ANCHOR DESIGN - MASONRY.

Faye Peate BEng (Hons)

AGENDA

1. **Background**
   - ✓ Masonry base material and main applications
   - ✓ Regulations framework
2. **Technical data**
   - ✓ ETA qualification process
   - ✓ On-site testing
3. **Design**
   - ✓ Scope: # anchors and possible arrangements
   - ✓ Design concept and details
4. **Hilti's masonry offering**
   - ✓ Overview of system components
   - ✓ Profis software masonry module

MASONRY IS AMONG THE OLDEST ARTS AND CRAFTS AND IT WAS USED BY ALL THE OLD CIVILISATIONS

3000 BC | 1000 BC | 500 AD

Stone Age → **Bronze Age** → **Iron Age** → **Middle Age**

Mesopotamia

Ancient Egypt | Ancient Greece | Ancient Rome

Ancient China | Imperial China

Ancient India | Mayan civilization

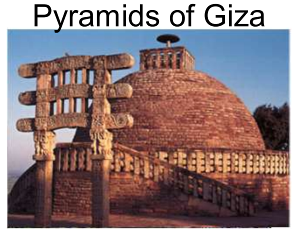

Walls of Babylon


Pyramids of Giza


Wall of China


Parthenon Athens


Colosseum Rome


Great Stupa India


Temple of Heaven

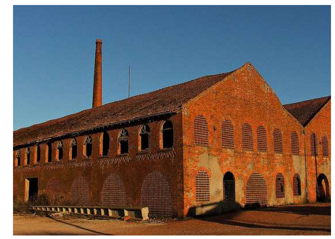

Maya Cross Temple

MASONRY WORKS CAN BE FOUND IN ALMOST ALL TYPE OF STRUCTURES AND BUILDINGS

Aqueducts

Bridges

Industry



Towers

Walls

Domestic

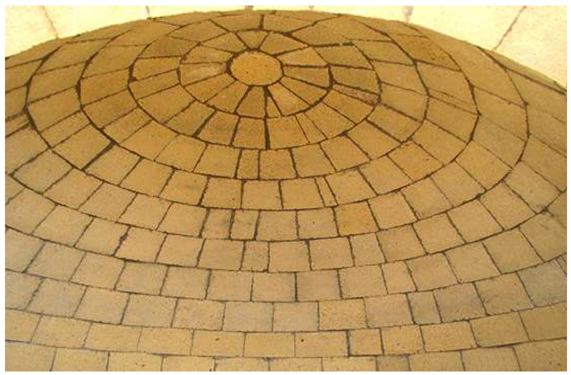
Castles

Pavements

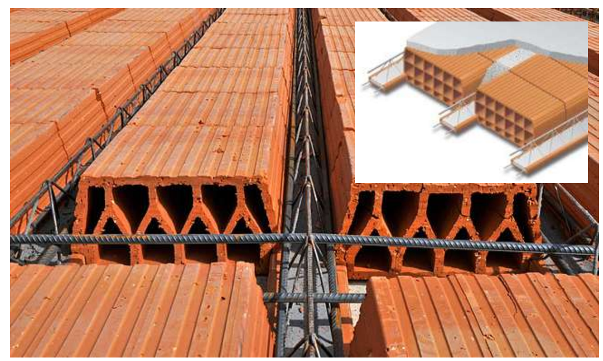
Education

MASONRY IS ALSO OFTEN USED IN HORIZONTAL STRUCTURAL MEMBERS: FLOORS, ROOFS AND DOMES

Roofs / Domes



Floors

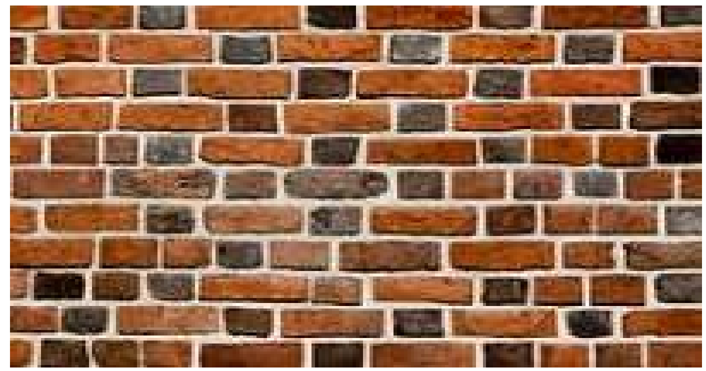


MASONRY IS AMONG THE OLDEST ARTS AND CRAFTS AND IT WAS USED BY ALL THE OLD CIVILISATIONS

Masonry is…

A construction system…

- used in building structures (walls, columns, ceilings, pavements, etc.)
- Constructed by aligning/overlaying individual units (brick, concrete block, stone, etc.)…
- joined together with or without a bonding mortar



TODAY, MASONRY IS STILL HIGHLY USED WITH A BIG VARIETY OF SELECTED MASONRY UNITS

Stone	Clay	Concrete	Others

Stone

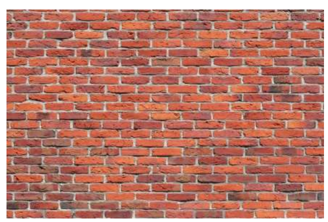
Rubble
rough shaped

Ashlar
shaped stones

Clay

Adobe
air dried, "mud brick"

Fired bricks
"regular clay brick"



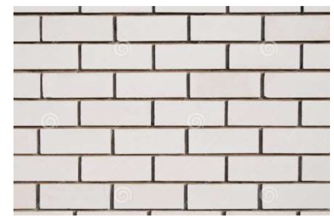
Concrete

Concrete bricks
light / normal weight

AAC autoclaved
aerated concrete

Others

Calcium Silicate
aka sand lime brick

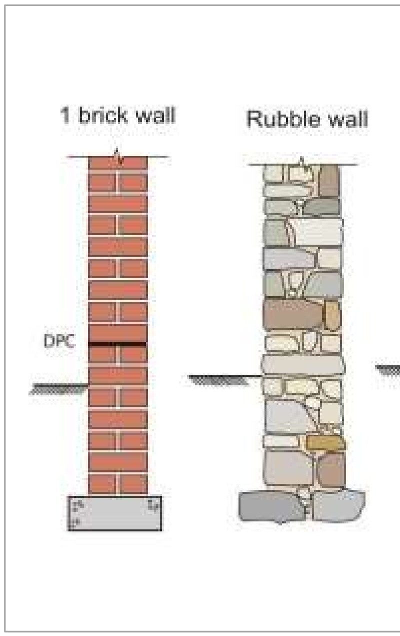


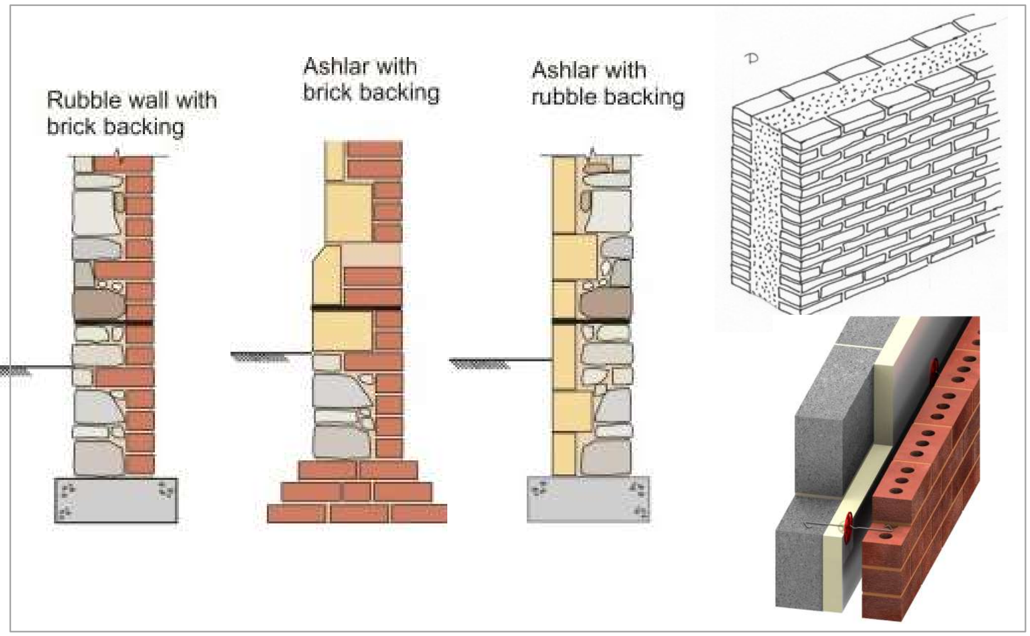
Too heterogeneous, large scatter between various masonry units

