VADEMECUM STOP

STEEL WIRE ROPE TIE BACKS

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ABRUZZO EARTHQUAKE 2009
COORDINATION TEAM FOR TEMPORARY WORKS

WORKING GROUP FOR THE VADEMECUM STOP
under the supervision of Sergio Basti - Central director for emergency and urgent technical rescue manual licensed by note no. EM3064/5001-11 dated 2009-06-15

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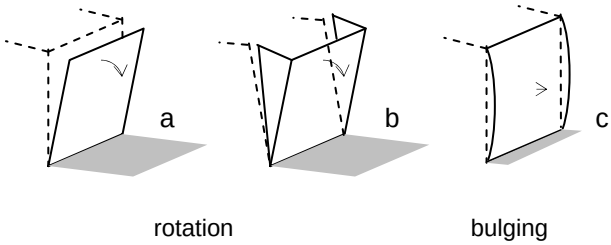
STEEL TIE BACKS: general recommendations

STOP-**TA**

Forces to constrain:

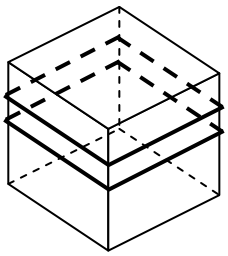


Description
Potential out of plane rotation of a wall due to:
a) break of the joint between the wall and connecting walls
b) break of the connecting wall

Evidence of bulging on the external walls

Function of the steel wire rope tie back: to prevent further rotation or bulging of the wall

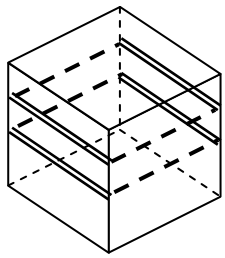
TYPES AND SELECTION CRITERIA



CE FULL EXTERNAL HOOP

Full winding possibility

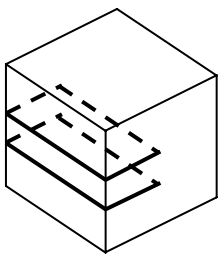
Walls not too wide to be restrained



TL TRANSOM WITH EXTERNAL SIDE WIRE ROPES

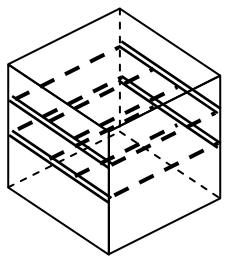
Opposed parallel walls whereon the transoms can be placed

Presence of cross walls which the wire ropes are tensioned close to



CP PARTIAL THROUGH HOOP

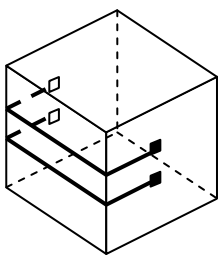
Presence of aligned side openings (or possibility to make holes) not in proximity to the wall to be restrained or possibility to make through holes in concrete or stone blocks



TI TRANSOM WITH THROUGH INTERNAL DISTRIBUTED WIRE ROPES

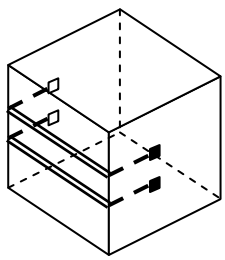
Opposed parallel walls whereon the transoms can be placed

Presence of member or spacing system in correspondence to wire ropes (beams/frameworks/floors)



CV CONSTRAINED HOOP

Presence of side walls whereon the wire rope is anchored in concrete or stone blocks not in proximity to the wall to be restrained



TV TRANSOM WITH CONSTRAINED SIDE WIRE ROPES

Presence of side walls whereon the wire rope is anchored in concrete or stone blocks not in proximity to the wall to be restrained

WARNING: tie backs should always be placed close to (or coupled to) members (main inside walls, stiff floors, main beams) able to perform a spacing function to avoid that their ends getting closer under traction or seismic actions

This symbol means that a solution is allowed only if the anchorage is made in concrete blocks, in squared stone blocks or in tight masonry

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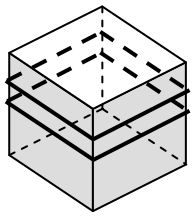
FULL AND PARTIAL HOOP: general recommendations

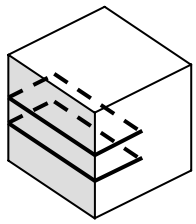
STOP-**TA**

CE FULL EXTERNAL HOOP

CP PARTIAL THROUGH HOOP

Wall to be retained





in opening

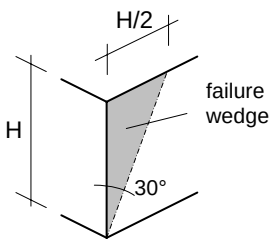
in hole

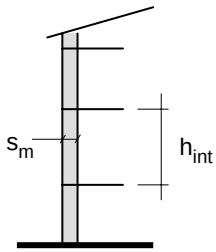
PRIMARY ZONE TO BE RETAINED:

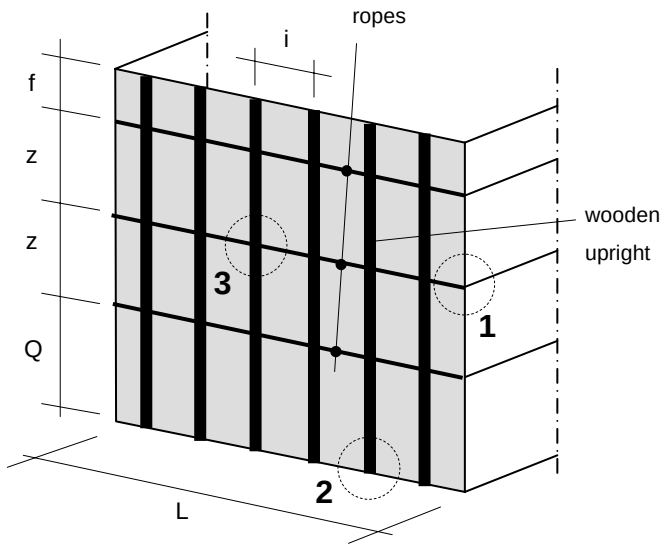
Rotation: upper half of the wall
Buckling: middle zone with larger bulging

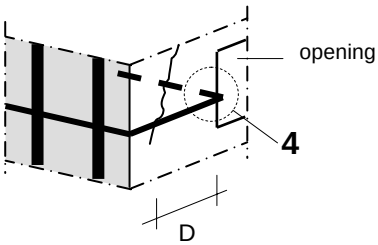
WARNING

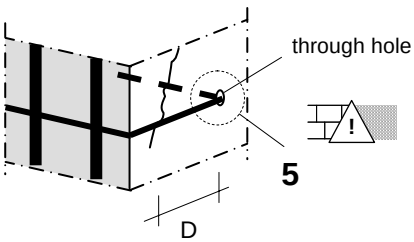
This symbol means that this solution is allowed only on concrete or stone blocks











Detail drawings are shown in the relevant sections

WARNING
The wire rope turn should always be placed beyond the failure wedge shown above

If evident cracks are present, the wire rope turn should be placed at a distance longer or equal to D, measured from the detachment crack, along the wire rope and in any case beyond the respect wedge

KEY

L = width of the wall to be restrained
H = height of the wall to be restrained
h_{int} = maximum space between two floors
s_m = average thickness of the masonry to be restrained
i = distance between uprights
z = distance between wire ropes
f = maximum extrusion of uprights over the top rope
D = minimum wire rope turning distance from the detachment crack
Q = bottom rope height

Definition of Q:
The bottom wire rope should be positioned at the same height as the failure wedge lower end (wall detachment crack beginning)
In case of full detachment it should be assumed Q = z

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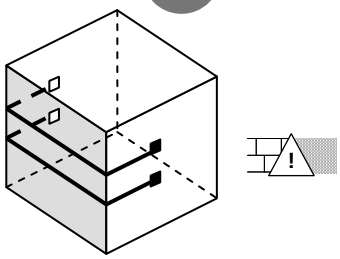
PARTIAL CONSTRAINED HOOP: general recommendations

STOP-**TA**

CV CONSTRAINED HOOP



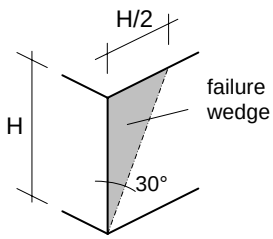
Wall to be retained

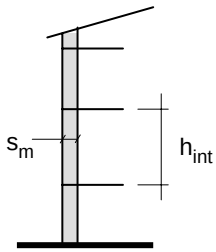
PRIMARY ZONE TO BE RETAINED:

