



6.2.5 ETAG 001, Part Three, Tab. 5.1, Line 6 (Functioning under repeated loads [$f_c = C20/25$, $d_{cut} = d_{cut,m}$])



Anchortype: Powers Fasteners Screwbolt			Date: 09.05.2007				
Task no.		: Z07 200					
Fastener size / delivery date		: Powers BT 10-120 / 26.02.2007					
Test type		: Suitability Tests (F6/S4 according test program IEA)					
Test description		: Functioning under repeated load ($n=10^5$ load cycles, $N_{\max} = 14,4$ kN, $N_{\min} = 7,1$ kN) in C20/25 (uncracked) according to CUAP, table 2, line 4, with $h_{\text{nom,max}}$ and $d_{\text{cut,m}}$					
Inspector / Technician		: Dipl.-Ing. C. Mahrenholtz / Mr. E. Lindenmeier					
Concrete	: C20/25	Cabinets	: MS 005 + StS 001				
Slab thickness h [mm]	: 200	Recording frequency [Hz]	: 5				
Hole depth h_0 [mm]	: ≥ 100	Torque wrench	: DM 023; 200 Nm				
Setting depth $h_{\text{nom,max}}$ [mm]	: 75	Hydraulic cylinder	: SHZ 006; 50 kN				
Drill bit diameter $d_{\text{cut,m}}$ [mm]	: 10,28	Load cell	: KMD 040; 50 kN; c.f. -6,549				
Drilling machine	: Hilti TE 25	Electronic transducer	: WA 104; c.f. -0,077				
Loading fixture $\varnothing / t$ [mm]	: 14,0/45,0		: WA 042; c.f. -0,0776				
Test no.		1	2	3	4	5	
Compression strength $f_{c,c 150}$ [N/mm ²]		29,7 on 02.05.2007; 28,4 on 12.7.2007 Slab: 11Z200/5/224, Casting Date: 02.03.2007					
Date of testing	[dd.mm.yyyy]	09.05.2007	10.05.2007	14.05.2007	15.05.2007	16.05.2007	
Drill hole depth h_0	[mm]	106	102	104	103	104	
Drill hole cleaning	[-]	Blowing 2x					
Tightening torque T_{inst}	[Nm]	68,7	62,0	59,0	62,2	88,1	
Test under repeated load:							
$N_{\min} / N_{\max}$	[kN]	14,4 / 7,1					
Displacement s at $N_{\max}$ after $n=0$ load alternations	[mm]	0,703	0,598	0,834	1,028	0,571	
Displacement s at $N_{\max}$ after $n=1$ load alternations	[mm]	0,714	0,608	0,846	1,044	0,578	
Displacement s at $N_{\max}$ after $n=10^5$ load alternations	[mm]	0,406	0,830	1,044	1,371	0,750	
Displacement s_{bl} after release	[mm]	0,032	0,058	0,062	0,197	-0,263	
Tension test:							
Time t for gaining N_u	[s]	49	66	64	48	38	
Average load speed v_m	[kN/s]	0,75	0,65	0,68	0,77	0,85	
Ultimate load N_u	[kN]	36,82	42,89	43,80	37,14	32,28	
Mean value $N_{u,m}$	[kN]	38,59					
Coefficient of variation	[%]	12,3					
Displacement s at N_u w/o s_{bl}	[mm]	1,42	2,22	2,07	1,38	0,89	
Displacement s at $0,5 N_{u,m}$	[mm]	0,33	0,35	0,31	0,42	0,30	
Mean value s at $0,5 N_{u,m}$	[mm]	0,34					
Coefficient of variation	[%]	14,1					
Setting depth obtained? [yes/no]		y	y	y	y	y	
Damage of the thread?		n	n	n	n	n	
Failure mode		P	P	P	P	P	
Diameter of concrete cone [cmxcm]		29x31	7x9	8x10	29x31	14x16	
Depth of concrete cone [cm]		5	2	2	5	3	
Legend of the failure mode		P = Pullout with concrete cone near the surface					

Table 6.52 First Protocol of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 10