MIND THAT MASONRY WALLS, ESPECIALLY EXTERNAL, CAN USE A COMBINATION OF DIFFERENT MASONRY TYPES

- **Proper jobsite inspection is strongly recommended to achieve a good definition of the base material**

Single masonry unit	2+ masonry unit





Note: DPC – damp-proof course – is a barrier to resist moisture rising through the structure by capillary action

ANCHORING APPLICATIONS IN MASONRY ARE REQUIRED FOR REHABILITATION OR NEW CONSTRUCTION

Rehabilitation

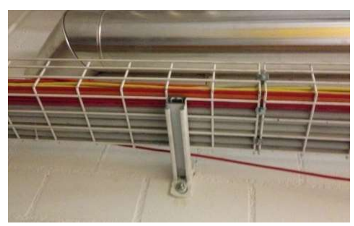
Repair/Strengthening
e.g. tying external walls

Facade support
when building a new core

New construction

Structural
e.g. slab support

Non-structural
e.g. M&E installations



Others

Formwork
stability fastenings

Temporary bracing
stability and/or plumb

MECHANICAL ANCHORS FOR MASONRY

- HUS
- HRD
- HLC
- HAM
- HUD
- HPS

<u>In summary for mechanical anchors …</u>

Commonly Shallow embedment depth to go into a single skin of masonry

Medium duty at best

Limited test data available in masonry

For critical applications prove by test on site, the CFA guidelines as referenced in BS 8539 give good guidance on this.

Most data is available for concrete giving an upper limit to the performance data.

CHEMICAL ANCHORS FOR MASONRY

- Specifiable HIT HY 270

- Approved HIT HY170

MASONRY DESIGN REQUIRES TESTING, APPROVAL DOCUMENTATION AND DESIGN REGULATIONS

- **EU regulation for masonry only available since April 2013**

		EU (EOTA)
Anchor resistance	**Qualification** (“testing”)	New! ETAG 029, Annex A (On-site tests – Annex B)
	Technical data (“approval”)	New! European Technical Approval: ETA
	Design method	New! ETAG 029, Annex C

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TECHNICAL DATA FOR MASONRY UNITS CAN BE TAKEN FROM ETA, HILTI TECH. DATA OR ON-SITE TESTS (O-S-T)

Is the brick in your jobsite covered by the ETA?

Hollow brick is covered if:
It exists in the ETA - with same material, resistance, size and cross section

Solid brick is covered if:
1. It exists in the ETA
2. It has the same material and higher resistance and/or size as a brick in the ETA

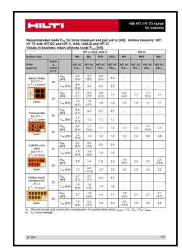
Y

Take design data from ETA

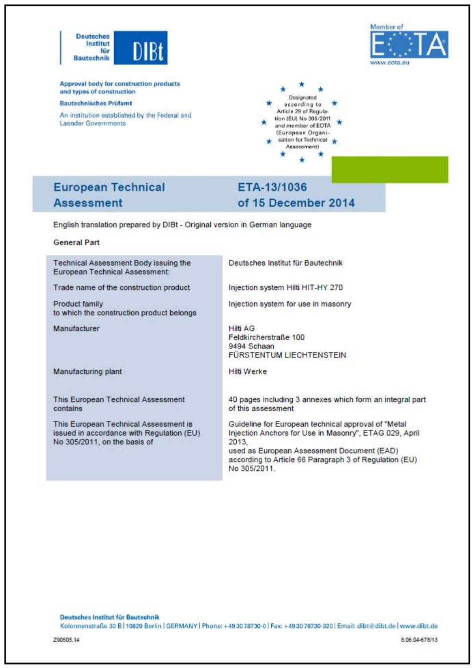
N

Perform O-S-T and evaluate results according to ETAG 029

Hilti Technical Data
(if your brick is an exact match to an FTM brick)



ETA PROVIDES TECHNICAL DATA FOR MOST MASONRY MATERIALS USED WORLDWIDE



Deutsches Institut für Bautechnik DIBt

Member of EOTA www.eota.eu

Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment **ETA-13/1036 of 15 December 2014**

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	Injection system Hilti HIT-HY 270
Product family to which the construction product belongs	Injection system for use in masonry
Manufacturer	Hilti AG Feldkircherstraße 100 9494 Schaan FÜRSTENTUM LIECHTENSTEIN
Manufacturing plant	Hilti Werke
This European Technical Assessment contains	40 pages including 3 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	Guideline for European technical approval of "Metal Injection Anchors for Use in Masonry", ETAG 029, April 2013, used as European Assessment Document (EAD) according to Article 66 Paragraph 3 of Regulation (EU) No 305/2011.

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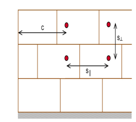
Z90505.14 8.06.04-678/13

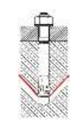
- **11 types of bricks** as per base material/configuration, with a wide range of market coverage

- **System combinations:** information on applicable rods, sleeves, mortar, dispensers and installation

- **Application variables**: dry/wet installation/use, spacing and edge distances, embedment depths, temperature ranges



- **Resistance loads,** characteristic R_k for different tension and shear failure modes

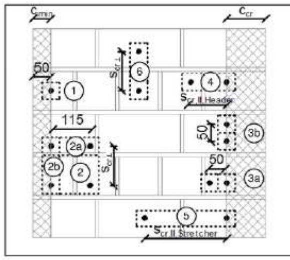


ETA DISPLAYS 2 INDIVIDUAL PAGES FOR EVERY BRICK, COMPILING THE MOST RELEVANT INFORMATION

Brick type: Solid clay brick Mz, 2DF

Table C4: Description of brick

Brick type		Solid Mz, 2DF
Bulk density	ρ [kg/dm³]	≥ 2,0
Compressive strength	f_b [N/mm²]	≥ 12
Code		EN 771 - 1
Producer		
Brick dimensions	[mm]	≥ 240 x 115 x 113
Minimum wall thickness	h_{min} [mm]	≥ 115



(1)	Single fastening
(2)	4 anchors at min. edge distance
(2a)	2 anchors horizontal at min. edge distance
(2b)	2 anchors vertical at min. edge distance
(3a)	2 anchors horizontal at characteristic edge distance
(3b)	2 anchors vertical at characteristic edge distance
(4)	Characteristic horizontal spacing in header
(5)	Characteristic horizontal spacing in stretcher
(6)	Charact. vertical spacing in header and stretcher

Table C5: Installation parameter for all anchor combinations (Table B3)

Anchor type		see Table B3
Edge distance	c_{min} [mm]	50
	c_{cr} [mm]	115
Spacing	$s_{min\,II}$ [mm]	50 at c_{cr} and 115 at c_{min}
	$s_{min\perp}$ [mm]	50 at c_{cr} and 115 at c_{min}
Header	$s_{cr\,II}$ [mm]	115
Stretcher	$s_{cr\,II}$ [mm]	240
Header and Stretcher	$s_{cr\perp}$ [mm]	115

Table C6: Group factor for group fastenings ($\alpha_g \le 2$ per group fastenings)

Group factor	$\alpha_{g,N\,II}$ $\alpha_{g,V\,II}$ $\alpha_{g,N\perp}$ $\alpha_{g,V\perp}$ [-]	2 at c_{cr} and s_{cr}
Group factor	$\alpha_{g,V\,II}$ $\alpha_{g,V\perp}$ [-]	0,3 for Position 2a, 3a, 3b
Group factor	$\alpha_{g,N\,II}$ $\alpha_{g,N\perp}$ [-]	1 for Position 2a, 3a, 3b

Hilti HIT-HY 270	
Performances solid clay brick Mz, 2DF Installation parameters and group factor	**Annex C4**

Characteristic resistances for all anchor combinations (see Table B3)