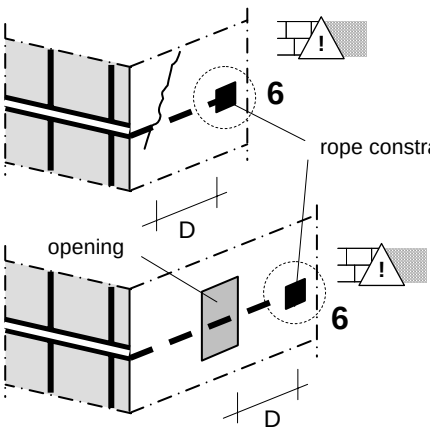
Rotation: upper half of the wall
Buckling: middle zone with larger bulging

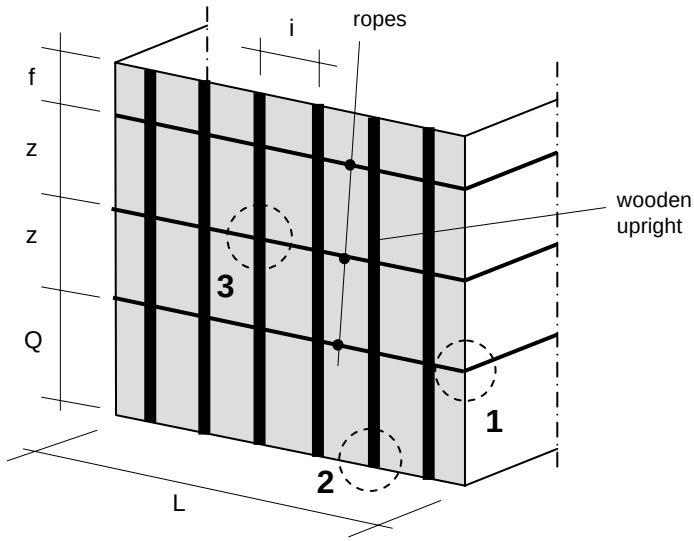
WARNING

This symbol means that this solution is allowed only if the anchorage is made in concrete or stone blocks or in tight masonry









Detail drawings are shown in the relevant sections

WARNING
The rope anchorage should always be placed beyond the failure wedge shown above

If evident cracks are present the wire rope anchorage should be placed at a distance longer or equal to D, measured from the detachment crack along the wire rope.
If the anchorage is placed beyond an opening, D should be measured from the internal edge of the opening.
In any case the anchorage should be placed beyond the failure wedge

KEY

L = width of the wall to be restrained
H = height of the wall to be restrained
h_{int} = maximum space between two floors
s_m = average thickness of the masonry to be restrained
i = distance between uprights
z = distance between wire ropes
f = maximum extrusion of uprights over the top rope
D = minimum constraint distance
Q = bottom wire rope height

Definition of Q:
The bottom wire rope should be positioned at the same height as the failure wedge lower end (wall detachment crack beginning)
In case of full detachment it should be assumed Q = z

All the elements should be designed according to Tables 1 and 2

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STEEL WIRE ROPE HOOPS: design

STOP-**TA**

Table 1
max L 10 m

CE

CP in opening

CP in hole

CV

SEISMIC CLASS A*					h_{int}											
					up to 3 m				3 - 4 m				4 - 5 m			
					s_m				s_m				s_m			
					up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m
L	up to 5 m	z	up to 1 m	Ø rope [mm]	12	12	14	14	12	12	14	14	12	12	14	14
				D min [m]	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
			1-2m	Ø rope [mm]	16	18	20	20	14	16	18	20	14	16	18	20
				D min [m]	2.2	1.9	1.8	1.7	2.0	1.8	1.7	1.6	1.9	1.7	1.6	1.6
	5-7m	z	up to 1 m	Ø rope [mm]	12	14	16	18	12	14	16	18	12	14	16	16
				D min [m]	1.6	1.4	1.3	1.2	1.4	1.3	1.2	1.1	1.3	1.2	1.1	1.1
			1-2m	Ø rope [mm]	18	20	22	24	18	20	22	24	16	20	22	24
				D min [m]	3.1	2.7	2.5	2.4	2.8	2.5	2.3	2.3	2.6	2.4	2.3	2.2
	7-10m	z	up to 1 m	Ø rope [mm]	16	18	20	20	14	16	18	20	14	16	18	20
				D min [m]	2.2	1.9	1.8	1.7	2.0	1.8	1.7	1.6	1.9	1.7	1.6	1.6
			1-2m	Ø rope [mm]	22	24	n.c.	n.c.	20	24	n.c.	n.c.	20	22	n.c.	n.c.
				D min [m]	4.4	3.9	3.6	3.4	4.0	3.6	3.4	3.2	3.7	3.4	3.2	3.1
z	up to 1 m	i	up to 1 m	upright section	10x10	10x10	10x10	13x13	10x10	10x10	10x10	13x13	10x10	10x10	10x10	10x10
				f max [m]	0.20	0.20	0.30	0.30	0.20	0.20	0.30	0.30	0.20	0.20	0.20	0.30
			1-1.5m	upright section	10x10	13x13	13x13	13x13	10x10	13x13	13x13	13x13	10x10	10x10	13x13	13x13
				f max [m]	0.30	0.20	0.20	0.40	0.20	0.30	0.30	0.40	0.20	0.30	0.30	0.40
			1.5-2m	upright section	13x13	13x13	15x15	15x15	10x10	13x13	13x13	15x15	10x10	13x13	13x13	15x15
				f max [m]	0.20	0.30	0.30	0.40	0.20	0.20	0.30	0.40	0.20	0.20	0.30	0.40
	1 - 2m	i	up to 1 m	upright section	13x13	13x13	15x15	15x15	13x13	13x13	15x15	15x15	13x13	13x13	15x15	15x15
				f max [m]	0.40	0.50	0.50	0.80	0.40	0.40	0.50	0.80	0.40	0.40	0.50	0.80
			1-1.5m	upright section	15x15	15x15	18x18	18x18	15x15	15x15	18x18	18x18	13x13	15x15	18x18	18x18
				f max [m]	0.40	0.50	0.50	0.80	0.40	0.50	0.50	0.80	0.40	0.50	0.50	0.80
			1.5-2m	upright section	15x15	18x18	20x20	2 15x15	15x15	18x18	20x20	2 15x15	15x15	18x18	18x18	20x20
				f max [m]	0.60	0.90	0.80	0.80	0.60	0.50	0.80	0.80	0.60	0.50	0.80	0.80

n.c. – solution not applicable (try other solutions)

Table 2
max L 10 m

CE

CP in opening

CP in hole

CV

SEISMIC CLASS B*					h_{int}											
					up to 3 m				3 - 4 m				4 - 5 m			
					s_m				s_m				s_m			
					up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m
L	up to 5 m	z	up to 1 m	Ø rope [mm]	12	12	12	12	12	12	12	12	12	12	12	12
				D min [m]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
			1-2m	Ø rope [mm]	14	14	16	18	12	14	16	18	12	14	16	16
				D min [m]	1.2	1.1	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	5-7m	z	up to 1 m	Ø rope [mm]	12	12	14	14	12	12	14	14	12	12	14	14
				D min [m]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
			1-2m	Ø rope [mm]	16	18	20	20	14	16	18	20	14	16	18	20
				D min [m]	1.7	1.5	1.4	1.3	1.5	1.4	1.3	1.2	1.4	1.3	1.2	1.2
	7-10m	z	up to 1 m	Ø rope [mm]	14	14	16	18	12	14	16	18	12	14	16	16
				D min [m]	1.2	1.1	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
			1-2m	Ø rope [mm]	18	20	22	24	18	20	22	24	16	20	22	24
				D min [m]	2.4	2.1	1.9	1.8	2.2	1.9	1.8	1.8	2.0	1.8	1.8	1.7
z	up to 1 m	i	up to 1 m	upright section	10x10	10x10	10x10	10x10	10x10	10x10	10x10	10x10	10x10	10x10	10x10	10x10
				f max [m]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
			1-1.5m	upright section	10x10	10x10	10x10	13x13	10x10	10x10	10x10	13x13	10x10	10x10	10x10	13x13
				f max [m]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
			1.5-2m	upright section	10x10	13x13	13x13	13x13	10x10	10x10	13x13	13x13	10x10	10x10	13x13	13x13
				f max [m]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	1 - 2m	i	up to 1 m	upright section	13x13	13x13	13x13	15x15	13x13	13x13	13x13	13x13	10x10	13x13	13x13	13x13
				f max [m]	0.20	0.50	0.50	0.50	0.20	0.50	0.50	0.50	0.20	0.50	0.50	0.50
			1-1.5m	upright section	13x13	15x15	15x15	18x18	13x13	13x13	15x15	15x15	13x13	13x13	15x15	15x15
				f max [m]	0.40	0.30	0.50	0.50	0.40	0.30	0.30	0.50	0.40	0.30	0.30	0.50
			1.5-2m	upright section	15x15	15x15	18x18	18x18	13x13	15x15	18x18	18x18	13x13	15x15	18x18	18x18
				f max [m]	0.30	0.40	0.40	0.60	0.30	0.40	0.40	0.60	0.30	0.40	0.40	0.60

