Department Structures, Safety and Fire (DSSF)
Division Mechanical Resistance and Fire (MRF)

Fire Evaluation

From the original report n°26048096

Date: 09/12/2013 **1st Issue**

Product: **PURE150-PRO injection system**
Design concept in terms of fire protection for post installed rebars

Client: **DeWalt**
Stanley Black & Decker Deutschland GmbH
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This evaluation comprises 9 pages, including 6 appendices.

This document is based on the fire evaluation of post-installed rebars CSTB report n°26048096.

1. Fire Evaluation

The CSTB received the demand from **DeWalt, Stanley Black & Decker Deutschland GmbH** on 04/11/2013 requesting a fire evaluation for post installed rebars using the **PURE150-PRO injection system**.

2. Documents on which the evaluation is based

[1] The fire evaluation report n°26048096 – PURE150-PRO, DeWalt, Stanley Black & Decker Deutschland GmbH, CSTB.

[2] ISO 834-1 Fire resistance Tests - Element of building construction – Part1 general requirements

[3] EN 1363-1 Fire resistance tests Part 1 General Requirements.

[4] NF EN 1991-1-2 Eurocode1 Actions on structures – Part 1-2: General actions - Actions on structures exposed to fire, 2003

[5] NF EN 1992-1-2 (+NA) Eurocode2 Design of concrete structures – Part 1-2: General rules – Structural fire design, 2005.

[6] NF EN 1993-1-2 (+NA) Eurocode3 Design of steel structures – Part 1-2: General rules – Structural fire design, 2005.

3. Description of the evaluated items

Bar diameters from Φ 8 to 32 mm are evaluated to fire for anchorage depths between 80 and 480 mm in C20/25 concrete. Two structural configurations are considered: the slab-slab connection and the slab-wall connection.

4. Design concepts in terms of fire protection

The outputs of this evaluation are:

- the maximal applicable bond stresses that can be used in the case of a slab-slab connection,
- the maximal applicable loads that can be used in the case of a slab-wall connection.

The design method is described in the CSTB report n°26048096 [1] and has 4 main steps (represented in figure 1). First, pullout tests are carried out at ambient temperature in order to determine a relationship between bond resistance and temperature. Secondly, a thermal calculation is carried out to determine the temperature profile along the rebar at each time during a fire. Thirdly, the bond resistances are associated to the temperatures using the two first steps. Finally, the load is calculated by integration of the bond resistances.

Thermal calculations, geometric considerations and safety coefficients are determined in accordance with Eurocode and standards [2-6]. The thermal analysis (step 2) is presented in the CSTB report n°26048096.