Table C7: Tension resistance at edge distance $c \ge c_{cr}$

Use category			**w/w = w/d**		**d/d**	
Service temperature range			**Ta**	**Tb**	**Ta**	**Tb**
Anchor size	h_{ef} [mm]	f_b [N/mm²]	$N_{Rk,p} = N_{Rk,b}$ [kN]			
All anchor	≥ 50	12	2,5 (3,0*)	2,5 (3,0*)	2,5 (3,0*)	2,5 (3,0*)
	≥ 80	12	3,5 (4,0*)	3,5 (4,0*)	3,5 (4,0*)	3,5 (4,0*)
	≥ 100	12	6,0 (7,0*)	6,0 (7,0*)	6,0 (7,0*)	6,0 (7,0*)

* CAC cleaning only

Table C8: Tension resistance at edge distance $c_{min} \le c < c_{cr}$

Use category			**w/w = w/d**		**d/d**	
Service temperature range			**Ta**	**Tb**	**Ta**	**Tb**
Anchor size	h_{ef} [mm]	f_b [N/mm²]	$N_{Rk,p} = N_{Rk,b}$ [kN]			
All anchor	all	12	1,5 (2,0*)	1,5 (2,0*)	1,5 (2,0*)	1,5 (2,0*)

* CAC cleaning only

Table C9: Shear resistance at edge distance $c \ge c_{cr}$

Use category			**w/w = w/d**		**d/d**	
Service temperature range			**Ta**	**Tb**	**Ta**	**Tb**
Anchor size	h_{ef} [mm]	f_b [N/mm²]	$V_{Rk,b}$ [kN]			
All anchor	all	12	2,0			

Table C10: Shear resistance at edge distance $c_{min} \le c < c_{cr}$

Use category			**w/w = w/d**		**d/d**	
Service temperature range			**Ta**	**Tb**	**Ta**	**Tb**
Anchor size	h_{ef} [mm]	f_b [N/mm²]	$V_{Rk,c}$ [kN]			
All anchor	all	12	calculation according ETAG029 Annex C, equation C5.6			

Table C11: Displacements

h_{ef}	N	δ_{N0}	$\delta_{N\infty}$	V	δ_{V0}	$\delta_{V\infty}$
[mm]	[kN]	[mm]	[mm]	[kN]	[mm]	[mm]
50	0,86	0,1	0,2	0,6	0,5	0,8
80	1,3	0,2	0,4	0,6	0,5	0,8
100	1,7	0,3	0,6	0,6	0,5	0,8

Hilti HIT-HY 270	
Performances solid clay brick Mz, 2DF Characteristic values of resistance under tension and shear loads Displacements	**Annex C5**

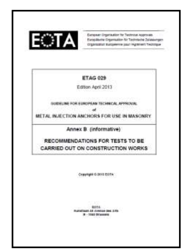
ON-SITE TESTING (O-S-T) – WHEN ETA OR HILTI TECHNICAL DATA DO NOT COVER YOUR MASONRY UNIT

$N_{rk} \rightarrow V_{rk}$

Only tension tests are required, shear can be derived from Tensile resistance, according to **ETAG029, Annex B**

Is your brick's base material present in ETA?

Y → O-S-T as per ETAG 029 Annex B


EOTA

European Organisation for Technical Approvals
Europäische Organisation für Technische Zulassungen
Organisation Européenne pour l'Agrément Technique

ETAG 029

Edition April 2013

GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL
of
METAL INJECTION ANCHORS FOR USE IN MASONRY

Annex B (informative)

RECOMMENDATIONS FOR TESTS TO BE CARRIED OUT ON CONSTRUCTION WORKS

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Covered in PROFIS

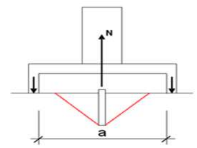
N → O-S-T as per other publications (e.g. BS 8539)

Not covered on PROFIS currently →requires an Engineering Judgement

MASONRY SITE TESTING - RESISTANCE LOADS: ETAG029

Tensile resistance

OPTION A: Pull out tests (destructive: ultimate load)

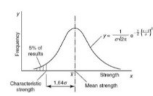


Resistance = $N_{rk1,}$ for <u>n</u> tests

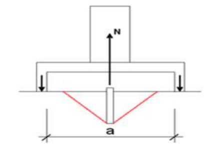
If $n \geq 15$: $N_{Rk1} = 0{,}5 \cdot N_1 \leq N_{Rk,ETA}$

If $5 \leq n < 15$: $N_{Rk1} = N_{5\%} \cdot \beta \leq N_{Rk,ETA}$

N_1 = mean of 5 smallest measured values at ultimate load
β taken from ETA for chosen base brick
$N_{5\%}$ = 5% fractile load



OPTION B: Proof load tests (non-destructive: load N_p)



$N_p \geq 0{,}8 \cdot N_{Sd} \cdot \gamma_M \cdot 1/\beta$

N_{sd} = design value of action
N_p = proof-load
γ_M = safety factor (2.5)

<u>If no visible movement or displacement,</u>
Resistance $\mathbf{N_{rk2}}$ can be obtained:

$N_{Rk2} = 1/0{,}8 \cdot N_p \cdot \beta \leq N_{Rk,ETA}$

Shear resistance

Shear based on tensile resistance, for both methods

if $V_{Rk,ETA} \geq N_{Rk,ETA}$: $V_{Rk1,2} = N_{Rk1,2} \leq V_{Rk,c}$

if $V_{Rk,ETA} < N_{Rk,ETA}$: $V_{Rk1,2} = N_{Rk1,2} \cdot (V_{Rk,ETA} / N_{Rk,ETA}) \leq V_{Rk,c}$

($V_{Rk,c}$ = brick edge failure, as per ETAG 029)

MASONRY SITE TESTING– DETAILS OF EXECUTION

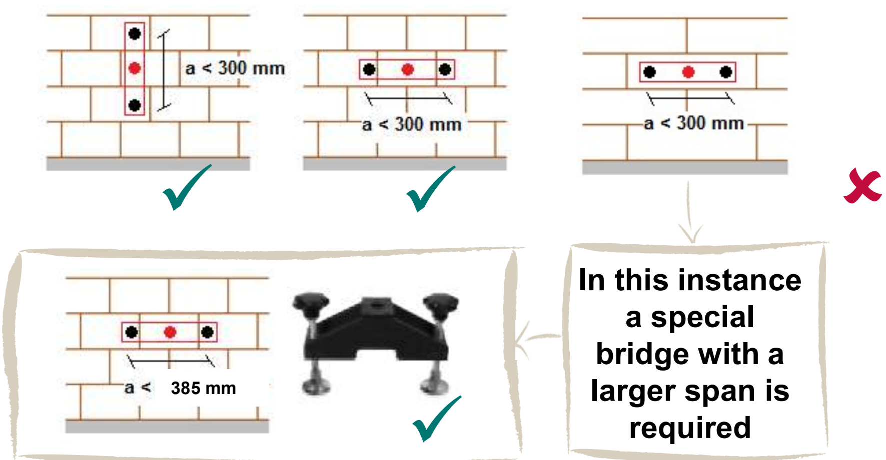
HOW TO DO IT

a) Tester supports in adjacent masonry units

or

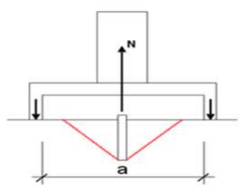
b) Distance ≥ 150 mm from the injection anchor

With the regular load bridge.



In this instance a special bridge with a larger span is required

E.g.: Tests performed with our **HAT28 Tester**



HILTI TECHNICAL DATA COVERS ADDITIONAL BRICKS, TESTED IN SAME WAY AS ETA QUALIFICATIONS

- Characteristic resistance loads and parameters for additional local bricks, information based on Hilti data available before ETA

- Tested following the ETA guidance

- Data obtained through testing performed as per **ETAG029 Annex B – on-site tests**

Same level of reliability as an ETA

Hilti HIT-HY 270 mortar for masonry

Design tension and shear resistances – Pull-out failure of the anchor, brick breakout failure and local brick failure at characteristic edge distance ($c \geq c_{cr}$) for single anchor applications