(*) For the seismic classes see Annex 1
If no Annex 1 is provided, seismic class A should be used

NOTE: the wire ropes have been sized with a safety factor to ultimate load equal to 2.5

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TRANSOM WITH SIDE HOOP: general recommendations

STOP-**TA**

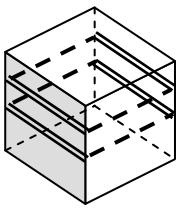
TL TRANSOM WITH EXTERNAL SIDE WIRE ROPE

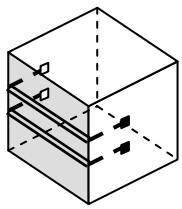
TV TRANSOM WITH CONSTRAINED SIDE WIRE ROPES

Wall to be retained

PRIMARY ZONE TO BE RETAINED:

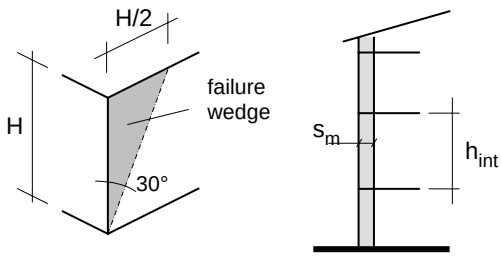
Rotation: upper half of the wall
Buckling: middle zone with larger bulging

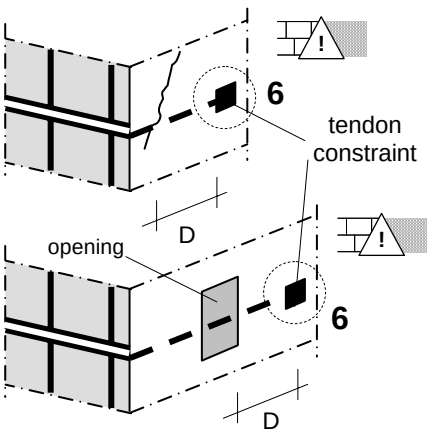


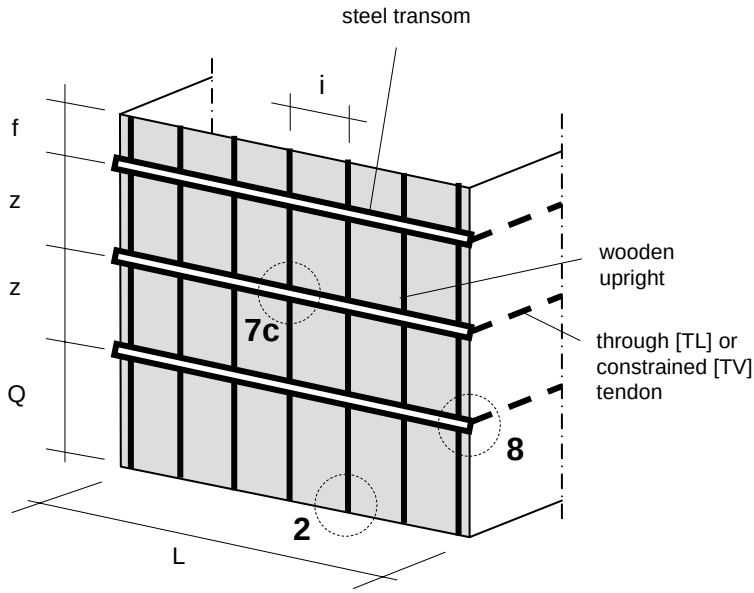


WARNING

This symbol means that this solution is allowed only if the anchorage is made in concrete or stone blocks or in tight masonry







Detail drawings are shown in the relevant sections

WARNING

The wire rope anchorage should always be placed beyond the failure wedge shown above

If evident cracks are present the wire rope anchorage should be placed at a distance longer or equal to D, measured from the detachment crack along the rope.
If the anchorage is placed beyond an opening, D should be measured from the internal edge of the opening.
In any case the anchorage should be placed beyond the failure wedge

KEY

L = width of the wall to be restrained
H = height of the wall to be restrained
h_{int} = maximum space between two floors
s_m = average thickness of the masonry to be restrained
i = distance between uprights
z = distance between transoms
f = maximum extrusion of uprights over the top transom
D = minimum anchorage distance
Q = bottom transom height

Definition of Q:
The bottom transom should be positioned at the same height as the failure wedge lower end (wall detachment crack beginning)
In case of full detachment it should be assumed Q = z

All the elements should be designed according to Tables 3 and 4

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TRANSOM WITH SIDE HOOP: design

STOP-**TA**

Table 3
max L 7 m

TL

TV

SEISMIC CLASS A*			z											
			up to 1.5 m				up to 3 m				up to 4 m			
			Sm				Sm				Sm			
			up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m
L	up to 5 m	Ø rope [mm]	14	16	16	18	18	20	24	n.c.	20	24	n.c.	n.c.
		transom	HEA140	HEA160	HEA160	HEA180	HEA200	HEA200	HEA220	n.c.	HEA200	HEA220	n.c.	n.c.
		D min [m]	1.3	1.1	1.0	1.0	2.5	2.2	2.0	n.c.	3.1	2.7	n.c.	n.c.
	5-7m	Ø rope [mm]	16	18	20	22	22	24	n.c.	n.c.	24	n.c.	n.c.	n.c.
		transom	HEA200	HEA200	HEA220	HEA240	HEA240	HEA260	n.c.	n.c.	HEA260	n.c.	n.c.	n.c.
		D min [m]	1.8	1.5	1.4	1.4	3.6	3.1	n.c.	n.c.	4.3	n.c.	n.c.	n.c.
i	up to 1 m	upright section	10x10	13x13	13x13	13x13	15x15	18x18	18x18	n.c.	18x18	20x20	n.c.	n.c.
		f max [m]	0.40	0.40	0.40	0.30	0.60	0.90	0.80	n.c.	0.90	1.10	n.c.	n.c.
	1-1.5 m	upright section	13x13	13x13	15x15	18x18	18x18	20x20	20x20	n.c.	20x20	2 18x18	n.c.	n.c.
		f max [m]	0.20	0.20	0.40	0.40	0.60	0.80	0.80	n.c.	0.90	1.10	n.c.	n.c.
	1.5 - 2 m	upright section	13x13	15x15	18x18	18x18	20x20	2 18x18	2 18x18	n.c.	2 18x18	2 20x20	n.c.	n.c.
		f max [m]	0.20	0.30	0.30	0.40	0.70	0.60	0.80	n.c.	0.90	1.10	n.c.	n.c.

Table 4
max L 7 m

TL

TV

SEISMIC CLASS B*			z											
			up to 1.5 m				up to 3 m				up to 4 m			
			Sm				Sm				Sm			
			up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m
L	up to 5 m	Ø rope [mm]	12	12	14	16	16	18	20	22	18	20	22	24
		transom	HEA140	HEA140	HEA140	HEA160	HEA160	HEA180	HEA200	HEA200	HEA180	HEA200	HEA220	HEA220
		D min [m]	1.0	1.0	1.0	1.0	1.8	1.6	1.5	1.4	2.2	1.9	1.8	1.8
	5-7m	Ø rope [mm]	14	16	16	18	18	20	24	n.c.	20	24	n.c.	n.c.
		transom	HEA160	HEA180	HEA200	HEA200	HEA220	HEA240	HEA240	n.c.	HEA220	HEA240	n.c.	n.c.
		D min [m]	1.3	1.1	1.0	1.0	2.5	2.2	2.0	n.c.	3.1	2.7	n.c.	n.c.
i	up to 1 m	upright section	10x10	10x10	10x10	13x13	13x13	15x15	18x18	18x18	18x18	18x18	20x20	20x20
		f max [m]	0.2	0.2	0.5	0.5	0.5	0.7	1.0	1.0	1.2	1.1	1.3	1.2
	1 - 1.5 m	upright section	10x10	13x13	13x13	15x15	15x15	18x18	18x18	20x20	18x18	20x20	2 18x18	2 18x18
		f max [m]	0.4	0.3	0.3	0.3	0.5	0.8	0.8	0.9	0.9	1.0	1.3	1.2
	1.5 - 2 m	upright section	13x13	13x13	15x15	18x18	18x18	18x18	20x20	2 18x18	20x20	2 18x18	2 20x20	2 20x20
		f max [m]	0.3	0.3	0.3	0.4	0.7	0.6	0.8	1.0	0.9	1.1	1.3	1.2

n.c. – solution not applicable (try other solutions)

(*) For the seismic classes see Annex 1
If no Annex 1 is provided, seismic class A should be used

NOTE: the wire ropes have been sized with a safety factor to ultimate load equal to 2.5

WARNING:
when L > 7 m, this solution is applicable only if it is possible to make an anchorage at a distance < 7 m on an intermediate main inside wall.
In this case the tables should be applied considering L as the distance between the two anchorage tendons.

