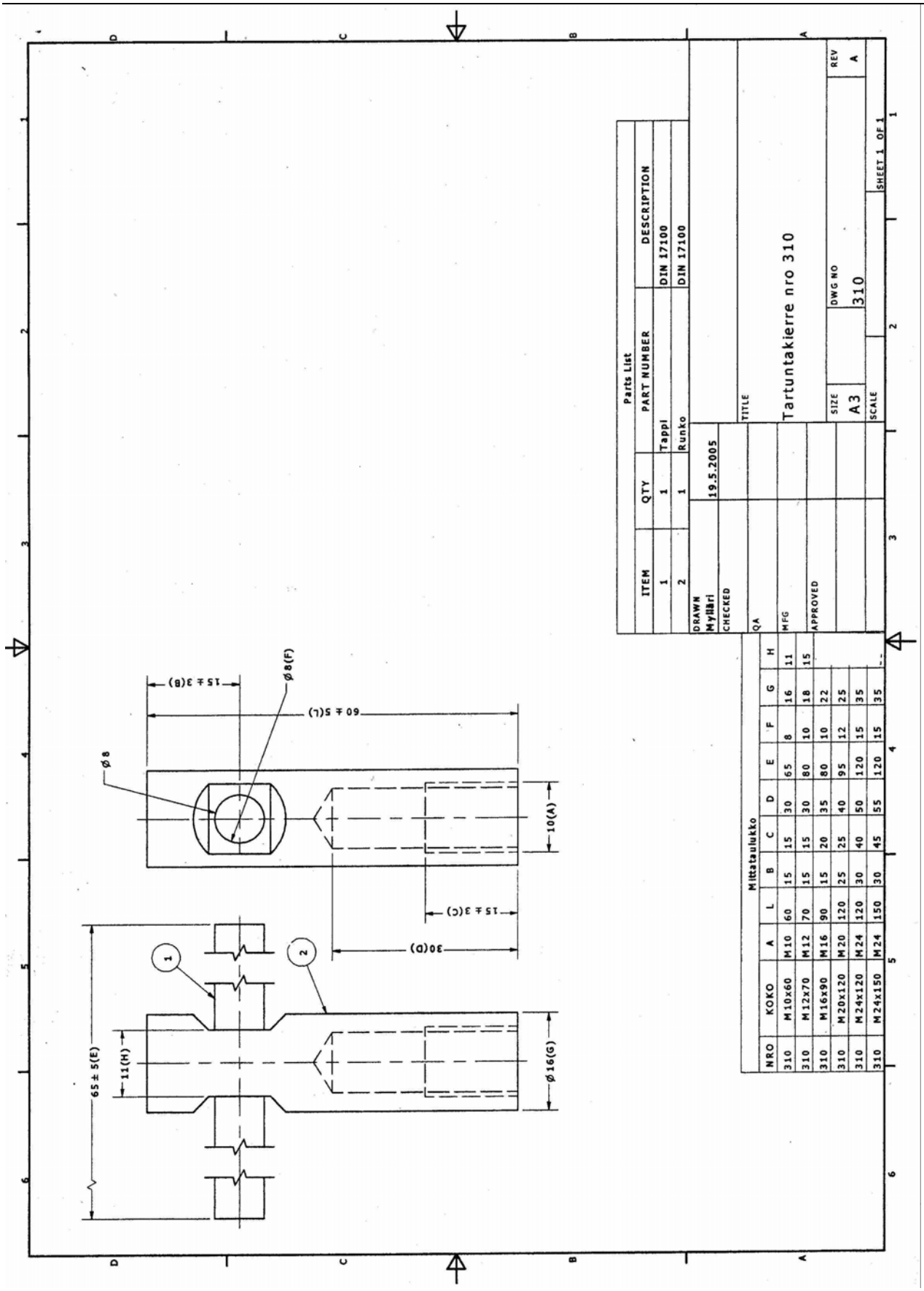
Appendices 2 pieces

Distribution Customer Original
VTT Original









