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SAFETY, STRUCTURES and FIRE
Mechanical tests and studies

Accreditation
N° 1-0301

TEST REPORT No ER 553 03 0529, Part 2

on

the POWERS FASTENERS "BT Screwbolt"

according to ETAG 001, Part 2

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It comprises 11 pages and 2 annexes.

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CONTENT

1. PURPOSE

As requested by Powers Fasteners, tests were performed on the BT Screwbolt in non-cracked concrete.
These tests were conducted according to the ETAG [1], appendix A. Only the admissible service condition tests, on single anchor not influenced by the edge and spacing effect, and in non cracked concrete have been performed.

2. REFERENCES

The test programme and the test conditions comply with the specifications laid down in the following documents:
[1] ETAG Guideline for European technical approval of anchors for use in concrete (June 1997)

3. ACCREDITATION

The laboratories of the Safety, Structures, and Fire Department of the CSTB are accredited by COFRAC's Test Section, French Accreditation Committee, for the following programmes, defined in Agreement 1-0301:

- no. 3 (tests on hydraulic concrete and its components)

- no. 39, part 2 (tests of mechanical fastening elements, tests of expansion anchors)

For cracked and non-cracked concrete: "As a signatory to the ILAC MRA, ICBO ES recognizes the technical equivalence of COFRAC accreditation of CSTB for the tests contained in this report."

4. SAMPLES

Installation	: CSTB
Manufacturer	: Powers Fasteners
Origin	: Powers Fasteners
Date of delivery	: See table 6.2 page 5
Observations	: none

Prepared at Marne la Vallée, 7 November 2003

The technician in charge of the tests	The engineer responsible for the tests	The Head of the Division
Alain LECLERC	Thierry GUILLET	Philippe RIVILLON

5. TEST PROGRAMME

The tables below define the general programme for the tests, which were performed in order to determine ultimate loads in non-cracked concrete.

These tests were carried out from 16/10/2003 to 05/11/2003 in the "Laboratoire Fixations"*(Test Laboratories for fixings)* of the CSTB at the MARNE-LA-VALLEE Research Centre.

Test series N°	Purpose of tests	Concrete	Load direction	Distances	Member thickness	Effective anchorage depth	M6.5	M8	M10	M12	M16
A1	Characteristic resistance for tension loading not influenced by edge and spacing effects	C20/25	N	$S>S_{CR,N}$ $C>C_{CR,N}$	>hmin	h_{ef} mini	5	5	5	5	5
						h_{ef} max	5	5	5	5	5

Table 5.1: Test programme on Concrete screw anchor

6. PREPARING THE TEST SPECIMENS

6.1 <u>Description of the bolts</u>

6.1.1 Principle

The Powers Fasteners BT Screwbolt has a constant pitch all over its length. The pitch is 30°. The screw has an hexagonal head formed with an integral washer, a dual lead thread and a chamfered tip.
The thread diameter and the shank diameter are constant along the entire length.
The screw is tightened into the concrete until the hexagonal head of the screw rest on the fixture.

6.1.2 Bolt materials

The Powers Fasteners screw anchors are manufactured from carbon steel. The surface is electrical galvanised.

Picture No.1: Powers Fasteners BT Screwbolt

6.1.3 Dimensions of the bolts

The following table shows the effective embedment depths for each anchor size. These specifications are given by Powers.

Table 6.1: Effective embedment depths of the screwbolts (in mm)

Type	M6.5	M8	M10	M12	M16
$h_{ef\ mini}$ [mm]	35	40	50	60	80
$h_{ef\ maxi}$ [mm]	50	60	75	90	120

6.1.4 Supplied by Powers

The anchors supplied by Powers is indicated in table 6.2.