Anchortype: Powers Fasteners Screwbolt						Date: 09.05.2007
BT 10-120 – Suitability test under repeated load						
Number of load alternations N	Displacement s [mm] at $N_{max} = 14,4$ kN					
	s	F6-1	F6-2	F6-3	F6-4	F6-5
0	ETD 1	0,879	0,363	0,546	1,422	0,698
	ETD 2	0,527	0,833	1,121	0,633	0,444
	Mean	0,703	0,598	0,834	1,028	0,571
1	ETD 1	0,871	0,371	0,559	1,429	0,708
	ETD 2	0,557	0,844	1,133	0,658	0,448
	Mean	0,714	0,608	0,846	1,044	0,578
10	ETD 1	0,855	0,383	0,566	1,436	0,740
	ETD 2	0,588	0,853	1,137	0,684	0,450
	Mean	0,722	0,618	0,852	1,060	0,595
100	ETD 1	0,847	0,417	0,594	1,462	0,795
	ETD 2	0,621	0,864	1,158	0,732	0,468
	Mean	0,734	0,641	0,876	1,097	0,632
1000	ETD 1	0,872	0,462	0,652	1,549	0,913
	ETD 2	0,651	0,919	1,223	0,799	0,536
	Mean	0,762	0,691	0,938	1,174	0,725
10000	ETD 1	0,899	0,509	0,708	1,633	1,141
	ETD 2	0,665	0,984	1,286	0,870	0,691
	Mean	0,782	0,747	0,997	1,252	0,916
50000	ETD 1	0,936	0,549	0,736	1,720	1,221
	ETD 2	0,698	1,047	1,327	0,953	0,756
	Mean	0,817	0,798	1,032	1,337	0,989
80000	ETD 1	0,961	0,568	0,756	1,734	1,260
	ETD 2	0,727	1,055	1,343	0,975	0,792
	Mean	0,844	0,812	1,050	1,355	1,026
100000	ETD 1	0,073	0,585	0,750	1,749	1,223
	ETD 2	0,738	1,075	1,338	0,992	0,276
	Mean	0,406	0,830	1,044	1,371	0,750
Displacement after release	ETD 1	-0,076	0,088	-0,079	0,334	-0,037
	ETD 2	0,140	0,028	0,203	0,059	-0,488
	Mean	0,032	0,058	0,062	0,197	-0,263

Table 6.53 Second Protocol of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 10