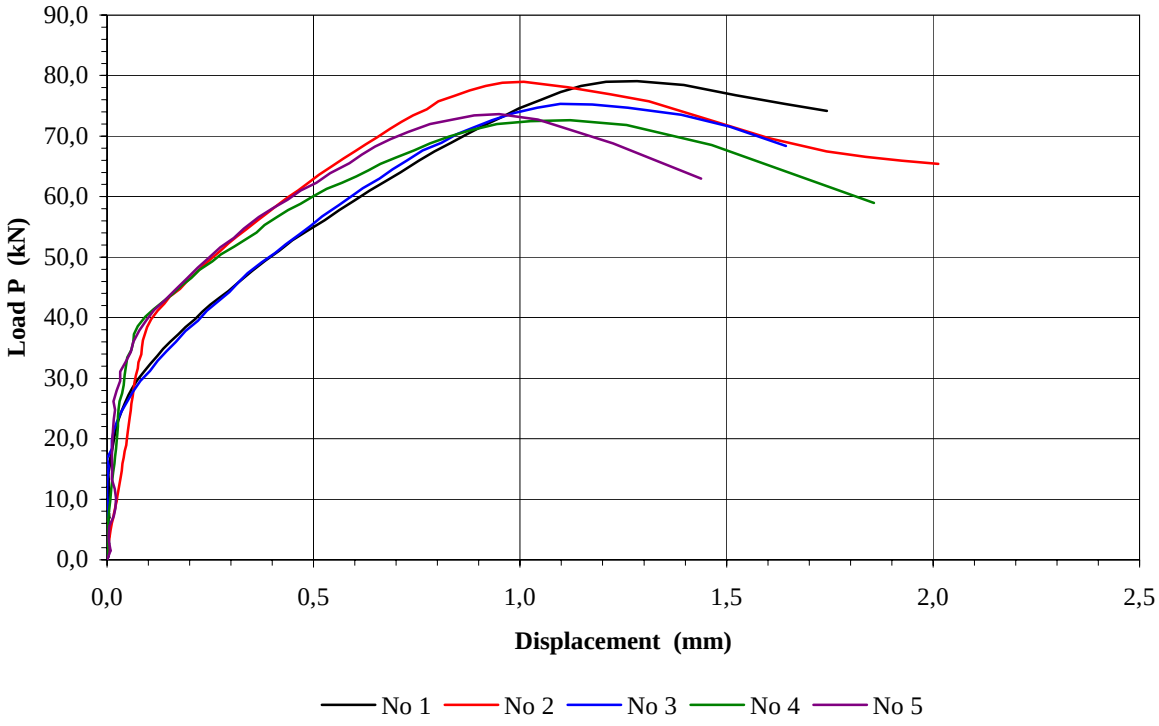


Fig. 1. Load-displacement curves for threaded inserts M24 * 120 R, tension tests.