Load type	Anchor size	h_{ef} [mm]	f_b [N/mm²]	w/w and w/d Ta (Loads [kN])	w/w and w/d Tb (Loads [kN])	d/d Ta (Loads [kN])	d/d Tb (Loads [kN])
HC1 - Hollow clay brick Hlz, 10DF (ETA data)							
$N_{Rd,p} = N_{Rd,b}$ (c_{cr} =150 mm)	HIT-V + HIT-SC M8, M10, M12, M16 HIT-IC + HIT-SC M8, M10, M12	≥ 80	12	2,2 (2,4*)	2,2 (2,4*)	2,2 (2,4*)	2,2 (2,4*)
			20	2,8 (3,2*)	2,8 (3,2*)	2,8 (3,2*)	2,8 (3,2*)
$V_{Rd,b}$ (c_{cr} = 150 mm)	HIT-V + HIT-SC M8, M10, M12 HIT-IC + HIT-SC M8	≥ 80	12	0,8			
			20	1,2			
	HIT-V + HIT-SC M16 HIT-IC + HIT-SC M10, M12		12	1,4			
			20	1,8			
HC2 - Hollow clay brick Italy Mattone Alveolater 50 (Hilti data)							
$N_{Rd,p} = N_{Rd,b}$ (c_{cr} = 50 mm)	HIT-V + HIT-SC M8, M10, M12, M16 HIT-IC + HIT-SC M8, M10, M12	≥ 80	16	1,8 (2,0*)	1,8 (2,0*)	1,8 (2,0*)	1,8 (2,0*)
	HIT-V + HIT-SC M8, M10, M12, M16	≥ 130		2,6 (3,0*)	2,6 (3,0*)	2,6 (3,0*)	2,6 (3,0*)
$V_{Rd,b}$ (c_{cr} = 150 mm)	HIT-V + HIT-SC M8, M10, M12, M16 HIT-IC + HIT-SC M8, M10, M12	≥ 80	16	1,4			
	HIT-V + HIT-SC M8, M10, M12, M16	≥ 130		2,6			
HC3 - Hollow clay brick Spain Termoarcilla (Hilti data)							
$N_{Rd,p} = N_{Rd,b}$ (c_{cr} = 50 mm)	HIT-V + HIT-SC M8, M10, M12, M16	≥ 50	22	0,6 (0,8*)	0,6 (0,8*)	0,6 (0,8*)	0,6 (0,8*)
	HIT-V + HIT-SC M8, M10, M12, M16 HIT-IC + HIT-SC M8, M10, M12	≥ 80		1,0 (1,2*)	1,0 (1,2*)	1,0 (1,2*)	1,0 (1,2*)
$V_{Rd,b}$ (c_{cr} = 150 mm)	HIT-V + HIT-SC M8, M10, M12, M16 HIT-IC + HIT-SC M8, M10, M12	≥ 50	22	1,8			
HC4 - Hollow clay brick Belgium Wienerberger Thermobrick (Hilti data)							
$N_{Rd,p} = N_{Rd,b}$ (c_{cr} = 50 mm)	HIT-V + HIT-SC M8, M10, M12, M16	≥ 50	21	0,5 (0,6 *)	0,5 (0,6 *)	0,5 (0,6 *)	0,5 (0,6 *)
	HIT-V + HIT-SC M8, M10, M12, M16 HIT-IC + HIT-SC M8, M10, M12	≥ 80		2,2 (2,6*)	2,2 (2,6*)	2,2 (2,6*)	2,2 (2,6*)
$V_{Rd,b}$ (c_{cr} = 150 mm)	HIT-V + HIT-SC M8, M10	≥ 50	21	2,4			
	HIT-V + HIT-SC M12, M16 HIT-IC + HIT-SC M8, M10, M12			2,8			
HC5 - Hollow clay brick Spain Hueco doble (Hilti data)							
$N_{Rd,p} = N_{Rd,b}$ (c_{cr} = 120 mm)	HIT-V + HIT-SC M8, M10, M12, M16	≥ 50	4	0,4	0,4	0,4	0,4
	HIT-V + HIT-SC M8	80		0,8 (1,0*)	0,8 (1,0*)	0,8 (1,0*)	0,8 (1,0*)
	HIT-V + HIT-SC M10 HIT-IC + HIT-SC M8, M10, M12			1,0 (1,2*)	1,0 (1,2*)	1,0 (1,2*)	1,0 (1,2*)
	HIT-V + HIT-SC M12, M16			1,4 (1,6*)	1,4 (1,6*)	1,4 (1,6*)	1,4 (1,6*)
$V_{Rd,b}$ (c_{cr} = 120 mm)	HIT-V + HIT-SC M8, M10, M12, M16 HIT-IC + HIT-SC M8, M10, M12	≥ 50	4	1,2			
HC6 - Hollow clay brick Belgium Wienerberger Powerbrick (Hilti data)							
$N_{Rd,p} = N_{Rd,b}$ (c_{cr} = 50 mm)	HIT-V + HIT-SC M8, M10, M12, M16	≥ 50	41	1,6 (1,8 *)	1,6 (1,8 *)	1,6 (1,8 *)	1,6 (1,8 *)
	HIT-V + HIT-SC M8, M10, M12, M16 HIT-IC + HIT-SC M8, M10, M12	≥ 80		2,6 (2,8*)	2,6 (2,8*)	2,6 (2,8*)	2,6 (2,8*)
$V_{Rd,b}$ (c_{cr} = 150 mm)	HIT-V + HIT-SC M8, M10	≥ 50	41	2,6			
	HIT-V + HIT-SC M12, M16 HIT-IC + HIT-SC M8, M10, M12			4,8			

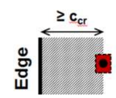
* Compressed Air Cleaning only

06 / 2015 13

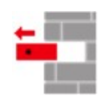
FASTENING TECHNOLOGY MANUAL (FTM) – COLLECTS AND PROVIDES INFORMATION FROM THE 3 SOURCES

- **More than 30 masonry units covered** (including ETA approved bricks and Hilti Technical Data).

- **Single anchors load data,** with no influence from edge distance, spacing, group factors and other parameters



- **8 failure modes covered**, including steel failure, brick failure, and removal of brick from the wall.



- **O-S-T required β factors** to use on the evaluation of on-site tests

Use of PROFIS Sofware is always recommended to avoid mistakes, to ensure swift design and also for all other applications not covered in FTM

HILTI TECHNICAL DATA – A REVISED DESIGN CONCEPT

Previous format

Global safety factor

HY-70 FTM → R_{rec}

$R_{rec} \geq S_k$

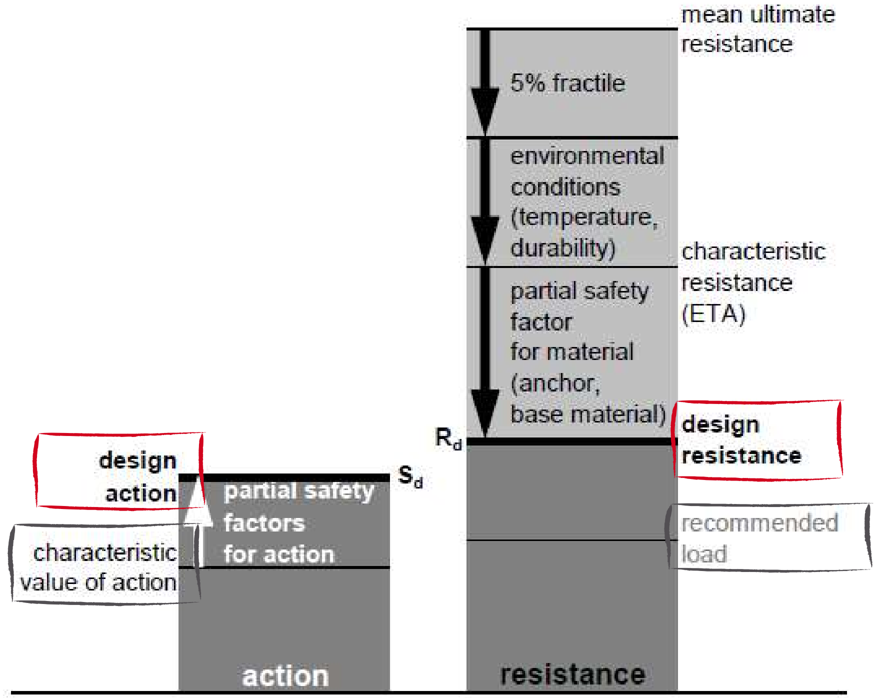
New format

Partial safety factor

HY-270 FTM → R_d

$S_d = S_k \times \gamma_F$

$R_d \geq S_d$



AGENDA

1. **Background**
   - ✓ Masonry base material and main applications
   - ✓ Regulations framework
2. **Technical data**
   - ✓ ETA qualification process
   - ✓ On-site testing
3. **Design**
   - ✓ Scope: # anchors and possible arrangements
   - ✓ Design concept and details
4. **Hilti's masonry offering**
   - ✓ Overview of system components
   - ✓ Profis software masonry module