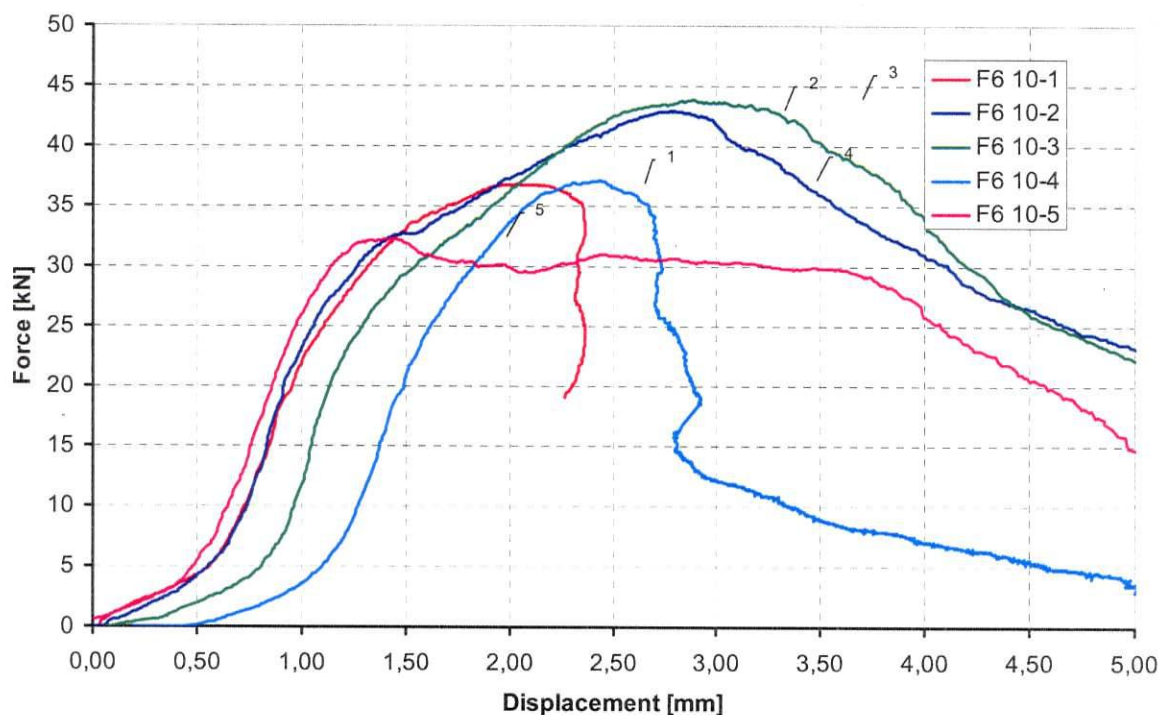


Figure 6.60 Load-Displacement Behaviour of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 10 after 1×10^6 load cycles

Remark: The electronic transducers were within the concrete cone at test F6 10-1, F6 10-4.

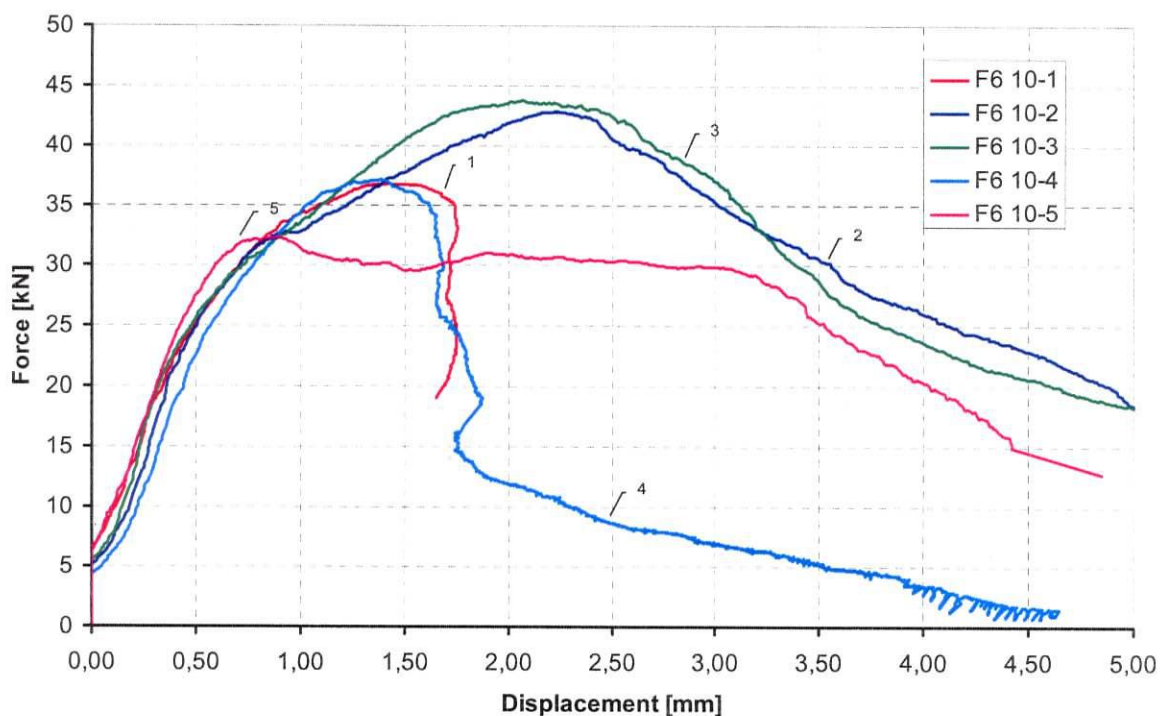


Figure 6.61 Load-Displacement Behaviour of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 10 after 1×10^6 load cycles; influence of slip on curve progression zeroed out calculative



Anchortype: Powers Fasteners Screwbolt

Date: 21.02.2007

Task no.	: Z07 200
Fastener size / delivery	: Powers BT 12-150 / 22.01.2007
Test type	: Suitability Tests (F6/S4 according test program IEA)
Test description	: Functioning under repeated load ($n=10^5$ load cycles, $N_{max} = 23,0$ kN, $N_{min} = 12,5$ kN) in C20/25 (uncracked) according to CUAP, table 2, line 4, with $h_{nom,max}$ and $d_{cut,m}$
Inspector / Technician	: Dipl.-Ing. Philipp Mahrenholtz / Mr. Peter Scherf

