Connessioni innovative per strutture in CLT

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Consulente tecnico Rothoblaas

27/05/2021

Connessioni innovative per strutture in CLT

Indice

THE TIMBER REVOLUTION

MJÖSA TOWER – NORVEGIA 2019
18 PIANI - 85,4m

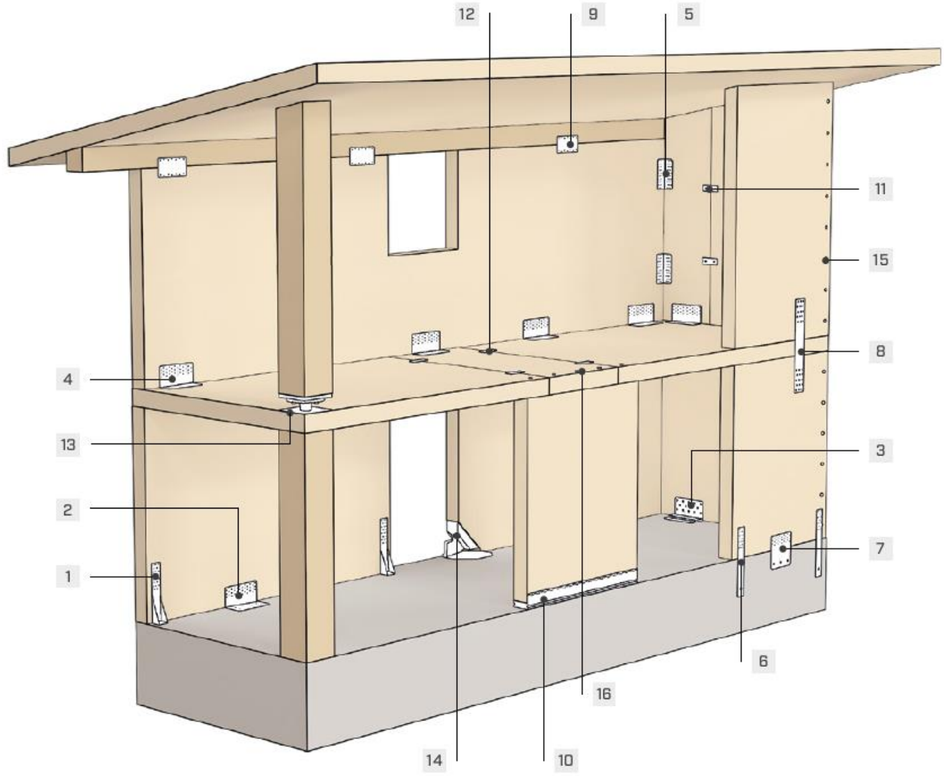
HOHO TOWER – AUSTRIA 2020
24 PIANIO - 84m

THE TIMBER REVOLUTION

Quando i carichi sono troppo alti, è difficile inserire il connettore standard nella parete in legno: sono quindi necessarie staffe su misura.

EDIFICIO A ROVERETO (TRENTO)- 9 PIANI

CHE CONNESSIONE DEVO SCEGLIERE?



ANGLE BRACKETS

They are used for both timber-to-timber and timber-to-concrete connections. Depending on the specific model, they can be used to transfer tensile and shear forces, or a combination of both forces. The addition of special washers improves their performance and versatility.

1 WHT
2 TITAN N
3 TITAN S + WASHER
4 TITAN V
5 TITAN F

TWO-DIMENSIONAL PLATES

They allow the transfer of both tensile and shear forces; depending on the type used, they are suitable for both timber-to-timber and timber-to-concrete connections. Using fasteners with different diameters means that a wide range of strengths can be covered.

6 WHT PLATE C
7 TITAN PLATE C
8 WHT PLATE T
9 TITAN PLATE T

SPECIAL CONNECTORS

A new range of simple solutions are available to solve complex problems from small residential buildings to multi-storey buildings. These solutions offer the opportunity for designers and builders to break the mould and find innovative solutions.

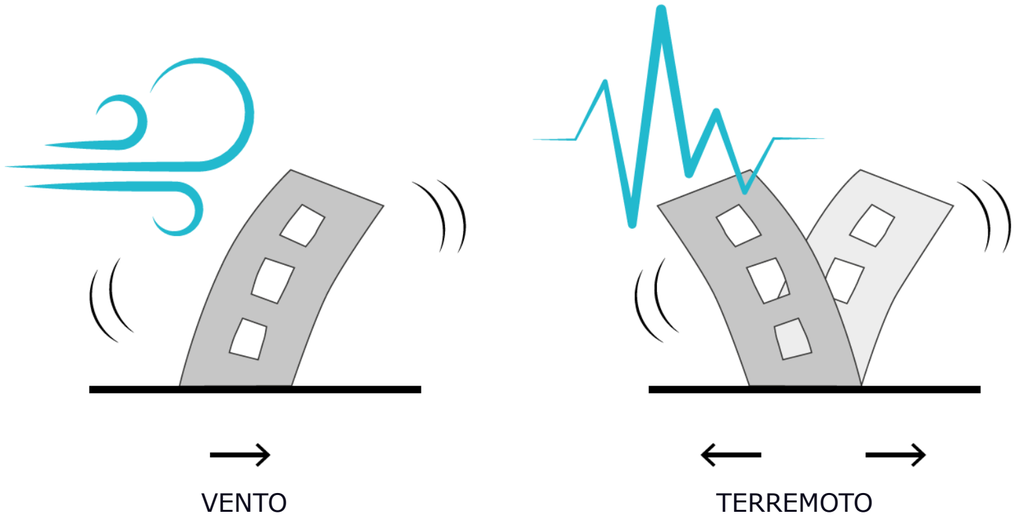
10 ALU START
11 SLOT
12 SLOT
13 SPIDER/PILLAR
14 X-RAD

SELF-DRILLING SCREWS

The self-tapping product range of screws that provide an optimal solution to satisfy the design requirements regardless of the type of external action.

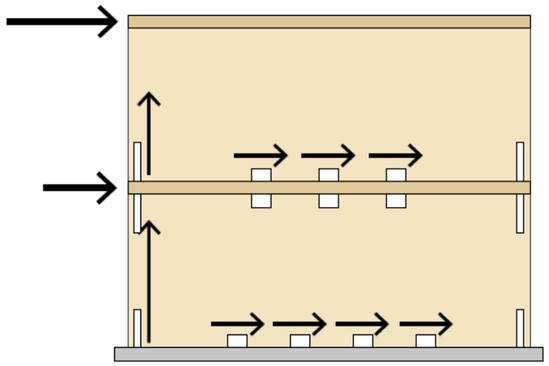
15 HBS/TBS screws
16 VGZ screws

PROGETTAZIONE PER FORZE ORIZZONTALI

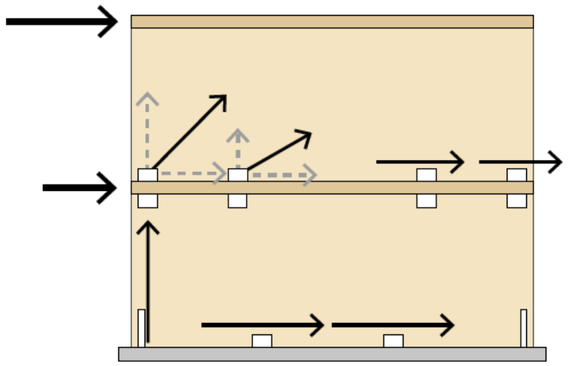


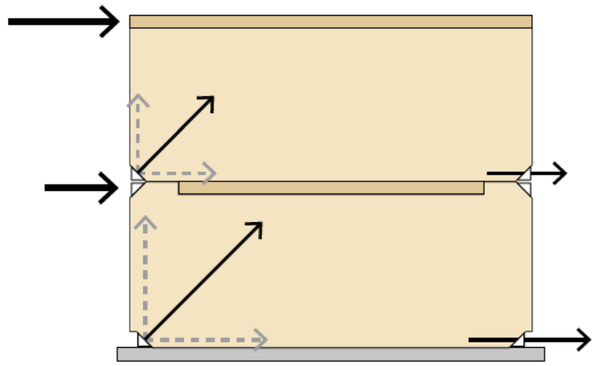
LOAD PATTERN

STANDARD APPROACH



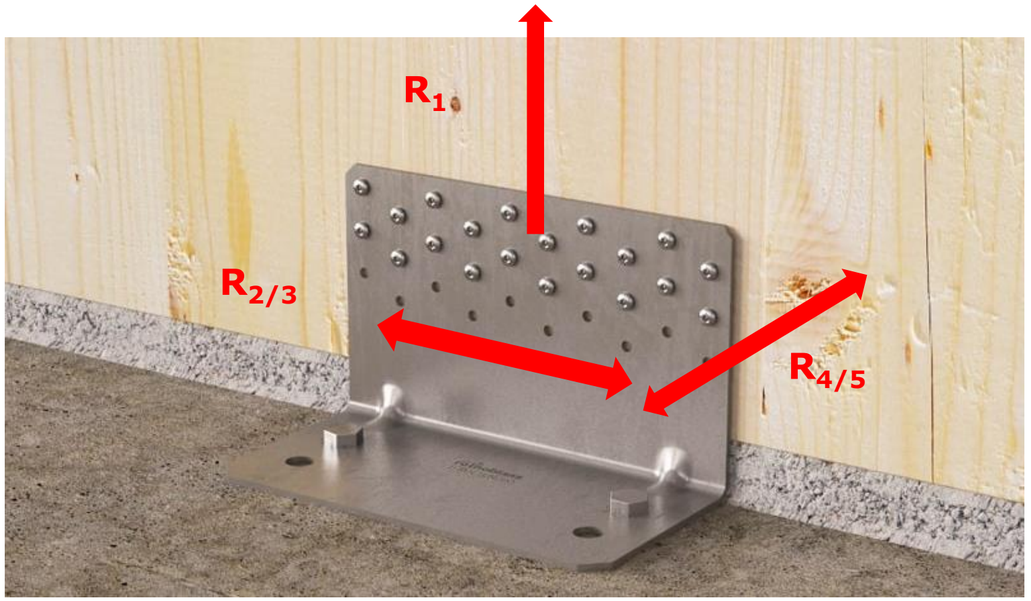
INNOVATIVE APPROACHES





ANGOLARI MODERNI

ESEMPIO: angolare TITAN N

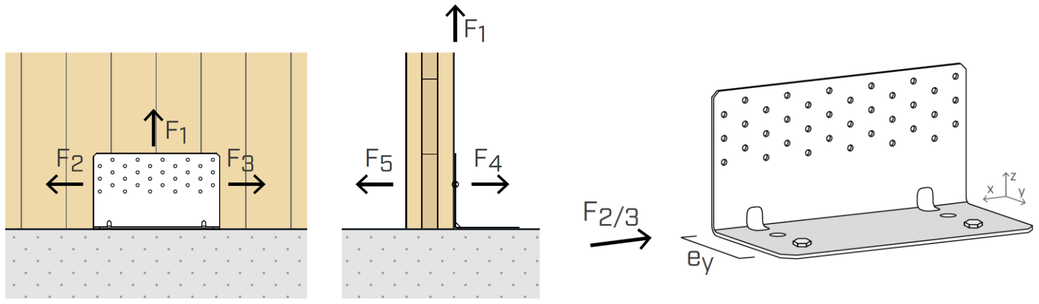


Applicazione legno/legno (chiodi Ø4 o viti Ø5).

Applicazione su legno/calcestruzzo (ancoranti chimici/avvitabili/meccanici).

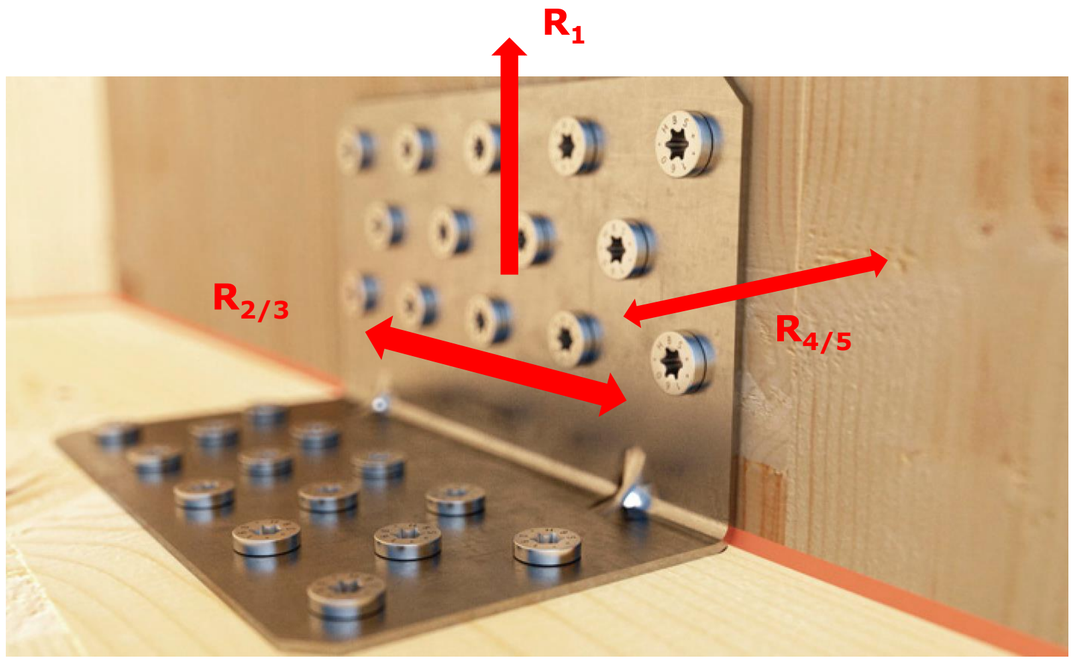
$R_{2/3,\ k,\ TIMBER} \leq 46$ kN

$R_{1,\ k,\ TIMBER} \leq 68$ kN (molto limitato dalla resistenza lato calcestruzzo)



ANGOLARI MODERNI CON VITI Ø8

ESEMPIO: Angolare Titan S



Applicazione legno / legno (viti speciali Ø8).