Table 6.2: Bolts delivered

Designation of the bolts	Date of dispatch	Quantity delivered
M6.5, h_{ef} mini (BT 6550)	08/10/03	100
M6.5, h_{ef} max (BT 6575)	08/10/03	50
M8, h_{ef} mini (BT 875)	08/10/03	50
M8, h_{ef} max (BT 8100)	08/10/03	50
M10, h_{ef} mini (BT 1075)	08/10/03	50
M10, h_{ef} max (BT 10100)	08/10/03	50
M12, h_{ef} mini (BT 1275)	08/10/03	50
M12, h_{ef} max (BT 12150)	22/10/03	25
M16, h_{ef} mini (BT 16100)	08/10/03	30
M16, h_{ef} max (BT 16150)	22/10/03	15

6.2 Description of the test concrete

6.2.1 Characteristics of the concrete slabs

The characteristics of the concrete composition as well as the way of making and storing the slabs comply with the requirements of the ETAG [1].

Table 6.3 below provides the nature of the constituents and the composition of the concrete that make up the test slabs.

Table 6.3: Composition of the concrete

Constituents	Origin	Quantities C20/25
0-8 Seine sand siliceous-limestone	from Bouaffles (27) (Morillon-Corvol factory)	998
4/20 Yonne rounded and crushed gravel siliceous-limestone	from Labrosse (77) (Sablières de la Seine factory)	817
Cement CPJ CEM 2/B-M(LL-S) 32,5R LS(CP2)	Gaurain	300
Water		225
Fresh concrete's total composition		2 340
W/C Water eff/Cement		0.75
Slump test:(Standard NF P 18-451: fresh concrete's slump)		10 to 15 cm

Comments:

The limit values of the concrete's characteristics are defined by the following equations:
$W/C \leq 0.75$

The strength of the concrete was determined, for each batch as follows:

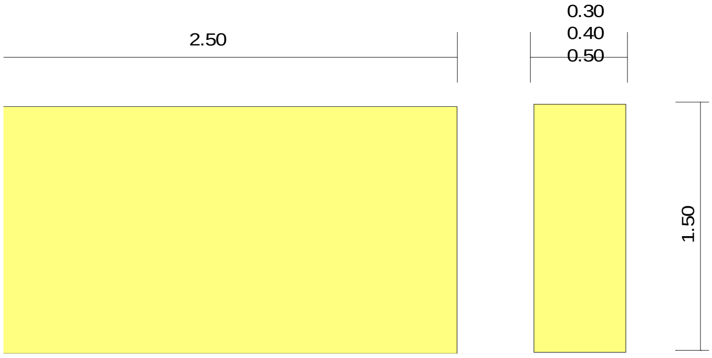
. after 28 days, providing that the concrete was kept in water at 20°C as specified in the French standard NF P 18-404, on cylinders 16/32 in diameter in compliance with the French standard NF P 18-406.

. at the time when the bolt pull-out test is performed, on cylinders 16/32 in diameter, providing that the concrete was kept in air under the same conditions as the test slabs'.

6.2.2 Dimensions of the concrete slabs

The supporting slabs in which the bolts are embedded have the following dimensions depending on the type test:

		L x w x d (m)
No. 1	individual pull-out tests, either vertical or oblique, in non-cracked concrete	2.50 x 1.50 x 0.40



N° 1: Slab for individual pull-out tests in non-cracked concrete

Note: The slabs type 1 is cast vertically

The load/displacement diagrams of each test given in appendix 2 contain, among other things, information regarding the test slabs:

– age of the slab at the time of testing,
– average compression strength of the slab concrete at the time of testing, the average value being measured on three cylinders stored under the same conditions as the test slab's,
– position of the bolt subjected to testing as a function of the edges of the slab and of the other bolts embedded in the same slab.

