DESIGN CONCEPT REGUPOL INODIS:
Practical examples - Web based design tool

Basic idea

The REGUPOL INODIS system decouples masonry infills from the surrounding reinforced concrete frame, allowing them to respond to combined in-plane and out-of-plane seismic actions. This innovative approach minimizes harmful interactions, improves structural resilience, and enables infill panels to safely withstand even strong earthquake loading.

Requirements Eurocodes

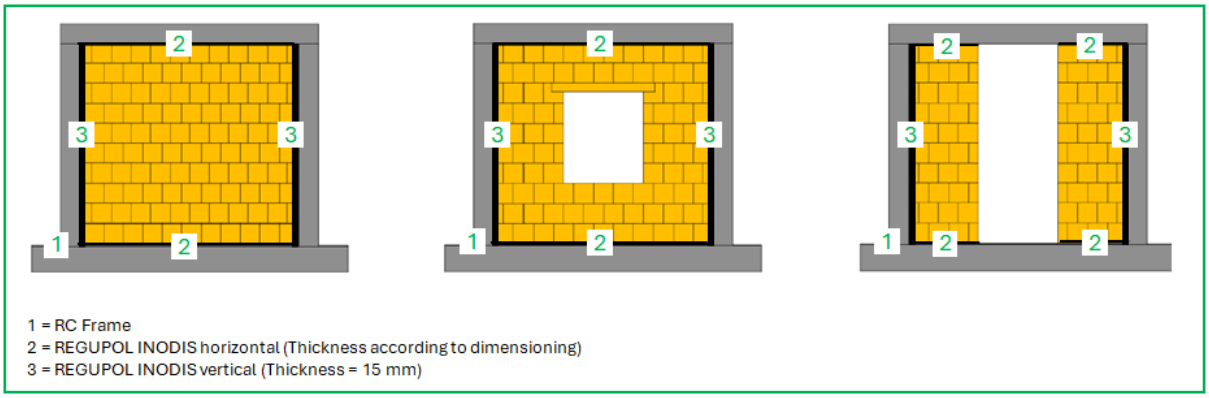
RC frames with masonry infills decoupled with the system REGUPOL INODIS can be designed as non-interacting masonry infills according to the Eurocodes as they meet the following criteria: minimal effect on the lateral stiffness and resistance of the structure, minimal interaction between the frame and the infill, and adequate safety against out-of-plane and combined in-plane and out-of-plane loading.

Performance objectives

The performance objectives of the Eurocodes, defined as the limit states Significant Damage (SD), Damage Limitation (DL) and Fully Operational (OP), are met by simple design rules with REGUPOL INODIS.

Design

The in-plane design of the system is simply carried out by calculating the required thickness of REGUPOL INODIS vertical based on the maximum interstorey drift taken from the standard building calculation using a bare frame model. Verification for out-of-plane actions is straightforward, as REGUPOL INODIS horizontal provides a stable arching effect. The REGUPOL INODIS system is designed and installed in the same way for infill panels with and without openings, and the design is carried out for the whole building or individual stories using simple design rules for the decisive panels, minimizing the structural engineer's workload. As an alternative a story by story calculation can be carried out to minimize the thickness.



1 = RC Frame
2 = REGUPOL INODIS horizontal (Thickness according to dimensioning)
3 = REGUPOL INODIS vertical (Thickness = 15 mm)

REGUPOL Germany GmbH & Co. KG
Head Office: Bad Berleburg
Siegen District Court, HRA 9854
VAT ID no.: DE 360 723 882

Deutsche Bank
IBAN DE82 4607 0090 0362 0259 00
BIC DEUTDEDK460

General Partner:
REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

INODIS DESIGN

Code

INODIS can be designed as a non-interacting infill panel in accordance with first and second Eurocode generation [1], [2], [3].

Design

The design includes the verifications for in-plane and out-of-plane loading. The in-plane verification is based on the requirements that the contribution to the lateral stiffness and seismic resistance of the structure is small and that the effects of the infill-frame interaction can be neglected. For the out-of-plane design, the connections to the RC frame and masonry infill must be verified for the out-of-plane loading.

In-plane verification

Verification of contribution to lateral stiffness

Non-interacting infills using REGUPOL INODIS are not included in the structural analysis model, as their contribution to lateral stiffness is negligible in accordance with EN 1998-1-2 [2]. This makes the analysis simpler, more robust, and less sensitive to uncertain infill properties. Design verification is therefore simplified and limited to local checks of the infill panels, both in-plane and out-of-plane.

Verification of transferred shear force

The verification may be considered satisfied if the shear force $V_{c,ap}$ transferred from the columns to the infill panel does not exceed 30% of the infill in-plane design resistance in shear $V_{ap,Rd}$:

$$V_{\mathrm{c,ap}} \leq 0{,}3\, V_{\mathrm{ap,Rd}} \tag{1}$$

The in-plane design resistance in shear $V_{\mathrm{ap,Rd}}$ is calculated as follows:

$$V_{\mathrm{ap,Rd}} = \frac{1}{\gamma_{\mathrm{M}}}\left[t_{ap}\, f_{vk0} \left(l_{ap} + \mu_f \frac{l_s}{1 - \mu_f \frac{h_{ap}}{l_{ap}}} \sin\alpha \right) \right] \cdot \rho_{op} \tag{2}$$

$V_{\mathrm{ap,Rd}}$	design resistance to horizontal shear of the infill panel;
γ_{M}	partial safety factor for SD according to EN 1998-1-2, 14.3(5), $\gamma_{\mathrm{M}} = 1.5$;
t_{ap}	infill panel thickness;
f_{vk0}	characteristic initial shear strength as given in EN 1996-1-1, 5.7.2.2;
l_{ap}	infill panel length;
μ_f	characteristic friction coefficient according to EN 1996-1-1, 5.7.2.3(4), should be taken equal to 0,4;
l_s	length of the diagonal of the panel

h_{ap} infill panel clear height;

α angle between the infill panel diagonal and the horizontal (beam);

ρ_{op} reduction factor in case of infills with openings according to EN 1998-1-2, 7.4.2.9.

The shear force $V_{\mathrm{c,ap}}$ may be calculated as:

$$V_{\mathrm{c,ap}} = \sigma_{sj,D}\, t_{ap}\, l_{\mathrm{cs}} \tag{3}$$

l_{cs} contact length of the compression strut in the infill panel along the column: $l_{\mathrm{cs}} = 0{,}25\frac{l_{\mathrm{ap}}}{cos^2\alpha}$

$\sigma_{sj,D}$ design average stress of the filling material along the contact length l_{cs} calculated with the design drift $d_{r,SD}$.

Out-of-plane verification

Verification of the infill

The design out-of-plane load $f_{\mathrm{ap,d}}$ should not exceed the design out-of-plane resistance $q_{lat,d}$. The design out-of-plane load per unit area may be calculated according to EN 1998-1-2, 7.2.1:

$$f_{\mathrm{ap,d}} = \frac{\gamma_{ap}\, m_{ap}\, S_{ap}}{A_N\, q_{ap,S}} \tag{4}$$

γ_{ap} performance factor in accordance with EN 1998-1-2, 7.2.2, $\gamma_{ap} = 1.0$;

m_{ap} mass of the infill panel per meter;

S_{ap} floor acceleration according to EN 1998-1-2, 7.2.1(6);

A_N net area of the infill;

$q_{ap,S}$ behaviour factor of the infill panel, $q_{ap,S} = 1.3$;

The out-of-plane design resistance per unit area of the infill panel, $q_{lat,d}$, is calculated in accordance with EN 1996-1-1, 8.4.3(6), considering only the vertical load direction.

$$q_{lat,d} = F_M\, f_d \frac{(0.9\, t_{ap} - d_a)\, t_{ap}}{h_{ap}^2} R_{ipoop} \frac{A_{arching}}{A_N} \tag{5}$$

F_M Factor, EN 1996-1-1-2025, 8.4.3, $F_M = 1.2$ and $F_M = 0.8$ for lightweight aggregate and autoclaved aerated concrete masonry units of Group 1 or other units than Group 1;

f_d design compressive strength of masonry in vertical direction;

d_a	deflection of the arch under design lateral load; may be assumed zero for infill panels with a height to thickness ratio ≤ 20;
R_{ipoop}	reduction factor for the interaction between in-plane and out-of-plane action effects. $R_{ipoop} = 1.0$ for non-interacting infills;
$A_{arching}$	sum of all areas of all infill wall segments extending over the wall height that can resist the arch thrust
A_N	net area of the infill

Verification of the rubber connection

In accordance with the assumed arching action, the verification is conservatively carried out without considering any load transfer to the column connections. It shall be verified that the design force per running metre $F_{Con,d}$ resulting from the out-of-plane load $f_{ap,d}$ does not exceed the design shear resistance $F_{Con,Rd}$ of the connection. For connections, the characteristic resistance per running metre is $F_{Con} = 34.4$ kN/m for masonry with regular mortar joints and $F_{Con} = 58.3$ kN/m for masonry with thin-bed mortar joints. These values were confirmed by tests on various masonry and mortar types [5] according to EN 1996-1-1 [4]. The resulting design out-of-plane force $F_{Con,Rd}$ of the infill is calculated as follows:

$$F_{ap,\mathrm{d}} = f_{\mathrm{ap,d}}\, A_{\mathrm{N}}$$

The design out-of-plane load per unit length is calculated with the total arching length l_{arching} of the infill:

$$F_{Con,\mathrm{Rd}} = \frac{F_{\mathrm{ap,d}}}{l_{\mathrm{arching}}\, \gamma_{\mathrm{M}}}$$

The arching length corresponds to the sum of the wall parts spanning over the full height with INODIS supports at top and bottom. The partial safety factor is applied with $\gamma_{\mathrm{M}} = 1.5$ according to EN 1998-1-2, 14.3(5).

DESIGN EXAMPLE: 6-storey building

Building description

The design of INODIS is illustrated for a regular 6-storey reinforced concrete frame structure with masonry infills. Figure 1 shows a 3D-view of the building, while Figure 2 depicts the ground plan configuration.