Concrete	: C20/25	Cabinets	: MS 004 + StS 001
Slab thickness h [mm]	: 320	Recording frequency [Hz]	: 5
Hole depth h_0 [mm]	: ≥ 120	Torque wrench	: DM 015; 200 Nm
Setting depth $h_{nom,max}$ [mm]	: 100	Hydraulic cylinder	: SHZ 006; 50 kN
Drill bit diameter $d_{cut,m}$ [mm]	: 12,30	Load cell	KMD 040; 6,549
Drilling machine	: Hilti TE 25	Electronic transducer	: WA 062; c.f. -0,0770
Loading fixture $\varnothing / t$ [mm]	: 48,5/13,5		: WA 062; c.f. -0,0770

Test no.		1	2	3	4	5	6
Compression strength $f_{c,c 150}$ [N/mm ²]		25,75 on 12.02.2007; Slab: 11Z196/7/207*, Casting Date: 20.12.2006)					
Date of testing [dd.mm.yyyy]		14.02.2007	15.02.2007	16.02.2007	19.02.2007	20.02.2007	21.02.2007
Drill hole depth h_0 [mm]		125,4	121,3	122,2	121,3	122,1	120,0
Drill hole cleaning [-]		Blowing 2x					
Tightening torque T_{inst} [Nm]		118,2	128,5	96,5	118,5	86,1	58,6
Test under repeated load:							
N_{min} / N_{max} [kN]		12,5 / 23,0					
Displacement s at N_{max} after $n=0$ load alternations [mm]		0,526	0,924	0,641	0,812	0,719	0,158
Displacement s at N_{max} after $n=1$ load alternations [mm]		0,538	0,929	0,650	0,831	0,749	1,171
Displacement s at N_{max} after $n=10^5$ load alternations [mm]		0,641	0,739	0,991	0,990	-	1,563
Displacement s_{bl} after release [mm]		0,472	-0,180	0,314	0,154	-	0,247
Tension test:							
Time t for gaining N_u [s]							
Average load speed v_m [kN/s]							
Ultimate load N_u [kN]		46,0	49,7	54,9	49,4	-	54,0
Mean value $N_{u,m}$ [kN]		50,8					
Coefficient of variation [%]		7,2					
Displacement s at N_u w/o s_{bl} [mm]		2,30	2,38	1,72	1,70	-	4,56
Displacement s at $0,5 N_{u,m}$ [mm]		0,60	1,03	0,77	0,79	-	1,01
Mean value s at $0,5 N_{u,m}$ [mm]		0,84					
Coefficient of variation [%]		21,4					
Setting depth obtained?		Yes	Yes	Yes	Yes	Yes	Yes
Damage of the thread?		No	No	No	No	No	No
Failure mode		P	P	P	P	P	P
Diameter of concrete cone [cm]		18x23	17x21	21x28	35x35	18x20	16x15
Depth of concrete cone [cm]		4,0	3,0	4,5	4,5	3,0	3,0

Table 6.54 First Protocol (Part 1) of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 12



Note	*) Same batch as slab 11Z196/7/207 therefore no reference tests required.
Legend of the failure mode	P = Pullout with concrete cone near the surface

Table 6.55 First Protocol (Part 2) of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 12