7. TEST CONDITIONS

7.1 Positioning of the bolts in the supporting concrete slab

a) Drilling

The holes are drilled according to the manufacturer's requirements:

- Type of rotary hammer
- Type of drill bits
- Nominal drilling diameter
- Nominal drilling length
- Spacing and edge distances

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Furthermore, a check is made as to whether the requirements concerning ETAG are respected, that is:

- Substrate slab face to be drilled: cast face
- Drilled hole cleaned with compressed air
- Respect for verticality of the hole: equal to or less than 5°
- Width of the drill bit cutting plate: measured every ten borings

7.2 Test equipment

7.2.1 Equipment for vertical load tests

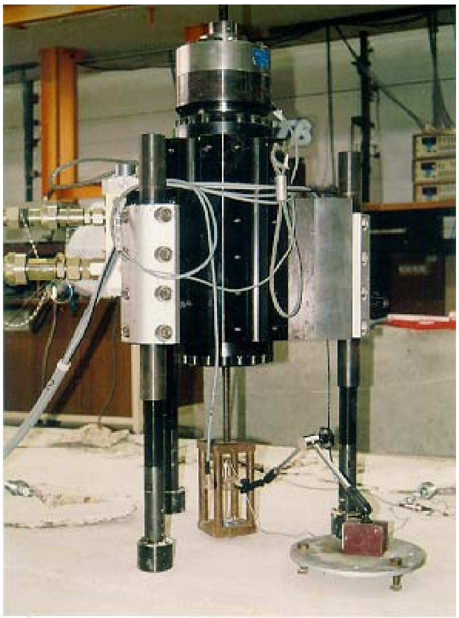
The tests were performed by using specific hydraulic jacks designed for tests carried out on anchor bolts.

The test equipment consists of a tubular piston hydraulic jack of ± 250 kN with low friction and liquid dampening. It has an adjustable wheelbase.

Each one is equipped with:

- an HBM displacement transducer, located in an anti rotation rod fastened to the top of the piston
- a load cell, with an instrument range, which complies with the expected load (± 50 kN, ± 100 kN or ± 250 kN)

This hydraulic jack is supplied by a SCHENCK motor-driven pump of 165 l/min, and is brought under control by a SCHENCK device, series 59 or a TEMA CONCEPT device ALLTEST.



Picture No. 2: test equipment intended for a vertical pull-out test

Picture No. 3: TEMA CONCEPT device, ALLTEST, intended for controlling the hydraulic jacks

7.3 Test procedures

7.3.1 Vertical pull out loads tests

The tests are carried out in compliance with the ETAG 001, appendix A

8. MEASURING EQUIPMENT

8.1 Measurement of the displacement

The displacement of the anchor bolt was measured by using a Vishay linear displacement transducer, with an instrument range of ± 10 mm.

The accuracy class is 0.2 according to the standard NF E 11 063 and the accuracy of measurement of the measured displacement is lower than 0.02 mm

The displacement transducer was placed:

- during the pull-out tests on individual anchors: on the top of the anchor bolt, in the direction of the load

8.2 Measurement of the load

The loads were measured by using load cells, whose characteristics are listed in table 8.1.

The instrument ranges were selected according to the value of the load to be measured.

Table 8.1: Characteristics of the cells

Nature	Measuring range	Characteristics of the cell to be used		
		Trademark	Instrument range	Accuracy class
Applied load to the anchor	≤ 5 000 daN ≤ 10 000 daN ≤ 25 000 daN	BETA - LEBOW LEBOW BETA	± 5 000 daN ± 10 000 daN ± 25 000 daN	Relative error lower than 2% of measuring range
Displacement of the anchor bolt	≤ 2 mm ≤ 10 mm ≤ 20 mm ≤ 50 mm	TNC - Vishay TNC - Vishay TNC - Vishay TNC	± 1 mm ± 5 mm ± 10 mm ± 25 mm	Class 0.2
Displacement of the hydraulic jack	± 50 mm	HBM	± 50 mm	Class 0.1
Tightening torque	≤ 50 N.m ≤ 200 N.m ≤ 400 N.m ≤ 1500 N.m	SAM SAM SAM FACOM	0 - 50 N.m 0 - 200 N.m 0 - 400 N.m 0 - 1500 N.m	± 1% of measurement ± 1% of measurement ± 1% of measurement ± 6% of measurement