Uso di legno / cemento (ancoranti chimici / avvitabili / meccanici).

$R_{2/3,\ k,\ TIMBER} \leq 85$ kN

$R_{1,\ k,\ STEEL} \leq 75$ kN (molto limitato dalla resistenza lato calcestruzzo)

ANGOLARI MODERNI CON VITI Ø8 - CARATTERISTICHE

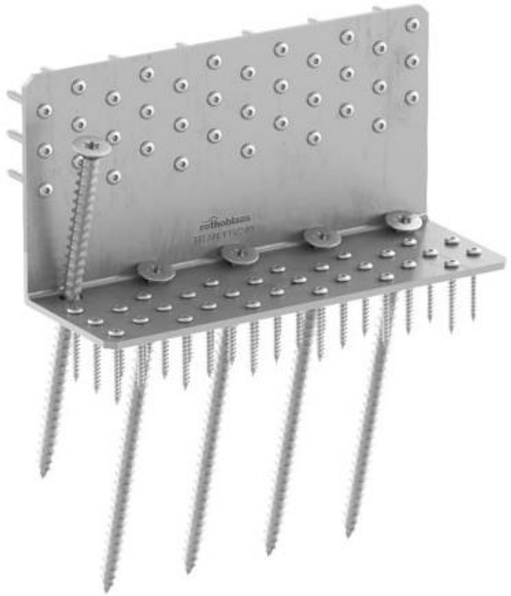
- Hanno molti dei vantaggi delle staffe angolari chiodate.
- Elevata resistenza, sia al taglio che alla trazione.
- Aumento della velocità di assemblaggio delle connessioni (poche viti di grande diametro).
- Riduzione dello sforzo fisico per gli operatori (rischio di rumore e vibrazioni).

Automatic hammer for single nails

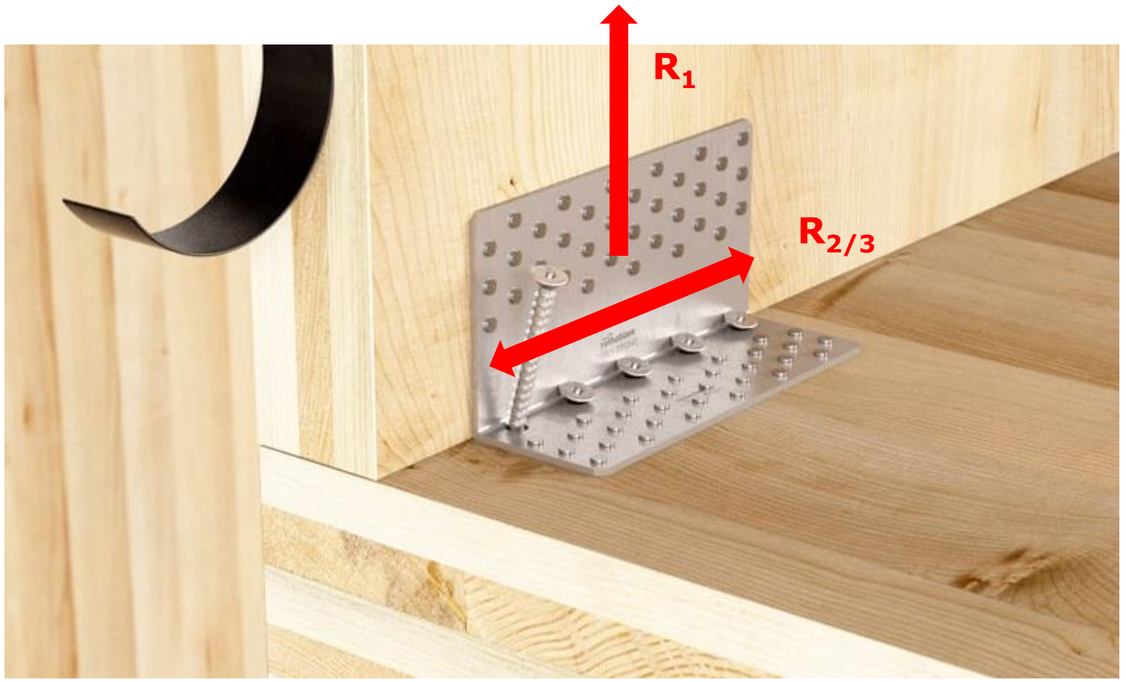
Automatic hammer for stick nails

Drill

ANGOLARI CON CHIODI E VITI A TUTTO FILETTO



ESEMPIO: angolare TITAN V



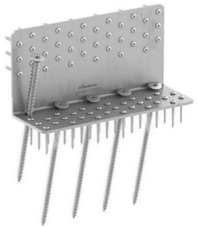
Utilizzare per connessioni legno/legno (chiodi Ø4 o viti Ø5 + viti a tuttofiletto Ø11).

Sistema innovativo in fase di brevetto.

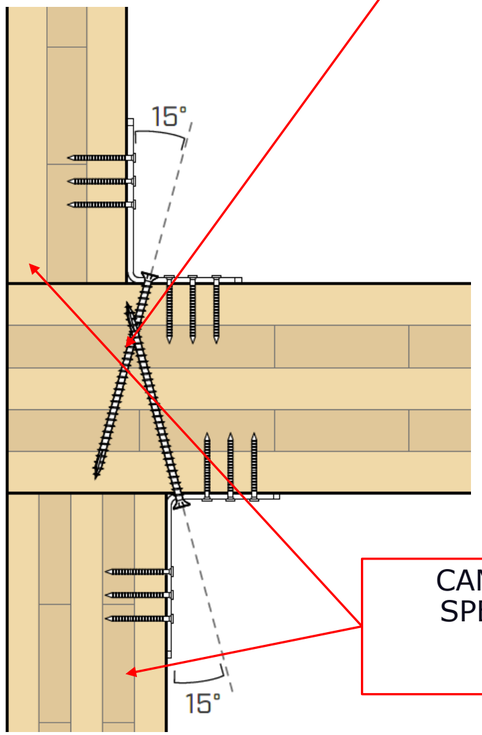
$R_{1,\,k,\,TIMBER} \leq 100$ kN

$R_{2\,/\,3,\,k,\,TIMBER} \leq 60$ kN

ANGOLARI CON CHIODI E VITI A TUTTO FILETTO - CARATTERISTICHE



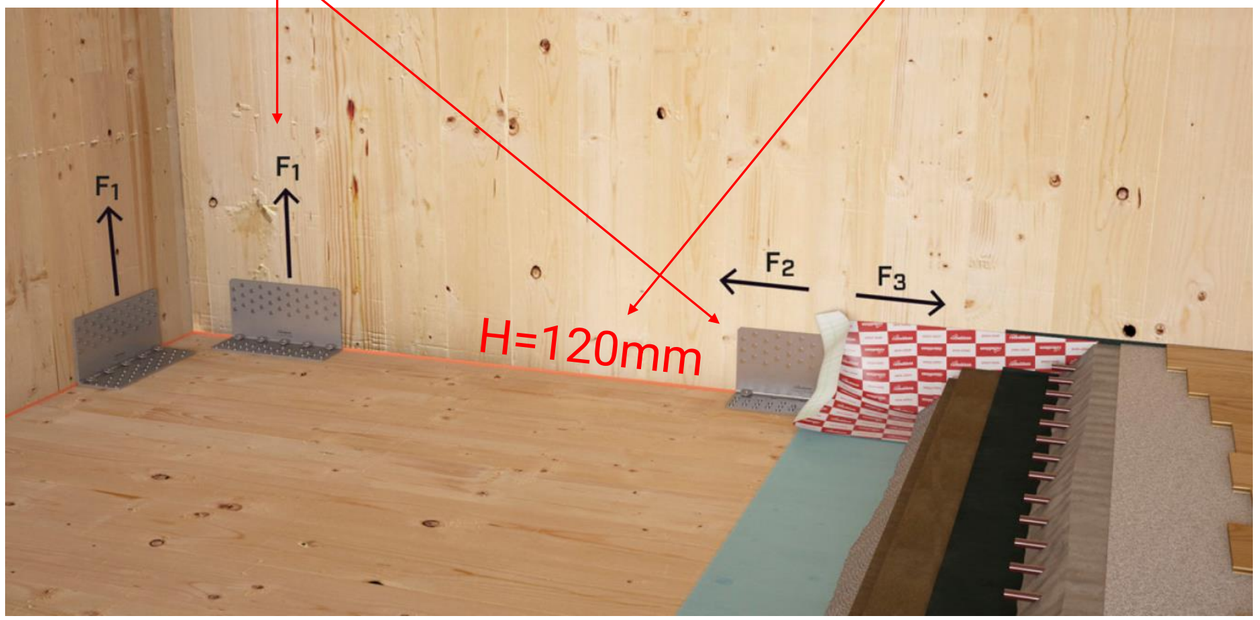
NO BARRA PASSANTE



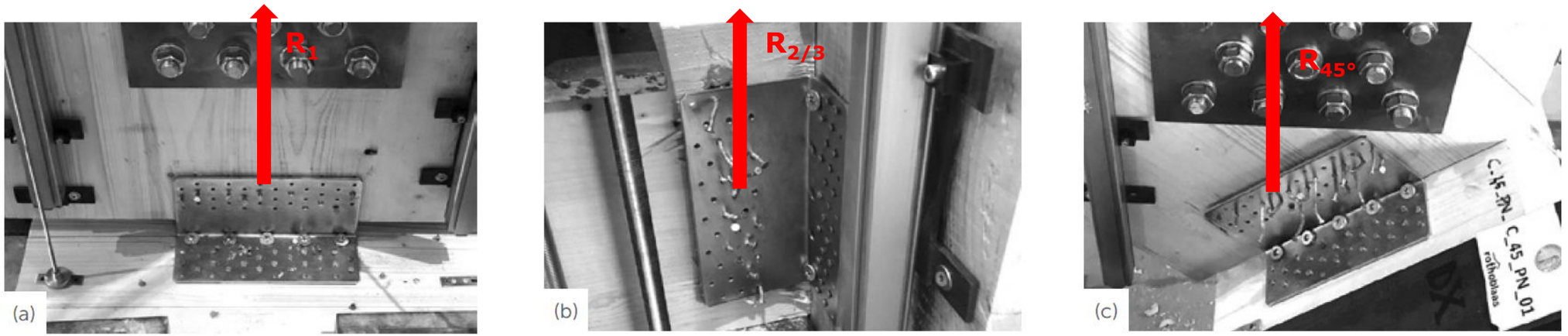
CAMBIO DI SPESSORE

STESSA PIASTRA SU TUTTA LA PARETE

HOLD-DOWN NELLO SPESSORE DEL PAVIMENTO PER PARETI A VISTA



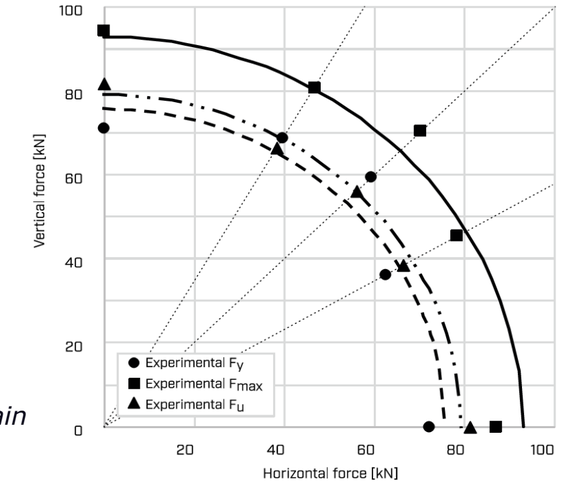
ANGOLARI CON CHIODI E VITI A TUTTO FILETTO - CARATTERISTICHE



Specimens brought to break through cyclic tests: tensile(a), shear(b) and stress at 45 °(c).

Progettato per avere una grande rigidità, associata a un cedimento duttile.