AS IN THE CASE OF CONCRETE, MASONRY DESIGN IS ALSO DONE FOR ALL DIFFERENT FAILURE MODES

Tension loads	Shear loads
Failure of the metal part	Failure of the metal part
Pull-out failure of the anchor	Local brick failure
Brick breakout failure	Brick edge failure
Pull out of one brick	Pushing out of one brick

Same as in concrete (Failure of the metal part)

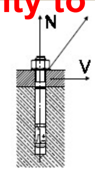
Similar to concrete pull-out failure (Pull-out failure of the anchor)

Similar to concrete pryout failure (Local brick failure)

Similar to concrete cone failure (Brick breakout failure)

Similar to concrete edge failure (Brick edge failure)

No similarity to concrete (Pull out of one brick; Pushing out of one brick)

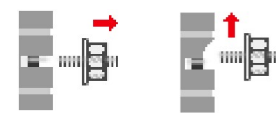


Choose the smallest value → Load combination ← Choose the smallest value

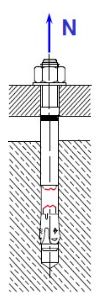
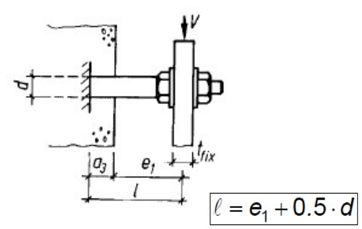
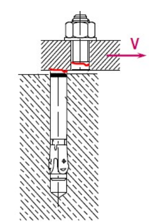
DESIGN METHOD

Failure mode: Failure of metal part

Tension (N) / Shear (V)



Evaluation for the highest loaded anchor

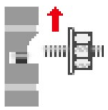
Tension: $N^h_{Sd} \leq N_{Rk,s} / \gamma_{Ms}$	**Shear: $V^h_{Sd} \leq V_{Rk,s} / \gamma_{Ms}$**	
	With lever arm	**Without lever arm**
		
$N_{rk,s} = A_s \cdot f_{uk}$	$V_{Rk,s} = \alpha_M \cdot M_{Rk,s} / l$	$V_{rk,s} = 0{,}5 \cdot A_s \cdot f_{uk}$

γ_{Ms} , $N_{rk,s}$, $V_{rk,s}$ and $M_{rk,s}$ to be taken from the relevant approval
α_M value should vary between 1.0 (no rotation restraint for fixture) and 2.0 (full restraint)

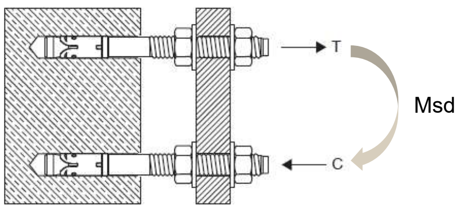
DESIGN METHOD

Failure of metal part – shear with lever arm

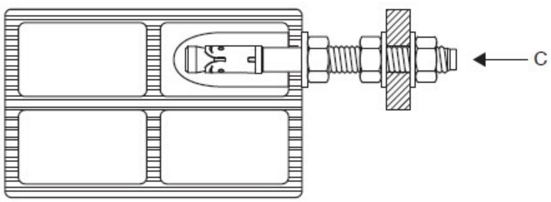
Shear (V)



Stand-off not permitted without grouting or plaster



Solid bricks
Push-in due to compression - splitting could occur on the other side of the brick



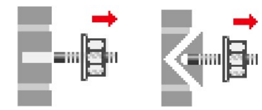
Hollow bricks
Stability only viable with clamping against brick – resistance value hard to define…

Clamping not permitted either

DESIGN METHOD

Failure modes: Pull-out of the anchor and brick breakout

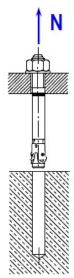
Tension (N)



Evaluation for: highest loaded anchor + group of anchors

Pull-out of anchor:

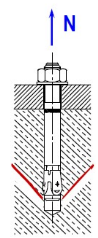
$N^{h}_{Sd} \leq N_{Rk,p} / \gamma_{Mm}$



Brick breakout:

$N_{Sd} \leq N_{Rk,b} / \gamma_{Mm}$

$N_{Sd}^{g} \leq N^{g}_{Rk} / \gamma_{Mm}$



$N_{Rk,p}$, $N_{Rk,b}$, γ_{M} values – ETA

ETA provides just one value for both failure modes, considering **$N_{Rk,p}$= $N_{Rk,b}$** (load for failure, whichever mode happens first).

Influence factors of resistance

- Positioning and spacing of the anchors on wall
- Orientation of brick on wall
- Cleaning method
- In-service temperature range
- Group factors
- Use category: dry or wet structure
- Influence of vertical joints

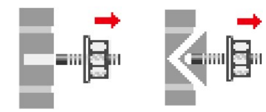
DESIGN METHOD

Failure modes: Pull-out of the anchor and brick breakout

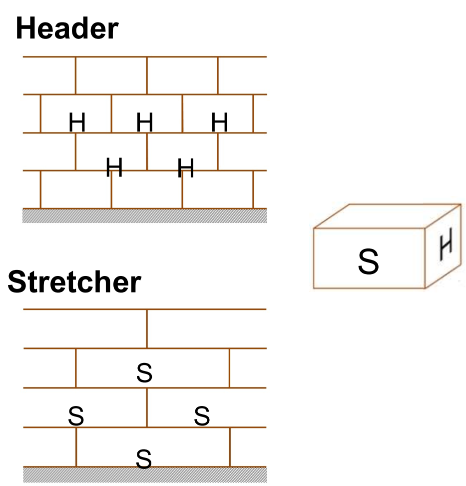
Influence factor: - Positioning and spacing of the anchors on wall

- Orientation of bricks on wall

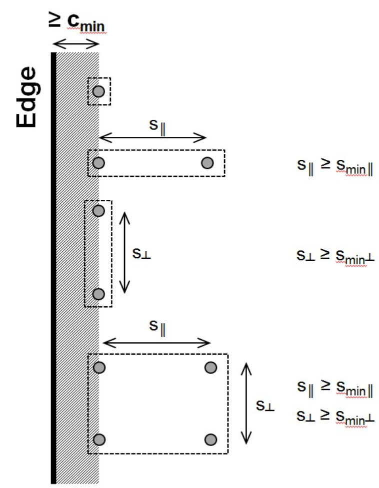
Tension (N)



Orientation of brick



Allowed anchor positions:

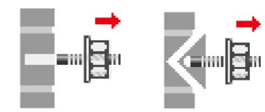


These factors will influence the choice of value from ETA Load tables

DESIGN METHOD

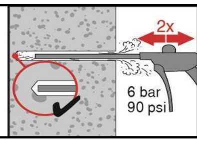
Failure modes: Pull-out of the anchor and brick breakout

Tension (N)



Influence factor: - Cleaning method

- Use category: dry or wet structure
- In-service temperature range

Cleaning method		**Manual Cleaning** (MC - for drill hole diameter $d_0 \leq 18$ mm and drill hole depth up to $h_0 = 100$ mm) or **Compressed air cleaning** (CAC – provides higher resistances for some brick types)

Use category: dry or wet structure **ETA: w/d = w/w**	Category **d/d** - **Installation and use** in structures subject to **dry**, internal conditions, Category **w/d** - **Installation in** dry or **wet** substrate and **use** in structures subject to **dry**, internal conditions (except calcium silicate bricks), Category **w/w** - **Installation and use** in structures subject to dry or **wet** environmental conditions.

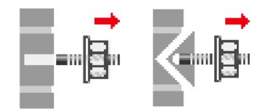
In-service temperature	Temperature range Ta:	-40 °C to +40 °C	(max. long term temperature +24 °C and max. short term temperature +40 °C)
	Temperature range Tb:	-40 °C to +80 °C	(max. long term temperature +50 °C and max. short term temperature +80 °C)

These factors will influence the choice of value from ETA Load tables

DESIGN METHOD

Failure modes: Pull-out of the anchor and brick breakout

Tension (N)



Influence factor: Group factor

Group factors (2 or 4 anchors)

2 Anchors: $N^{g}_{Rk} = \alpha_{g,N} \cdot N_{Rk}$

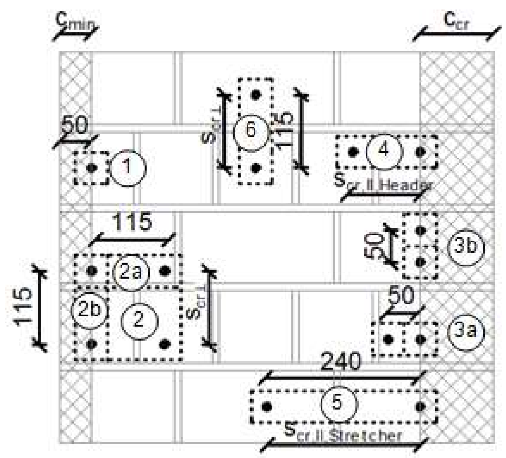
4 Anchors: $N^{g}_{Rk} = (\alpha_{g,N} \parallel \cdot \alpha_{g,N} \perp) \cdot N_{Rk} \leq \mathbf{2 \cdot N_{Rk}}$

$\boldsymbol{\alpha_{g,N}}$ depends on anchor position, wall configuration, brick type and orientation.