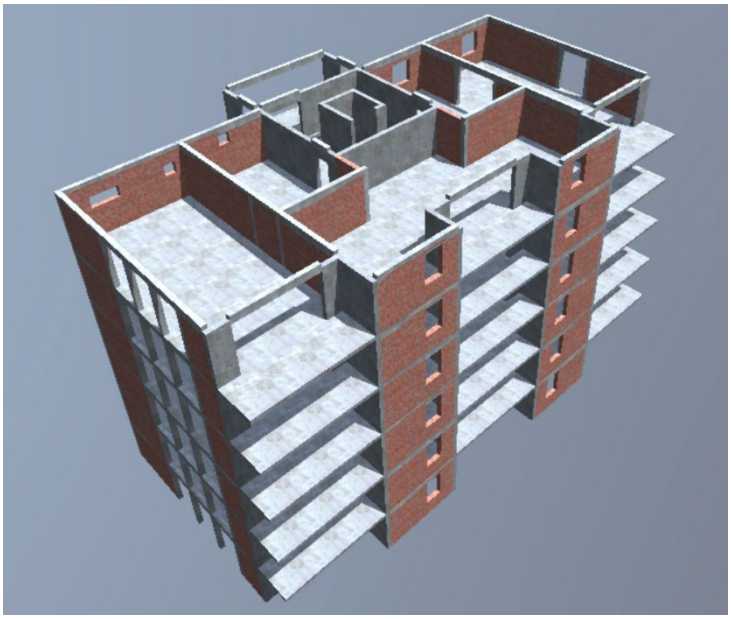


Figure 1: 3D-view of the 6-storey building

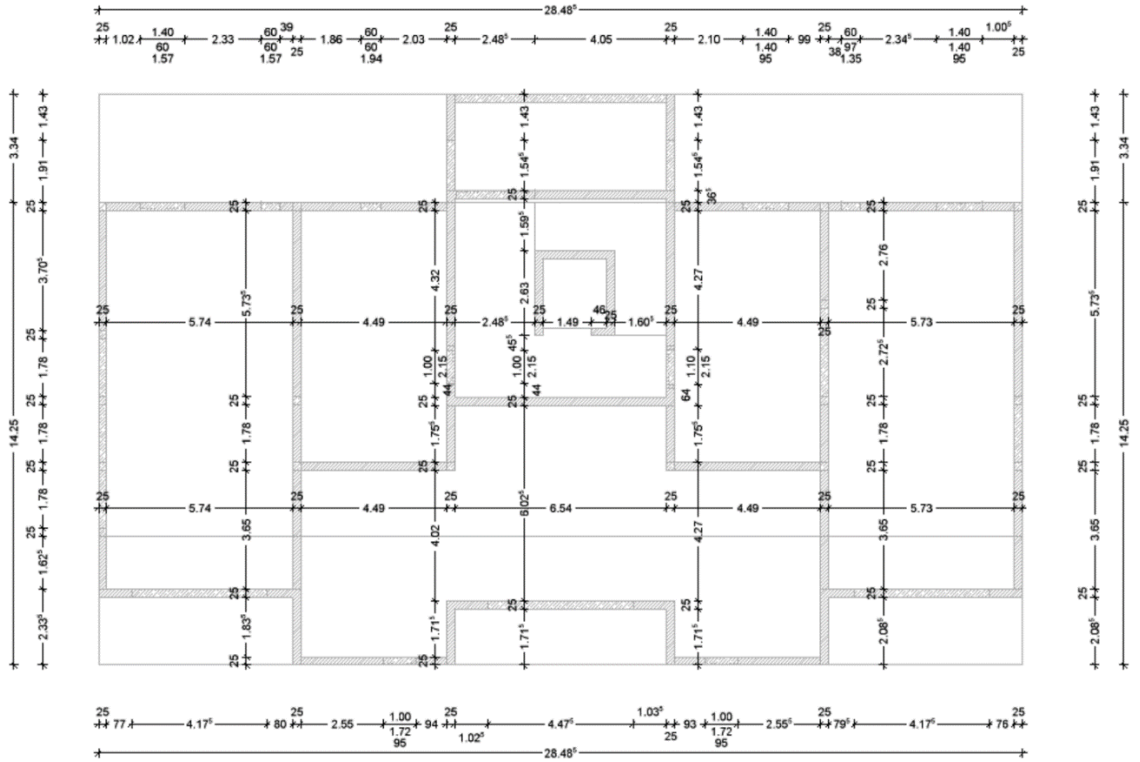
REGUPOL Germany GmbH & Co. KG
Head Office: Bad Berleburg
Siegen District Court, HRA 9854
VAT ID no.: DE 360 723 882

Deutsche Bank
IBAN DE82 4607 0090 0362 0259 00
BIC DEUTDEDK460

General Partner:
REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel



[m]

Figure 2: Ground plan of the 6-storey building

The infills are constructed using the vertically perforated brick known as Porotherm 25 [7] and thin bed mortar. The material and strength characteristics are given in Table 1.

Table 1: Material and strength characteristics of the vertically perforated brick Porotherm 25

Thickness: t = 250 mm
Brick strength: f_b = 10 N/mm²
Masonry strength: f_k = 4,52 N/mm²
Characteristic initial shear strength: : f_{vk0} = 0,3 N/mm²
Mass: 0,78 t/m³
Thin bed mortar class: M10

The verifications are performed for three representative frames: a solid infilled frame as well as frames with window and door openings (Figure 3).

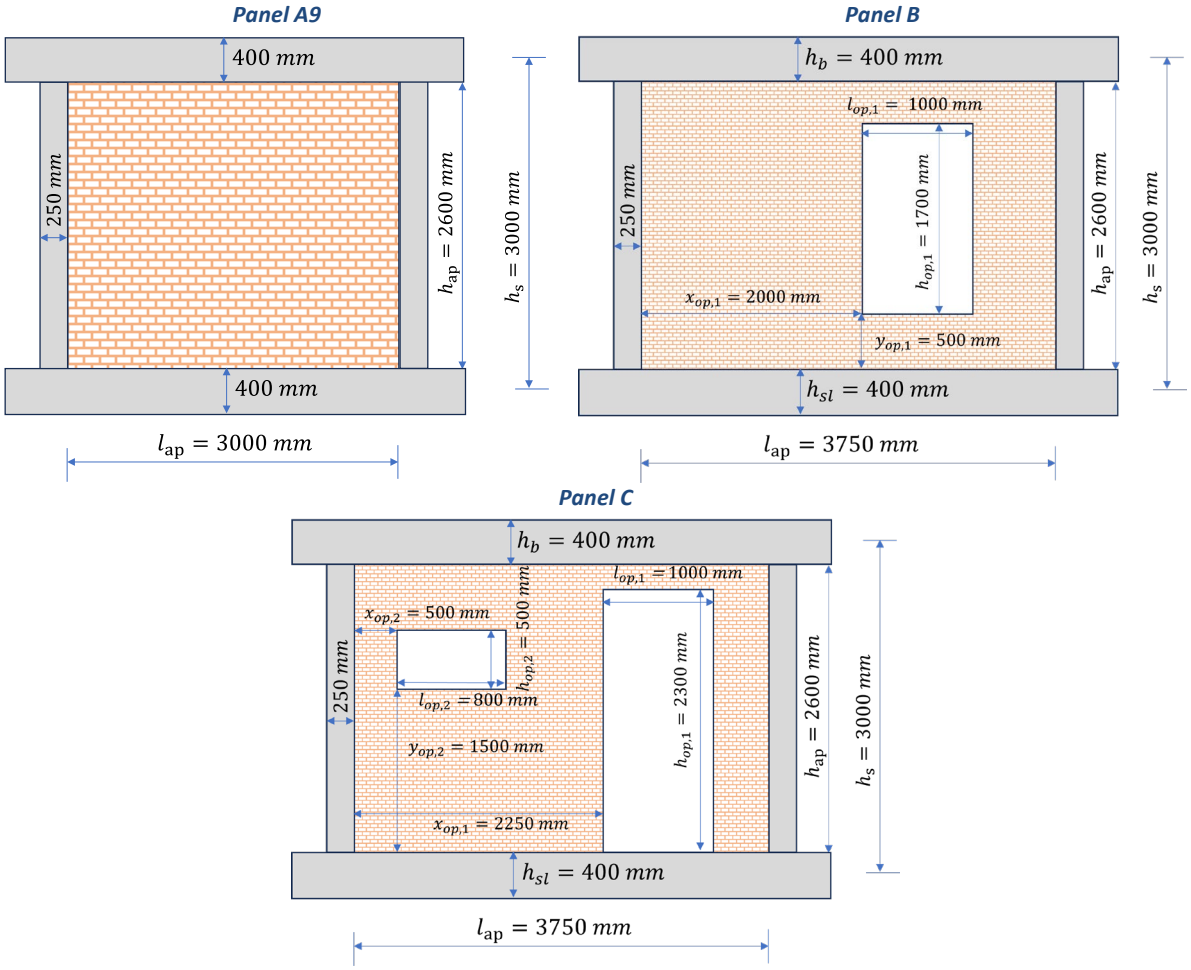


Figure 3: Geometry of panel A (solid), Panel B (window opening) and Panel C (door opening)

Interstory drift and floor acceleration

The building is designed in accordance with EN 1998-1-2 [2] for a maximum interstorey drift of 1%, corresponding to a maximum relative displacement of $d_{r,SD} = 30$ mm. The maximum spectral acceleration at the building site with rock conditions is $S_\alpha = 2.0$ m/s^2. The structural analysis results in a maximum floor acceleration of $S_{ap} = 11$ m/s^2. The REGUPOL INODIS system is subsequently designed and verified to provide adequate in-plane and out-of-plane resistance under this seismic demand.

Input values

Geometry, material and strength parameter of masonry and mortar, safety factors

Panel	γ_M [-]	μ_f [-]	f_{vk0} $\left[\frac{N}{mm^2}\right]$	f_b $\left[\frac{N}{mm^2}\right]$	f_k $\left[\frac{N}{mm^2}\right]$	f_m $\left[\frac{N}{mm^2}\right]$	t_{ap} [mm]	h_{ap} [mm]	l_{ap} [mm]	α [°]	l_s $[mm]$	l_{cs} $[mm]$	h_s $[mm]$	$\gamma_{r,SD}$ $[mm]$
A	1.5	0.4	0.3	10.0	4.52	10.0	250	2600	3000	40.9	3790	1313	3000	1.0
B	1.5	0.4	0.3	10.0	4.52	10.0	250	2600	3750	34.7	4563	1388	3000	1.0
C	1.5	0.4	0.3	10.0	4.52	10.0	250	2600	3750	34.7	4563	1388	3000	1.0

Performance factor, density, behaviour factor, openings

Panel	γ_{ap} [-]	ρ_d $\left[\frac{kg}{m^3}\right]$	S_{ap} $\left[\frac{m}{s^2}\right]$	$q_{ap,S}$ [-]	$l_{op,1}$ [mm]	$h_{op,1}$ [mm]	$l_{op,2}$ [mm]	$h_{op,2}$ [mm]	A_{op} $[m^2]$	α_a [%]	ρ_{op} [−]
A	1.0	780	0.3	1.3	-	-	-	-	-	-	1.0
B	1.0	780	0.3	1.3	1000	1700	-	-	17e5	17.44	0.525
C	1.0	780	0.3	1.3	1000	2300	800	500	20e5	26.67	0.442

REGUPOL INODIS

The design calculation is carried out for REGUPOL INODIS vertical plus with a thickness of 50 mm in combination with REGUPOL INODIS horizontal [6]. Finally, a tabulated comparison with the results for different thicknesses is provided.