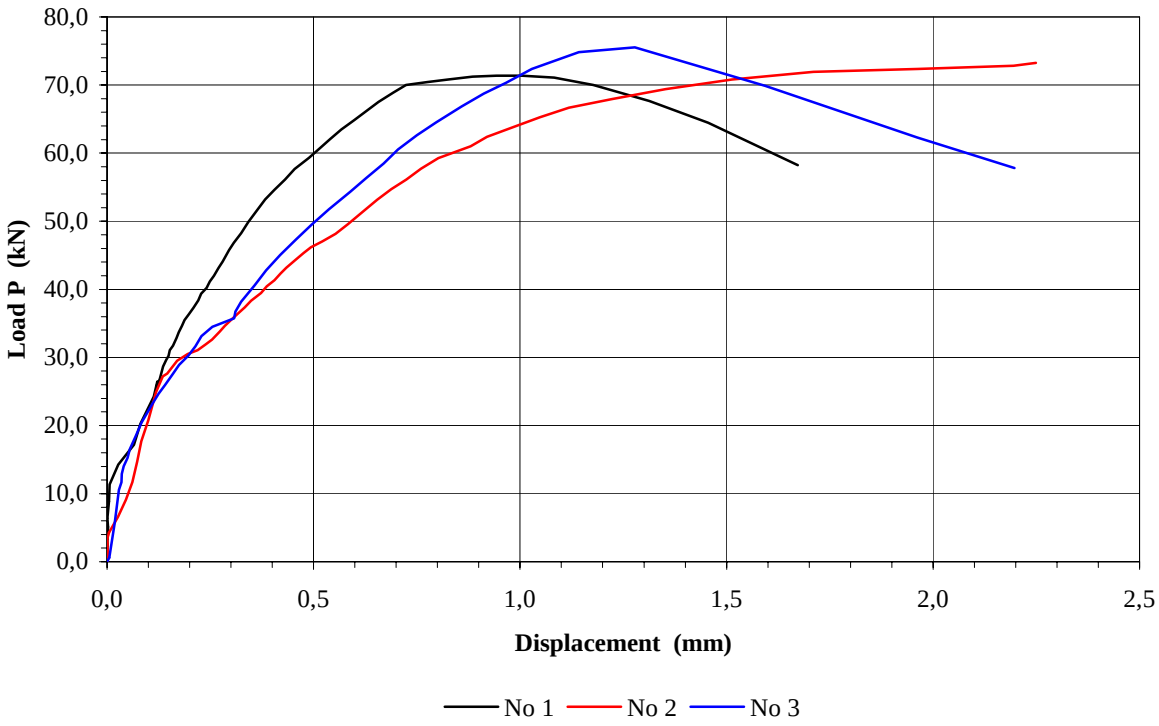


Fig 2. Load-displacement curves for threaded inserts M24 * 120, tension tests.

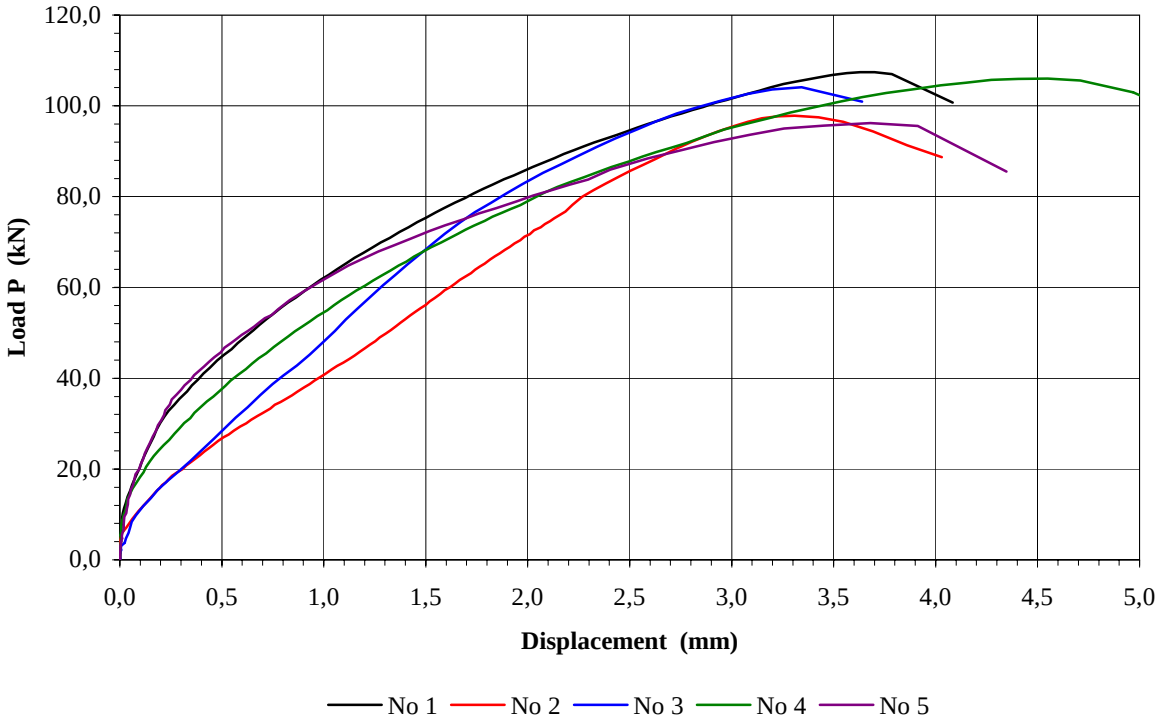


Fig 3. Load-displacement curves for threaded inserts M24 * 150 R, tension tests.