Example: Solid Clay Brick

$\alpha_{g,N} \parallel, \alpha_{g,N} \perp = 2.0$ at c_{cr} and S_{cr}

$\alpha_{g,N} \parallel, \alpha_{g,N} \perp = 1.0$ for pos. 2a,3a,3b



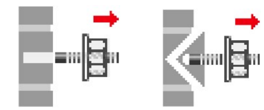
These factors are taken from the ETA and will multiply the value chosen from the ETA Load tables

DESIGN METHOD

Failure modes: Pull-out of the anchor and brick breakout

Influence factor: Vertical Joints

Tension (N)



$$N_{Sd} \leq \alpha_j \cdot N_{Rk,p} / \gamma_{Mm}$$
$$N_{Sd} \leq \alpha_j \cdot N_{Rk,b} / \gamma_{Mm}$$

Effect of vertical joints on tension resistance

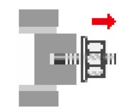
- Joints Filled
  - Joints visible
    - **α_j =1.00**
  - Joints not visible
    - **α_j =0.75**
- Joints not filled
  - Joints visible
    - $c \geq c_{min}$
      - **α_j =1.00**
    - $c < c_{min}$
      - **α_j =0.75**
  - Joints not visible
    - **α_j = 0.75**

These factors are taken from the ETA and will multiply the value chosen from the ETA Load tables

DESIGN METHOD

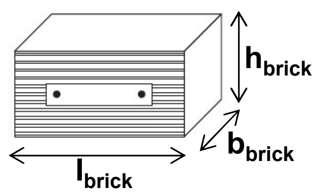
Failure mode: Pull-out of one brick

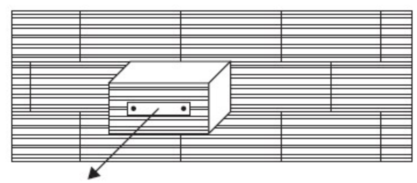
Tension (N)



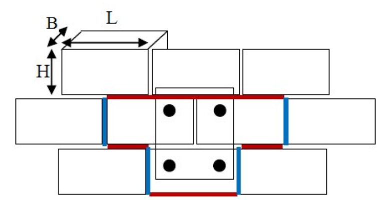
Evaluation for: total load - anchor or group of anchors

$$N_{Sd} \leq N_{Rk,pb} / \gamma_{Mm}$$

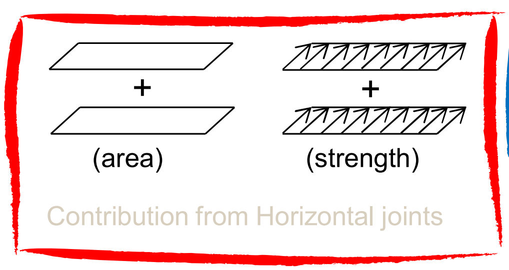


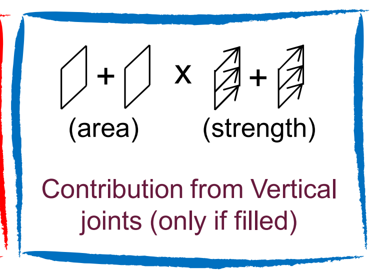


Example with adjacent bricks

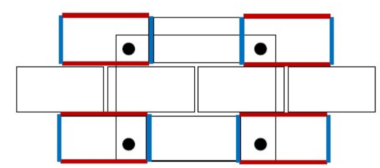


$$N_{Rk,pb} = 2 \cdot l_{brick} \cdot b_{brick} \cdot (0,5 \cdot f_{vko} + 0,4 \cdot \sigma_d) + b_{brick} \cdot h_{brick} \cdot f_{vko}$$





Example with non- adjacent bricks



σ_d = design compressive stress (loads on top of brick)
f_{vko} = initial shear strength, depends on brick and mortar type (EN 1996-1-1, Table 3.4)

DESIGN METHOD

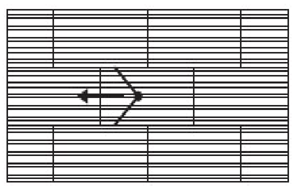
Failure modes: Local brick failure and Brick edge failure

Evaluation for: effective anchors

Local brick failure:

$V_{Sd} \leq V_{Rk,b} / \gamma_{Mm}$

$V_{Sd}^{g} \leq V^{g}_{Rk} / \gamma_{Mm}$

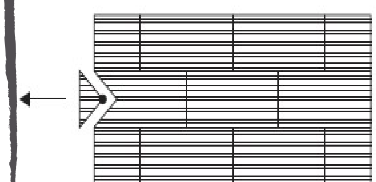


$c \geq c_{cr}$

Brick edge failure:

$V_{Sd} \leq V_{Rk,c} / \gamma_{Mm}$

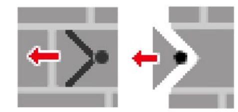
$V_{Sd}^{g} \leq V^{g}_{Rk} / \gamma_{Mm}$



$c < c_{cr}$

$V_{Rk,b}$, $V_{Rk,c}$, γ_M values – ETA

Shear (V)



Influence factors of resistance (same as for tension)

- Positioning and spacing of the anchors on wall
- Orientation of brick on wall
- In-service temperature range
- Group factors
- Use category: dry or wet structure
- Influence of vertical joints

DESIGN METHOD

Failure modes: Local brick failure and Brick edge failure

Influence factor: Group factor

Group factors (2 or 4 anchors)

2 Anchors: $V^{g}_{Rk} = \alpha_{g,V} \cdot V_{Rk}$

4 Anchors: $N^{g}_{Rk} = (\alpha_{g,V} \parallel \cdot \alpha_{g,V} \perp) \cdot V_{Rk} \leq \mathbf{2 \cdot V_{Rk}}$

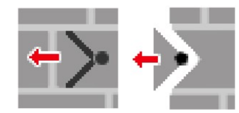
$\boldsymbol{\alpha_{g,V}}$ depends on anchor position, wall configuration, brick type and orientation.

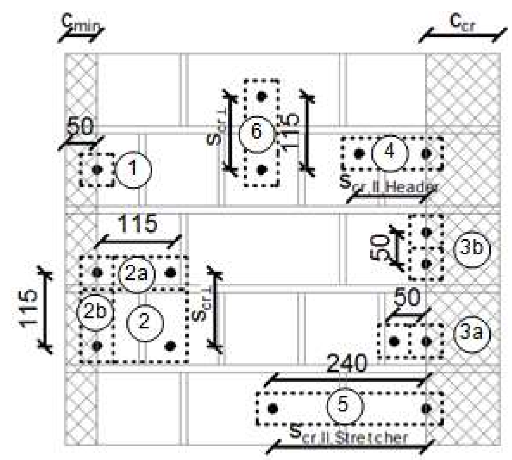
Example: Solid Clay Brick

$\alpha_{g,V} \parallel, \alpha_{g,V} \perp = 2.0$ at c_{cr} and S_{cr}

$\alpha_{g,V} \parallel, \alpha_{g,V} \perp = 0.3$ for pos. 2a,3a,3b

Shear (V)



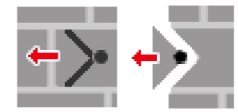


These factors are taken from the ETA and will multiply the value chosen from the ETA Load tables

DESIGN METHOD

Failure modes: Local brick failure and Brick edge failure

Shear (V)