Aprono un nuovo modo di progettare,
con l'utilizzo di una resistenza TENSION-SHEAR
dominio



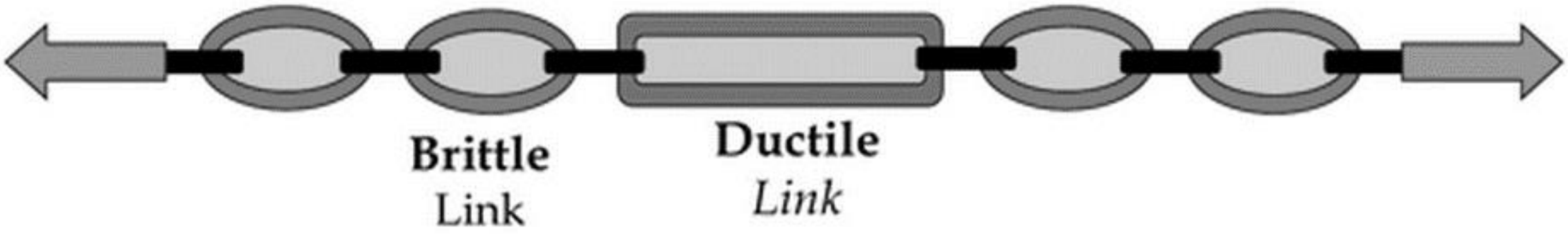
Experimental resistance domain

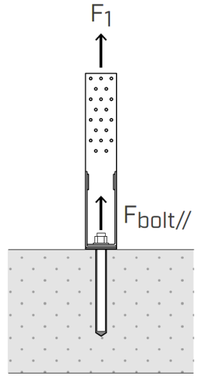
DUTTILITA’ DELLA CONNESSIONE

STEEL SIDE

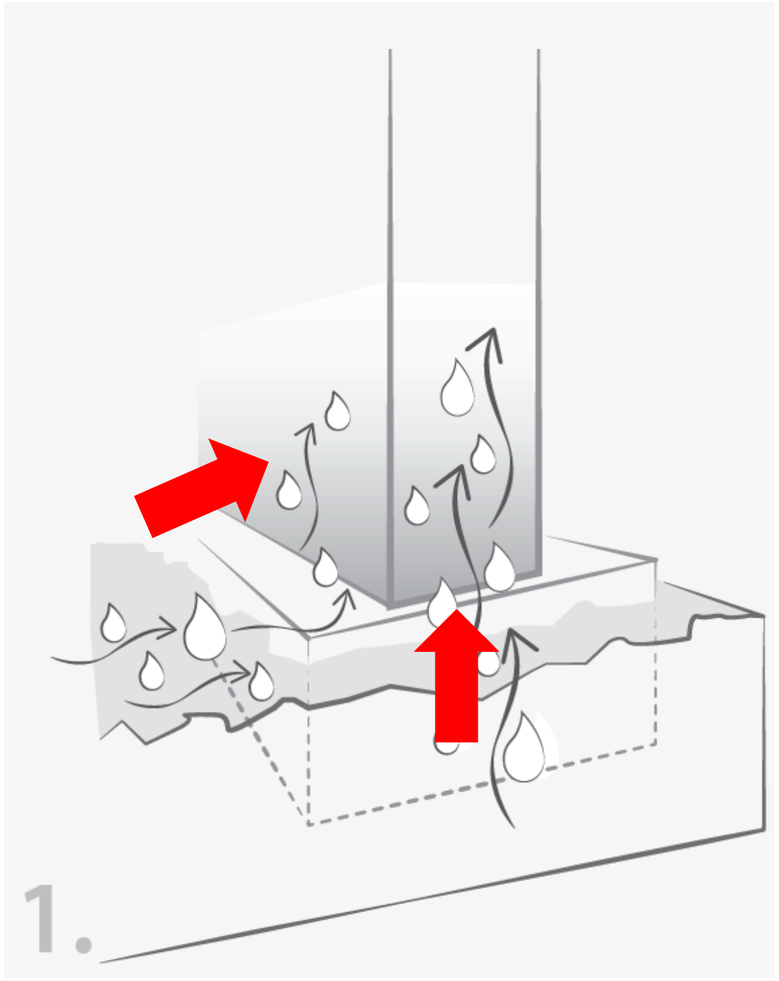
TIMBER SIDE

CONCRETE SIDE





ATTACCO A TERRA - ALUSTART



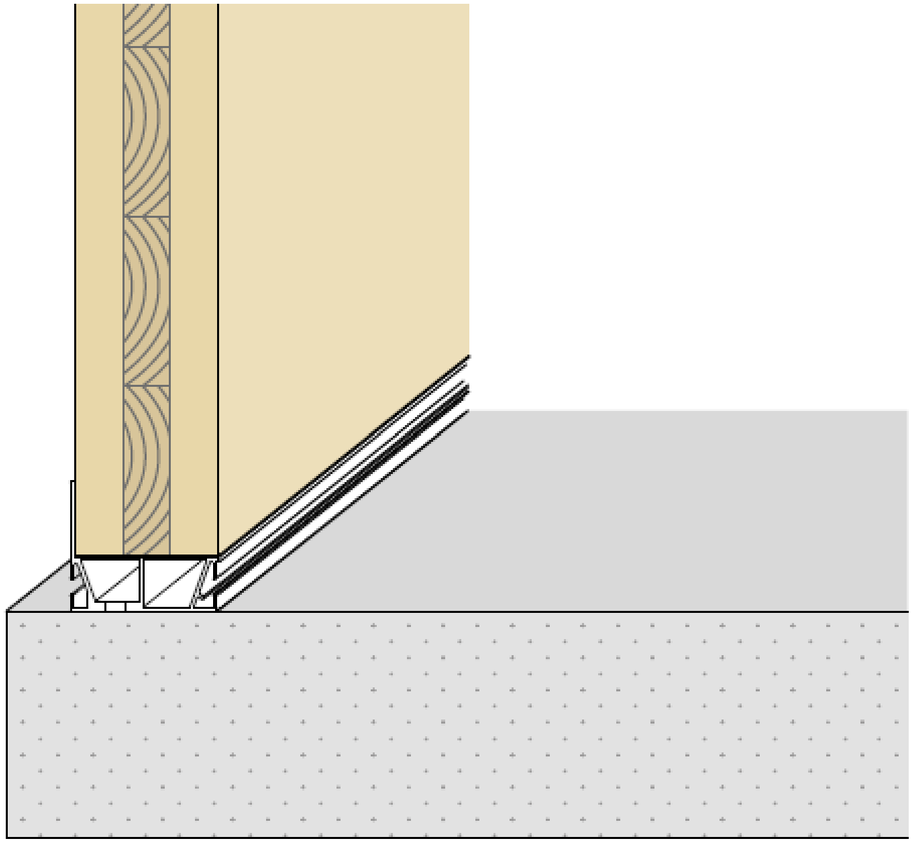
Umidità nel legno dovuta alla capillarità

Protezione della struttura in legno in un vecchio rifugio in montagna in Italia

ATTACCO A TERRA

- Separato dal suolo
- Impermeabilizzato
- Tolleranze del cordolo di calcestruzzo con la struttura in legno

ALUSTART

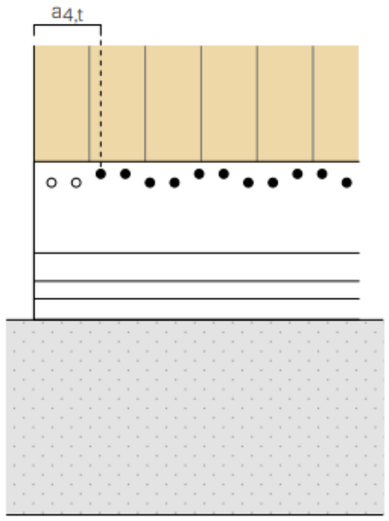


Soluzione per il collegamento di base dell'edificio in legno

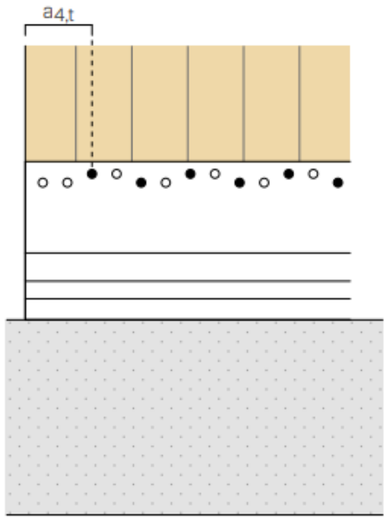
- Collegamento strutturale di pannelli di legno
- Sollevamento e livellamento di pannelli in CLT e telaio in legno
- Possibilità di trasferire alla fondazione gli sforzi di taglio, trazione (con hold-down) e compressione.