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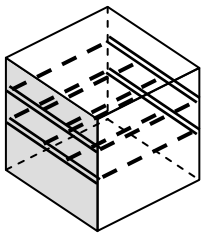
THROUGH INTERNAL DISTRIBUTED ROPES: general recommendations

STOP-**TA**

TI TRANSOM WITH THROUGH INTERNAL DISTRIBUTED WIRE ROPES

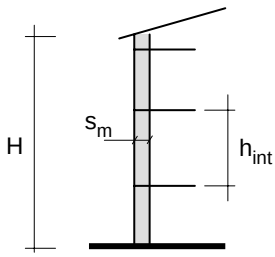


Wall to be retained

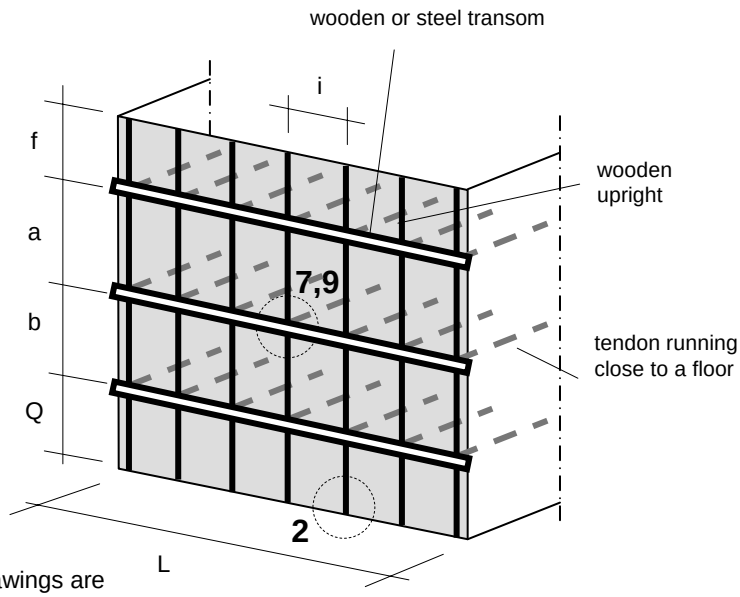
PRIMARY ZONE TO BE RETAINED:

Rotation: upper half of the wall
Buckling: middle zone with larger bulging

WARNING:
tendons may be positioned at floors soffit or extrados.
In case of wooden floors, tendons should be positioned close to the main girders.
When the scaffolding is perpendicular to the tendons, make sure that the planking can provide a spacer function. If not, spacing elements should be positioned beside the tendons.



$z = \max(a,b) = h_{int}$



Detail drawings are shown in the relevant section

KEY

L = width of the wall to be restrained
H = height of the wall to be restrained
h_{int} = maximum space between two floors
s_m = average thickness of the masonry to be restrained
i = distance between uprights
z = reference design distance (equal to the maximum distance between floors)
f = maximum extrusion of uprights over the top transom
Q = bottom transom height

Definition of Q:
The bottom transom should be positioned at the same height as the first damaged floor.
In case of full detachment, the bottom transom should be placed close to the first floor.

All the elements should be designed according to Tables 5 and 6

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Diapositiva 9

firekbb5 Removed "so"
firekbb; 15/05/2012

THROUGH INTERNAL DISTRIBUTED ROPES: design

STOP-**TA**

Table 5

TI

SEISMIC CLASS A*			h_{int}											
			up to 3 m				3 - 4 m				4 - 5 m			
			s_m				s_m				s_m			
			up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m
i	up to 1 m	Ø rope [mm]	12	14	16	16	14	16	16	18	14	16	18	20
		wooden transom	15x15	18x18	20x20	20x20	18x18	20x20	2 15x15	2 18x18	18x18	20x20	2 18x18	2 18x18
		steel transom	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160
		upright section	13x13	15x15	18x18	18x18	15x15	18x18	20x20	2 18x18	18x18	20x20	2 18x18	2 20x20
		f max [m]	0.6	0.5	0.8	0.7	0.9	1.1	1.0	1.3	1.2	1.5	1.5	1.5
	1 - 1.5 m	Ø rope [mm]	14	16	18	20	16	18	20	n.c.	18	20	n.c.	n.c.
		wooden transom	18x18	2 15x15	2 18x18	2 18x18	20x20	2 18x18	2 18x18	n.c.	2 15x15	2 18x18	n.c.	n.c.
		steel transom	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	n.c.	2UPN160	2UPN160	n.c.	n.c.
		upright section	15x15	18x18	18x18	20x20	18x18	20x20	2 18x18	n.c.	20x20	2 20x20	n.c.	n.c.
		f max [m]	0.4	0.6	0.7	0.9	0.8	1.1	1.3	n.c.	1.2	1.4	n.c.	n.c.
	1.5 - 2 m	Ø rope [mm]	16	18	20	n.c.	18	20	n.c.	n.c.	20	n.c.	n.c.	n.c.
		wooden transom	2 18x18	2 18x18	2 20x20	n.c.	2 18x18	2 20x20	n.c.	n.c.	2 18x18	n.c.	n.c.	n.c.
		steel transom	2UPN160	2UPN160	2UPN160	n.c.	2UPN160	2UPN160	n.c.	n.c.	2UPN160	n.c.	n.c.	n.c.
		upright section	18x18	18x18	20x20	n.c.	20x20	2 18x18	n.c.	n.c.	2 18x18	n.c.	n.c.	n.c.
		f max [m]	0.5	0.6	0.8	n.c.	0.7	1.1	n.c.	n.c.	1.2	n.c.	n.c.	n.c.

Table 6

TI

SEISMIC CLASS B*			h_{int}											
			up to 3 m				3 - 4 m				4 - 5 m			
			s_m				s_m				s_m			
			up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m	up to 0.4 m	0.4-0.6m	0.6-0.8m	0.8-1m
i	up to 1 m	Ø rope [mm]	12	12	12	14	12	12	14	16	12	14	16	16
		wooden transom	13x13	15x15	18x18	18x18	15x15	18x18	18x18	20x20	15x15	18x18	20x20	2 15x15
		steel transom	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160
		upright section	13x13	13x13	15x15	18x18	15x15	18x18	18x18	20x20	18x18	18x18	20x20	2 18x18
		f max [m]	0.5	0.7	0.7	1.0	0.8	1.1	1.0	1.2	1.2	1.4	1.5	1.5
	1 - 1.5 m	Ø rope [mm]	12	14	16	16	14	16	18	18	14	16	18	20
		wooden transom	15x15	18x18	20x20	2 15x15	18x18	20x20	2 15x15	2 18x18	18x18	2 15x15	2 18x18	2 20x20
		steel transom	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160
		upright section	13x13	15x15	18x18	18x18	18x18	18x18	20x20	2 18x18	18x18	2 18x18	2 18x18	2 20x20
		f max [m]	0.5	0.8	0.7	0.9	0.9	1.0	1.3	1.2	1.1	1.4	1.5	1.5
	1.5 - 2 m	Ø rope [mm]	14	16	18	20	16	18	20	n.c.	16	20	n.c.	n.c.
		wooden transom	18x18	20x20	2 18x18	2 18x18	20x20	2 18x18	2 18x18	n.c.	2 18x18	2 18x18	n.c.	n.c.
		steel transom	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	2UPN160	n.c.	2UPN160	2UPN160	n.c.	n.c.
		upright section	15x15	18x18	18x18	20x20	18x18	20x20	2 18x18	n.c.	20x20	2 18x18	n.c.	n.c.
		f max [m]	0.4	0.6	0.8	1.0	0.7	1.1	1.0	n.c.	1.2	1.4	n.c.	n.c.

n.c. – solution not applicable (try other solutions)

(*) For the seismic classes see Annex 1
If no Annex 1 is provided, seismic class A should be used

NOTE: the wire ropes have been sized with a safety factor to ultimate load equal to 2.5