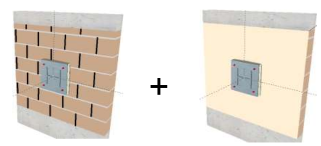


Influence factor: Vertical Joints

$$V_{Sd} \leq \alpha_{j,b} \cdot V_{Rk,b} / \gamma_{Mm}$$
$$V_{Sd} \leq \alpha_{j,c} \cdot V_{Rk,c} / \gamma_{Mm}$$

Effect of vertical joints on shear resistance

- Joints 2 to 5 mm
  - Joints visible
    - Joints filled
      - $\alpha_{j,b}$=1.00, $\alpha_{j,c}$=1.00
    - Joints not filled
      - **Free edge**
  - Joints not visible
    - Joints filled
      - $\alpha_{j,b}$=0.75, $\alpha_{j,c}$=1.00
    - Joints not filled
      - **No solution**
- Joints > 5mm
  - Joints visible
    - **Free edge**
  - Joints not visible
    - **No solution**



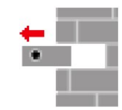
Not logical, thus not possible on PROFIS – plaster would have to be removed from the fastening area

These factors are taken from the ETA and will multiply the value chosen from the ETA Load tables

DESIGN METHOD

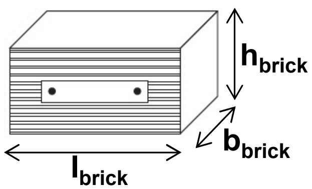
Failure mode: Pushing out of one brick

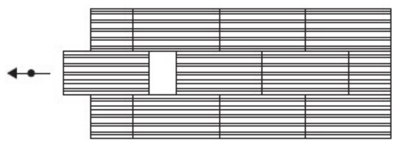
Shear (V)



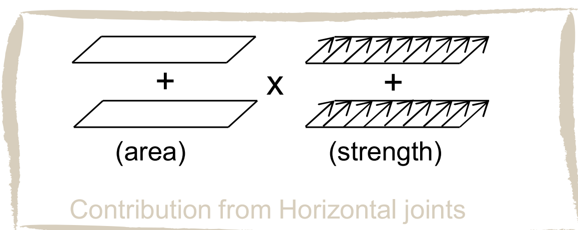
Evaluation for: total load - anchor or group of anchors

$$V_{Sd} \le V_{Rk,pb} / \gamma_{Mm}$$

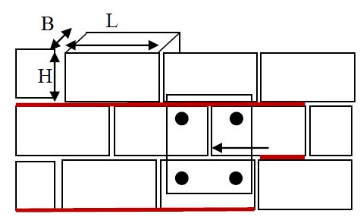




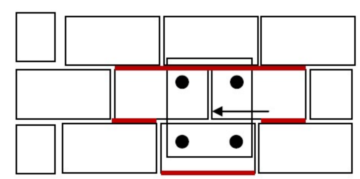
$$V_{Rk,pb} = 2 \cdot l_{brick} \cdot b_{brick} \cdot (0{,}5 \cdot f_{vko} + 0{,}4 \cdot \sigma_d)$$



Example with filled vertical joints



Example with non-filled joints

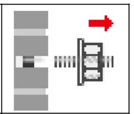
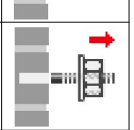
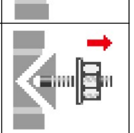
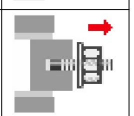


σ_d = design compressive stress (loads on top of brick)
f_{vko} = initial shear strength, depends on brick and mortar type (EN 1996-1-1, Table 3.4)

DESIGN METHOD

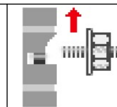
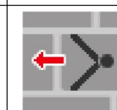
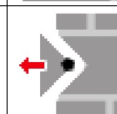
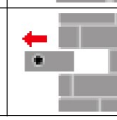
Failure modes: Load Combination N + V

Tension loads

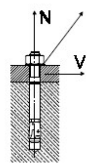
Failure of the metal part	
Pull-out failure of the anchor	
Brick breakout failure	
Pull out of one brick	

Choose the smallest value

Shear loads

Failure of the metal part	
Local brick failure	
Brick edge failure	
Pushing out of one brick	

Choose the smallest value

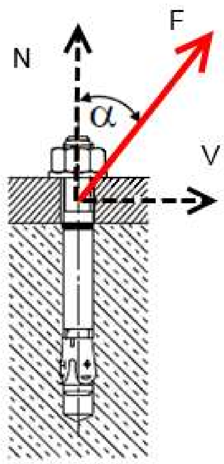


Load combination

DESIGN METHOD

Failure modes: Load Combination N + V

Having verified the tension and shear loads…



$$\beta_V = \frac{V_{Sd}}{V_{Rd}} \qquad \beta_V \leq 1.0$$

$$\beta_N = \frac{N_{Sd}}{N_{Rd}} \qquad \beta_N \leq 1.0$$

…the N + V combination must be also analised:

$\beta_N + \beta_V \leq 1.2$ for solid masonry

$\beta_N + \beta_V \leq 1.0$ for hollow or perforated masonry

AGENDA

1. **Background**
   - ✓ Masonry base material and main applications
   - ✓ Regulations framework
2. **Technical data**
   - ✓ ETA qualification process
   - ✓ On-site testing
3. **Design**
   - ✓ Scope: # anchors and possible arrangements
   - ✓ Design concept and details
4. **Hilti's masonry offering**
   - ✓ Overview of system components
   - ✓ Profis software masonry module

ONE FLEXIBLE AND APPROVED SYSTEM SOLUTION FOR ALL TYPES OF MASONRY BASE MATERIAL

- Easy to dispense
- Odourless, no styrene or phenols
- Best manual & battery dispensers

Dispenser

HIT-HY 270 mortar

- Combinable composite sleeves
- Mortar filling control & centering ring

Sleeves

HIT-S 1m

HIT-MV

HIT-SC

Elements

HIT-V

HIT-C

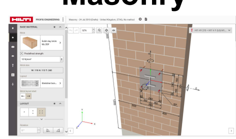
HIT-IC

HIT-HY 270 System

Approval & Technical Data

- Best Masonry ETA
- Comprehensive technical data, also for additionally tested local bricks

PROFIS Engineering - Masonry

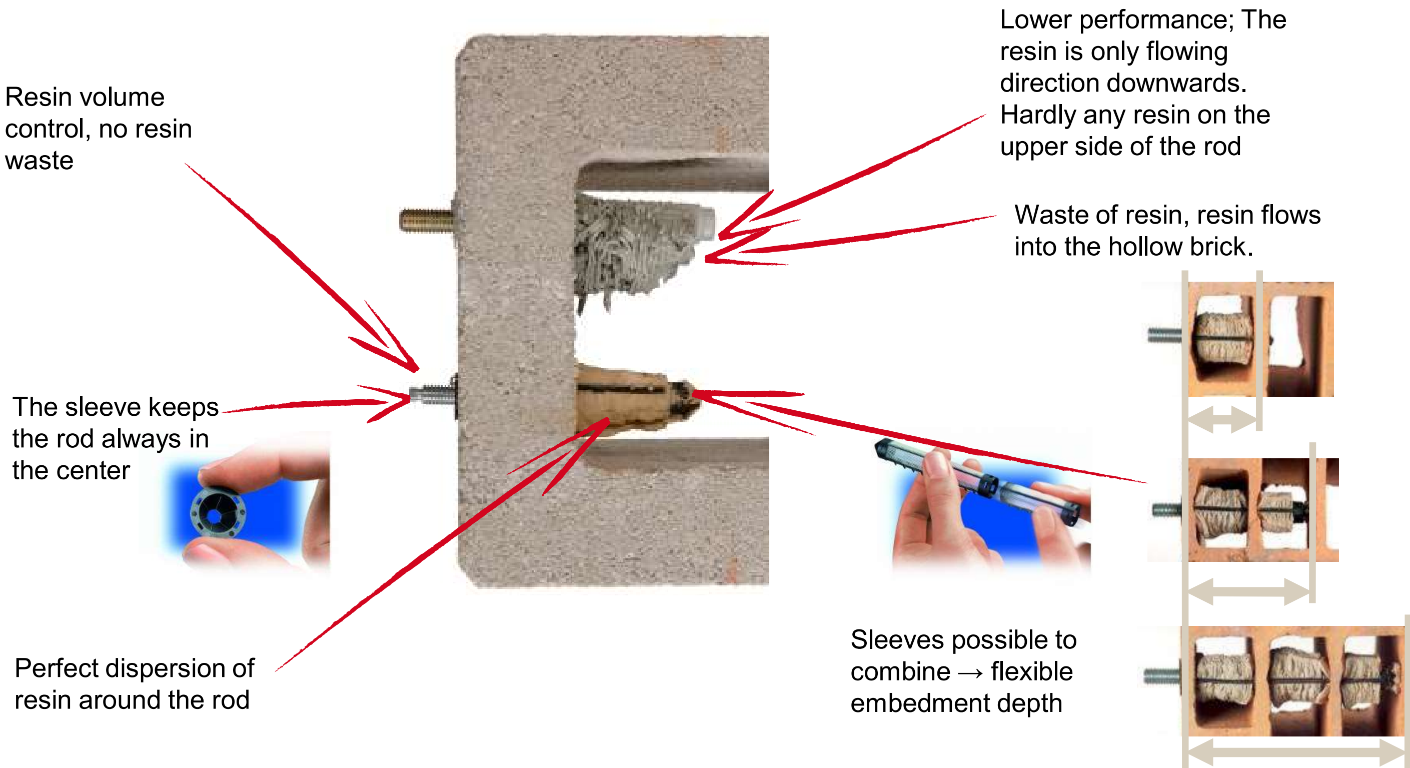


- Unique and practicable design software
- Two design options (basic, advanced)