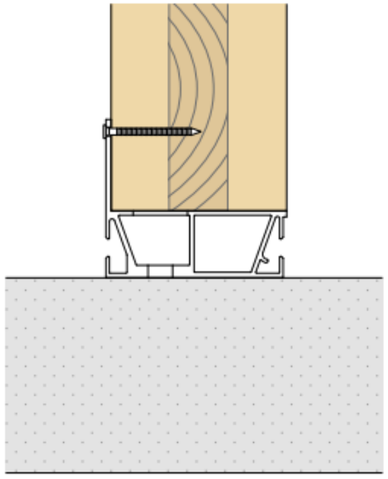
ALUSTART – RESISTENZA A TAGLIO

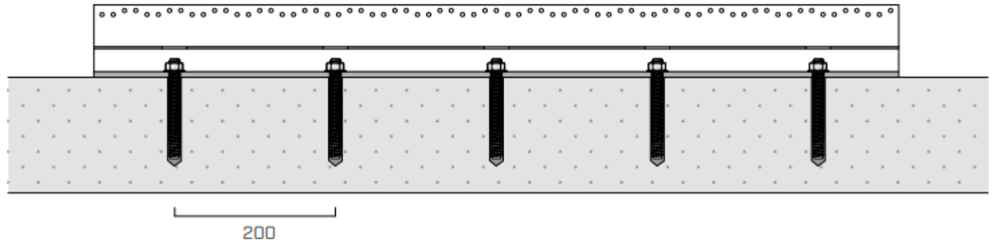
FULL NAILING ON CLT



PARTIAL NAILING ON CLT

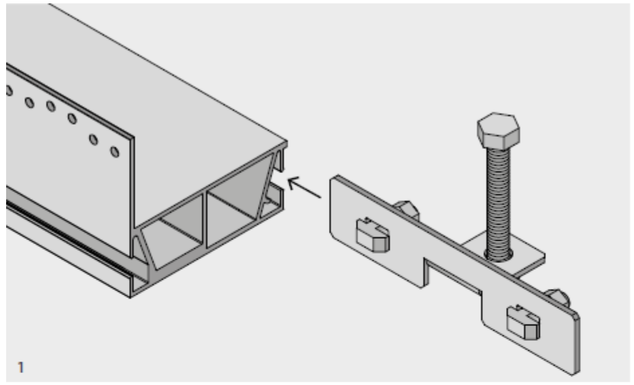


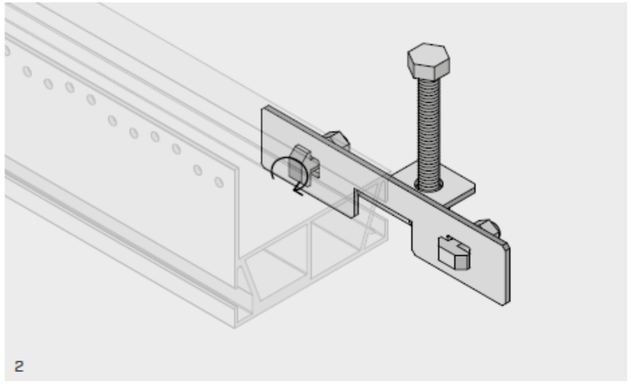


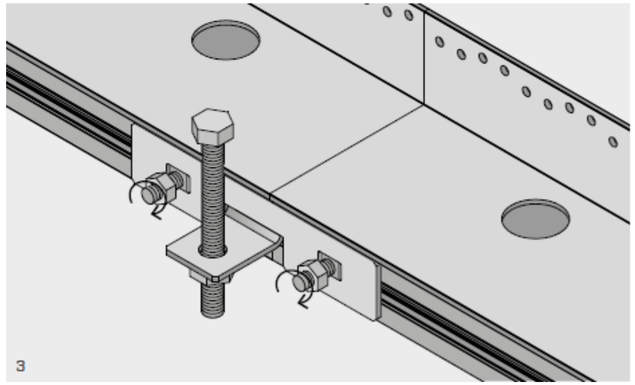


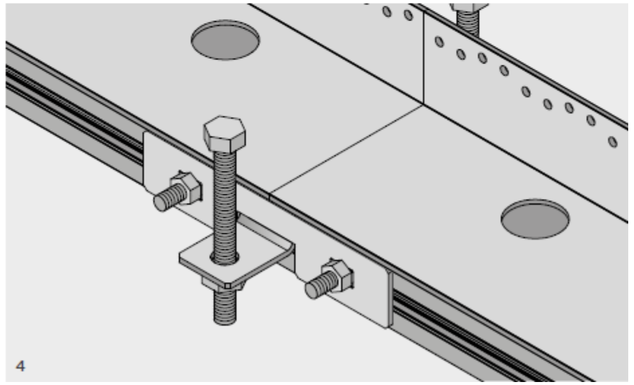
ALUSTART - JIG START DIME
ALLINEAMENTO ALTIMETRICO DEI PROFILI

JIG START I



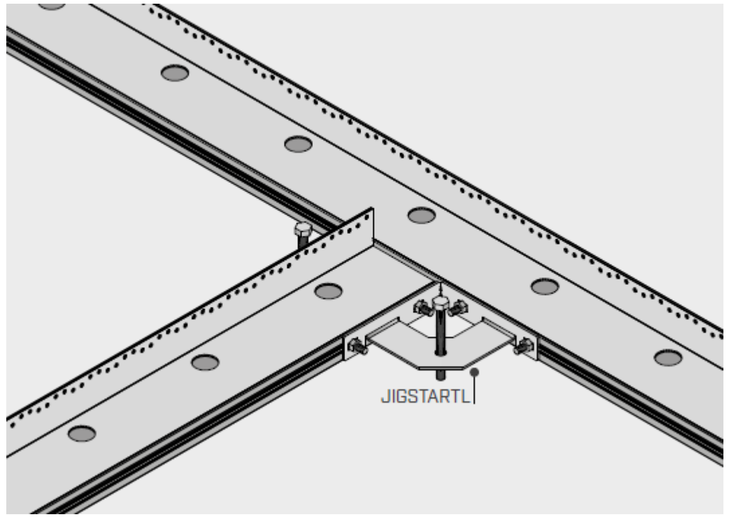






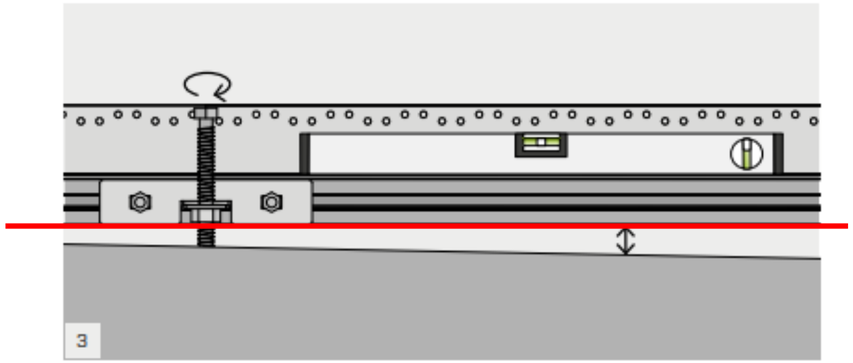
Dima lineare

JIG START L

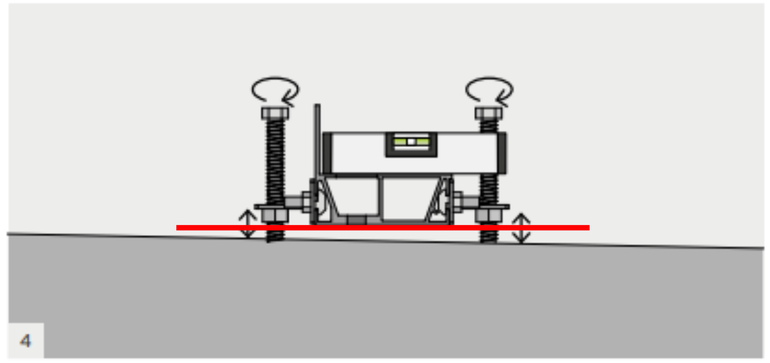


Dima ad angolo – 90°

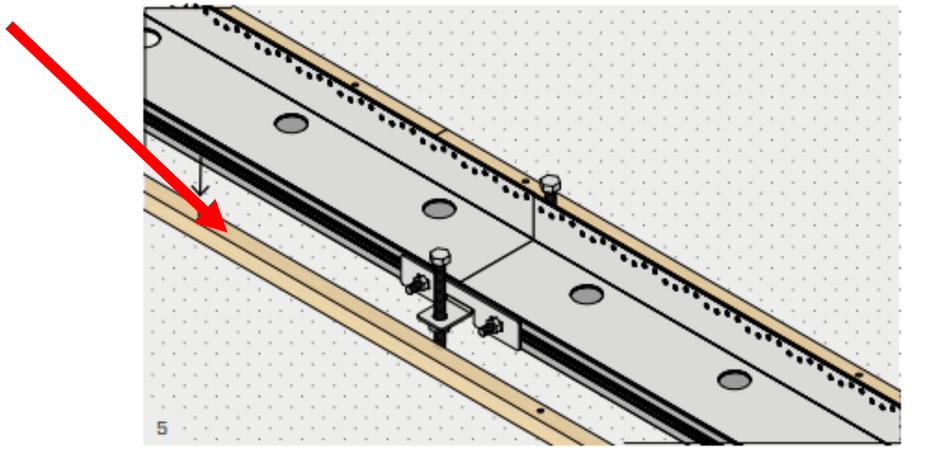
ALUSTART - JIG START DIME
ALLINEAMENTO ALTIMETRICO DEI PROFILI



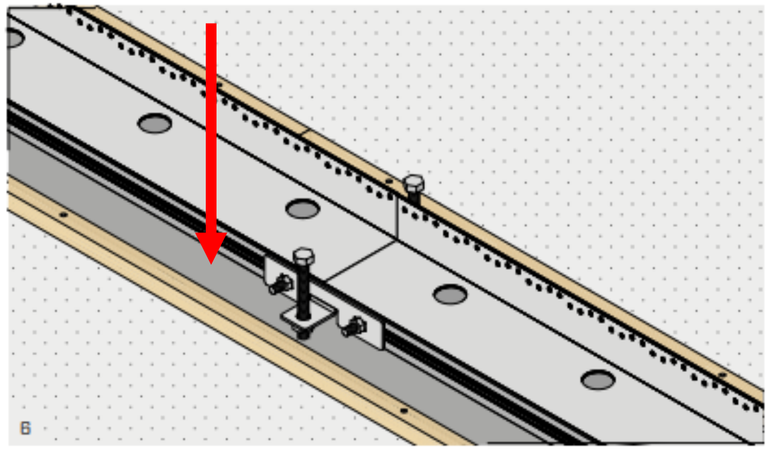
Longitudinal levelling of ALU START rods.



Lateral levelling of the rods.



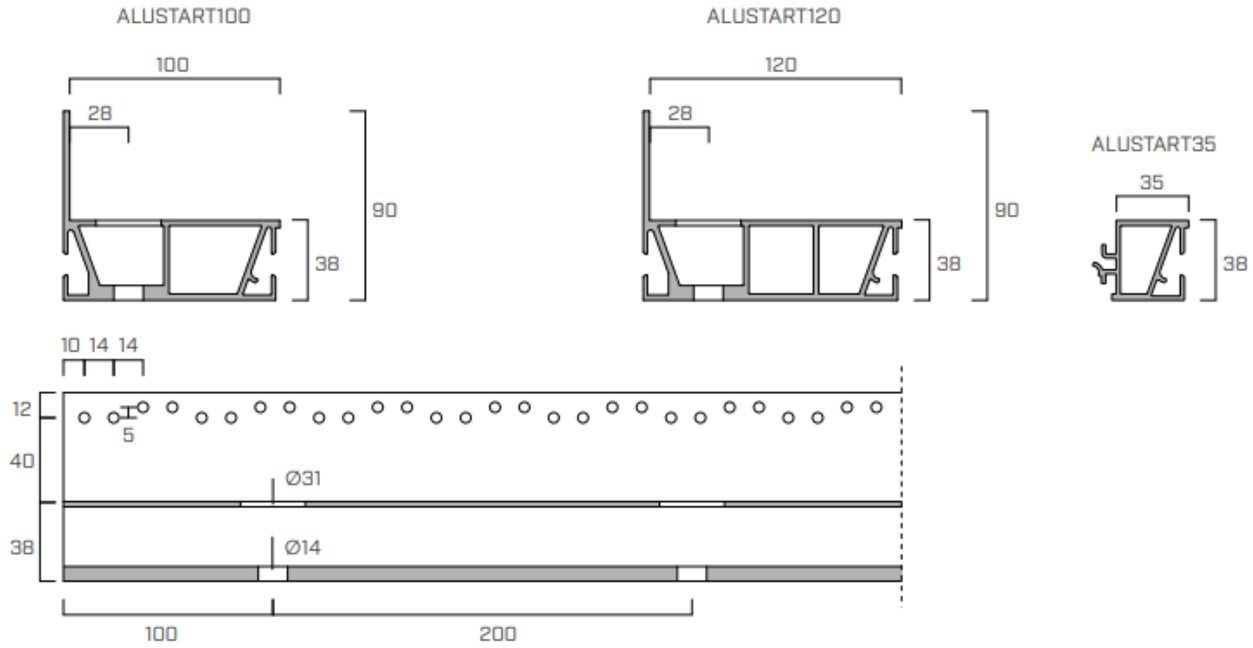
Construction of formwork with timber battens.



Creation of the bedding layer between the profile and the concrete support.

ALUSTART – GEOMETRIA

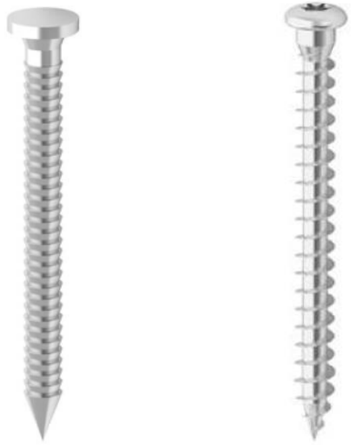
GEOMETRY



CODE	B	H	L	n_V Ø5	n_H Ø14
	[mm]	[mm]	[mm]	[pcs]	[pcs]
ALUSTART100	100	90	2400	171	12
ALUSTART120	120	90	2400	171	12
ALUSTART35	35	38	2400	-	-

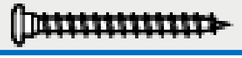
- Disegni tecnici disponibili sul sito web (.dwg, BIM)
- Possibilità di utilizzo su pannelli di diverso spessore (100-200 mm)

ALUSTART – PRODOTTI PER IL FISSAGGIO



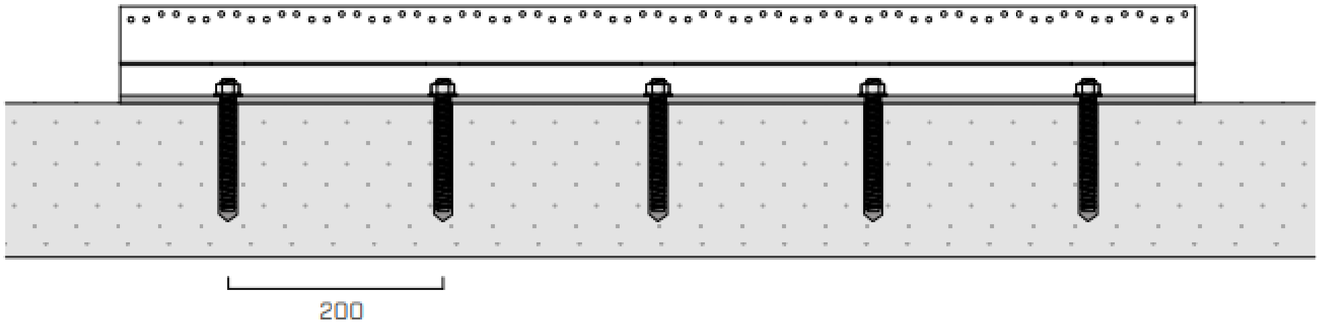
VITI Ø5 o CHIODI Ø4

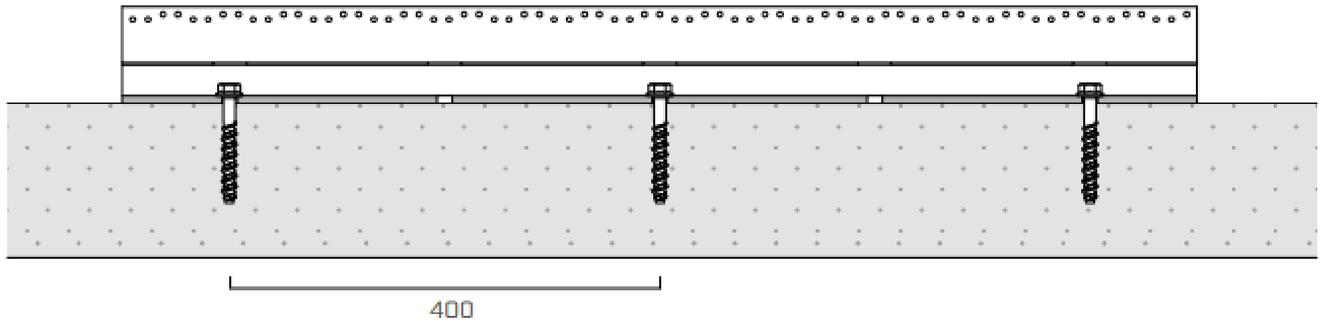
Prodotti aggiuntivi per il fissaggio

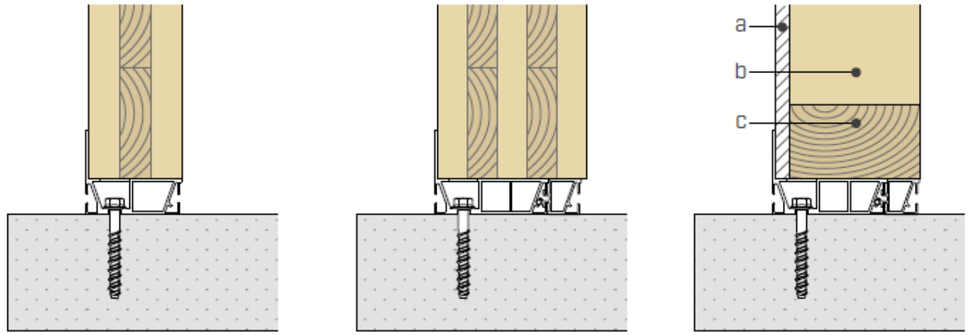
type	description		d [mm]	support	page
LBA	Anker nail		4		548
LBS	screw		5		552
SKR-E	screw mechanical anchor		12		491
AB1	expansion mechanical anchor		M12		496
VIN-FIX PRO	chemical anchor		M12		511
EPO-FIX PLUS	chemical anchor		M12		517