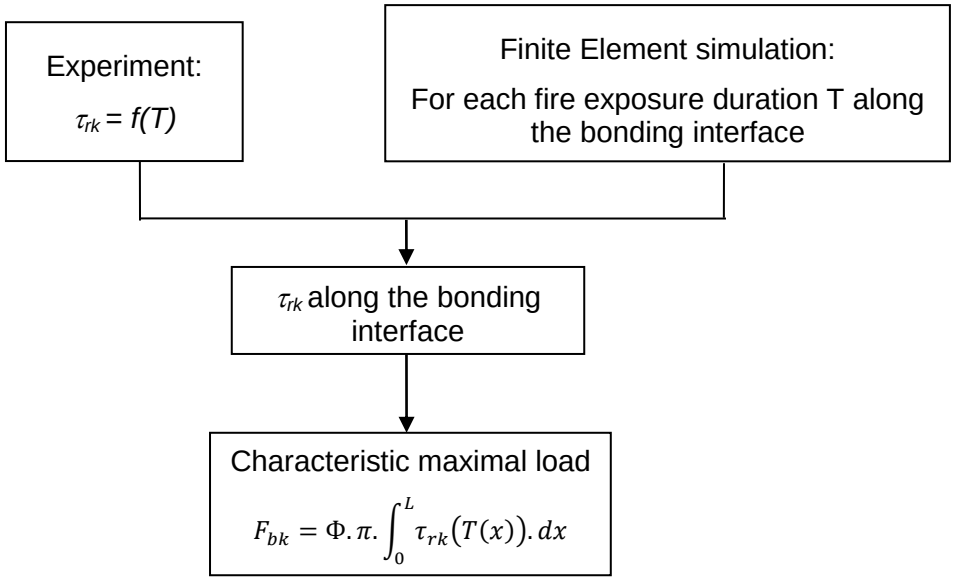

Figure 1: Method to determine the applicable loads in fire conditions

Where:

τ_{rk} is the characteristic bonding resistance.

T is the temperature.

F_{bk} is the characteristic maximum load applicable to the rebar at a given time.

L is the embedment length.

Φ is the rebar diameter.

Champs-sur-Marne, 25/11/2013

Dr.-Ing. Nicolas Pinoteau

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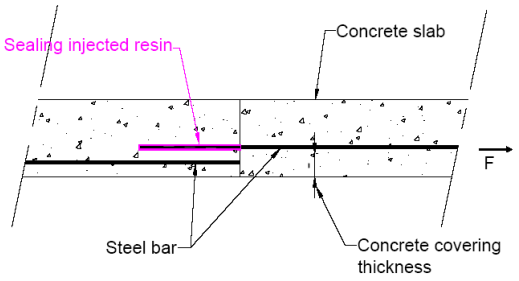
Appendix 1.1:

Maximum applicable bond stress for a slab-slab connection

The table presents characteristic bond resistances for a **Slab-Slab connection** using **C20/25 concrete** and rebars with a yield strength f_y**=500 N/mm²** in an **ISO 834-1 fire** (at 30, 60, 90, 120, 180 and 240 min) for concrete covers between 30 and 220 mm.

Post-installed rebars shall be designed in ambient temperature conditions before being designed in fire conditions.



PURE150-Pro	Characteristic maximal bond stress (N/mm²)					
Concrete cover (mm)	**R 30**	**R 60**	**R 90**	**R 120**	**R 180**	**R240**
30	0,4					
40	0,8					
50	1,6	0,3				
60	3,2	0,5				
70		0,9	0,4			
80		1,6	0,6	0,3		
90		2,6	0,9	0,5		
100			1,3	0,7	0,3	
110			2,0	1,0	0,4	
120			3,0	1,4	0,6	0,3
130				2,1	0,8	0,4
140	3,5			2,9	1,0	0,5
150					1,4	0,7
160		3,5			1,9	0,9
170			3,5		2,5	1,2
180					3,3	1,5
190				3,5		1,9
200					3,5	2,5
210						3,1
220						3,5

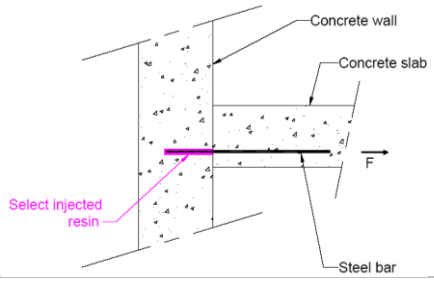
The present table is aimed at supplying data for the design of the injection anchoring system when exposed to fire. This study does not deal with the mechanical design at ambient temperature, neither does it deal with the design according to other accidental solicitations, these shall be done in addition.

Appendix 2.1:

Maximum applicable loads for a slab-wall connection for Φ 8 and 10 mm

The table presents characteristic load resistances for a **Wall-Slab connection** using **C20/25 concrete** and rebars with a yield strength f_y**=500 N/mm²** in an **ISO 834-1 fire** (at 30, 60, 90, 120, 180 and 240 min) for Φ 8 and 10 mm.

Post-installed rebars shall be designed in ambient temperature conditions before being designed in fire conditions.