Anchortype: Powers Fasteners Screwbolt					Date: 21.02.2007		
BT 12-150 – Suitability test under repeated load							
Number of load alternations N	Displacement s [mm] at N _{max} = 23,0 kN						
	s	F6-1	F6-2	F6-3	F6-4	F6-5	F6-6
0	ETD 1	0,672	0,376	0,939	0,917	1,155	0,525
	ETD 2	0,380	1,472	0,342	0,707	0,283	1,791
	Mean	0,526	0,924	0,641	0,812	0,719	1,158
1	ETD 1	0,693	0,368	0,963	0,956	1,220	0,531
	ETD 2	0,383	1,489	0,337	0,706	0,277	1,810
	Mean	0,538	0,929	0,650	0,831	0,749	1,171
10	ETD 1	0,696	0,367	1,000	0,966	1,277	0,529
	ETD 2	0,380	1,506	0,320	0,705	0,247	1,840
	Mean	0,538	0,937	0,660	0,836	0,762	1,185
100	ETD 1	0,709	0,370	1,068	0,973	1,377	0,530
	ETD 2	0,379	1,565	0,336	0,728	0,242	1,1933
	Mean	0,544	0,968	0,702	0,851	0,810	1,232
1000	ETD 1	0,724	0,370	1,089	1,002	1,468	0,566
	ETD 2	0,382	1,697	0,511	0,753	0,246	2,053
	Mean	0,553	1,034	0,800	0,878	0,857	1,310
10000	ETD 1	0,747	0,382	1,121	1,002	1,588	0,623
	ETD 2	0,407	1,084	0,531	0,815	0,274	2,239
	Mean	0,577	0,733	0,826	0,909	0,931	1,431
50000	ETD 1	0,788	0,391	1,177	1,057	1,628	0,667
	ETD 2	0,451	1,040	0,747	0,872	0,313	2,310
	Mean	0,620	0,716	0,962	0,965	0,971	1,489
80000	ETD 1	0,795	0,410	1,189	1,080	1,643	0,733
	ETD 2	0,467	1,044	0,762	0,898	0,330	2,352
	Mean	0,631	0,727	0,976	0,989	0,987	1,543
100000	ETD 1	0,808	0,422	1,215	1,081	-	0,753
	ETD 2	0,473	1,055	0,767	0,899	-	2,372
	Mean	0,641	0,739	0,991	0,990	-	1,563
Displacement after release	ETD 1	0,583	-0,700	0,399	0,005	-	0,120
	ETD 2	0,360	0,340	0,229	0,303	-	0,374
	Mean	0,472	-0,180	0,314	0,154	-	0,247

Table 6.56 Second Protocol of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 12

Remark F6-5: Just after having reached 100,000 load cycles, the power control deteriorated and the screw was pulled-out.

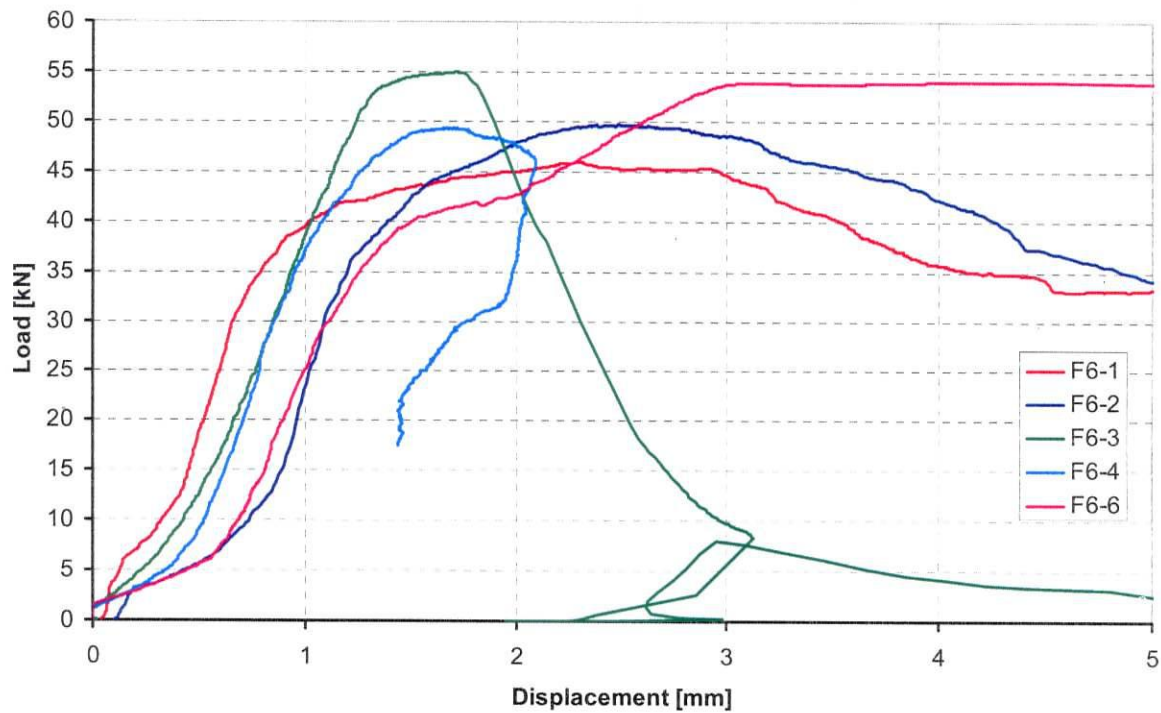


Figure 6.62 Load-Displacement Behaviour of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 12 after 1×10^6 load cycles