ALUSTART – PRODOTTI PER IL FISSAGGIO

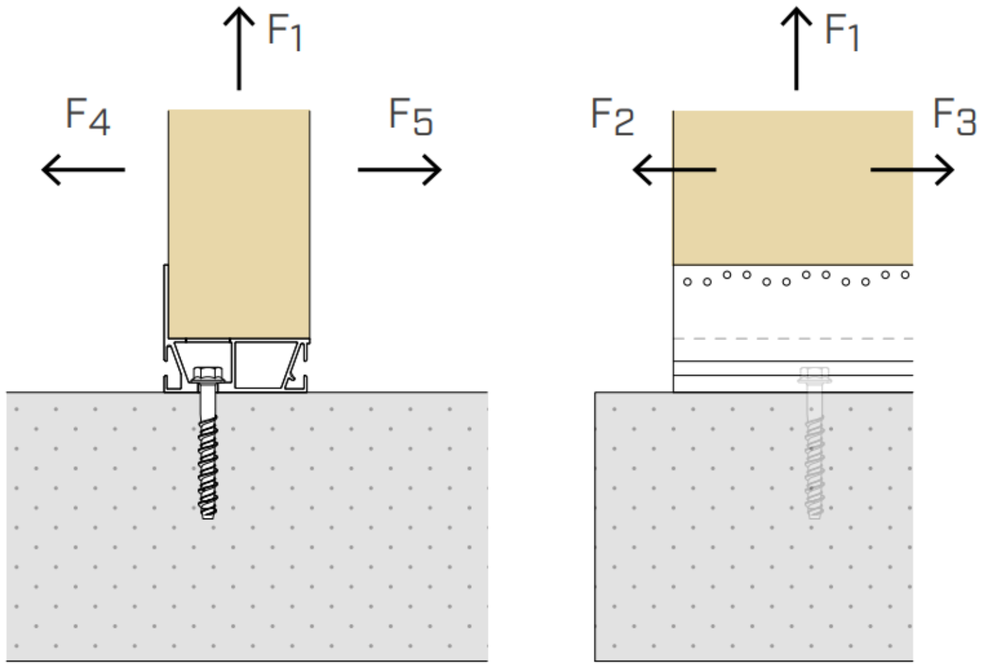
Viti o ancoranti meccanici



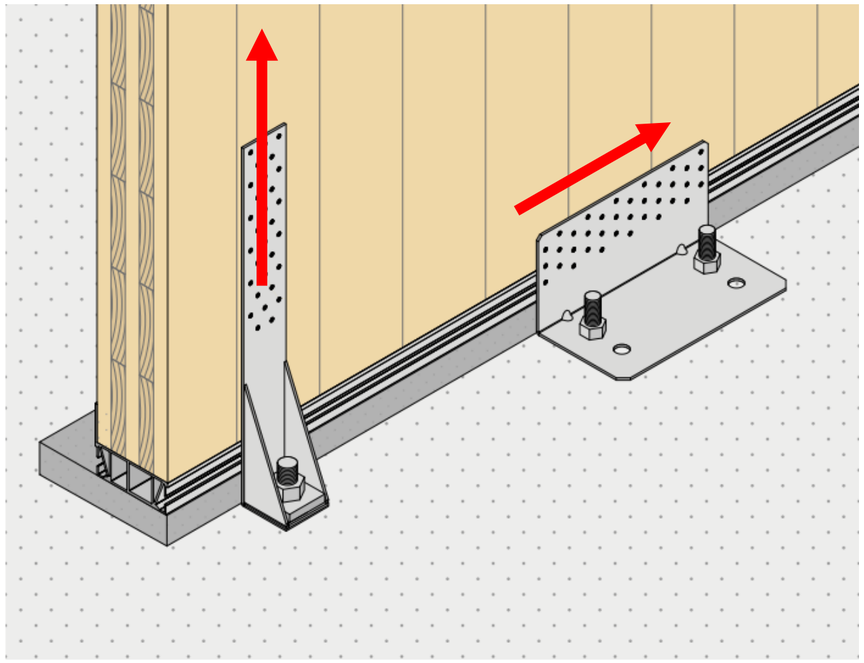




DIREZIONI DI RESISTENZA

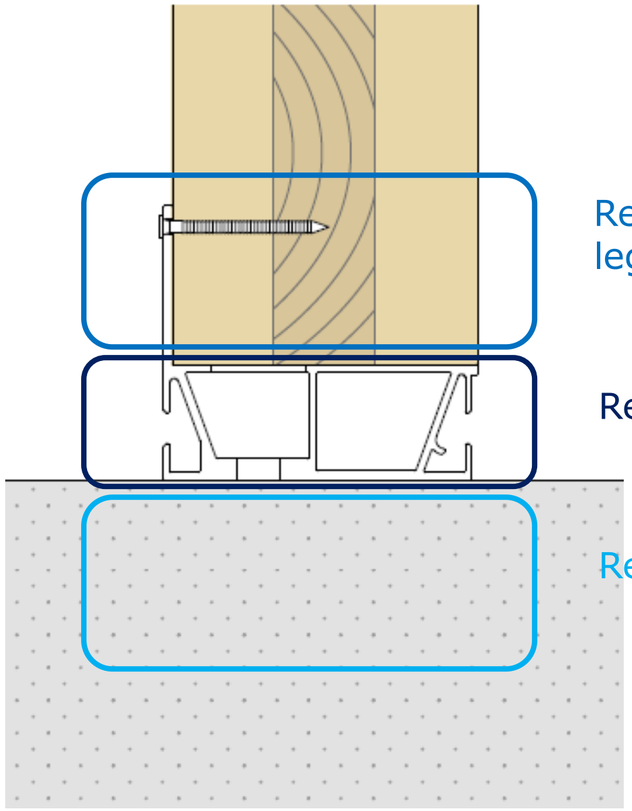


Le staffe angolari di resistenza al taglio non sono sempre necessarie.



RESISTENZA MECCANICA

Le 3 resistenze della connessione alla base



Resistenza lato legno - Collegamento tra alluminio e legno

Resistenza del materiale (alluminio)

Resistenza del collegamento al calcestruzzo

RESISTENZA MECCANICA– COMPRESSIONE

RESISTENZA A COMPRESSIONE $F_{1,c}$ LATO ALLUMINIO

	ALLUMINIO	
installazione	$R_{1,c\ aluminium}$	
	γ_{alu}	$R_{1,c,k}$ [kN/m]
ALU START 100 ALU START 120 ALU START 100 + 35 ALU START 120 + 35	γ_{M1}	721,9

Valori ottenuti da test e validi per tutti i profili, anche combinati con prolunga.

CONFERENCE TRACK TOUR 2021

VELOCIZZAZIONE CANTIERE: MONTAGGIO PRECISO E RAPIDO E RIDUZIONE DEL NUMERO DI CONNETTORI

ESEMPIO DI CANTIERE

CONFERENCE TRACK TOUR 2021

ESEMPIO DI CANTIERE

CONNESSIONE A TAGLIO PER PARETI- SLOT

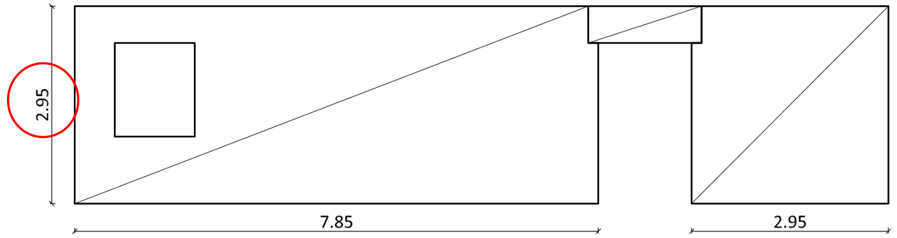
CONNETTERE PANNELLI DI CLT

LA STESSA PARETE IN CLT ... DIVERSI MODI PER TAGLIARLA ... DIVERSI COMPORTAMENTI STRUTTURALI ...

ESEMPI:

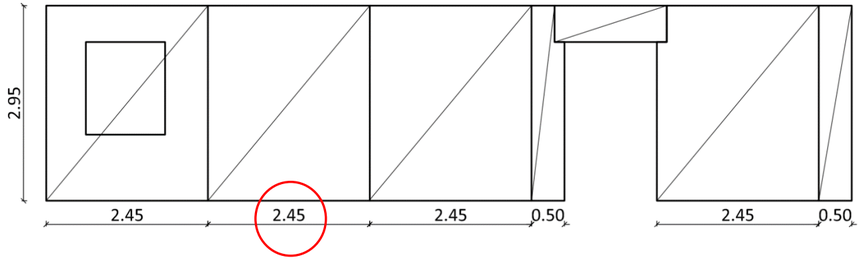
TRASPORTO VERTICALE STANDARD

Altezza massima 2,95 m



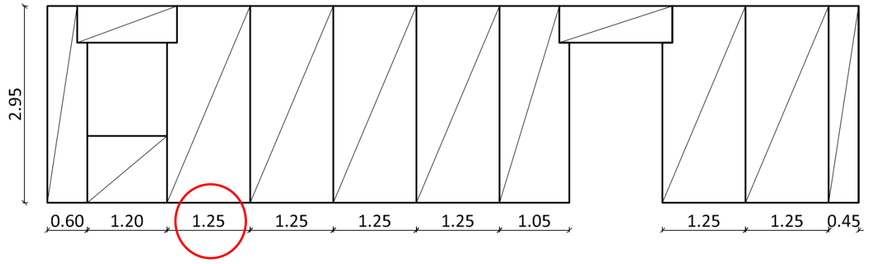
TRASPORTO ORIZZONTALE STANDARD

Larghezza massima 2,45 m



PANNELLI DI PICCOLA LARGHEZZA

Larghezza massima 1,25 m



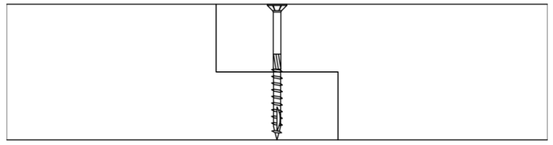
... COME COLLEGARE I PANNELLI IN CLT?

CONNETTERE PANNELLI DI CLT

SISTEMI STANDARD DI CONNESSIONE

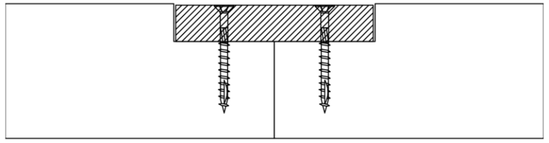
HALF-LAP JOINT + SCREWS

V_{Rk}=3.1 kN/screw (696 lbs)



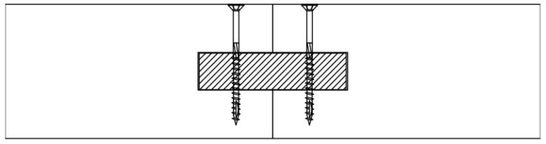
TOP PLYWOOD BOARD + SCREWS

V_{Rk}=2.2 kN/screws' couple (494 lbs)



INTERNAL BOARD + SCREWS

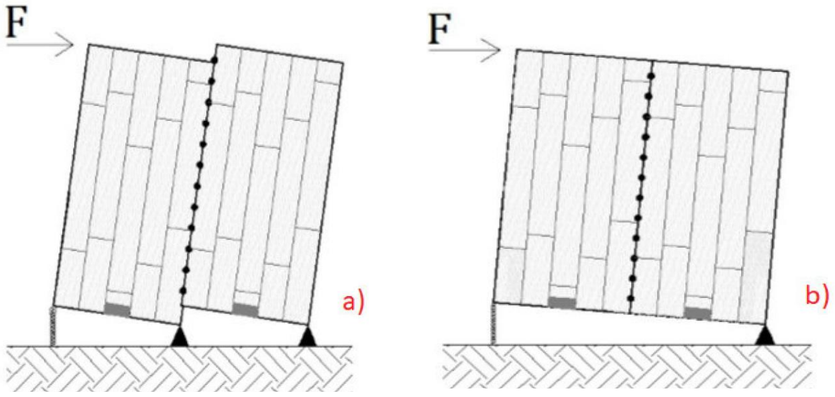
V_{Rk}=3.0 kN/screw's couple (674 lbs)



INNOVAZIONE

CONNETTORE SLOT

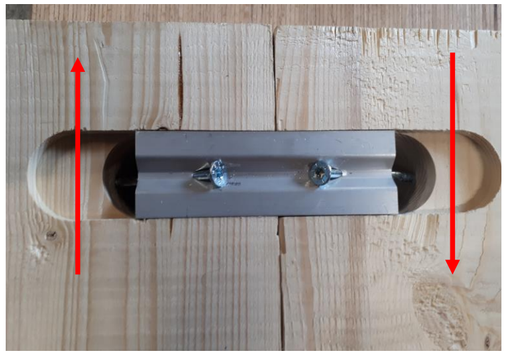
COMPORTAMENTO COME UNA PARETE SINGOLA: CONNESSIONE A TAGLIO DI ELEVATA RIGIDEZZA



a) Coupled panels behavior

b) single panel behavior (STIFF SHEARWALL)

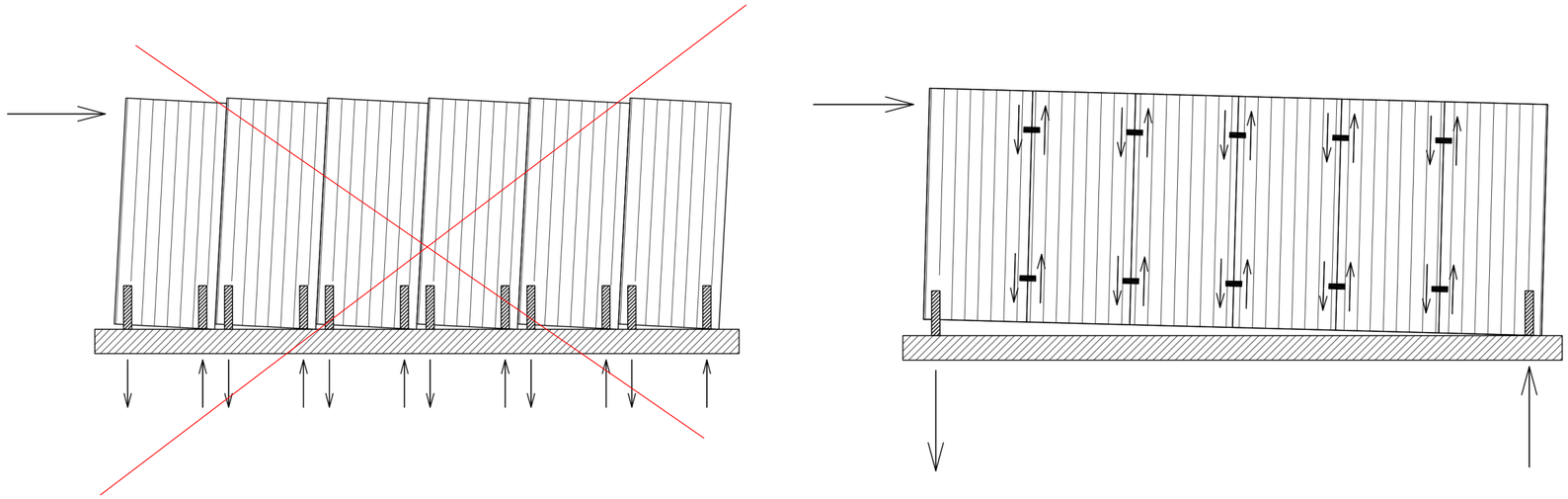
CONNETTORE IN ALLUMINIO INSERITO ALL'INTERNO DI UNA FRESATA



CONNETTERE PANNELLI DI CLT

PERCHÉ VOGLIAMO UN COMPORTAMENTO MONOLITICO?