PURE 150-Pro									
Rebar diameter	**Drill hole diameter**	**Rebar maximum load**	**Rebar anchorage depth**	**Characteristic maximum force in the rebar (kN)**					
Φ (mm)	**D (mm)**	**F (kN)**	**Ls (mm)**	**R 30**	**R 60**	**R 90**	**R 120**	**R 180**	**R 240**
8	**12**	**25,2**	**80**	5,3	1,7	0,9	0,6	0,5	0,5
			95	9,9	3,1	1,6	1,1	0,9	0,8
			110	15,8	5,4	2,6	1,9	1,2	1,2
			125	22,5	9,3	4,3	2,9	2,0	1,7
			135	25,2	12,6	6,1	4,0	2,5	2,0
			140		14,4	7,1	4,7	2,8	2,3
			155		20,5	11,2	7,3	4,2	3,1
			170		25,2	16,3	11,0	6,1	4,2
			185			22,2	15,7	8,5	5,7
			195			25,2	19,3	10,9	7,0
			200				21,1	12,1	7,8
			210				25,2	14,9	9,3
			215					16,6	10,2
			230					21,7	13,7
			240					25,2	16,3
			245						17,9
			260						22,7
			270						25,2
10	**14**	**39,3**	**100**	13,2	4,2	2,2	1,7	1,2	1,1
			115	20,5	7,1	3,6	2,6	1,9	1,6
			130	28,7	12,1	5,7	4,0	2,6	2,2
			145	37,4	18,3	9,3	6,2	3,7	3,1
			150	39,3	20,8	10,9	7,1	4,3	3,4
			160		25,8	14,3	9,6	5,4	4,2
			175		33,8	20,6	14,3	7,8	5,7
			185		39,3	25,5	18,0	9,8	7,0
			190			27,9	20,2	11,0	7,6
			205			35,9	26,9	15,2	10,2
			215			39,3	32,0	18,8	12,6
			220				34,5	20,6	13,8
			230				39,3	24,8	16,6
			235					27,0	18,3
			250					34,0	23,9
			265					39,3	30,1
			280						36,9
			285						39,3

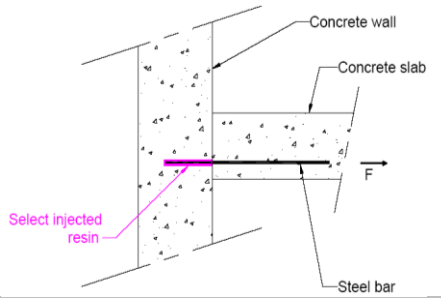
Calculations are carried out taking the minimal concrete cover (CSTB report n°26048096). Intermediate values may be interpolated linearly. Extrapolation is not possible. The present table is aimed at supplying data for the design of the injection anchoring system when exposed to fire. This study does not deal with the mechanical design at ambient temperature, neither does it deal with the design according to other accidental solicitations, these shall be done in addition.

Appendix 2.2:

Maximum applicable loads for a slab-wall connection for Φ 12 and 14 mm

The table presents characteristic load resistances for a **Wall-Slab connection** using **C20/25 concrete** and rebars with a yield strength $\mathbf{f_y}$**=500 N/mm²** in an **ISO 834-1 fire** (at 30, 60, 90, 120, 180 and 240 min) for Φ 12 and 14 mm.

Post-installed rebars shall be designed in ambient temperature conditions before being designed in fire conditions.