Panel	Column	Beam
A, B, C	REGUPOL INODIS vertical plus - 50 mm	REGUPOL INODIOS horizontal - 15 mm

Verification

In-plane verification

Verification of transferred shear force

It must be verified that the contact force $V_{c,ap}$ transferred from the columns to the infill panel should not exceed 30% of the in-plane design resistance in shear $V_{ap,Rd}$ of the infill panel:

$$\boldsymbol{V_{c,ap} \leq 0,3\, V_{ap,Rd}}$$

Panel A

$$V_{ap,Rd,A} = \frac{1}{\gamma_M}\left[t_{ap}\, f_{vk0}\left(l_{ap} + \mu_f \frac{l_s}{1-\mu_f \frac{h_{ap}}{l_{ap}}} \sin\alpha\right)\right]$$

$$= \frac{1}{1.5}\left[250 \cdot\ 0.3\left(3000 + 0{,}4\frac{\sqrt{(3000^2 + 2600^2)}}{1 - 0.4\,\frac{2600}{3000}} \sin 0.714\right)\right] \cdot 10^{-3} = \mathbf{229.59\ kN}$$

$$V_{c,ap,A} = \sigma_{sj,D}\, t_{ap}\, l_{cs} = 0.0468\frac{N}{mm^2} \cdot 250\ mm \cdot 1313\ mm = \mathbf{15.35\ kN \leq 68.8\ kN}$$

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Niels Pöppel

Panel B

$$V_{\text{ap,Rd,B}} = \frac{1}{\gamma_M}\left[t_{ap}\, f_{vk0}\left(l_{ap} + \mu_f \frac{l_s}{1-\mu_f \frac{h_{ap}}{l_{ap}}}\sin\alpha\right)\right]\cdot \rho_{\text{op,B}}$$

$$= \frac{1}{1{,}5}\left[250 \cdot\ 0.3\left(3750 + 0.4\frac{\sqrt{(3750^2 + 2600^2)}}{1 - 0.4\,\frac{2600}{3750}}\sin 0.606\right)\right]\cdot 10^{-3}\cdot 0.525 = \mathbf{136.13\ kN}$$

$$V_{\text{c,ap.B}} = \sigma_{sj,D}\, t_{ap}\, l_{\text{cs}} = 0.0468\frac{N}{mm^2}\cdot 250\ mm \cdot 1388\ mm = \mathbf{16.2\ kN \le 40.8\ kN}$$

Panel C

$$V_{\text{ap,Rd,C}} = \frac{1}{\gamma_M}\left[t_{ap}\, f_{vk0}\left(l_{ap} + \mu_f \frac{l_s}{1-\mu_f \frac{h_{ap}}{l_{ap}}}\sin\alpha\right)\right]\cdot \rho_{\text{op,C}}$$

$$= \frac{1}{1{,}5}\left[250 \cdot\ 0{,}3\left(3750 + 0.4\frac{\sqrt{(3750^2 + 2600^2)}}{1 - 0.4\,\frac{2600}{3750}}\sin 0.606\right)\right]\cdot 10^{-3}\cdot 0.341 = \mathbf{88.52\ kN}$$

$$V_{\text{c,ap,C}} = \sigma_{sj,D}\, t_{ap}\, l_{\text{cs}} = 0.0468\frac{N}{mm^2}\cdot 250\ mm \cdot 1388\ mm = \mathbf{16.2\ kN \le 26.6\ kN}$$

The design average stress $\sigma_{sj,D}$ of the rubber material is determined for all panels for a design drift of $d_{r,SD} = 30$ mm with $\gamma_{r,SD} = 1.0$ as experimental tests confirm that REGUPOL INODIS can accommodate drift levels exceeding 2% when properly designed [8], [9]:

$$d_{r,SD} = 30\ \text{mm} \cdot\ \gamma_{r,SD} = 30 \cdot 1.0 = 30\ mm$$

Note that interstorey drift relates to the total storey height; since the infill extends only over the clear height h_{ap}, the top displacement is proportionally reduced.

$$d_{r,SD} = \frac{30}{3000}\cdot\left(3000 - \frac{400}{2}\right) = 28\ mm$$

As REGUPOL INODIS horizontal provides sliding at top and bottom, the design interstorey drift can be reduced by 50 % for all panels:

$$d_{r,SD} = 0{,}5 \cdot 28 = 14\ mm$$

This allows the design strain ε_d to be calculated for the selected rubber thickness of 50 mm. Using this, the corresponding design stress is determined from stress-strain curve of REGUPOL INODIS vertical plus:

$$\varepsilon_d = \frac{d_{r,SD}}{t_r} = \frac{14}{50} = 0.28 \Rightarrow\ \sigma_{s,D} = 0{,}0935\ \frac{N}{mm^2}$$

The corresponding maximum stress σ_{max} is determined using the stress-displacement curve (Figure 3) of Regupol INODIS vertical plus. Assuming a linear stress distribution along the contact length, the design average stress $\sigma_{sj,D}$ can be calculated for both panels to:

$$\sigma_{sj,D} = \sigma_{max} \cdot 0{,}5 = 0{,}0935 \cdot 0{,}5 = \ 0{,}0468 \ \frac{N}{mm^2}$$

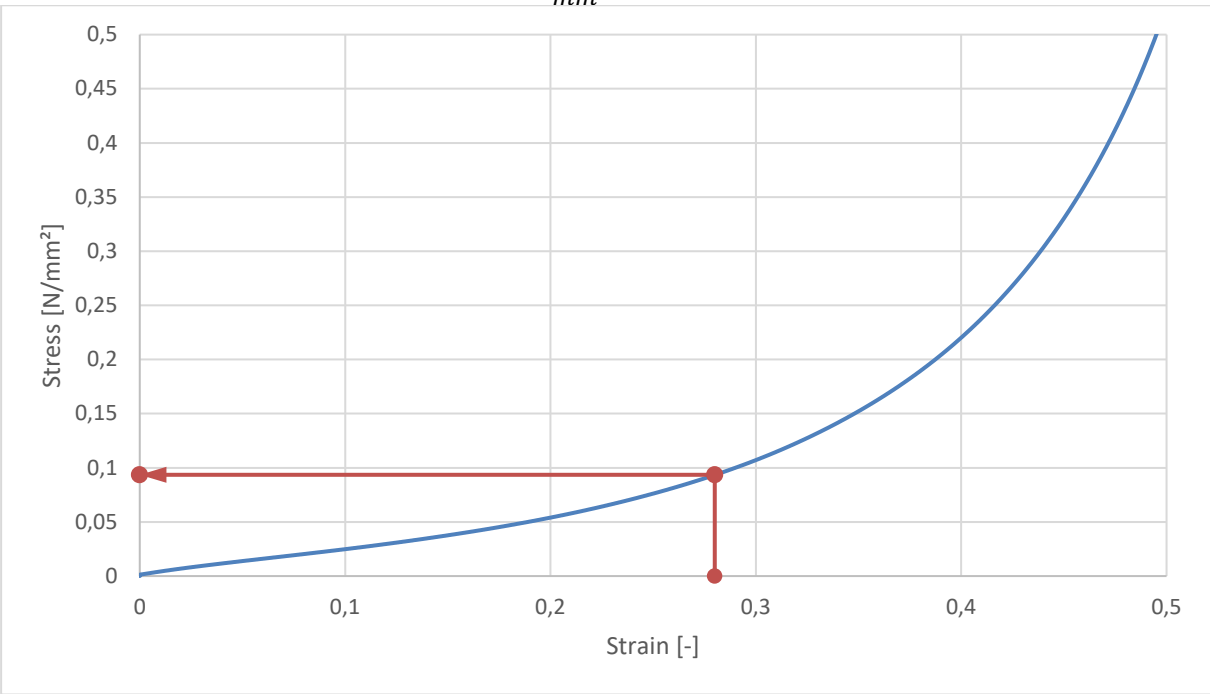


Figure 4: Stress-displacement relationship for REGUPOL INODIS vertical plus [5]

Thickness optimization and maximum allowable drifts

Table 6 summarizes the results for the maximum allowable drifts at an interstorey drift of 1%, both for optimized thicknesses and for the standard thicknesses of 25 mm and 50 mm. The drift values are rounded up to the nearest millimeter.

Table 2: Maximum allowable drifts for optimized thickness at 1%drift and for standard thicknesses of REGUPOL INODIS vertical plus

Panel	Design Scenario	Thickness	Max. allowable drift d_r	Drift Ratio Θ_r
A	Max allowable drift	25 mm	**26 mm**	0,85 %
		50 mm	**51 mm**	1,70 %
	Optimized thickness for 1 % drift	**30 mm**	30 mm	1,00 %
B	Max allowable drift	25 mm	**22 mm**	0,73 %
		50 mm	**44 mm**	1,46 %
	Optimized thickness for 1 % drift	**35 mm**	30 mm	1,00 %
C	Max allowable drift	25 mm	**18 mm**	0,63 %
		50 mm	**37 mm**	1,25 %
	Optimized thickness for 1 % drift	**40 mm**	30 mm	1,00 %

Out-of-plane verification

Design out-of-plane load

Panel A

$$f_{\mathrm{ap,d}} = \frac{\gamma_{ap}\, m_{ap}\, S_{ap}}{A_{\mathrm{N}}\, q_{ap,S}} = \frac{1.0 \cdot 0.78\frac{t}{m^3} \cdot 0.25\ m \cdot 2.6\ m \cdot 3.75\ m \cdot 11.0\ m/s^2}{2.6\ m \cdot 3.0\ m \cdot 1.3} = 1.65\ kN/m^2$$

Panel B

$$f_{\mathrm{ap,d}} = \frac{\gamma_{ap}\, m_{ap}\, S_{ap}}{A_{\mathrm{N}}\, q_{ap,S}} = \frac{1.0 \cdot 0.78\frac{t}{m^3} \cdot 0.25\ m \cdot (2.6\ m \cdot 3.75\ m - 1.0 \cdot 1.7) \cdot 11.0\ m/s^2}{(2.6\ m \cdot 3.75\ m - 1.0\ m \cdot 1.7\ m) \cdot 1.3} = 1.65\ kN/m^2$$

Panel C

$$f_{\mathrm{ap,d}} = \frac{\gamma_{ap}\, m_{ap}\, S_{ap}}{A_{\mathrm{N}}\, q_{ap,S}} = \frac{1.0 \cdot 0.78\frac{t}{m^3} \cdot 0.25\ m \cdot (2.6\ m \cdot 3.75\ m - 1.0 \cdot 2.3 - 0.8 \cdot 0.5\ m) \cdot 11.0\ m/s^2}{(2.6\ m \cdot 3.75\ m - 1.0 \cdot 2.3\ m - 0.8 \cdot 0.5\ m) \cdot 1.3} = 1.65\ kN/m^2$$

Out-of-plane resistance

The out-plane resistance is calculated using the arching effect in vertical direction only. The reduction factor for the interaction between in-plane and out-of-plane action effects is considered with $R_{ipoop} = 1.0$ for non-interacting infills.