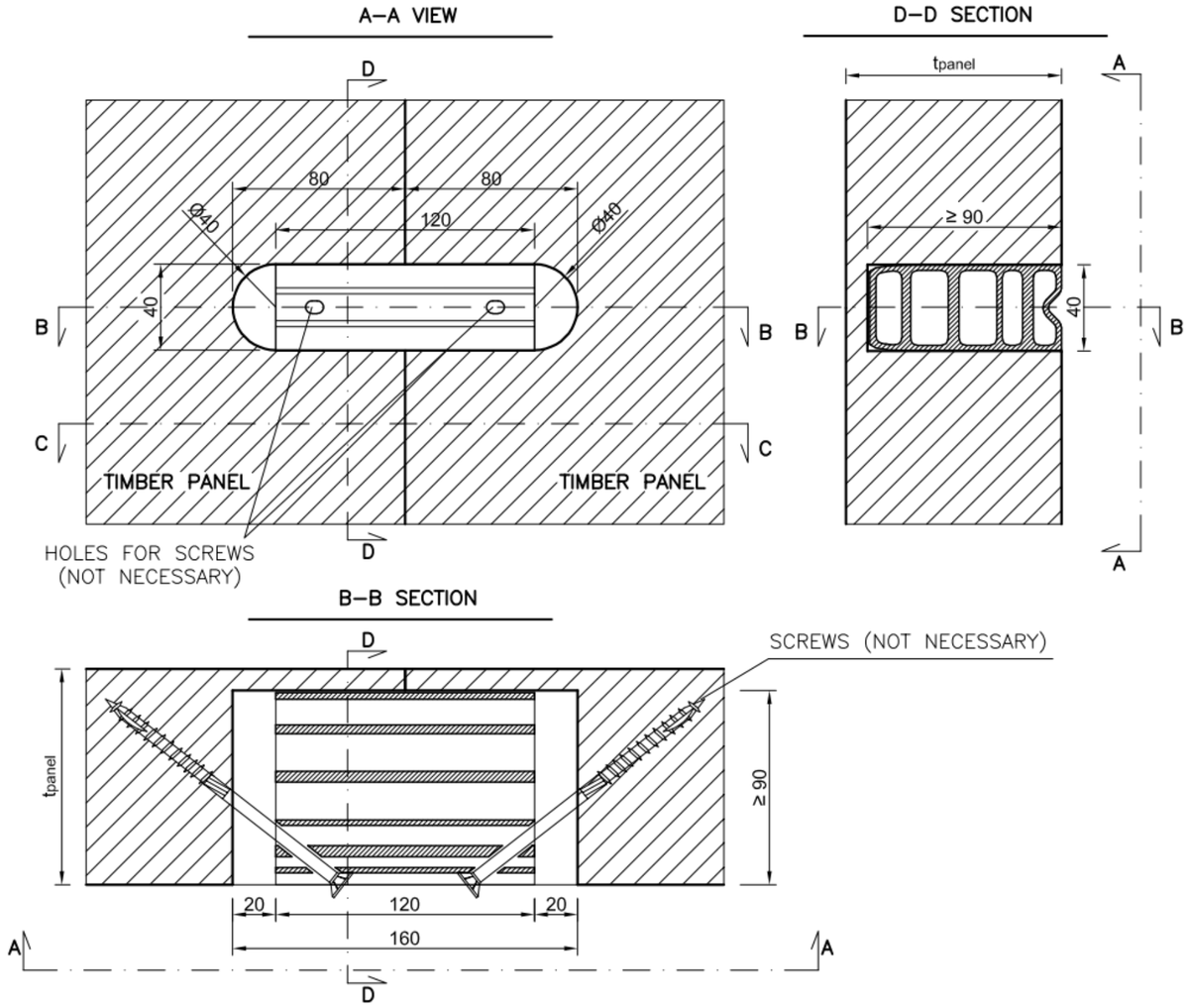
VOGLIAMO METTERE FISSAGGI SOLO ALL'ESTREMITÀ DELLE PARETI (NON ALL'ESTREMITÀ DI OGNI PANNELLO CLT)) = riduzione dei costi.



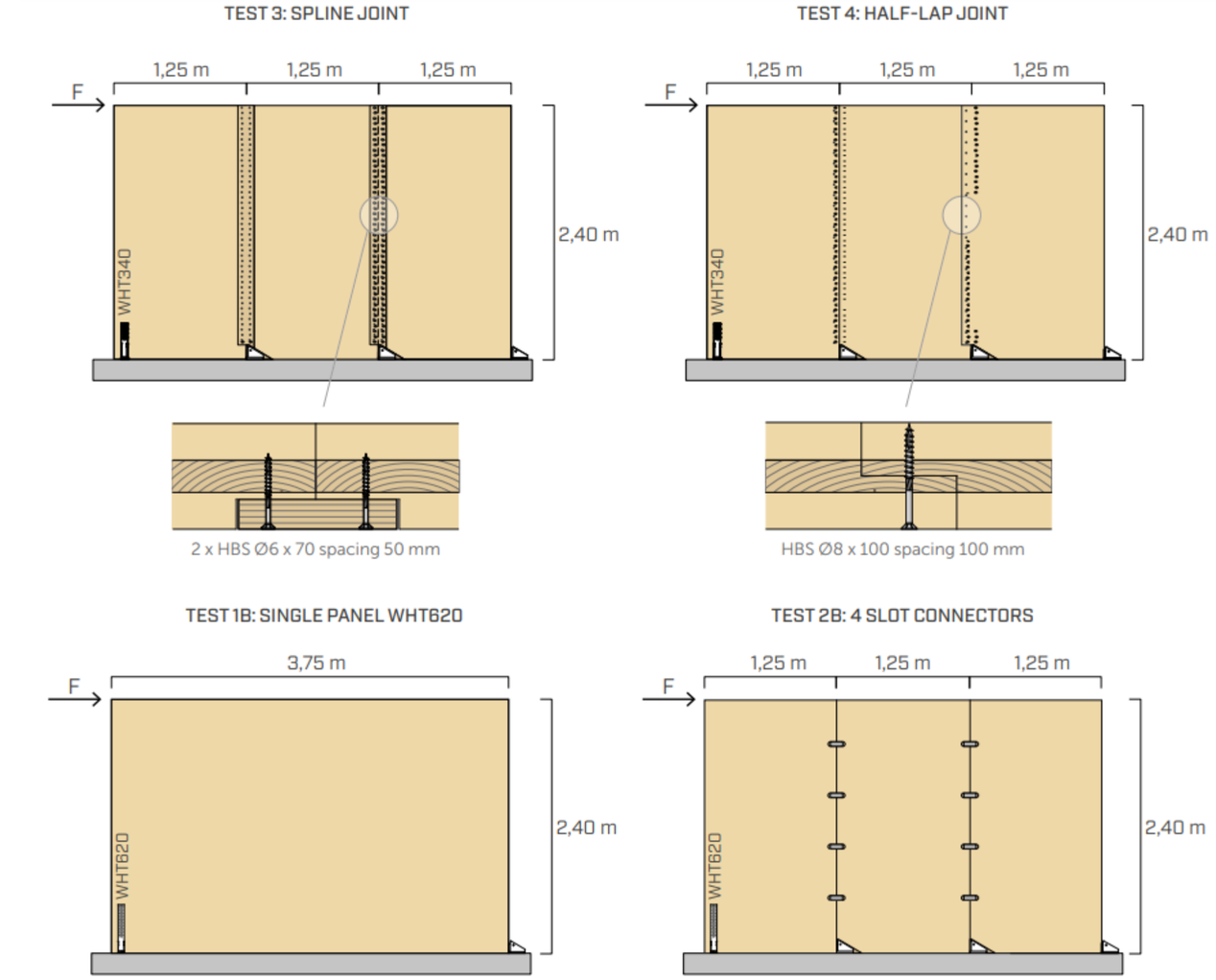
- POSSIAMO PRODURRE PANNELLI STANDARD IN CLT 1,25m E «SALDARLI» UTILIZZANDO UN RIGIDO
- CONNESSIONE → riduzione dei costi.

- UTILIZZANDO LE PARETI MONOLITICHE LA RIGIDITÀ DELLA PARETE NON È INFLUENZATA DA COME DECIDIAMO DI TAGLIARE LE PARETI → possiamo decidere di tagliare i pannelli in clt seguendo solo le esigenze di trasporto, sollevamento e costo.

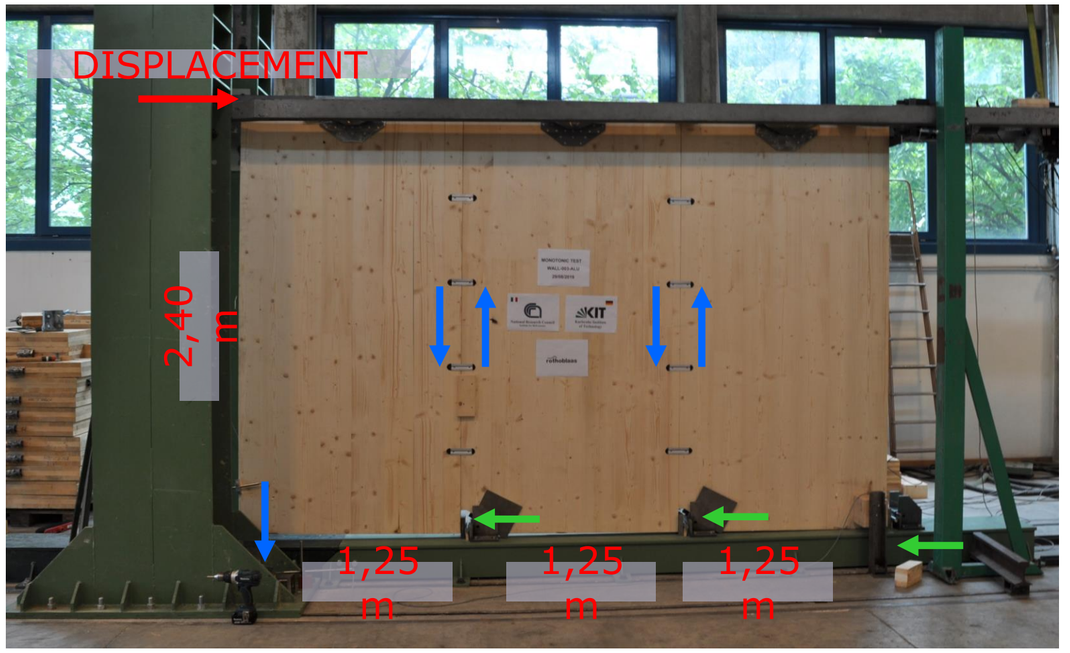
CONNETTERE PANNELLI DI CLT



TIME SAVING SLOT CONNECTOR

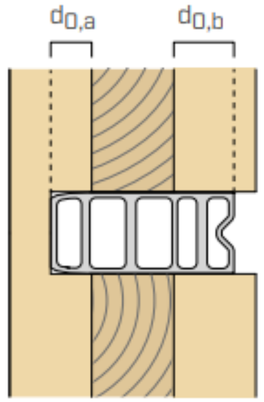


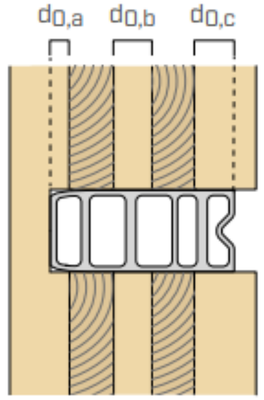
Nel 2019 è stata condotta una campagna sperimentale su pareti a grandezza naturale presso i laboratori CNR-IBE di S.Michele All'Adige. Lo scopo della campagna è di determinare il comportamento rotazionale di pareti multi-pannello, assemblate utilizzando diversi sistemi di connessione. I test sono a controllo di spostamento.