PURE 150-Pro									
Rebar diameter	**Drill hole diameter**	**Rebar maximum load**	**Rebar anchorage depth**	**Characteristic maximum force in the rebar (kN)**					
Φ (mm)	**D (mm)**	**F (kN)**	**Ls (mm)**	**R 30**	**R 60**	**R 90**	**R 120**	**R 180**	**R 240**
12	**16**	**56,5**	**120**	26,1	9,0	4,7	3,4	2,5	2,3
			135	35,7	14,7	7,3	5,1	3,4	3,1
			150	46,1	22,0	11,5	7,5	5,0	4,2
			165	56,5	30,7	17,4	11,0	7,1	5,7
			180		40,2	24,8	15,8	9,9	7,8
			195		50,3	33,2	22,0	13,8	10,4
			205		56,5	39,3	26,9	17,2	12,6
			210			42,5	29,5	19,1	13,8
			225			52,5	37,9	25,6	18,2
			235			56,5	43,9	30,6	21,9
			240				47,0	33,2	23,9
			255				56,5	41,6	30,6
			270					50,6	38,2
			280					56,5	43,6
			285						46,6
			300						55,4
			305						56,5
14	**18**	**77,0**	**140**	45,0	18,2	9,3	6,8	4,3	4,0
			150	53,1	23,8	12,6	8,8	5,4	5,0
			160	61,2	30,0	16,6	11,5	6,8	5,9
			170	69,7	36,8	21,4	14,7	8,5	7,3
			180	77,0	43,9	27,2	18,9	10,6	8,7
			190		51,5	33,4	23,9	13,2	10,6
			200		59,5	40,2	29,5	16,3	12,7
			210		67,5	47,4	35,7	20,2	15,4
			220		75,9	54,8	42,2	24,7	18,5
			225		77,0	58,7	45,6	27,3	20,3
			230			62,6	49,2	30,0	22,2
			240			70,6	56,5	35,7	26,7
			250			77,0	64,3	41,9	31,7
			260				72,0	48,4	37,1
			270				77,0	55,3	43,0
			280					62,4	49,2
			290					70,0	55,7
			300					77,0	62,6
			310						69,7
			320						77,0

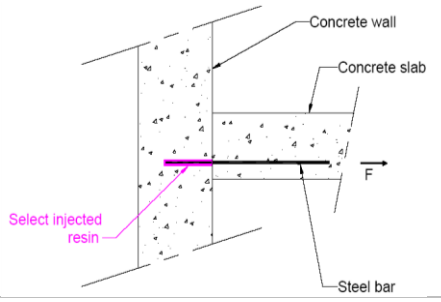
Calculations are carried out taking the minimal concrete cover (CSTB report n°26048096). Intermediate values may be interpolated linearly. Extrapolation is not possible. The present table is aimed at supplying data for the design of the injection anchoring system when exposed to fire. This study does not deal with the mechanical design at ambient temperature, neither does it deal with the design according to other accidental solicitations, these shall be done in addition.

Appendix 2.3:

Maximum applicable loads for a slab-wall connection for Φ 16 and 20 mm

The table presents characteristic load resistances for a **Wall-Slab connection** using **C20/25 concrete** and rebars with a yield strength f_y**=500 N/mm²** in an **ISO 834-1 fire** (at 30, 60, 90, 120, 180 and 240 min) for Φ 16 and 20 mm.

Post-installed rebars shall be designed in ambient temperature conditions before being designed in fire conditions.



PURE 150-Pro									
Rebar diameter	**Drill hole diameter**	**Rebar maximum load**	**Rebar anchorage depth**	**Characteristic maximum force in the rebar (kN)**					
Φ (mm)	**D (mm)**	**F (kN)**	**Ls (mm)**	**R 30**	**R 60**	**R 90**	**R 120**	**R 180**	**R 240**
16	**20**	**100,6**	**160**	69,7	31,4	16,9	12,3	7,9	6,7
			170	79,2	38,7	22,0	15,7	9,8	7,9
			180	89,0	46,6	27,9	19,9	12,1	9,6
			190	98,7	55,0	34,6	25,0	15,1	11,5
			195	100,6	59,3	38,2	27,9	16,6	12,7
			200		63,7	41,8	30,9	18,5	13,8
			210		72,8	49,5	37,6	22,7	16,6
			220		82,1	57,8	44,9	27,8	20,0
			230		91,6	66,3	52,5	33,5	23,9
			240		100,6	75,1	60,5	39,9	28,6
			250			84,3	68,8	46,7	33,8
			260			93,6	77,5	54,0	39,6
			270			100,6	86,5	61,8	46,0
			280				95,6	69,9	52,9
			290				100,6	78,2	60,2
			300					86,8	67,8
			310					95,8	75,8
			320					100,6	83,8
			330						92,2
			340						100,6
20	**25**	**157,1**	**200**	135,4	70,3	45,0	33,1	20,3	16,3
			215	153,9	86,5	58,5	44,4	27,2	21,1
			220	157,1	92,1	63,2	48,6	29,8	23,0
			230		103,4	73,3	57,3	36,2	27,2
			245		121,1	89,0	71,6	46,9	34,9
			260		139,1	105,4	86,8	59,3	44,6
			275		157,1	122,6	102,8	73,0	55,7
			290			140,3	119,5	87,4	68,3
			305			157,1	136,8	102,9	81,8
			320				154,5	119,4	96,4
			325				157,1	125,0	101,5
			335					136,3	111,9
			350					153,7	127,9
			355					157,1	133,5
			365						144,5
			380						157,1