Panel A, B, C

$$q_{lat,d} = F_M\, f_d \frac{(0.9\ t_{ap} - d_a)\ t_{ap}}{h_{ap}^2} R_{ipoop} = 0.8\ \frac{4{,}52\ N/mm^2}{1{,}5}\ \frac{(0.9 \cdot 250\ \mathrm{mm} - 0) \cdot 250\ mm}{2600^2\ mm^2} 1.0 = 20.06\frac{kN}{m^2}$$

Out-of-plane verification

Panel A

$A_{arching} = 2.6\ m \cdot 3.0\ m = 7.8\ m^2$ $A_N = 2.6\ m \cdot 3.0\ m = 7.8\ m^2$ $\frac{A_{arching}}{A_N} = 1.0$

$$\boldsymbol{q_{lat,d} = 20.06\frac{kN}{m^2} \geq f_{\mathrm{ap,d}} = 1.65\frac{kN}{m^2}}$$

Panel B

$A_N = 2.6\ m \cdot 3.75\ m - 1.0\ m \cdot 1.7\ m = 8.05\ m^2$ $A_{arching} = 2.6\ m \cdot 3.75\ m - 1.0 \cdot 2.6\ m = 7.15\ m^2$

$$\frac{A_{arching}}{A_N} = 0.89$$

$$\boldsymbol{q_{lat,d} = 20.06\frac{kN}{m^2} \cdot 0.89 = 17{,}82\ \frac{kN}{m^2} \geq f_{\mathrm{ap,d}} = 1.65\frac{kN}{m^2}}$$

Panel C

$A_N = 2.6\ m \cdot 3.75\ m - 1.0\ m\ \cdot 2.3\ m - 0.8\ m\ \cdot 0.5\ m = 7.05\ m^2$
$A_{arching} = 2.6\ m \cdot 3.75\ m - 1.0 \cdot 2.6\ m - 0.8 \cdot 2.6\ m = 5.07\ m^2$
$\frac{A_{arching}}{A_N} = 0.72$

$$q_{lat,d} = 20.06 \frac{kN}{m^2} \cdot 0.72 = 14.43\ \frac{kN}{m^2} \geq f_{\mathrm{ap,d}} = 1.65 \frac{kN}{m^2}$$

Verification of the rubber connection

Panel A

$F_{\mathrm{Con,d}} = f_{\mathrm{ap,d}}\ A_{\mathrm{N}} = 1.65 \frac{kN}{m^2} \cdot 2.6\ m \cdot 3.0\ m = 12.87\ kN$
Total length with arching effect: $l_{\mathrm{arching}} = 3.0\ m$

$$F_{Con,Rd} = \frac{F_{\mathrm{Con}}}{\gamma_{\mathrm{M}}} = \frac{58.3 \frac{kN}{m}}{1.5} = 38.87 \frac{kN}{m} \geq F_{Con,d} = \frac{12.87\ kN}{2 \cdot 3.0\ m} = 1.98 \frac{kN}{m}$$

Panel B

$F_{\mathrm{ap,d}} = f_{\mathrm{ap,d}}\ A_{\mathrm{N}} = 1.65 \frac{kN}{m^2} \cdot (2.6\ m \cdot 3.75\ m - 1.0\ m \cdot 1.7\ m) = 13.28\ kN$
Total length with arching effect: $l_{\mathrm{arching}} = 2.75\ m$

$$F_{Con,Rd} = \frac{F_{\mathrm{Con}}}{\gamma_{\mathrm{M}}} = \frac{58.3 \frac{kN}{m}}{1.5} = 38.87\ \frac{kN}{m} \geq F_{\mathrm{Con,d}} = \frac{13.28\ kN}{2 \cdot 2.75\ m} = 2.41 \frac{kN}{m}$$

Panel C

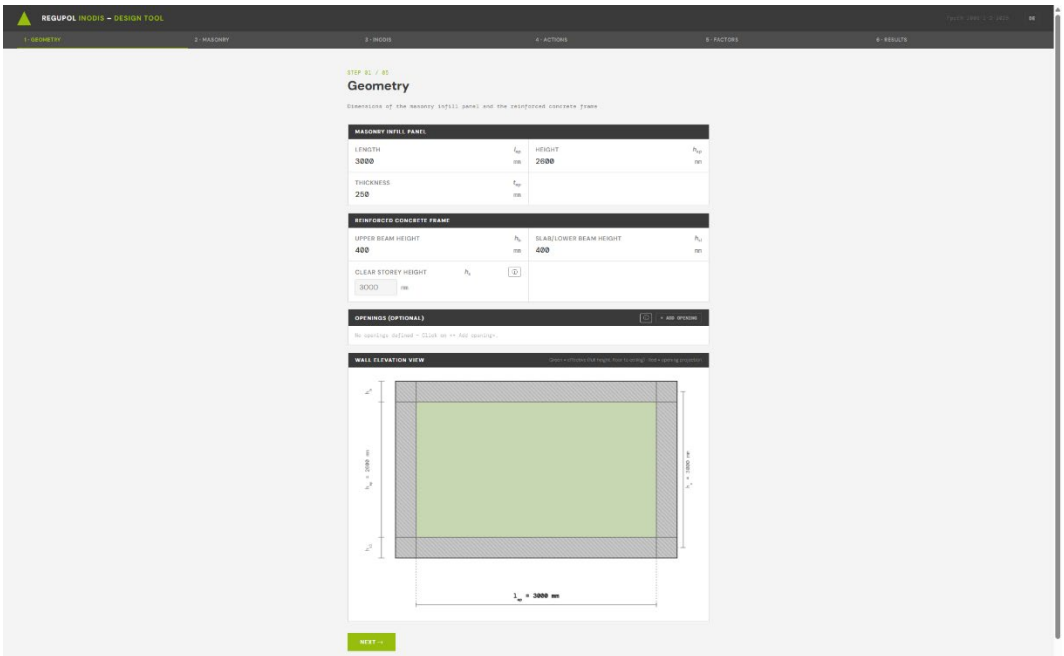
$F_{\mathrm{ap,d}} = f_{\mathrm{ap,d}}\ A_{\mathrm{N}} = 1.65 \frac{kN}{m^2} \cdot (2.6\ m \cdot 3.75\ m - 1.0\ m \cdot 2.6\ m - 0.8\ m \cdot 0.5\ m) = 11{,}63\ kN$
Total length with arching effect: $l_{\mathrm{arching}} = 2.75\ m$

$$F_{Con,Rd} = \frac{F_{\mathrm{Con}}}{\gamma_{\mathrm{M}}} = \frac{58.3 \frac{kN}{m}}{1.5} = 38.87 \frac{kN}{m} \geq F_{Con,d} = \frac{11.63\ kN}{2 \cdot 1.95\ m} = 2.98 \frac{kN}{m}$$

Application: Web-based design tool

In the following the three infill panels A, B and C are designed with the web-based tool REGUPOL INODIS – WEB Design. The web-based design tool is available on the INODIS website (https://inodis.regupol.com/).

Annex 1: Infill Panel A



STEP 01 / 05

Geometry

Dimensions of the masonry infill panel and the reinforced concrete frame

MASONRY INFILL PANEL

LENGTH l_{ap} 3000 mm	HEIGHT h_{ap} 2600 mm
THICKNESS t_{ap} 250 mm	

REINFORCED CONCRETE FRAME

UPPER BEAM HEIGHT h_b 400 mm	SLAB/LOWER BEAM HEIGHT h_{sl} 400 mm
CLEAR STOREY HEIGHT h_s 3000 mm	

OPENINGS (OPTIONAL) + ADD OPENING

No openings defined - Click on «+ Add opening».

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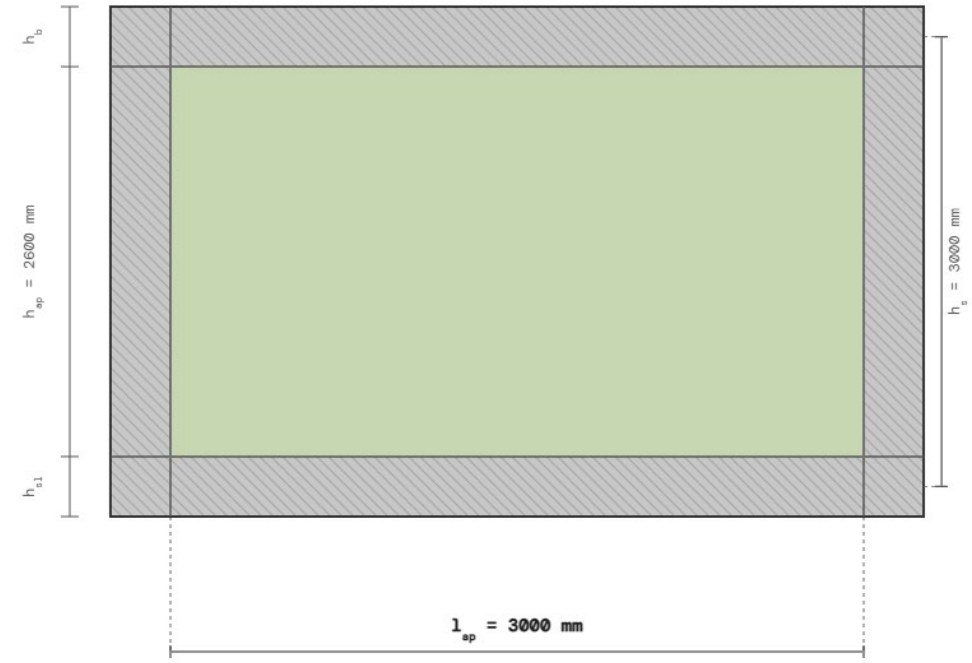
REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

WALL ELEVATION VIEW

Green = effective (full height, floor to ceiling) · Red = opening projection



NEXT →

STEP 02 / 05

Masonry

Strength and material properties

STRENGTH VALUES

CHARACTERISTIC INITIAL SHEAR STRENGTH (EN 1996-1-1-2005) f_{vk0}	CHARACTERISTIC COMPRESSIVE STRENGTH f_k
0,30 N/mm²	4,52 N/mm²

MATERIAL PROPERTIES

FRICTION COEFFICIENT μ_f	DENSITY OF INFILL ρ_d
0,40 –	780 kg/m³

MORTAR TYPE

MORTAR TYPE

(●) Thin-bed mortar ( ) Standard mortar

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REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel, Niels Pöppel

STEP 03 / 05

REGUPOL INODIS

Product selection and rubber properties

PRODUCT SELECTION

REGUPOL VERTICAL PRODUCT

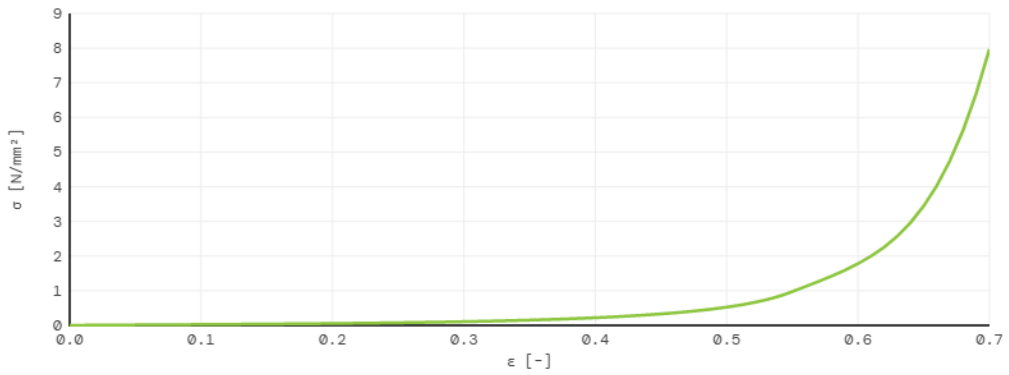
○ REGUPOL vertical ◉ REGUPOL vertical plus