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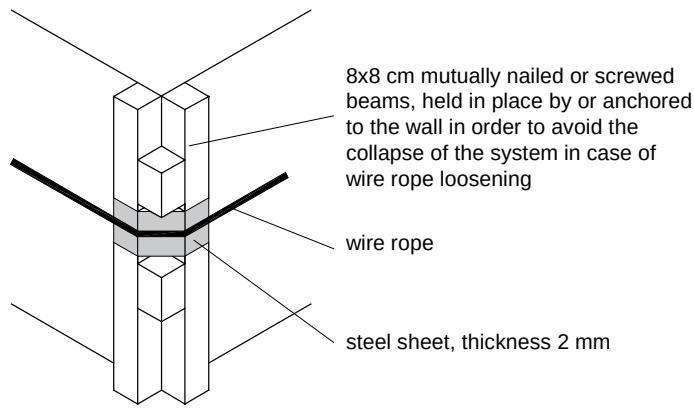
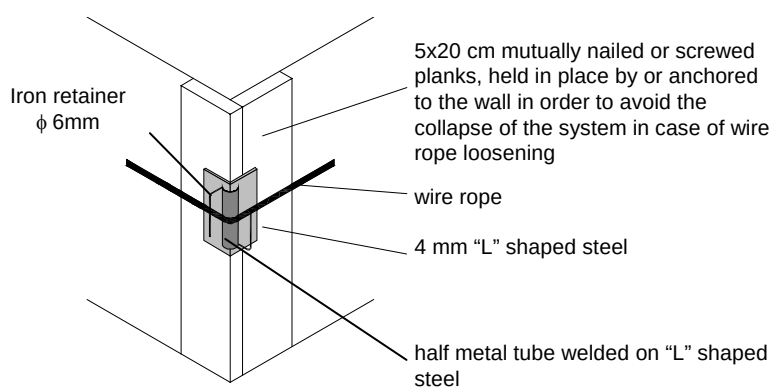
STEEL TENDONS: construction details

STOP-**TA**

Detail **1**	**WIRE ROPE DEFLECTION ON MASONRY CORNER**
a BEAMS AND STEEL SHEET MASONRY CORNER ANGULAR	
b PLANKS AND ROUNDED PLATE MASONRY CORNER ANGULAR	

NOTE: a, b are alternative solutions

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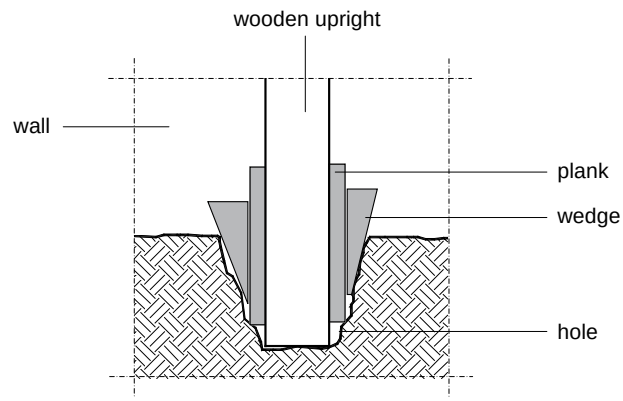
STEEL TENDONS: construction details

STOP-**TA**

Detail 2 — UPRIGHT BASE

a

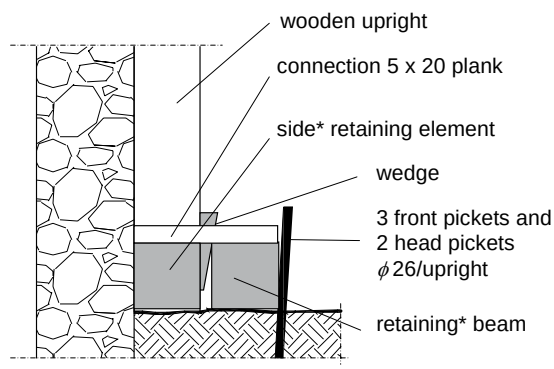
IN GROUND
BASE ANCHOR



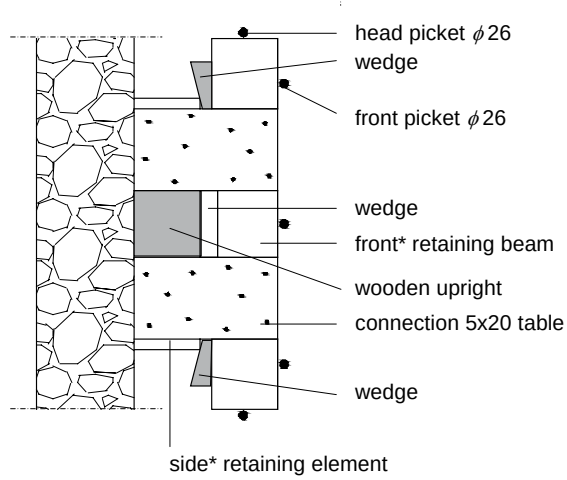
b

ABOVE GROUND
BASE ANCHOR

VERTICAL SECTION



PLAN



(*) the side retaining elements and the front retaining beam should have the same dimensions as the vertical uprights

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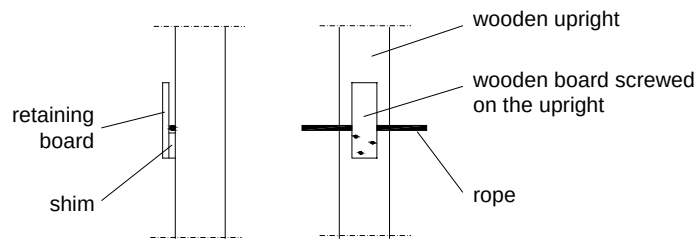
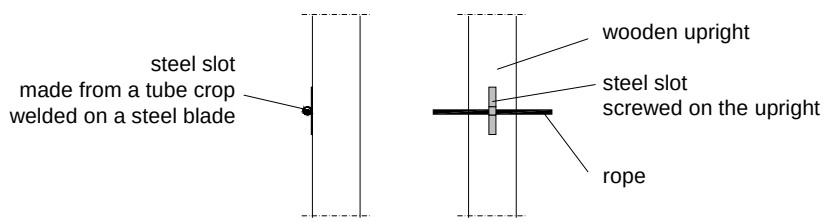
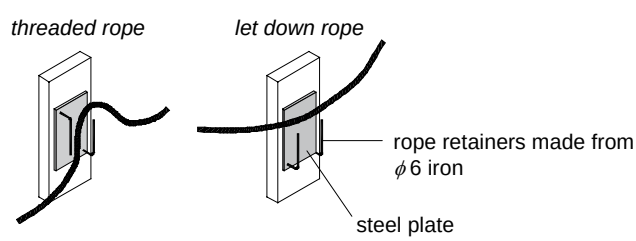
STEEL TENDONS: construction details

STOP-**TA**

Detail **3**	**WIRE ROPE-UPRIGHT CROSSING**
a WOODEN SADDLE SUPPORT	
b STEEL SLOT SUPPORT	
c STEEL PLATE AND RETAINERS SUPPORT	 Each element should be held in place by or anchored to the wall in order to avoid the collapse of the system in case of rope loosening

NOTE: a, b and c are equivalent and alternative solutions

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STEEL TENDONS: construction details

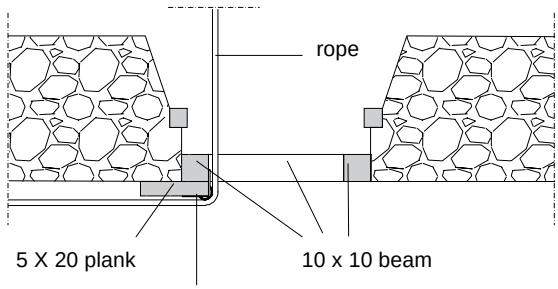
STOP-**TA**

Detail 4 — WIRE ROPE DEFLECTION ON EDGE OF OPENING

a

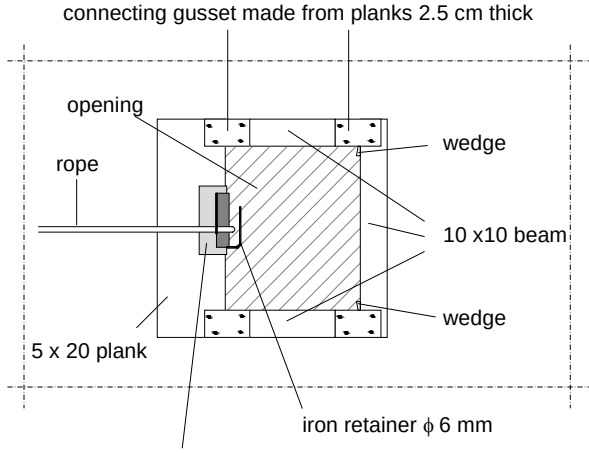
ROPE DEFLECTION
ON OPENING EDGE

HORIZONTAL SECTION



deflection steel plate made from a half metal tube
welded on the edge and aimed at increasing the bend radius

FRONT VIEW



deflection steel plate made from a half metal tube
welded on the edge and aimed at increasing the bend radius