Hilti Service Package

- Professional on-site testing service
- Evaluation and consultancy
- On-site support
- Installation guidance

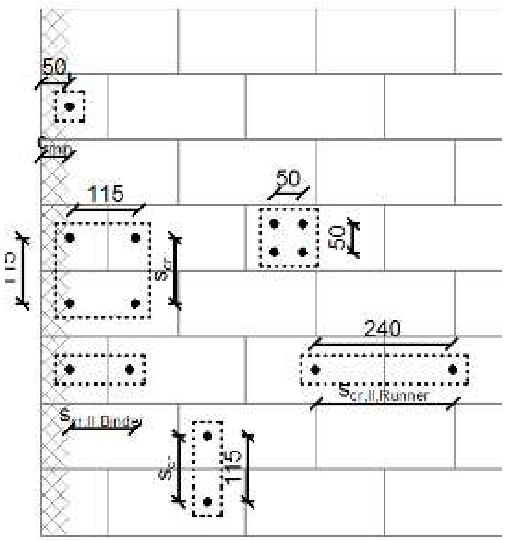
HIT-HY 270 COMPOSITE SLEEVE SYSTEM IS RELIABLE, SAVES RESIN AND OFFERS FLEXIBLE EMBEDMENT DEPTHS



HY270 WITH UNBEATABLE FLEXIBILITY REGARDING POSITION OF THE FASTENING POINT

Hilti HIT-HY270

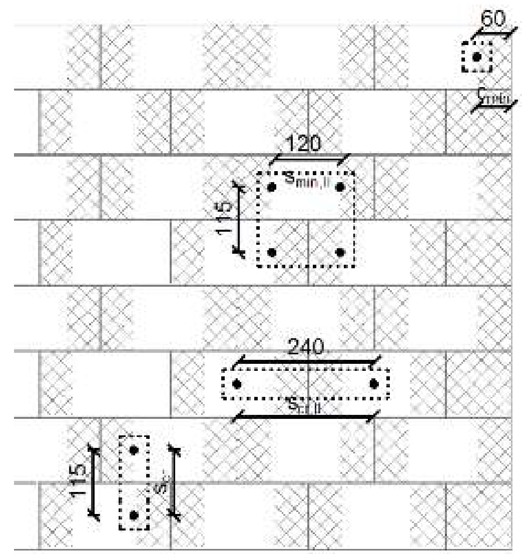
Example: Solid brick 2DF: 240x115x113



Legend:
Not Usable area for fastening
Minimal width of bracket holes

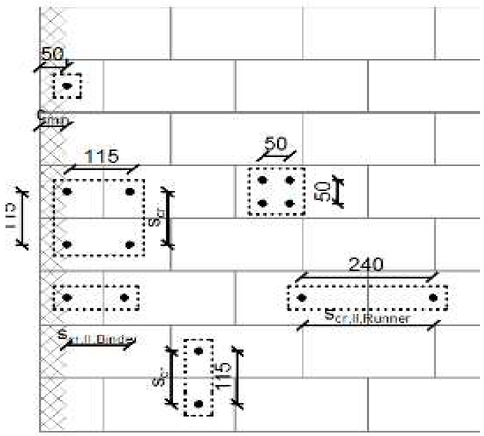
A.N.Other resin brand

Example: Solid brick 2DF: 240x115x113



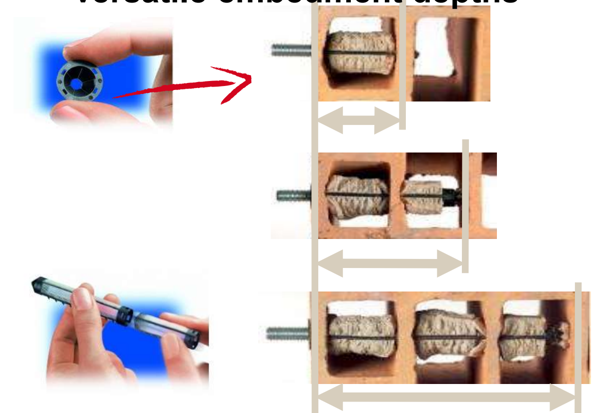
HIT-HY 270 SYSTEM OFFERS UNBEATABLE RELIABILITY AND FLEXIBILITY FOR YOUR APPLICATION

Highest degree of freedom for anchor placement in masonry walls



- Minimum edge distances
- Minimum spacing between anchors
- Fixation on vertical and horizontal joints
- Fastening even on coated walls

Easy and reliable installation allowing versatile embedment depths



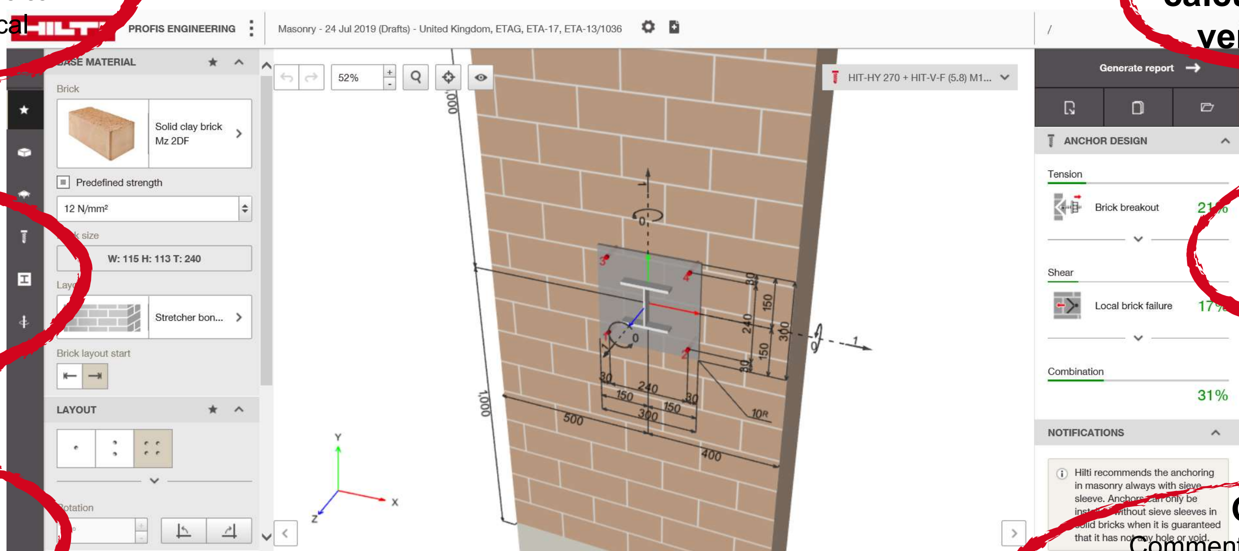
- Mortar volume control, no waste
- Perfect dispersion of mortar around the rod
- The sleeve keeps the rod always in the center
- Sleeves possible to combine → flexible embedment depth

MASONRY EXPERT DESIGN WITH PROFIS ANCHOR

Different levels of technical data
ETA, Hilti Technical Data.

Simple product selection

3d data input
Similar to standard concrete designs in PE



Direct calculations and verifications

Variable embedment options

Guidance
Comments and suggestions for increasing the resistance with anchor arrangement optimization

THANK YOU

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