RUBBER THICKNESS REGUPOL VERTICAL (PLUS)

THICKNESS t_r

50 mm

STRESS–STRAIN CURVE · REGUPOL VERTICAL PLUS



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General Partner:
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Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

STEP 04 / 05

Seismic Actions

Floor acceleration spectrum and relative interstorey displacement

FLOOR ACCELERATION SPECTRUM

FLOOR ACCELERATION S_{ap}

11,0 m/s²

Calculation according to FprEN 1998-1-2, section 7.2.1 / EN 1998-2004, section 4.3.5.2

RELATIVE INTERSTOREY DISPLACEMENT AND BEHAVIOUR FACTOR

RELATIVE INTERSTOREY DISPLACEMENT d_r

30 mm

BEHAVIOR FACTOR INFILL PANEL $q_{ap,S}$

1,3 –

Calculation according to FprEN 1998-1-2, section 7.2.1 / EN 1998-2004, section 4.3.5.2

ARCH DEFLECTION d_a

0 mm

= 0 if h_ap / t_ap ≤ 20 according to EN 1996-1-1-2005

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REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel, Niels Pöppel

STEP 05 / 05

Design Factors

PARTIAL AND PERFORMANCE FACTORS

PARTIAL SAFETY FACTOR γ_M 1,5 –	PERFORMANCE FACTOR γ_{ap} 1,0 –
FACTOR F_M ⓘ 0,8 – F_M = 1.2 for Group 1 masonry units; F_M = 0.8 for lightweight aggregate and autoclaved aerated concrete masonry units of Group 1 or other groups (EN 1996-1-1-2025, 8.4.3)	AMPLIFICATION FACTOR $\gamma_{r,SD}$ ⓘ 1,0 – $\gamma_{r,SD}$ = 1.0 as tests confirmed that REGUPOL INODIS can accommodate drift levels exceeding 2% when properly designed.
REDUCTION FACTOR R_{ipoop} ⓘ 1,0 – = 1.0 for non-interacting infills according to FprEN 1998-1-2-2025	

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REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel, Niels Pöppel

6 · RESULTS

Verification Results

FprEN 1998-1-2-2025 · REGUPOL INODIS

All verifications passed
The masonry infill panel is designed for the specified actions.

✓ IN-PLANE VERIFICATION · FprEN 1998-1-2-2025, 7.4.3.2

$\eta = V_{c,ap} / (0.3 \cdot V_{ap,Rd})$ — **0.223 ≤ 1**

DESIGN SHEAR RESISTANCE OF INFILL PANEL $V_{ap,Rd}$ 229.59 kN	DESIGN SHEAR FORCE TRANSFERRED FROM COLUMN $V_{c,ap}$ 15.33 kN
COMPRESSIVE STRAIN IN REGUPOL VERTICAL PLUS ε_d 0.28 -	DESIGN STRESS OF REGUPOL VERTICAL PLUS $\sigma_{x,D}$ 0.09 N/mm²
MAX. ALLOWABLE INTERSTOREY DISPLACEMENT $d_{r,apt}(t_r=50mm)$ 51.10 mm	OPTIMAL INODIS VERTICAL THICKNESS $t_{r,apt}$ 29.4 mm

✓ OUT-OF-PLANE VERIFICATION · FprEN 1998-1-2-2025, 7.4.3.3

COMPRESSION STRUT VERIFICATION

$\eta = f_{ap,d} / q_{1st,d}$ — **0.082 ≤ 1**

DESIGN HORIZONTAL SEISMIC FORCE $F_{ap,d}$ 12.87 kN	DESIGN OUT-OF-PLANE LOAD PER UNIT AREA $f_{ap,d}$ 1.65 kN/m²
DESIGN OUT-OF-PLANE RESISTANCE PER UNIT AREA $q_{1st,d}$ 20.06 kN/m²	DESIGN COMPRESSIVE STRENGTH OF MASONRY f_d 3.01 N/mm²

REGUPOL INODIS HORIZONTAL – CONNECTION VERIFICATION

$\eta = F_{Con,d} / F_{Con,Rd}$ — **0.055 ≤ 1**

DESIGN FORCE PER RUNNING METRE $F_{Con,d}$
2.15 kN/m

DESIGN RESISTANCE PER RUNNING METRE $F_{Con,Rd}$

Based on connections tests for different masonry types (Institut für Ziegelforschung e.V. (IZF), Am Zehnthof 197, 45307 Essen: Anschlusstests für das Entkopplungssystem INODIS, 2025).

38.87 kN/m

INTERMEDIATE VALUES

l_{cs} 1313.3 mm Contact length of compression strut	θ_r 1.00 % Design drift ratio
TOP DISPLACEMENT u_{top} 28.0 mm	REDUCED TOP DISPLACEMENT $0{,}5{\cdot}u_{top}$ 14.0 mm
REDUCTION FACTOR ρ_{op} 1.00 -	ANGLE OF INFILL PANEL DIAGONAL α 40.91 °

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Head Office: Bad Berleburg
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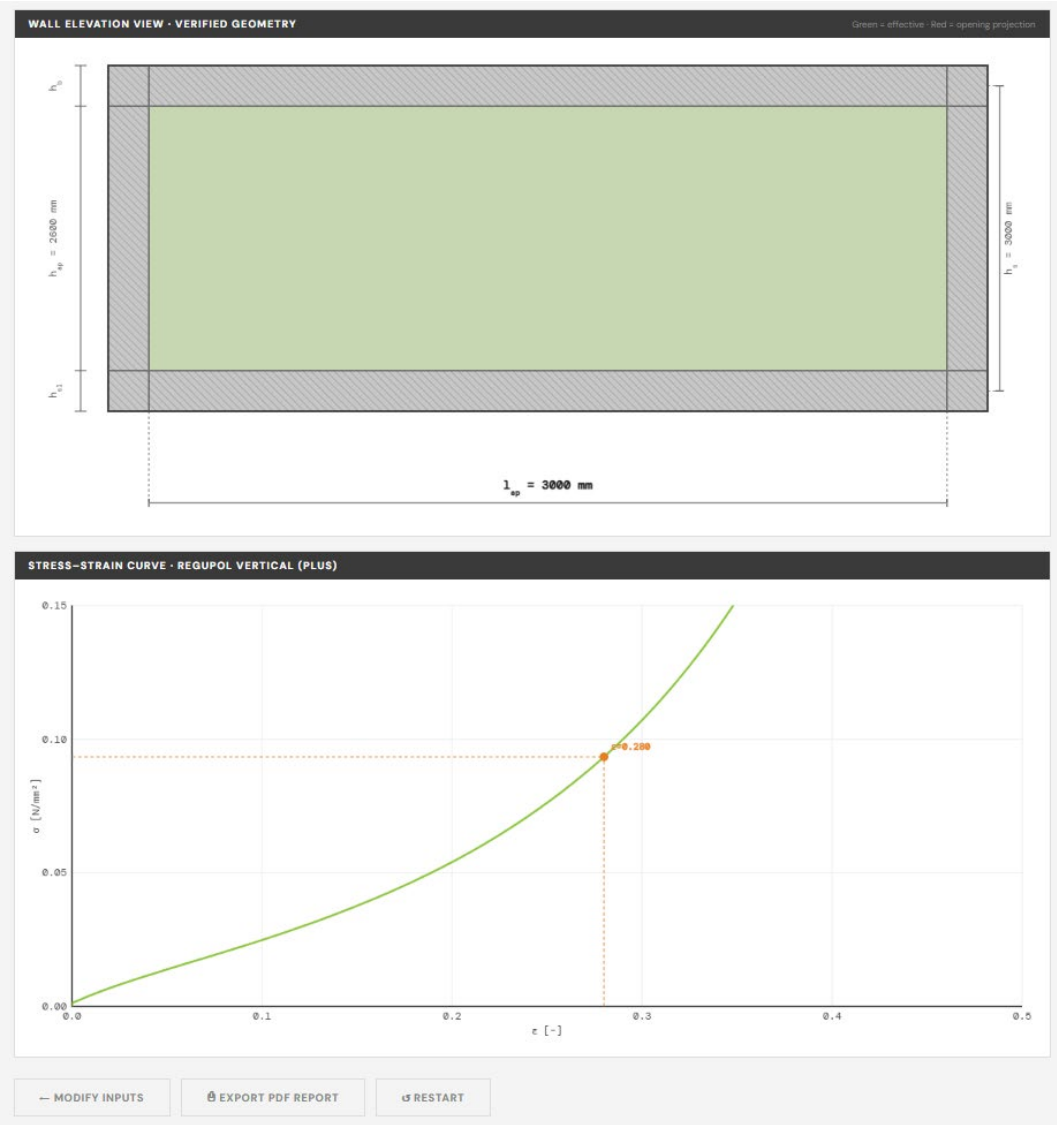
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel, Niels Pöppel



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Head Office: Bad Berleburg
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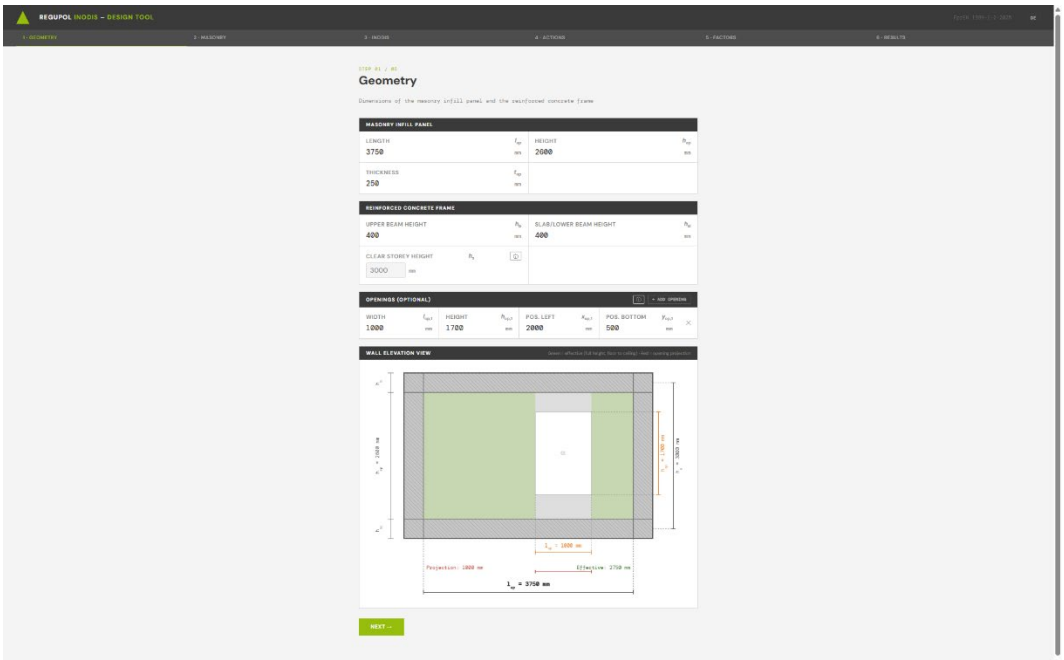
phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