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STEEL TENDONS: construction details

STOP-**TA**

Detail 5

WIRE ROPE PASSING THROUGH A HOLE

a

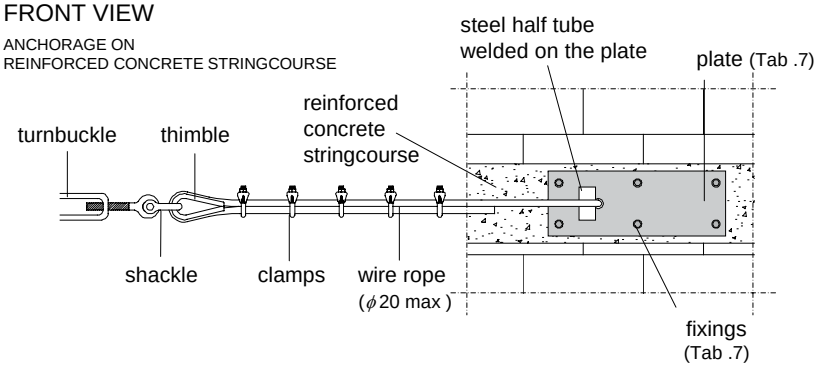
ROPE DEFLECTION PASSING THROUGH A MASONRY HOLE

WARNING

this solution is allowed only if the anchorage is made in concrete or stone blocks or in tight masonry

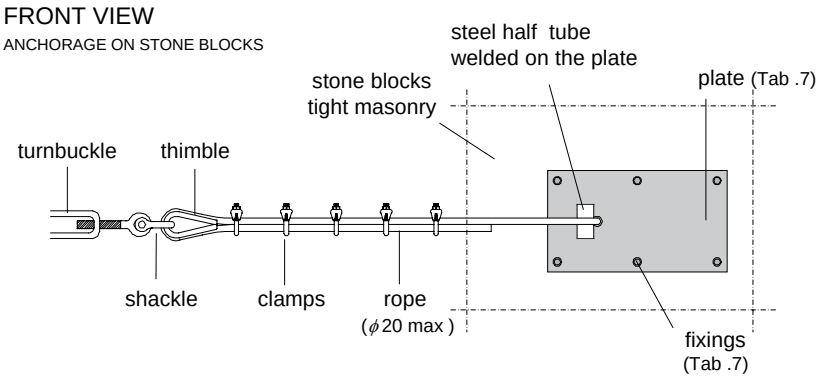
FRONT VIEW

ANCHORAGE ON REINFORCED CONCRETE STRINGCOURSE

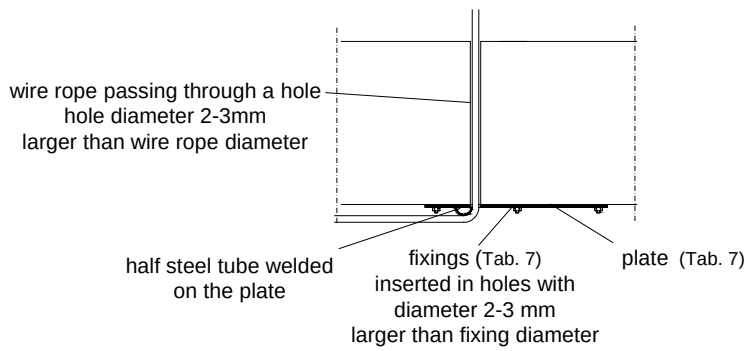


FRONT VIEW

ANCHORAGE ON STONE BLOCKS



HORIZONTAL SECTION



NOTE: for the wire rope assembly details see page 19/22

WARNING: if the anchorage is made on stone blocks, the fixings should be inserted to incorporate more blocks

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STEEL TENDONS: construction details

STOP-**TA**

Detail 6 — WIRE ROPE ANCHORAGE

a

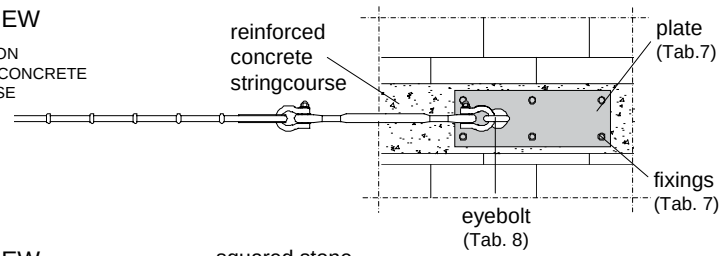
DOUBLE PLATE WITH THROUGH BAR ANCHORAGE

WARNING

this solution is allowed only if the anchorage is made in concrete or stone blocks or in tight masonry

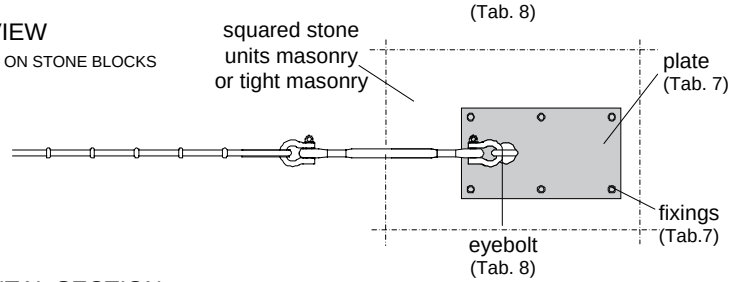
FRONT VIEW

ANCHORAGE ON REINFORCED CONCRETE STRINGCOURSE

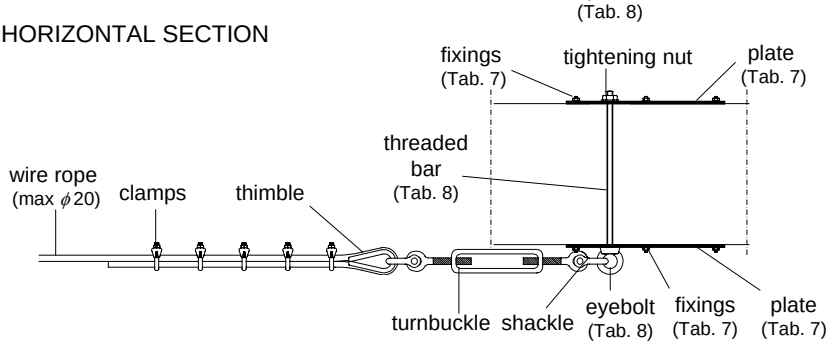


FRONT VIEW

ANCHORAGE ON STONE BLOCKS



HORIZONTAL SECTION



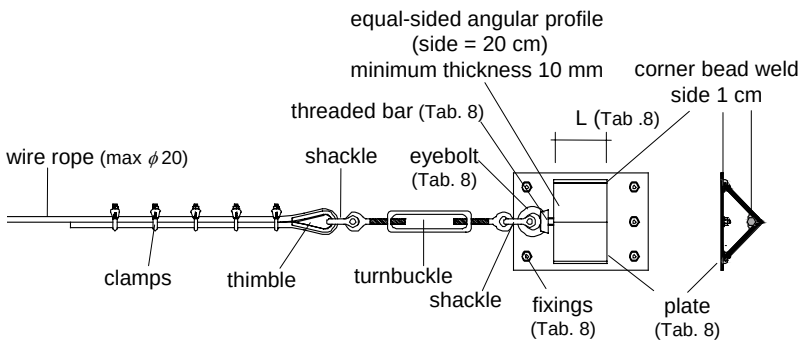
b

SINGLE PLATE WITH BAR ON ANGULAR SECTION ANCHORAGE

WARNING

this solution is allowed only if the anchorage is made in concrete or stone blocks or in tight masonry

FRONT VIEW — SECTION



WARNING: this solution should be used only in cases where positioning an internal back-plate (solution a) is not feasible.

see next page

WARNING: if the anchorage is made on stone blocks, the fixings should be inserted to incorporate more blocks