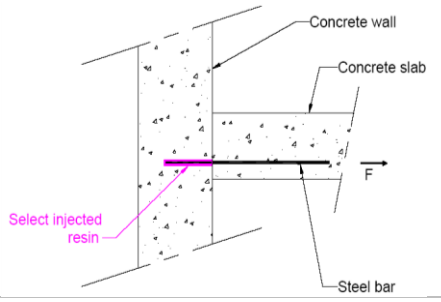
Calculations are carried out taking the minimal concrete cover (CSTB report n°26048096). Intermediate values may be interpolated linearly. Extrapolation is not possible. The present table is aimed at supplying data for the design of the injection anchoring system when exposed to fire. This study does not deal with the mechanical design at ambient temperature, neither does it deal with the design according to other accidental solicitations, these shall be done in addition.

Appendix 2.4:

Maximum applicable loads for a slab-wall connection for Φ 22 and 24 mm

The table presents characteristic load resistances for a **Wall-Slab connection** using **C20/25 concrete** and rebars with a yield strength f_y**=500 N/mm²** in an **ISO 834-1 fire** (at 30, 60, 90, 120, 180 and 240 min) for Φ 22 and 24 mm.

Post-installed rebars shall be designed in ambient temperature conditions before being designed in fire conditions.



PURE 150-Pro									
Rebar diameter	**Drill hole diameter**	**Rebar maximum load**	**Rebar anchorage depth**	**Characteristic maximum force in the rebar (kN)**					
Φ (mm)	**D (mm)**	**F (kN)**	**Ls (mm)**	**R 30**	**R 60**	**R 90**	**R 120**	**R 180**	**R 240**
22	**27**	**190,0**	**220**	176,1	101,2	69,6	53,4	32,9	25,3
			230	189,9	113,8	80,6	63,0	39,7	30,0
			235	190,0	120,2	86,2	68,2	43,5	32,4
			240		126,7	92,1	73,3	47,5	35,4
			250		139,7	103,9	84,1	56,0	41,8
			260		152,9	116,0	95,3	65,2	48,9
			270		166,3	128,5	107,1	75,1	57,0
			280		179,8	141,4	119,1	85,4	65,8
			290		190,0	154,5	131,5	96,3	75,1
			300			167,7	144,1	107,4	84,9
			310			181,0	157,0	119,2	95,3
			320			190,0	170,0	131,2	106,0
			330				183,2	143,6	117,4
			340				190,0	156,2	128,9
			350					168,9	140,8
			360					182,0	152,9
			370					190,0	165,2
			380						177,9
			390						190,0
24	**29**	**226,2**	**240**	226,2	135,8	87,9	70,3	45,6	35,6
			255		156,5	106,2	86,9	58,2	44,9
			270		177,8	125,3	104,8	72,7	56,4
			285		199,5	145,5	123,7	88,5	69,7
			300		221,5	166,3	143,5	105,6	84,3
			305		226,2	173,3	150,1	111,5	89,6
			315			187,4	163,8	123,7	100,3
			330			209,1	184,6	142,7	117,4
			345			226,2	206,0	162,5	135,5
			360				226,2	183,0	154,5
			375					204,0	173,9
			390					225,3	194,1
			395					226,2	200,9
			405						214,7
			415						226,2