VALORI DI RESISTENZA

			$R_{v,k}$ [kN]	k_{ser} [kN/mm]
CLT [5]	$\sum d_0$ [6] =	40 [mm]	**34.37**	17,50
		45 [mm]	**37.81**	
		49 [mm]	**40.57**	
		50 [mm]	**41.26**	
		55 [mm]	**44,70**	
		59 [mm]	**47.46**	
		60 [mm]	**48.15**	
		65 [mm]	**51.59**	
		69 [mm]	**54.35**	
LVL softwood	cross grain veneer [7]		**52.72**	24,00
	parallel grain veneer [8]		**70.97**	
LVL hardwood	cross grain veneer [9]		**125.71**	48.67
	parallel grain veneer [10]		**116.59**	
glulam [11]			**68.13**	25.67





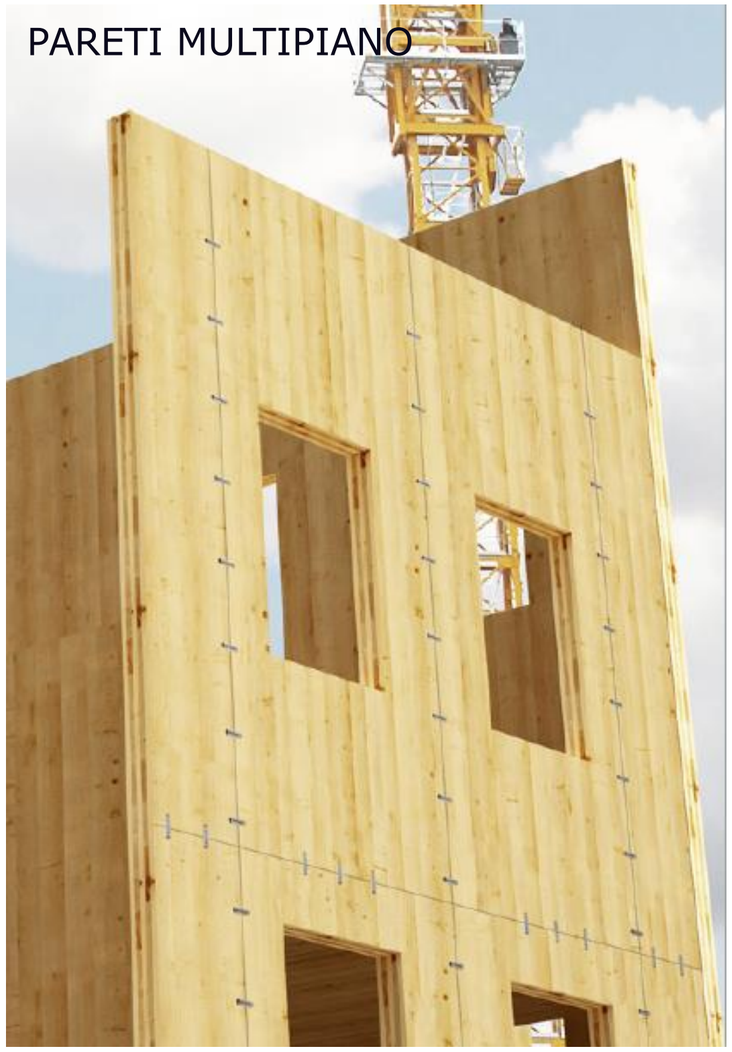
$$\sum d_0 = d_{0,a} + d_{0,b} + d_{0,c}$$

APPLICAZIONE

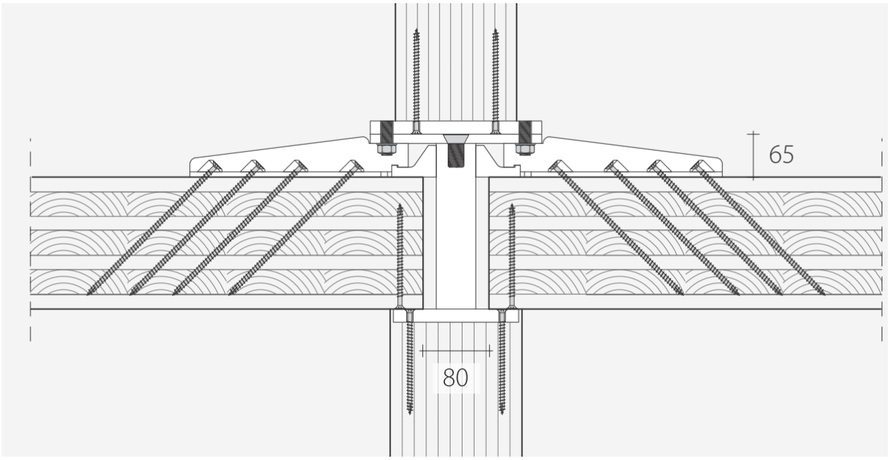
PANNELLI DI PARETE

PANNELLI DI SOLAIO

PARETI MULTIPIANO

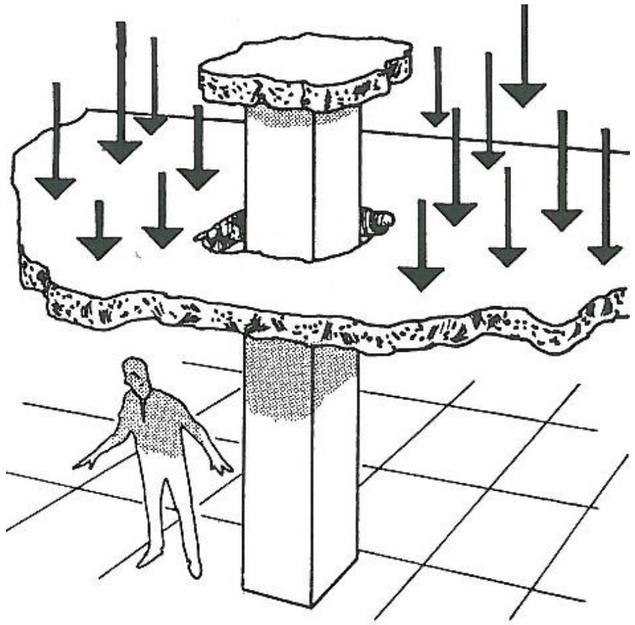


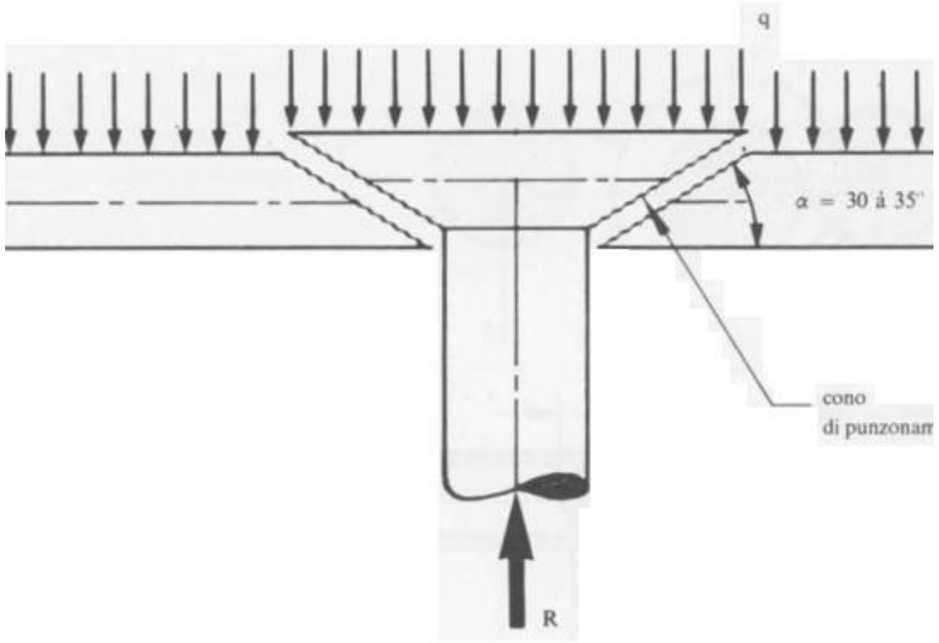
SPIDER CONNECTION



SPIDER

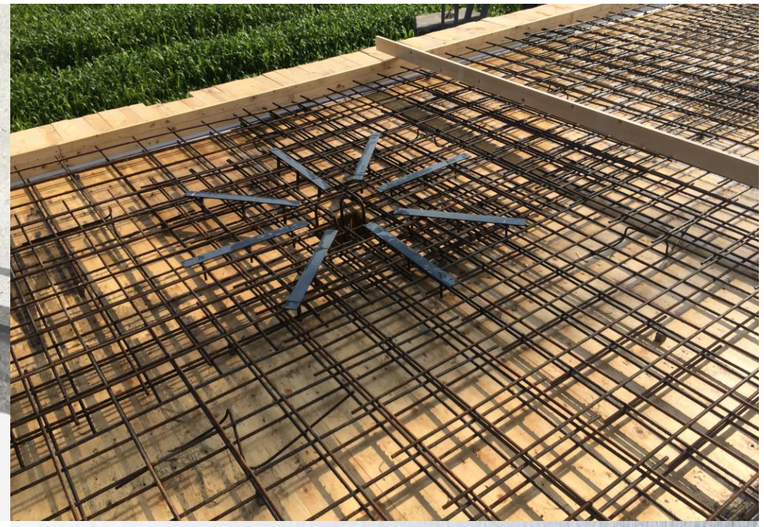
SPIDER CONNECTION

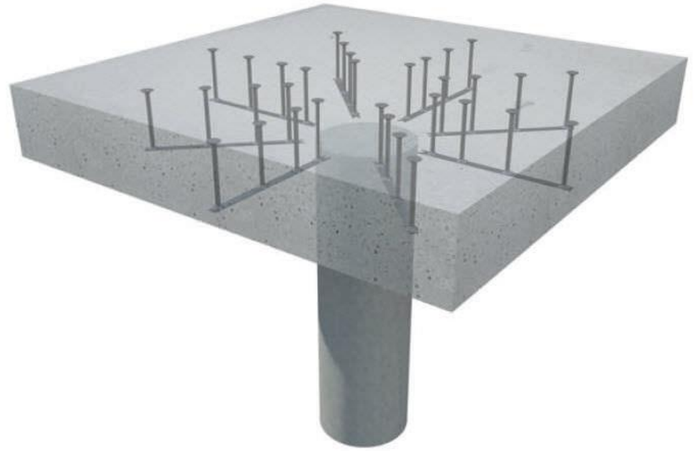




PUNZONAMENTO NELLE STRUTTURE IN CALCESTRUZZO

SPIDER CONNECTION





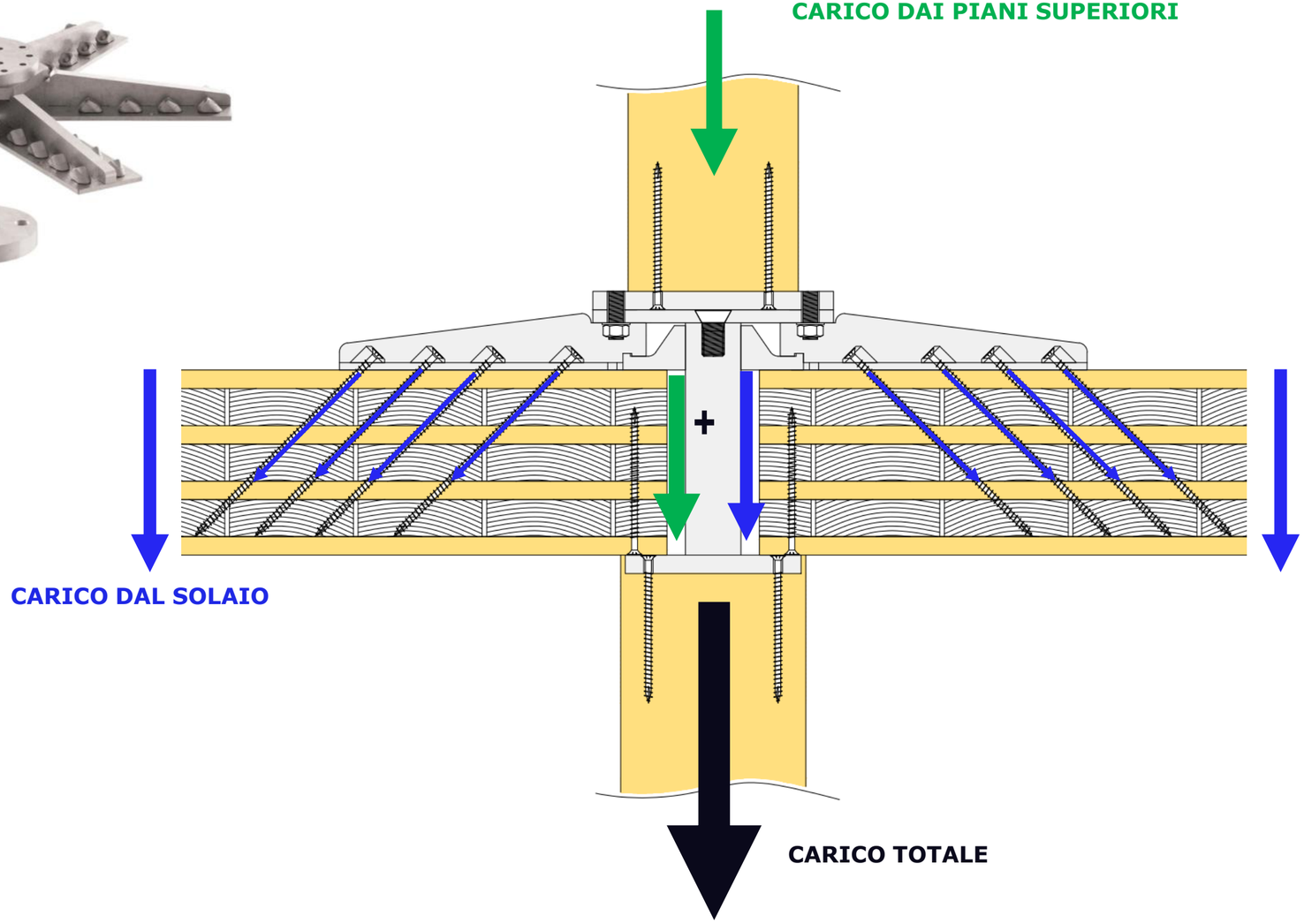
PUNZONAMENTO NELLE STRUTTURE IN CALCESTRUZZO