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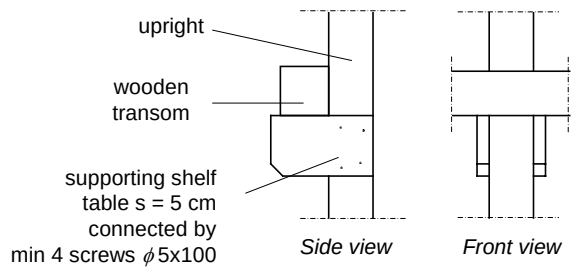
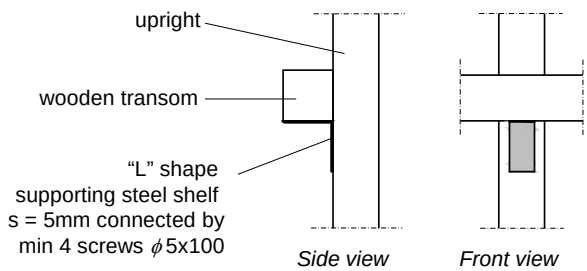
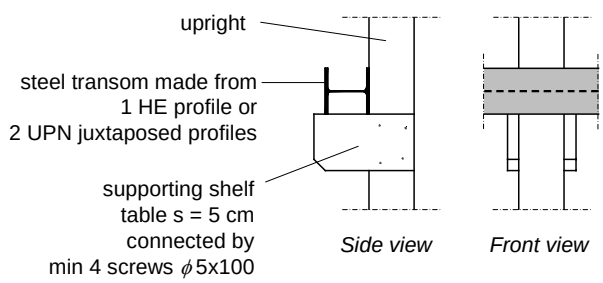
STEEL TENDONS: constructional details

STOP-**TA**

Detail **7**	**TRANSOM-UPRIGHT CROSSING**
a WOODEN TRANSOM SUPPORT WITH WOODEN SHELVES	
b WOODEN TRANSOM SUPPORT WITH STEEL SHELVES	
c STEEL TRANSOM SUPPORT WITH STEEL SHELVES	

NOTE: a, b and c are equivalent and alternative solutions

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STEEL TENDONS: constructional details

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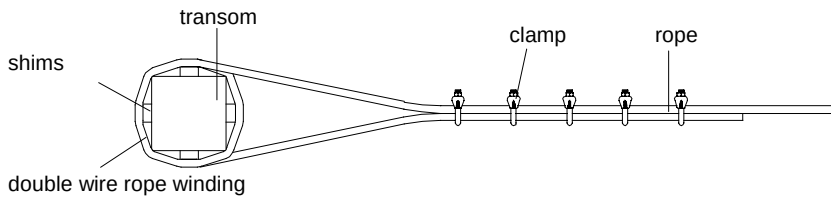
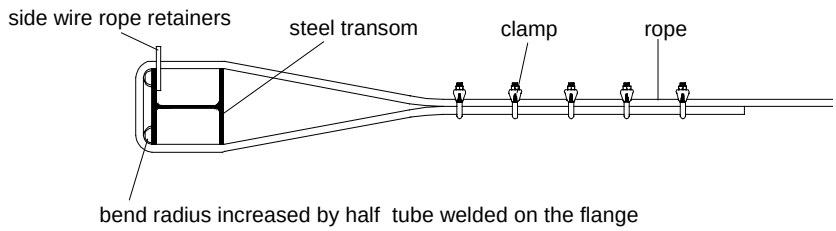
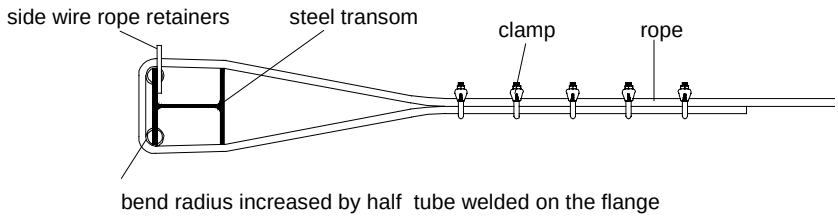
Detail **8**	**TRANSOM-TENDON CROSSING**
a WINDING ON WOODEN TRANSOM	
b WINDING ON SINGLE STEEL TRANSOM	 Alternative choice: 

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STEEL TENDONS: constructional details

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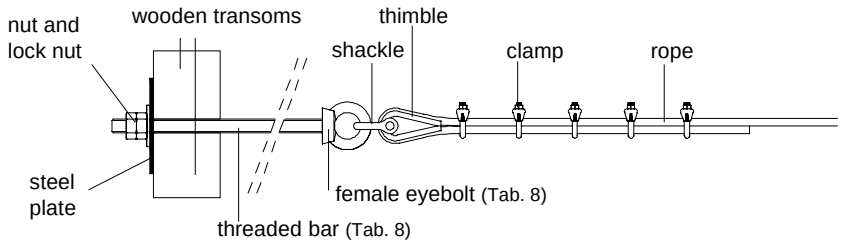
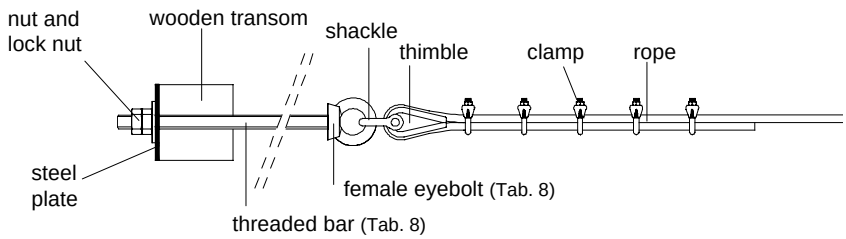
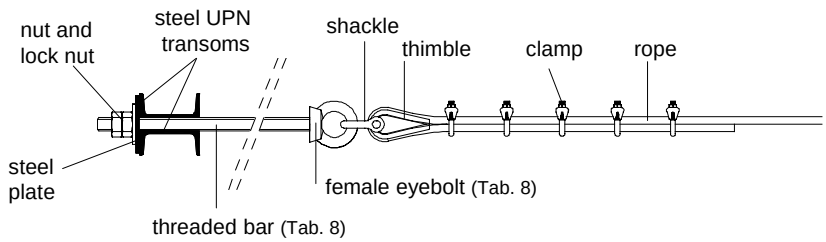
Detail **9**	**TRANSOM-TENDON CROSSING**
a BOLTED PLATE LAID ON DOUBLE WOODEN TRANSOM	
b BOLTED PLATE LAID ON WOODEN TRANSOM WITH THROUGH HOLE	
c BOLTED PLATE LAID ON COUPLED STEEL UPN TRANSOMS	

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STEEL TENDONS: constructional details

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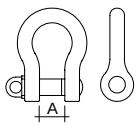
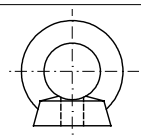
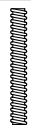
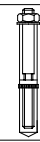
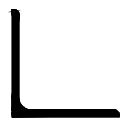
Table 7 – Direction for designing details 5 and 6a

material	rope (mm)	plate dimensions (cm x cm)	plate thickness (cm)	fixing number and diameter	typical scheme
concrete	ϕ 12 – 20	55 x 20	1.0	6 ϕ 12 mm	
squared stone blocks or tight masonry	ϕ 12 – 20	55 x 30	1.0	6 ϕ 12 mm	

Table 8 – Directions for designing details 6b and 9

details 6b e 9						detail 6b		
steel rope type S10 ZN	shackle		female eyebolt		bar	rectangular plate	fixings	equal-"L" shape angular
								
diameter (mm)	A (mm)	WLL (*)	ISO thread	WLL (*)	diameter	dimensions (cm x cm)	number and diameter (mm)	length L (cm)
ϕ 12 -14	A26	3.25T o 3 1/4T	M30	3.6T	ϕ 30	50 x 35	5 ϕ 12 mm	15
ϕ 16 - 18	A31	4.75T o 4 3/4T	M36	5.1T	ϕ 36			15
ϕ 20	A36	6.50T o 6 1/2T	M42	7.0T	ϕ 42			20

(*) WWL is a code stamped on the elements. When elements having the WWL code reported in this table are not available, elements with higher WWL code may be used.

WARNINGS

The figures reported in Tables 7 and 8 have been defined referring to the Hilti HDA-P M12 mechanical anchoring (masonry hole ϕ 22 mm),
or
Würth W-HAZ M12 mechanical anchoring (masonry hole ϕ 18 mm)

Other anchoring types may be used provided that their performances are equivalent or higher*.

When drilling holes, a minimum distance of 30 mm should be foreseen between the hole axis and the plate edge.

(*) When chemical plugs are used, in order to assure the same tensile and shear resistance as the mechanical steel plugs defined in Tables 7 and 8, information should be sought from the plug manufacturer in regard to masonry quality, bar diameter, steel class.