Remark F6-4: The electronic transducers were within the concrete cone.

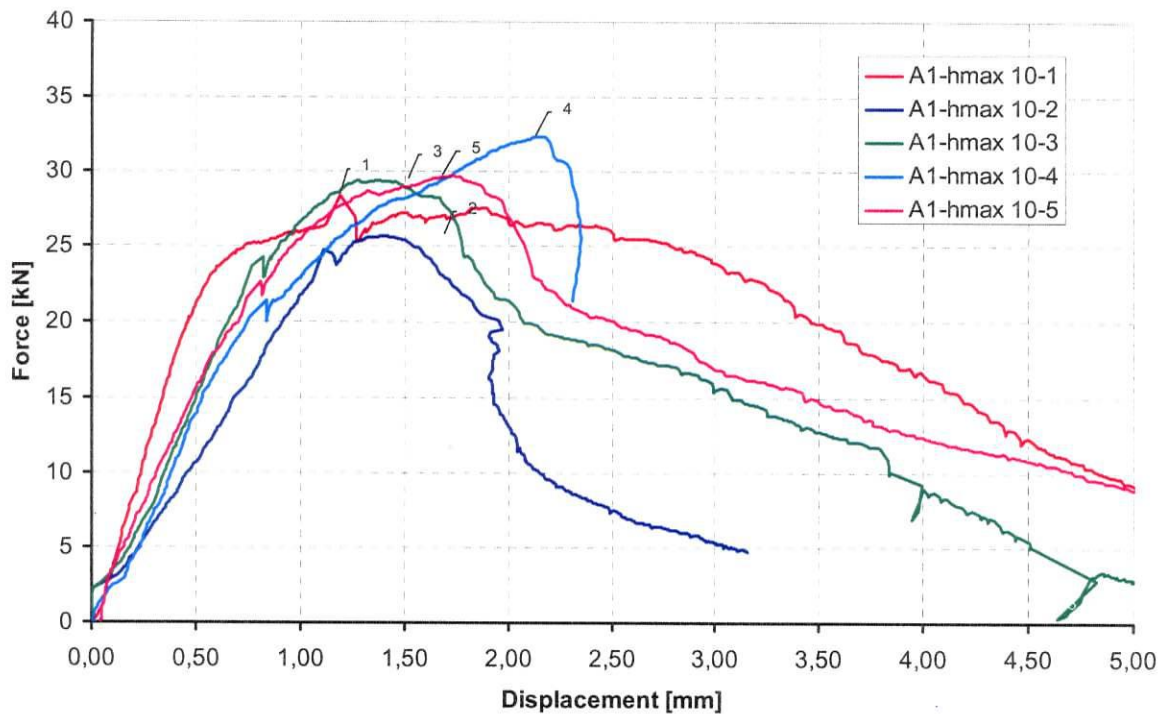


Figure 6.63 Load-Displacement Behaviour of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 12 after 1×10^6 load cycles; influence of slip on curve progression zeroed out calculative