Annex 2: Infill Panel B



STEP 01 / 05

Geometry

Dimensions of the masonry infill panel and the reinforced concrete frame

MASONRY INFILL PANEL

LENGTH l_{ap} 3750 mm	HEIGHT h_{ap} 2600 mm
THICKNESS t_{ap} 250 mm	

REINFORCED CONCRETE FRAME

UPPER BEAM HEIGHT h_b 400 mm	SLAB/LOWER BEAM HEIGHT h_{sl} 400 mm
CLEAR STOREY HEIGHT h_s 3000 mm	

OPENINGS (OPTIONAL) + ADD OPENING

WIDTH $l_{op,1}$	HEIGHT $h_{op,1}$	POS. LEFT $x_{op,1}$	POS. BOTTOM $y_{op,1}$
1000 mm	1700 mm	2000 mm	500 mm

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Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

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Head Office: Bad Berleburg
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phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

STEP 02 / 05

Masonry

Strength and material properties

STRENGTH VALUES

CHARACTERISTIC INITIAL SHEAR STRENGTH (EN 1996-1-1-2005) f_{vk0}	CHARACTERISTIC COMPRESSIVE STRENGTH f_k
0,30 N/mm²	4,52 N/mm²

MATERIAL PROPERTIES

FRICTION COEFFICIENT μ_f	DENSITY OF INFILL ρ_d
0,40 -	780 kg/m³

MASONRY AND MORTAR TYPE

MORTAR TYPE

(●) Thin-bed mortar ( ) Standard mortar

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info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

STEP 03 / 05

REGUPOL INODIS

Product selection and rubber properties

PRODUCT SELECTION

REGUPOL VERTICAL PRODUCT

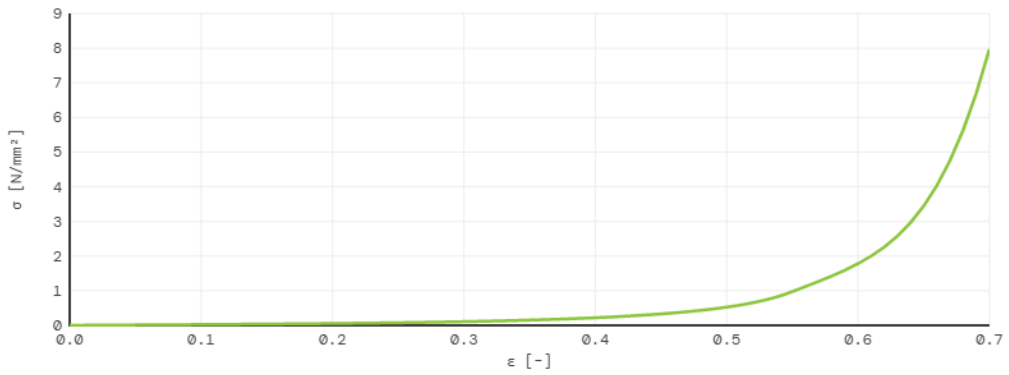
○ REGUPOL vertical ◉ REGUPOL vertical plus

RUBBER THICKNESS REGUPOL VERTICAL (PLUS)

THICKNESS t_r

50 mm

STRESS–STRAIN CURVE · REGUPOL VERTICAL PLUS



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REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

STEP 04 / 05

Seismic Actions

Floor acceleration spectrum and relative interstorey displacement

FLOOR ACCELERATION SPECTRUM

FLOOR ACCELERATION S_{ap}

11,0 m/s²

Calculation according to FprEN 1998-1-2, section 7.2.1 / EN 1998-2004, section 4.3.5.2

RELATIVE INTERSTOREY DISPLACEMENT AND BEHAVIOUR FACTOR

RELATIVE INTERSTOREY DISPLACEMENT d_r

30 mm

BEHAVIOR FACTOR INFILL PANEL $q_{ap,S}$

1,3 –

Calculation according to FprEN 1998-1-2, section 7.2.1 / EN 1998-2004, section 4.3.5.2

ARCH DEFLECTION d_a

0 mm

= 0 if h_ap / t_ap ≤ 20 according to EN 1996-1-1-2005

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REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel, Niels Pöppel

STEP 05 / 05

Design Factors

PARTIAL AND PERFORMANCE FACTORS

PARTIAL SAFETY FACTOR γ_M 1,5 –	PERFORMANCE FACTOR γ_{ap} 1,0 –
FACTOR F_M ⓘ 0,8 – F_M = 1.2 for Group 1 masonry units; F_M = 0.8 for lightweight aggregate and autoclaved aerated concrete masonry units of Group 1 or other groups (EN 1996-1-1-2025, 8.4.3)	AMPLIFICATION FACTOR $\gamma_{r,SD}$ ⓘ 1,0 – $\gamma_{r,SD}$ = 1.0 as tests confirmed that REGUPOL INODIS can accommodate drift levels exceeding 2% when properly designed.
REDUCTION FACTOR R_{ipoop} ⓘ 1,0 – = 1.0 for non-interacting infills according to FprEN 1998-1-2-2025	

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Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel, Niels Pöppel

6 · RESULTS

Verification Results

FprEN 1998-1-2-2025 · REGUPOL INODIS

All verifications passed
The masonry infill panel is designed for the specified actions.

IN-PLANE VERIFICATION · FprEN 1998-1-2-2025, 7.4.3.2

$\eta = V_{c,ap} / (0.3 \cdot V_{ap,Rd})$ — 0.397 ≤ 1

DESIGN SHEAR RESISTANCE OF INFILL PANEL $V_{ap,Rd}$ — 136.13 kN	DESIGN SHEAR FORCE TRANSFERRED FROM COLUMN $V_{c,ap}$ — 16.20 kN
COMPRESSIVE STRAIN IN REGUPOL VERTICAL PLUS ε_d — 0.28 -	DESIGN STRESS OF REGUPOL VERTICAL PLUS $\sigma_{A,D}$ — 0.09 N/mm²
MAX. ALLOWABLE INTERSTOREY DISPLACEMENT $d_{r,opt}$ (t_r =50mm) — 43.78 mm	OPTIMAL INODIS VERTICAL THICKNESS $t_{r,opt}$ — 34.3 mm

OUT-OF-PLANE VERIFICATION · FprEN 1998-1-2-2025, 7.4.3.3

COMPRESSION STRUT VERIFICATION

$\eta = f_{ap,d} / q_{lat,d}$ — 0.093 ≤ 1

DESIGN HORIZONTAL SEISMIC FORCE $F_{ap,d}$ — 13.28 kN	DESIGN OUT-OF-PLANE LOAD PER UNIT AREA $f_{ap,d}$ — 1.65 kN/m²
DESIGN OUT-OF-PLANE RESISTANCE PER UNIT AREA $q_{lat,d}$ — 17.82 kN/m²	DESIGN COMPRESSIVE STRENGTH OF MASONRY f_d — 3.01 N/mm²

REGUPOL INODIS HORIZONTAL – CONNECTION VERIFICATION

$\eta = F_{Con,d} / F_{Con,Rd}$ — 0.062 ≤ 1

DESIGN FORCE PER RUNNING METRE $F_{Con,d}$ — 2.42 kN/m

DESIGN RESISTANCE PER RUNNING METRE $F_{Con,Rd}$ — 38.87 kN/m

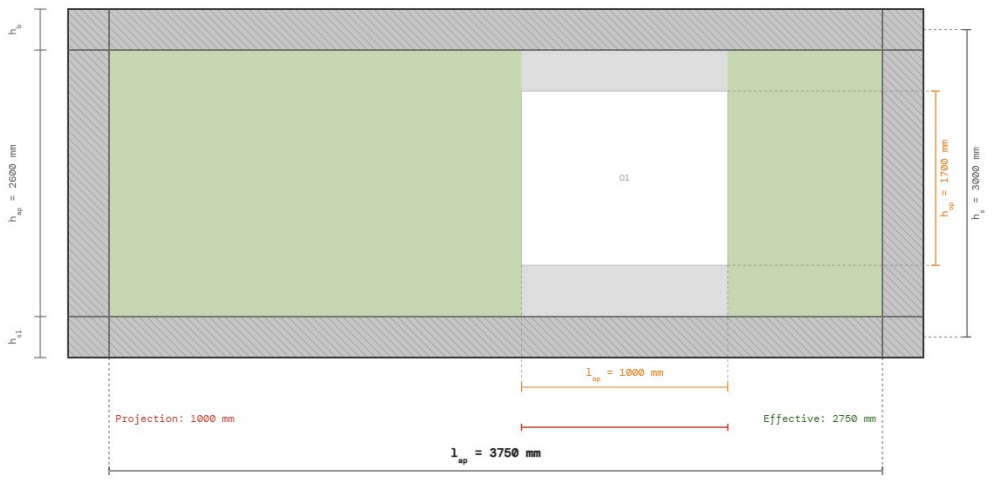
Based on connections tests for different masonry types (Institut für Ziegelforschung e.V. (IZF), Am Zehnthof 197, 45307 Essen: Anschlusstests für das Entkopplungssystem INODIS, 2025).

INTERMEDIATE VALUES

l_{cs} — 1388.2 mm — Contact length of compression strut	θ_r — 1.00 % — Design drift ratio
TOP DISPLACEMENT u_{top} — 28.0 mm	REDUCED TOP DISPLACEMENT $0{,}5 \cdot u_{top}$ — 14.0 mm
REDUCTION FACTOR ρ_{op} — 0.52 -	ANGLE OF INFILL PANEL DIAGONAL α — 34.73 °

WALL ELEVATION VIEW · VERIFIED GEOMETRY

Green = effective · Red = opening projection



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General Partner:
REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

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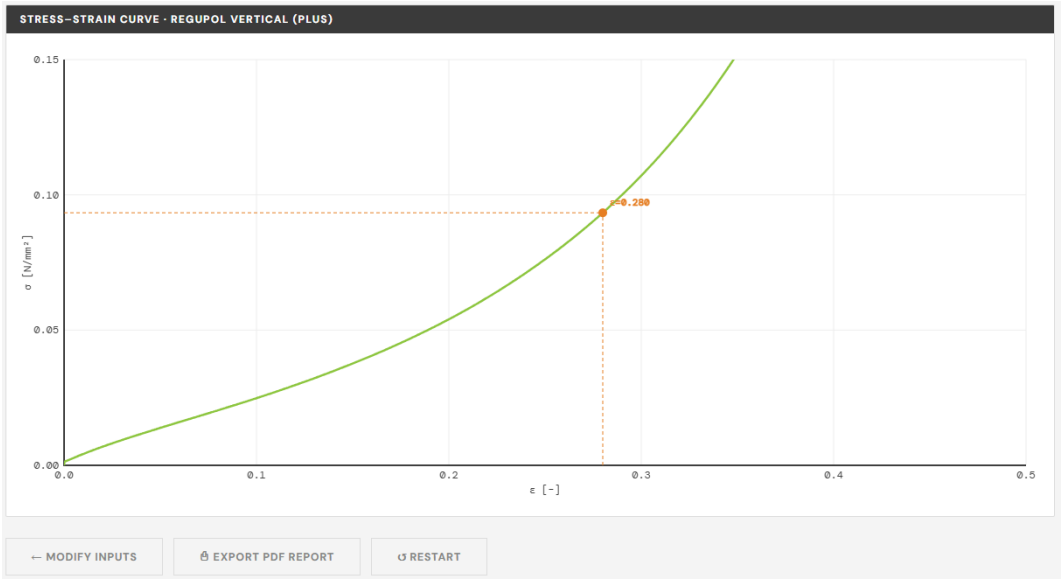
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel, Niels Pöppel