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STEEL TENDONS: constructional details

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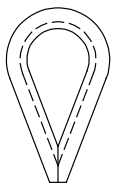
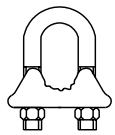
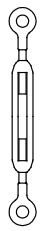
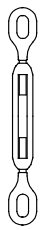
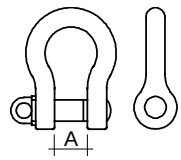
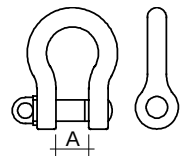
Table 9 – Coordination between assembly elements (global safety factor equal to 2.5)

Steel rope type S10 Zn		Zinc plated RL thimble	CAV type clamp	O-O type turnbuckle	II B type turnbuckle	Omega shackle for O-O type turnbuckle		Omega shackle for II – B type turnbuckle	
									
Diameter (mm)	Capacity (t) (**) (S.F. = 2.5)	Dimensions	Marking	ISO thread	ISO thread	A (mm)	WLL(*)	A (mm)	WLL(*)
ϕ 12	3.52	12 A18	marked 13	M22	A27	22	2.00T o 2 T	26	3.25T or 3 1/4T
ϕ 14	4.78	16 A23.5	marked 14	M24	A30	26	3.25T o 3 1/4T	31	4.75T or 4 3/4T
ϕ 16	6.24	16 A23.5	marked 16	M27	A33	26	3.25T o 3 1/4T	31	4.75T or 4 3/4T
ϕ 18	7.92	20 A29.5	marked 18	M33	A36	31	4.75T o 4 3/4T	36	6.50T or 6 1/2T
ϕ 20	9.76	20 A29.5	marked 19	M36	A39	36	6.50T o 6 1/2T	36	6.50T or 6 1/2T
ϕ 22	11.78	22 A32	marked 22	M39	A45	36	6.50T o 6 1/2T	43	8.50T or 8 1/2T
ϕ 24	14.02	24 A35	marked 26	-	A52	-	-	43	8.50T or 8 1/2T

(*) WWL is a code stamped on the elements. When elements having the WWL code reported in this table are not available, elements with higher WWL code may be used.

(**) these figures refer to the TECI ® catalogue 2009. However, ropes and ancillary elements from other manufacturers may be used provided that their performances are not lower than those reported in the table.

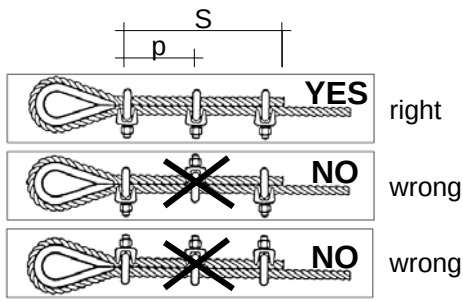


Table 10 – Directions for rope tightening with clamps

ϕ rope (mm)	CAV clamp marking	N clamps	step p (cm)	overlapping S (cm)
12	13	5	7.5	35
14	14	5	8.5	40
16	16	5	10.0	45
18	18	5	11.0	50
20	19	5	12.0	55
22	22	7	13.0	85
24	26	7	14.5	95

Data and figures taken from TECI ® catalogue 2009

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STEEL TENDONS: precautions and warnings

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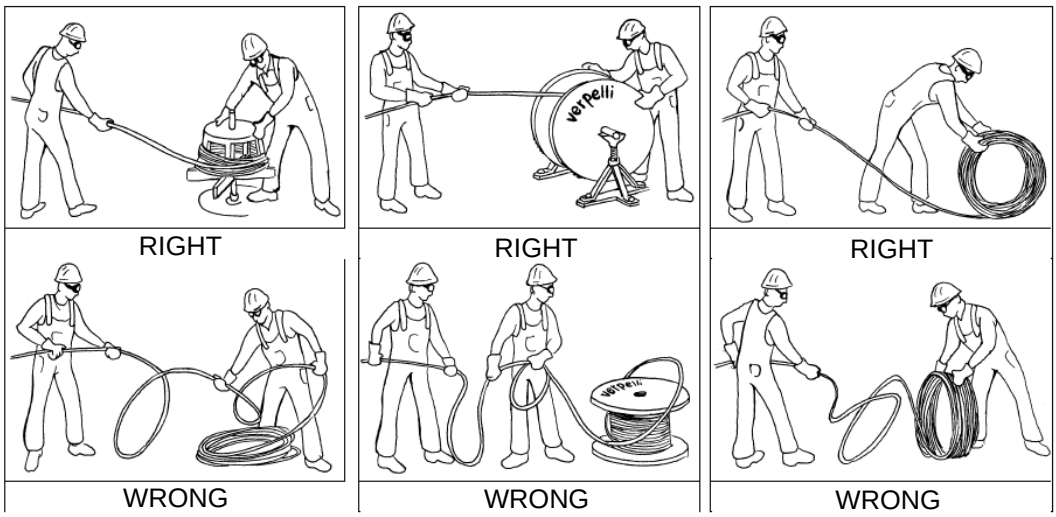


Figure taken from the website www.verpelli.it

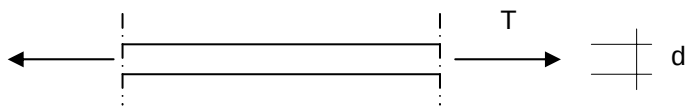
Tendons should never be loaded in exceedance of their capacity.

Tendons should always be inspected prior to their use.
Damaged tendons should never be used.
Tendons should never be bent close to sleeves, splices, cable terminals.

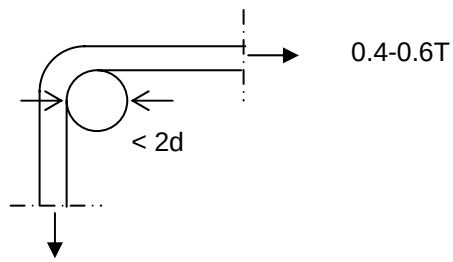
Steel ropes shall not be bent around small pins.
If, for example, a rope is bent around a pin whose diameter is equal to twice the rope one, the rope ultimate load is decreased from **40 to 60%**, thus reducing and loosing its capacity.

Consequently, in these cases, the use of suitable protections such as **thimbles and edge protectors** is advised.

WARNING
Ropes bending around small-radius elements should be avoided



When ropes are bent around small-radius elements (less than twice the rope diameter), the capacity should be reduced to 40-60% of the nominal one



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USE OF STEEL ROPES AND THEIR ANCILLARY ELEMENTS

General directions

The choice should be made taking into account design instructions as well as assembling conditions of cables.

When “comfortable” working conditions are present, long cables may be used (50, 100, 200 m) thus limiting the discontinuity points.
When “uncomfortable” working conditions are present, short cables may be used (10, 20, 30 m) thus increasing the discontinuity points.

Preliminary checks
The preliminary cable check only consists of examining its length and the nominal cable diameter as well as the solidity and strength of ancillary elements. The cable should not show any signs of damage, severe wear or wires bending at any point. The rope diameter should be measured by a gauge, positioned as shown in figure.

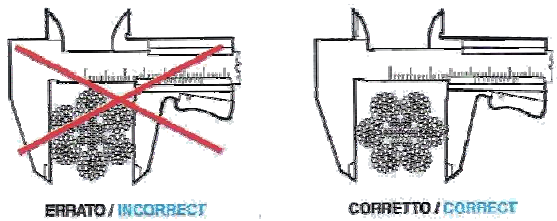

Figure taken from the Teci ® catalogue 2009

Extremity eyelets assembly
The eyelet should be made as shown in figure,
the first clamp should be placed as close as possible to the eyelet and the others spaced by 5-6 times the rope diameter (see Table 8).

The junction between two cables should be done by mutually inserting a turnbuckle and two omega shackles (cable – eyelet – shackle – turnbuckle –shackle – eyelet – cable).

Tensioning
The cable may be tensioned in two phases: the first one consists in closing the cable as a ring or fastening it to fixed points using suitable devices (Tirfor, small tackles, etc.) providing large displacements of the extremities; the second one consists in tensioning the cable by operating all the turnbuckles, possibly in an even manner.

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STEEL ROPES TENDONS AND HOOPS

Field of application:
Tendons and hoop systems applied to buildings damaged by earthquakes.

General assumptions
The measures described in this procedure are intended to restrain load bearing walls with a thickness up to 1 m.
At page 1/22 several solutions aimed at protecting the ongoing damage are shown. The various schemes are coded and explained in terms of applicability and for each of them the design parameters are pointed out.
Once the most suitable solution for a particular case has been defined, reference should be made to the relevant section for the chosen solution code.
For each solution, the assembly conditions are shown and the reference geometrical design parameters are defined.
After the evaluation of the geometrical parameters for a particular case, and taking into account the seismic class (see Annex 1), the elements dimensions should be selected according to the relevant tables.
The details shown in the diagrams that are in dashed circles can be found on the relevant pages from 9/22 to 17/22.
During the assembly of elements and the laying operations, the additional directions given in pages 18/22, 19/22, 20/22 e 21/22 apply.

WARNING
All the dimensional figures (rope and ancillary elements) and the proposed assembly solutions have been defined so that a minimum safety factor equal to 2.5 is assured for single elements and for the whole system.
All the dimensional figures given in this procedure should be intended as minimum design values.
In the execution phase, sections with larger dimensions or elements with higher capacity than prescribed may be used.

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