Anchortype: Powers Fasteners Screwbolt		Date: 15.10.2007				
Task no.	: Z07 200					
Fastener size / delivery date	: Powers BT 16-150 / 05.10.2007					
Test type	: Suitability Tests (F6/S4 according test program IEA)					
Test description	: Functioning under repeated load ($n=10^5$ load cycles, $N_{max} = 25,1$ kN, $N_{min} = 10,5$ kN) in C20/25 (uncracked) according to CUAP, table 2, line 4, with $h_{nom,max}$ and $d_{cut,m}$					
Inspector / Technician	: Dipl.-Ing. C. Mahrenholtz / Mr. E. Lindenmeier					
Concrete	: C20/25	Cabinets	: MS 003 + StS 001			
Slab thickness h [mm]	: 200	Recording frequency [Hz]	: 5			
Hole depth h_0 [mm]	: ≥ 135	Torque wrench	: DM 015; 200 Nm			
Setting depth $h_{nom,max}$ [mm]	: 110	Hydraulic cylinder	: SHZ 004; 250 kN			
Drill bit diameter $d_{cut,m}$ [mm]	: 16,28	Load cell	: KMD 017; 250 kN; 24,9380			
Drilling machine	: Hilti TE 25	Electronic transducer	: WA 065; 0,0765			
Loading fixture $\varnothing / t$ [mm]	: 20,0/40,0		: WA 102; 0,0775			
Test no.		1	2	3	5	6
Compression strength $f_{c,c 150}$	[N/mm ²]	30,8 on 06.08.2007; 26,7 on 05.10.2007 Slab: 11Z200/1/219, Casting Date: 16.02.2007				
Date of testing	[dd.mm.yyyy]	15.10.2007	16.10.2007	17.10.2007	21.10.2007	22.10.2007
Drill hole depth h_0	[mm]	147	152	136	143	140
Drill hole cleaning	[-]	Blowing 2x				
Tightening torque T_{inst}	[Nm]	56,8/118	152/170	107/171	63,1/133	152/230
Test under repeated load:						
N_{min} / N_{max}	[kN]	10,5 / 25,1				
Displacement s at N_{max} after $n=0$ load alternations	[mm]	1,496	1,644	1,180	1,661	0,994
Displacement s at N_{max} after $n=1$ load alternations	[mm]	1,513	1,656	1,214	1,695	1,004
Displacement s at N_{max} after $n=10^5$ load alternations	[mm]	2,006	1,987	1,775	2,811	1,175
Displacement s_{bl} after release	[mm]	0,735	0,610	0,605	1,849	0,085
Tension test:						
Time t for gaining N_u	[s]	88		59	39	110
Average load speed v_m	[kN/s]	0,69		1,02	1,12	0,54
Ultimate load N_u	[kN]	60,84	65,36	60,61	43,57	59,16
Mean value $N_{u,m}$	[kN]	57,91				
Coefficient of variation	[%]	14,4				
Displacement s at N_u w/o s_{bl}	[mm]	5,76	3,56	3,82	4,74	5,92
Displacement s at $0,5 N_{u,m}$	[mm]	3,00	2,61	2,37	4,12	1,85
Mean value s at $0,5 N_{u,m}$	[mm]	2,79				
Coefficient of variation	[%]	30,6				
Setting depth obtained? [yes/no]		y	y	y	y	y
Damage of the thread?		n	n	n	y	n
Failure mode		P	P	P	S	P
Diameter of concrete cone [cmxcm]		22x23	16x21	14x21	-	13x17
Depth of concrete cone [cm]		3	3	3	-	2

Table 6.57 First Protocol (Part 1) of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 16



Legend of the failure mode	P = Pullout with concrete cone near the surface S = Steel failure
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Table 6.58 First Protocol (Part 2) of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 16