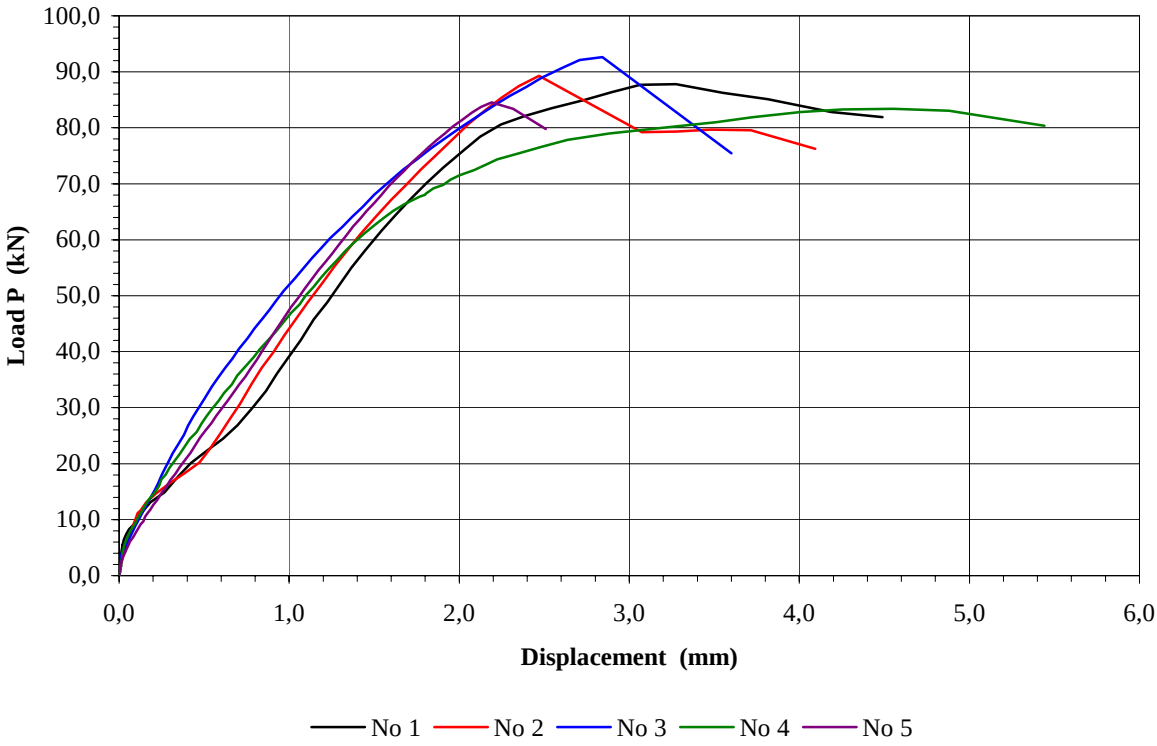


Fig 13. Load-displacement curves for threaded inserts M24 * 120 R, shear tests.