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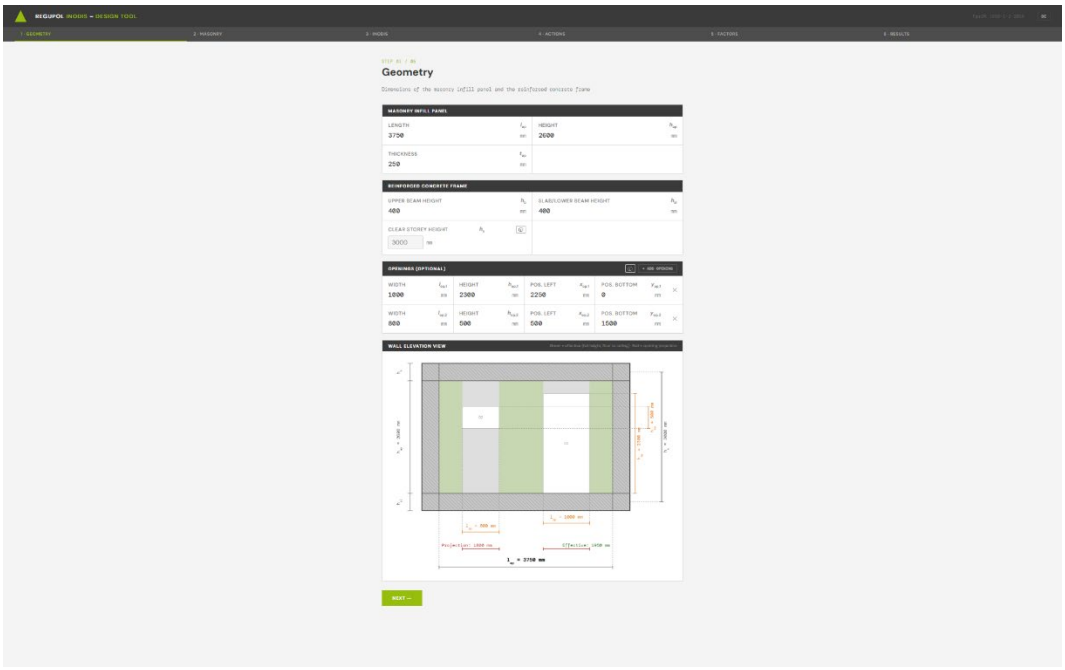
REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

Annex 3: Infill Panel C



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REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
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phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

STEP 01 / 05

Geometry

Dimensions of the masonry infill panel and the reinforced concrete frame

MASONRY INFILL PANEL

LENGTH l_{ap} 3750 mm	HEIGHT h_{ap} 2600 mm
THICKNESS t_{ap} 250 mm	

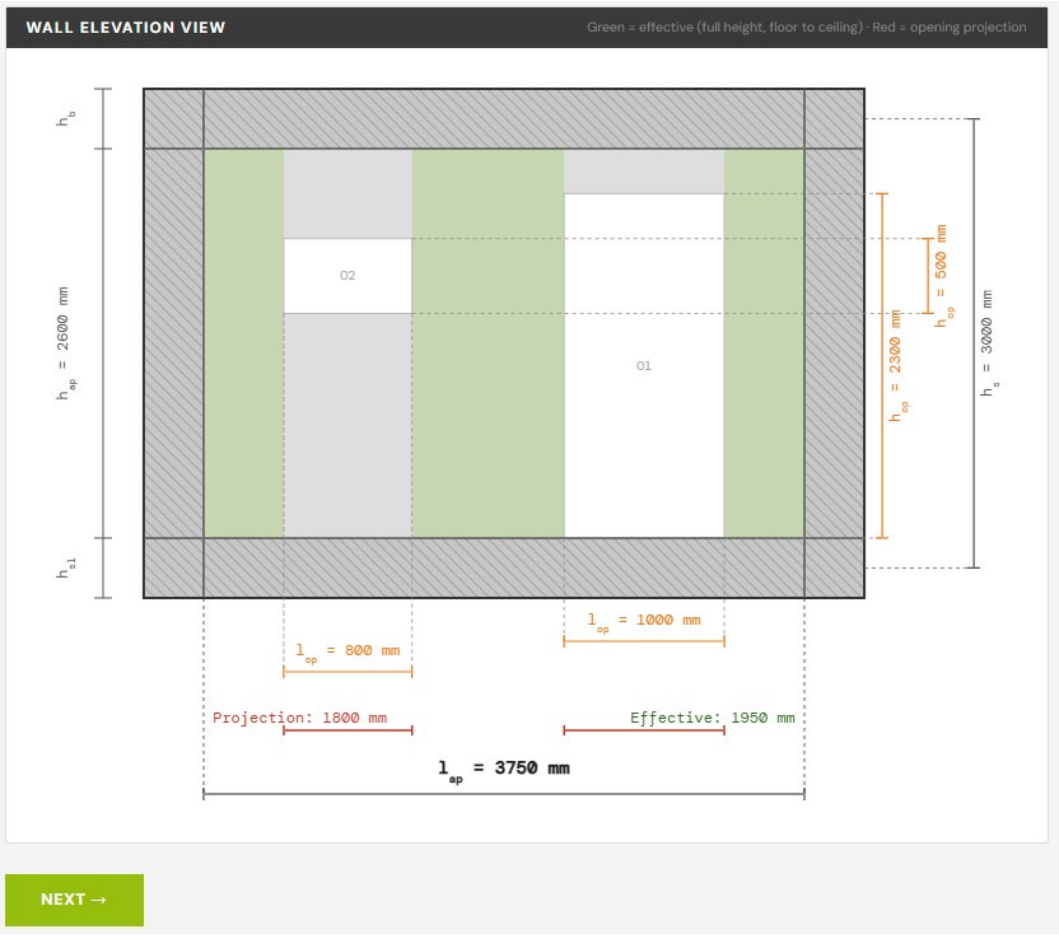
REINFORCED CONCRETE FRAME

UPPER BEAM HEIGHT h_b 400 mm	SLAB/LOWER BEAM HEIGHT h_{sl} 400 mm
CLEAR STOREY HEIGHT h_s ⓘ 3000 mm	

OPENINGS (OPTIONAL)

ⓘ + ADD OPENING

WIDTH	HEIGHT	POS. LEFT	POS. BOTTOM	
$l_{op,1}$ 1000 mm	$h_{op,1}$ 2300 mm	$x_{op,1}$ 2250 mm	$y_{op,1}$ 0 mm	×
$l_{op,2}$ 800 mm	$h_{op,2}$ 500 mm	$x_{op,2}$ 500 mm	$y_{op,2}$ 1500 mm	×



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phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

STEP 02 / 05

Masonry

Strength and material properties

STRENGTH VALUES

CHARACTERISTIC INITIAL SHEAR STRENGTH (EN 1996-1-1-2005) f_{vk0}	CHARACTERISTIC COMPRESSIVE STRENGTH f_k
0,30 N/mm²	4,52 N/mm²

MATERIAL PROPERTIES

FRICTION COEFFICIENT μ_f	DENSITY OF INFILL ρ_d
0,40 -	780 kg/m³

MASONRY AND MORTAR TYPE

MORTAR TYPE

(●) Thin-bed mortar ( ) Standard mortar

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REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
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phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

STEP 03 / 05

REGUPOL INODIS

Product selection and rubber properties

PRODUCT SELECTION

REGUPOL VERTICAL PRODUCT

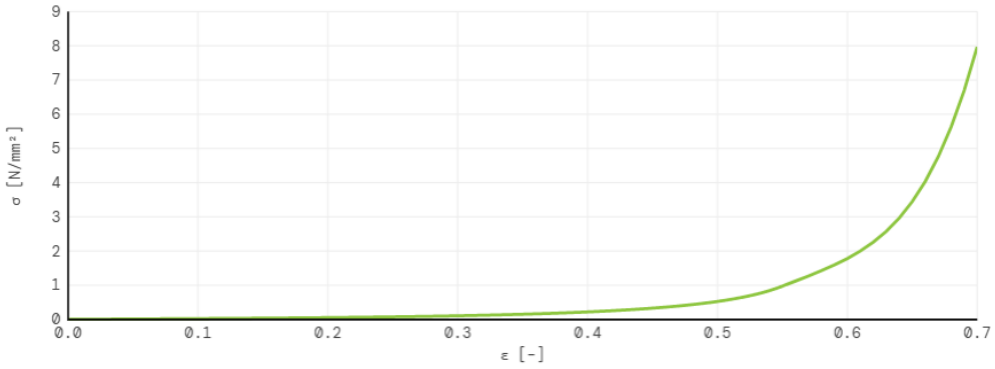
○ REGUPOL vertical ◉ REGUPOL vertical plus

RUBBER THICKNESS REGUPOL VERTICAL (PLUS)

THICKNESS t_r

50 mm

STRESS–STRAIN CURVE · REGUPOL VERTICAL PLUS



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Siegen District Court, HRA 9854
VAT ID no.: DE 360 723 882

Deutsche Bank
IBAN DE82 4607 0090 0362 0259 00
BIC DEUTDEDK460

General Partner:
REGUPOL Germany Verwaltungs GmbH
Head Office: Bad Berleburg
Siegen District Court, HRB 13420

phone +49 2751 803-0
info@regupol.de
www.regupol.com

Managing directors:
Jost Sebastian Pöppel, Sven Christian Pöppel,
Niels Pöppel

STEP 04 / 05

Seismic Actions

Floor acceleration spectrum and relative interstorey displacement

FLOOR ACCELERATION SPECTRUM

FLOOR ACCELERATION S_{ap}

11,0 m/s²

Calculation according to FprEN 1998-1-2, section 7.2.1 / EN 1998-2004, section 4.3.5.2

RELATIVE INTERSTOREY DISPLACEMENT AND BEHAVIOUR FACTOR

RELATIVE INTERSTOREY DISPLACEMENT d_r

30 mm

BEHAVIOR FACTOR INFILL PANEL $q_{ap,S}$

1,3 –

Calculation according to FprEN 1998-1-2, section 7.2.1 / EN 1998-2004, section 4.3.5.2

ARCH DEFLECTION d_a

0 mm

= 0 if h_ap / t_ap ≤ 20 according to EN 1996-1-1-2005

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STEP 05 / 05

Design Factors

PARTIAL AND PERFORMANCE FACTORS

PARTIAL SAFETY FACTOR γ_M 1,5 –	PERFORMANCE FACTOR γ_{ap} 1,0 –
FACTOR F_M ⓘ 0,8 – F_M = 1.2 for Group 1 masonry units; F_M = 0.8 for lightweight aggregate and autoclaved aerated concrete masonry units of Group 1 or other groups (EN 1996-1-1-2025, 8.4.3)	AMPLIFICATION FACTOR $\gamma_{r,SD}$ ⓘ 1,0 – $\gamma_{r,SD}$ = 1.0 as tests confirmed that REGUPOL INODIS can accommodate drift levels exceeding 2% when properly designed.
REDUCTION FACTOR R_{ipoop} ⓘ 1,0 – = 1.0 for non-interacting infills according to FprEN 1998-1-2-2025	

← BACK | RUN VERIFICATION ▶

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6 · RESULTS

Verification Results

FprEN 1998-1-2-2025 · REGUPOL INODIS

All verifications passed
The masonry infill panel is designed for the specified actions.