Anchortype: Powers Fasteners Screwbolt						Date: 15.10.2007
BT 16-150 – Suitability test under repeated load						
Number of load alternations N	Displacement s [mm] at $N_{max} = 25,1$ kN					
	s	F6-1	F6-2	F6-3	F6-4	F6-5
0	ETD 1	1,562	2,943	0,883	1,648	1,555
	ETD 2	1,429	0,344	1,476	1,674	0,433
	Mean	1,496	1,644	1,180	1,661	0,994
1	ETD 1	1,579	3,052	0,927	1,685	1,565
	ETD 2	1,446	0,259	1,501	1,704	0,442
	Mean	1,513	1,656	1,214	1,695	1,004
10	ETD 1	1,581	3,133	0,975	1,775	1,607
	ETD 2	1,495	0,216	1,528	1,729	0,435
	Mean	1,538	1,675	1,252	1,752	1,021
100	ETD 1	1,672	3,277	1,060	1,891	1,634
	ETD 2	1,513	0,248	1,567	1,822	0,435
	Mean	1,593	1,763	1,314	1,857	1,035
1000	ETD 1	1,793	3,465	1,246	2,185	1,657
	ETD 2	1,626	0,330	1,724	2,105	0,447
	Mean	1,710	1,898	1,485	2,145	1,052
10000	ETD 1	1,948	3,155	1,361	2,475	1,727
	ETD 2	1,816	0,369	1,839	2,387	0,468
	Mean	1,882	1,762	1,600	2,431	1,098
50000	ETD 1	2,060	3,460	1,400	2,618	1,775
	ETD 2	1,856	0,445	1,897	2,538	0,511
	Mean	1,958	1,953	1,649	2,578	1,143
80000	ETD 1	2,099	3,444	1,434	2,720	1,837
	ETD 2	1,854	0,503	1,926	2,639	0,539
	Mean		1,974	1,680	2,680	1,188
100000	ETD 1	2,148	3,289	1,525	2,829	1,806
	ETD 2	1,864	0,685	2,024	2,792	0,543
	Mean	2,006	1,987	1,775	2,811	1,175
Displacement after release	ETD 1	1,170	1,449	0,710	1,858	0,160
	ETD 2	0,300	-0,230	0,500	1,840	0,009
	Mean	0,735	0,610	0,605	1,849	0,085

Table 6.59 Second Protocol of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 16

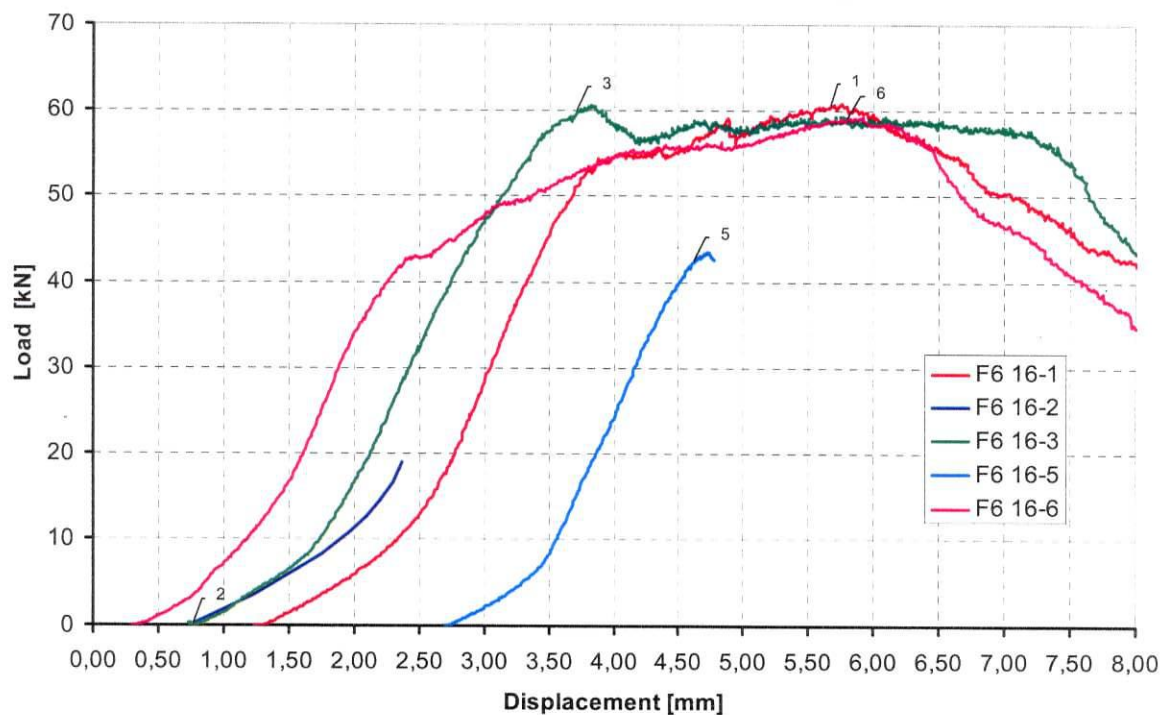


Figure 6.64 Load-Displacement Behaviour of the Series F6 (according test program IEA) with $h_{nom,max}$ on Powers Screwbolts BT 16 after 1×10^6 load cycles