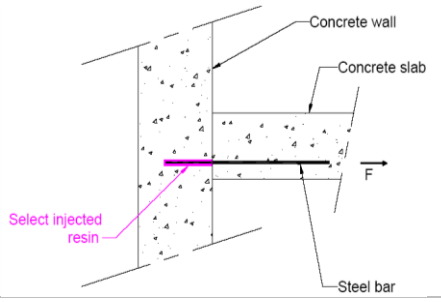
Calculations are carried out taking the minimal concrete cover (CSTB report n°26048096). Intermediate values may be interpolated linearly. Extrapolation is not possible. The present table is aimed at supplying data for the design of the injection anchoring system when exposed to fire. This study does not deal with the mechanical design at ambient temperature, neither does it deal with the design according to other accidental solicitations, these shall be done in addition.

Appendix 2.5:

Maximum applicable loads for a slab-wall connection for Φ 25 and 32 mm

The table presents characteristic load resistances for a **Wall-Slab connection** using **C20/25 concrete** and rebars with a yield strength f_y**=500 N/mm²** in an **ISO 834-1 fire** (at 30, 60, 90, 120, 180 and 240 min) for Φ 25 and 32 mm.

Post-installed rebars shall be designed in ambient temperature conditions before being designed in fire conditions.



PURE 150-Pro									
Rebar diameter	**Drill hole diameter**	**Rebar maximum load**	**Rebar anchorage depth**	**Characteristic maximum force in the rebar (kN)**					
Φ (mm)	**D (mm)**	**F (kN)**	**Ls (mm)**	**R 30**	**R 60**	**R 90**	**R 120**	**R 180**	**R 240**
25	**30**	**245,5**	**250**	245,5	155,9	104,0	84,6	56,0	43,2
			260		170,3	117,1	96,6	65,5	50,5
			270		185,2	130,6	109,1	75,6	58,7
			280		200,3	144,4	122,2	86,5	67,7
			290		215,5	158,7	135,5	98,0	77,5
			300		230,9	173,1	149,4	109,9	87,9
			310		245,5	187,9	163,5	122,5	98,7
			320			202,6	177,8	135,4	110,2
			330			217,8	192,4	148,6	122,2
			340			233,2	207,1	162,4	134,8
			350			245,5	222,0	176,4	147,6
			360				237,1	190,6	160,8
			370				245,5	205,2	174,3
			380					219,8	188,2
			390					234,6	202,1
			400					245,5	216,4
			410						231,0
			420						245,5
32	**40**	**402,1**	**320**	402,1	347,0	249,5	200,3	153,4	127,3
			330		366,9	268,3	218,0	169,1	141,6
			340		386,7	287,2	236,0	185,5	156,6
			350		402,1	306,3	254,3	202,3	172,0
			360			325,6	272,8	219,5	188,0
			370			345,0	291,6	237,2	204,5
			380			364,5	310,5	255,2	221,4
			390			384,4	329,6	273,6	238,8
			400			402,1	348,8	292,0	256,3
			410				368,4	310,8	274,3
			420				388,0	329,8	292,5
			430				402,1	348,8	311,0
			440					368,1	329,6
			450					387,7	348,2
			460					402,1	367,2
			470						386,3
			480						402,1

Calculations are carried out taking the minimal concrete cover (CSTB report n°26048096). Intermediate values may be interpolated linearly. Extrapolation is not possible. The present table is aimed at supplying data for the design of the injection anchoring system when exposed to fire. This study does not deal with the mechanical design at ambient temperature, neither does it deal with the design according to other accidental solicitations, these shall be done in addition.