IN-PLANE VERIFICATION · FprEN 1998-1-2-2025, 7.4.3.2

$\eta = V_{c,ap} / (0.3 \cdot V_{ap,Rd})$ — **0.610 ≤ 1**

DESIGN SHEAR RESISTANCE OF INFILL PANEL $V_{ap,Rd}$: 88.52 kN	DESIGN SHEAR FORCE TRANSFERRED FROM COLUMN $V_{c,ap}$: 16.20 kN
COMPRESSIVE STRAIN IN REGUPOL VERTICAL PLUS ε_d: 0.28 -	DESIGN STRESS OF REGUPOL VERTICAL PLUS $\sigma_{a,D}$: 0.09 N/mm²
MAX. ALLOWABLE INTERSTOREY DISPLACEMENT $d_{r,capt}(t_r=50mm)$: 37.59 mm	OPTIMAL INODIS VERTICAL THICKNESS $t_{r,opt}$: 39.9 mm

OUT-OF-PLANE VERIFICATION · FprEN 1998-1-2-2025, 7.4.3.3

COMPRESSION STRUT VERIFICATION

$\eta = f_{ap,d} / q_{lat,d}$ — **0.114 ≤ 1**

DESIGN HORIZONTAL SEISMIC FORCE $F_{ap,d}$: 11.63 kN	DESIGN OUT-OF-PLANE LOAD PER UNIT AREA $f_{ap,d}$: 1.65 kN/m²
DESIGN OUT-OF-PLANE RESISTANCE PER UNIT AREA $q_{lat,d}$: 14.43 kN/m²	DESIGN COMPRESSIVE STRENGTH OF MASONRY f_d: 3.01 N/mm²

REGUPOL INODIS HORIZONTAL – CONNECTION VERIFICATION

$\eta = F_{Con,d} / F_{Con,Rd}$ — **0.077 ≤ 1**

DESIGN FORCE PER RUNNING METRE $F_{Con,d}$: 2.98 kN/m

DESIGN RESISTANCE PER RUNNING METRE $F_{Con,Rd}$

Based on connections tests for different masonry types (Institut für Ziegelforschung e.V. (IZF), Am Zehnthof 197, 45307 Essen: Anschlusstests für das Entkopplungssystem INODIS, 2025).

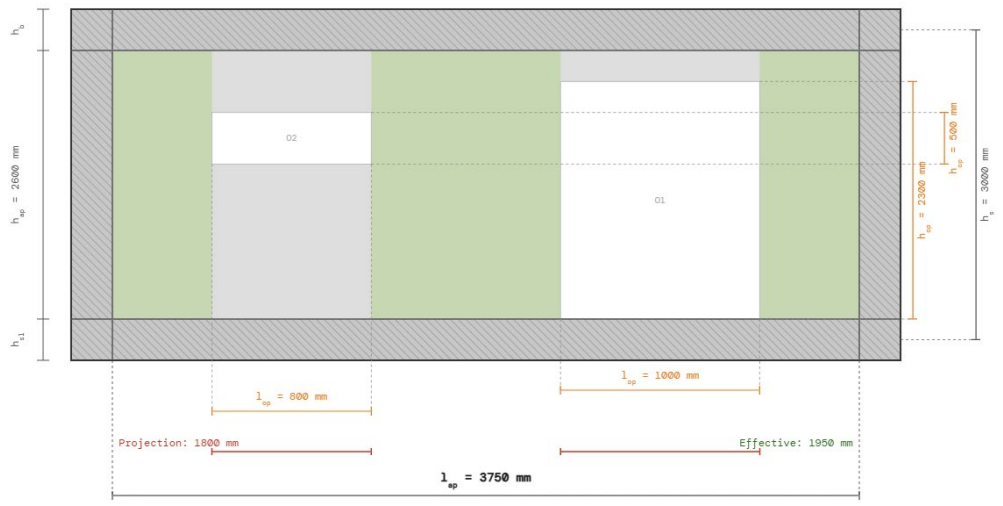
38.87 kN/m

INTERMEDIATE VALUES

l_{cs}: 1388.2 mm — Contact length of compression strut	θ_r: 1.00 % — Design drift ratio
TOP DISPLACEMENT u_{top}: 28.0 mm	REDUCED TOP DISPLACEMENT $0{,}5{\cdot}u_{top}$: 14.0 mm
REDUCTION FACTOR ρ_{op}: 0.34 -	ANGLE OF INFILL PANEL DIAGONAL α: 34.73 °

WALL ELEVATION VIEW · VERIFIED GEOMETRY

Green = effective · Red = opening projection



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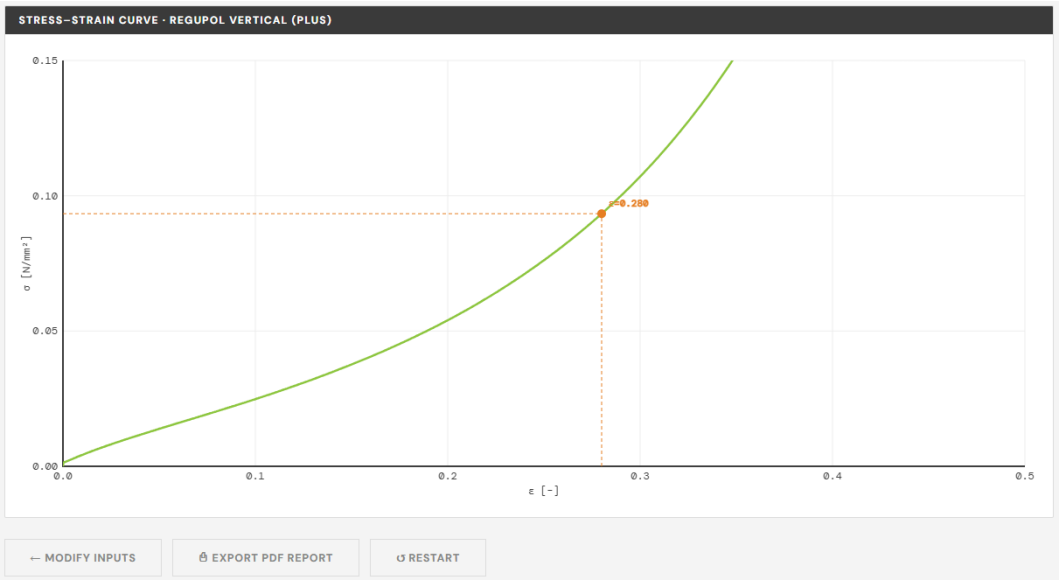

Literature

[1] FprEN 1998-1-1, Eurocode 8: Design of structures for earthquake resistance – Part 1-1: General rules and seismic action, CEN/TC 250, 2024.

[2] FprEN 1998-1-2, Eurocode 8: Design of structures for earthquake resistance – Part 1-2: Seismic actions on buildings, CEN/TC 250, 2025.

[3] EN 1998-1, Eurocode 8:

[4] EN 1996-1-1, Eurocode 6: Design of masonry structures – Part 1-1: General rules for reinforced and unreinforced masonry structures, European Committee for Standardization, 2005.

[5] Institut für Ziegelforschung e.V. (IZF), Am Zehnthof 197, 45307 Essen: Anschlusstests für das Entkopplungssystem REGUPOL INODIS, 2025.

[6] REGUPOL Germany GmbH & Co. KG, “REGUPOL INODIS: Seismic resistant decoupling system,” [Online]. Available: https://acoustics.regupol.com/products/range/regupol-inodis/regupol-inodis/. [Accessed 01 June 2026].

[7] Wienerberger GmbH, “Porotherm 25 Profi,” [ONLINE]. Available: https://www.wienerberger.rs/zid/proizvodi/Porotherm-opeka/porotherm-25-profi.html. [Accessed 01 June.2026]

[8] Filip Manojlovski et al.: Flexible joints for seismic-resilient design of masonry-infilled RC frames, Scientific Data 12:1266, https://doi.org/10.1038/s41597-025-05515-6, 2025

[9] Milijaš, A., Marinković, M., Butenweg, C., Klinkel, S.: Experimental investigation on the seismic performance of reinforced concrete frames with decoupled masonry infills: considering in-plane and out-of-plane load interaction effects. Bulletin of Earthquake Engineering, DOI: 10.1007/s10518-024-02012-w, 2024.

DISCLAIMER

REGUPOL INODIS

REGUPOL INODIS is a structural decoupling system for reducing seismic damage to non-load-bearing masonry walls in reinforced concrete structures. The product has been developed and tested on the basis of the latest engineering findings to reduce damage to walls and structural elements during earthquake events.

When correctly deployed by a professionally qualified person, **REGUPOL INODIS** provides the function of a non-interacting infill in accordance with EN 1998-1-2 Buildings, Section 7.4.3. This protection can only be ensured if the product has been properly implemented. If proper planning and execution are not fulfilled, the protective effects of the products cannot be guaranteed.

It is expressly stated that **REGUPOL INODIS** is not designed or certified to prevent the collapse of a building. The product does not replace structural design measures for earthquake protection in accordance with applicable standards (e.g. Eurocode 8) and is to be used exclusively as a supplementary system for mitigating damage to non-load-bearing components. **REGUPOL INODIS** is expressly not intended for earthquake protection measures other than those described above and is not suitable for the strengthening/upgrading of existing buildings.

In the event of damage as a result of an earthquake – in particular in the case of personal injury or building collapse – no liability can be assumed if applicable building regulations, static structural requirements, or professional planning and execution of the overall system have not been complied with or if **REGUPOL INODIS** has been used outside the recommended conditions of use. **REGUPOL INODIS** was developed and tested under defined laboratory conditions. Since seismic activities deviate from these defined conditions in individual cases, it cannot be ruled out that damage to masonry walls and consequential damage may occur despite professional planning and construction. No liability can be accepted for **REGUPOL INODIS** products in this case either.

Responsibility for the correct planning, selection, integration, and monitoring of the product lies with the executing specialist architects, structural engineers, and the construction companies performing the work. The selection of specialist planners is always performed by those responsible for the construction project at their own responsibility. Specialist architects, structural engineers, and all other parties involved in the construction project are in no contractual relationship with **REGUPOL Germany** and also do not act as vicarious agents or agents for **REGUPOL Germany**. Liability for planning or design errors can therefore not be assumed under any legal aspect.