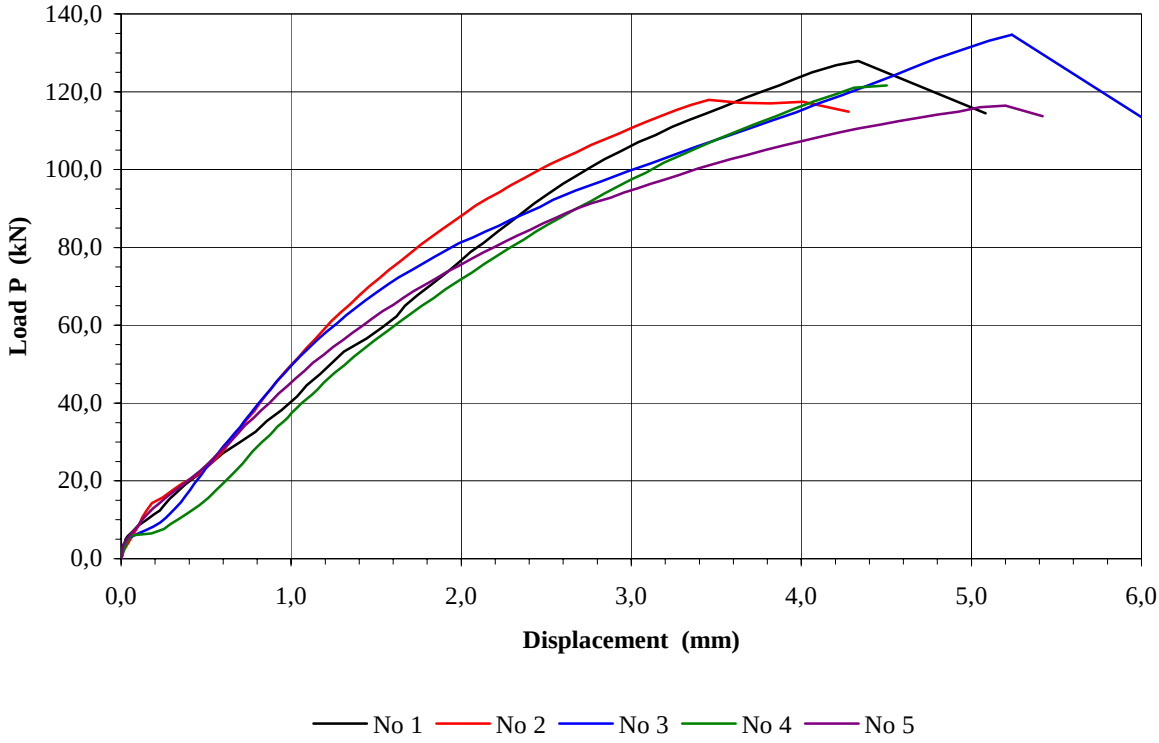


Fig 14. Load-displacement curves for threaded inserts M24 * 150 R, shear tests.

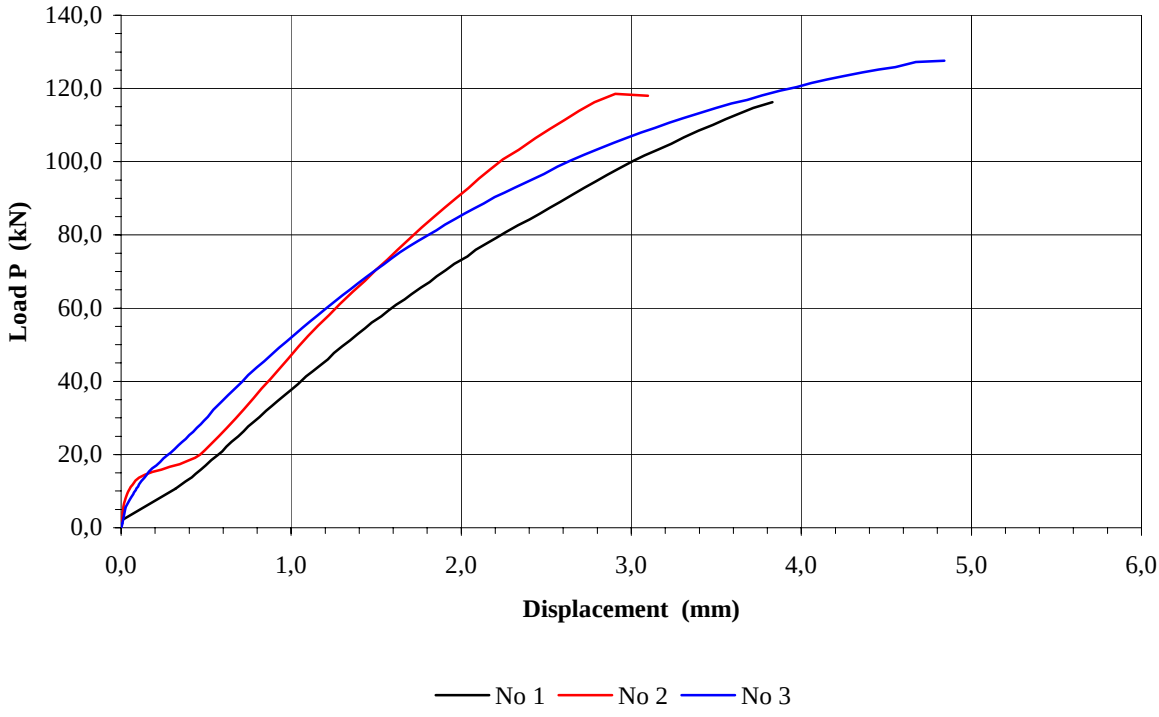


Fig 15. Load-displacement curves for threaded inserts M24 * 150, shear tests.