9. DATA ACQUISITION AND DATA PROCESSING DEVICE

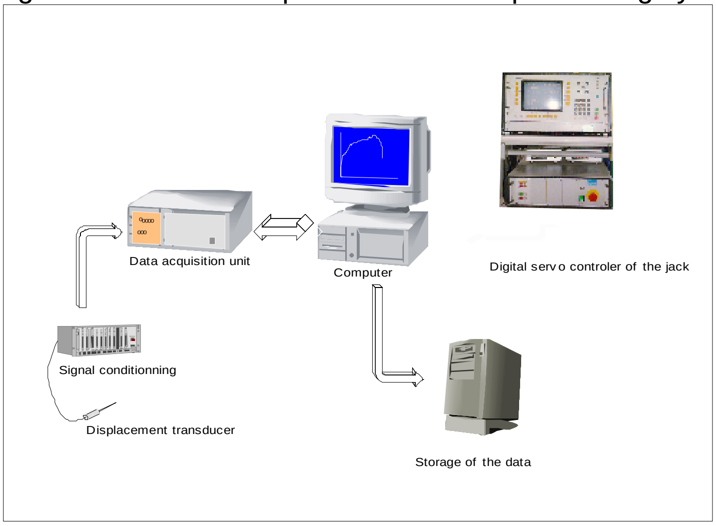
The reception and processing of the analogue signals transmitted by the instruments are undertaken by using the following computer equipment:

- a data acquisition system which, in compliance with the microcomputer instructions, makes it possible for the measurements provided by the different transducers to be read and stored,

- a data acquisition programme

A post processing is performed using MICROSOFT EXCEL. The statistical values are deduced from the tests, and the diagram of the tests, are printed for each test series.

Figure 9.1: diagram of the data acquisition and data processing system



10. TEST RESULTS

The test results are analysed according to the ETAG.

The test results are mentioned as follows in the diagrams of the appendix 2, which specify, for each test, the "load-displacement " curves recorded during the test.

Each diagram provides us with the following information:

. the test reference as mentioned in table 4.1 and 4.2 (general test programme),
. all the test parameters,
. for each test, the individual failure load $F^t_{u,i}$.

The displacement d_i corresponding to a 0.5 $F^t_{u,m}$ failure load where $F^t_{u,m}$ is the mean failure load and the failure mode observed, indicated by the following codification:

Table 10.1: Failure modes

French notation	UK notation	Failure mode
Béton	Concrete	Concrete cone failure in tension or concrete edge failure in shear
Acier vis	Steel screw	Steel failure of the anchor in the threaded part, in tension or shear
Acier réduit	Steel neck	Steel failure of the anchor in the reduced part, in tension or shear
Glissement	Pull-out	Pull-out failure mode
Pull-through	Pull-through	Pull-through failure mode
Pry-out	Pry-out	Pry-out failure mode
Splitting	Splitting	Splitting failure mode

and, for each test series, the following calculated values:

- $F^t_{um} = \frac{1}{n}\sum_{i=1}^{n} F^t_{ui}$: mean failure load
- $\sigma(F) = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(F^t_{ui} - F^t_{um})^2}$: standard deviation of the failure loads
- $\sigma(d) = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(d_i - d_m)^2}$: standard deviation of the displacements d_i

  with $d_m = \frac{1}{n}\sum_{i=1}^{n} d_i$
- $v(F) = \frac{\sigma(F)}{F^t_{u,m}}$: coefficient of variation of the failure loads
- $v(d) = \frac{\sigma(d)}{d_m}$: coefficient of variation of the displacements

The following table sum up the ultimate failure load reach during the tests.

	M6.5		M8		M10		M12		M16	
	h_{ef} mini	h_{ef} max	h_{ef} mini	h_{ef} max	h_{ef} mini	h_{ef} max	h_{ef} mini	h_{ef} max	h_{ef} mini	h_{ef} max
	35	50	40	60	50	75	60	90	80	120
F^t_{um} [kN]	6	9.15	11.2	22.6	15.9	36.5	20.5	45.6	30.7	68.3
v(F) [%]	8.1	6.4	6.8	6.6	17.4	13.7	13.9	4	12.3	6.4

Table 10.2: Failure loads

END OF REPORT