SOLAI IN CLT
SORRETTI DA TRAVI IN LAMELLARE

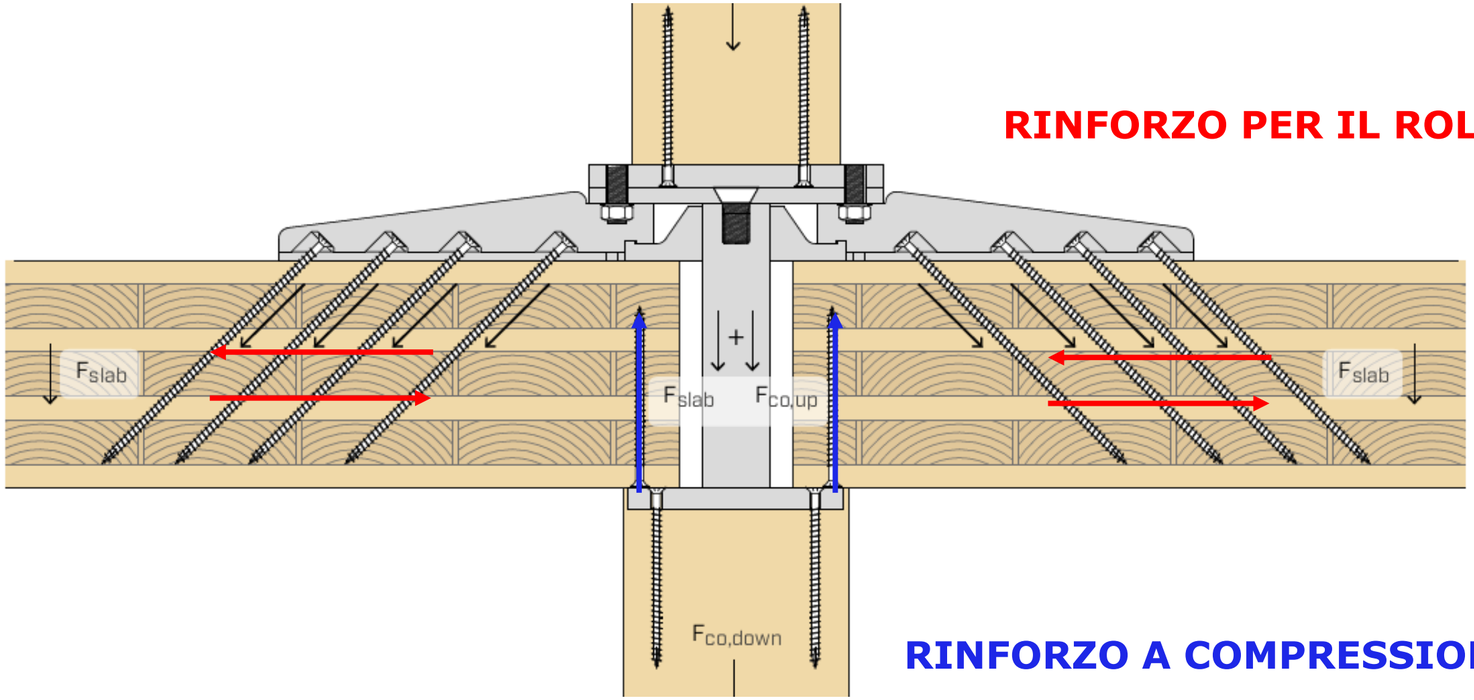
CONNECTION

SOLAI SORRETTI DA APPOGGI PUNTUALI

SPIDER CONNECTION – TRASMISSIONE DEI CARICHI



SPIDER CONNECTION – TRASMISSIONE DEI CARICHI

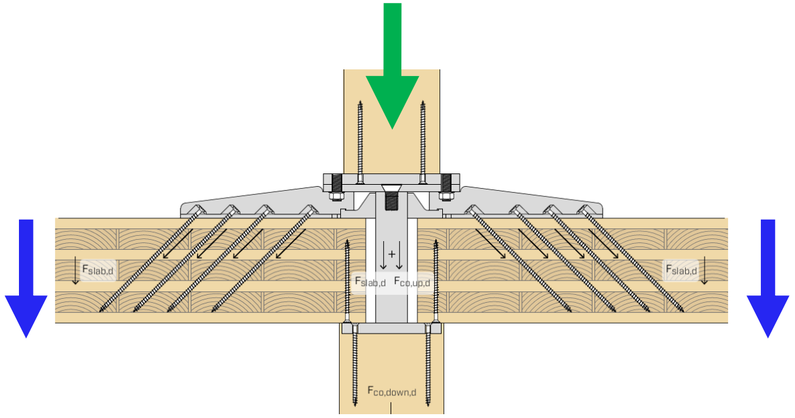


RINFORZO PER IL ROLLING SHEAR

RINFORZO A COMPRESSIONE PERPENDICOLARE ALLA FIBRA

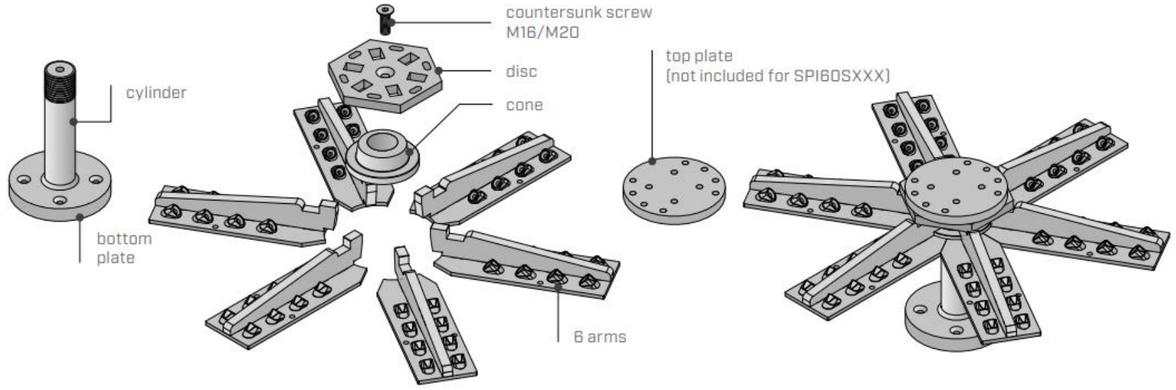
SPIDER CONNECTION – RESISTENZA DELLA CONNESSIONE

Type	CLT FLOOR THICKNESS 160 [mm]		180 [mm]		200 [mm]		220 [mm]		240 [mm]		160 + 160 [mm]		COLUMN
	$F_{co,up,d}$ [kN]	$F_{slab,d}$ [kN]	$F_{co,up,d}$ [kN]	$F_{slab,d}$ [kN]	$F_{co,up,d}$ [kN]	$F_{slab,d}$ [kN]	$F_{co,up,d}$ [kN]	$F_{slab,d}$ [kN]	$F_{co,up,d}$ [kN]	$F_{slab,d}$ [kN]	$F_{co,up,d}$ [kN]	$F_{slab,d}$ [kN]	
SPI 60 S	345	296	290	349	240	401	185	454	135	506	245	394	GL32h
SPI 80 S	630	296	575	349	525	401	470	454	420	506	530	394	
SPI 80 M	920	296	865	349	815	401	760	454	710	506	820	394	
SPI 80 L	1.215	296	1.185	349	1.135	401	1.080	454	1.030	506	1.140	394	
SPI 100 S	1.515	296	1.515	349	1.515	401	1.515	454	1.475	506	1.515	394	LVL GL75
SPI 100 M	1.965	296	1.930	349	1.895	401	1.855	454	1.820	506	2.030	394	
SPI 120 S	2.490	296	2.440	349	2.385	401	2.335	454	2.280	506	2.395	394	
SPI 120 M	2.855	296	2.855	349	2.855	401	2.855	454	2.855	506	2.855	394	
SPI 100 L	3.805	296	3.805	349	3.805	401	3.805	454	3.805	506	3.805	394	STEEL
SPI 120 L	4.840	296	4.840	349	4.840	401	4.840	454	4.840	506	4.840	394	

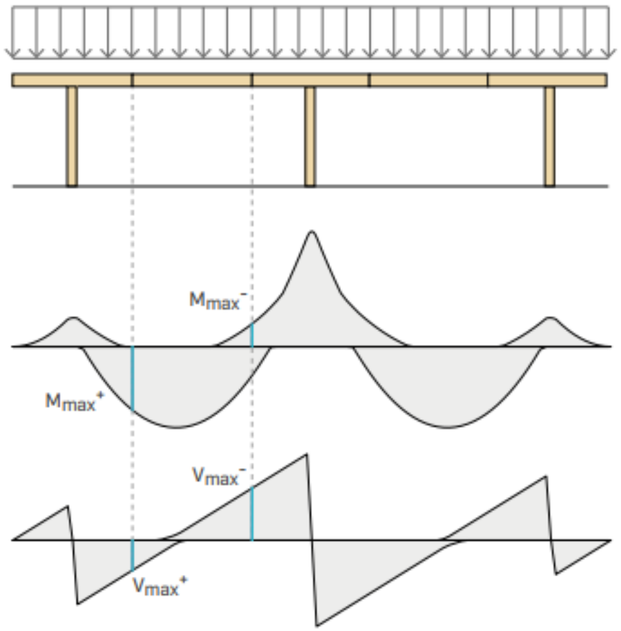


SPIDER CONNECTION

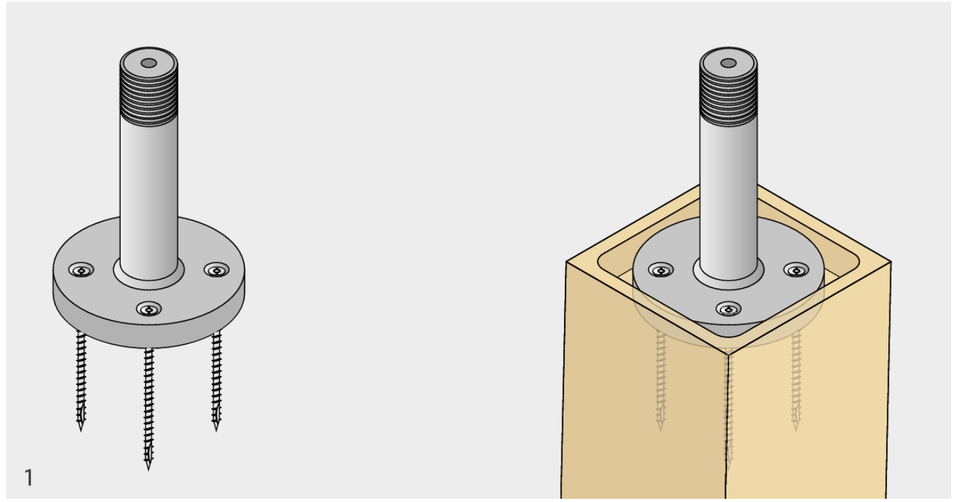
Each code includes the following components:

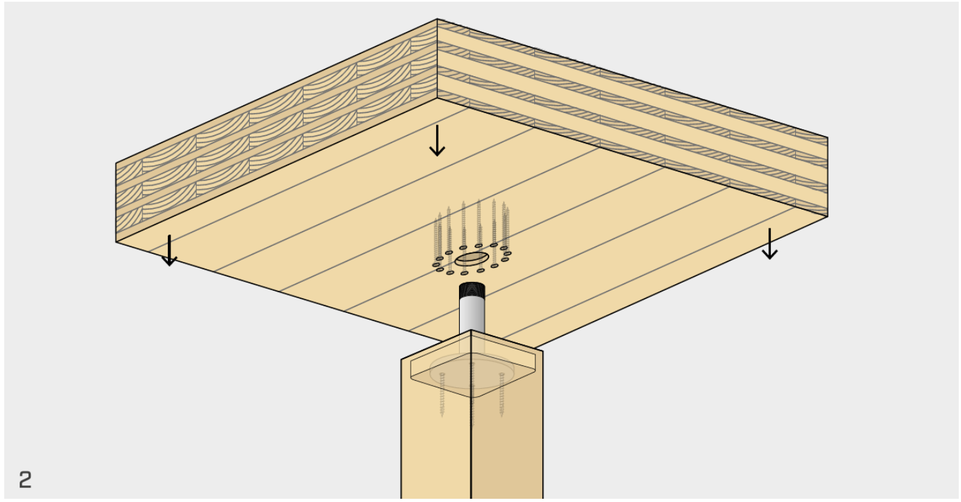


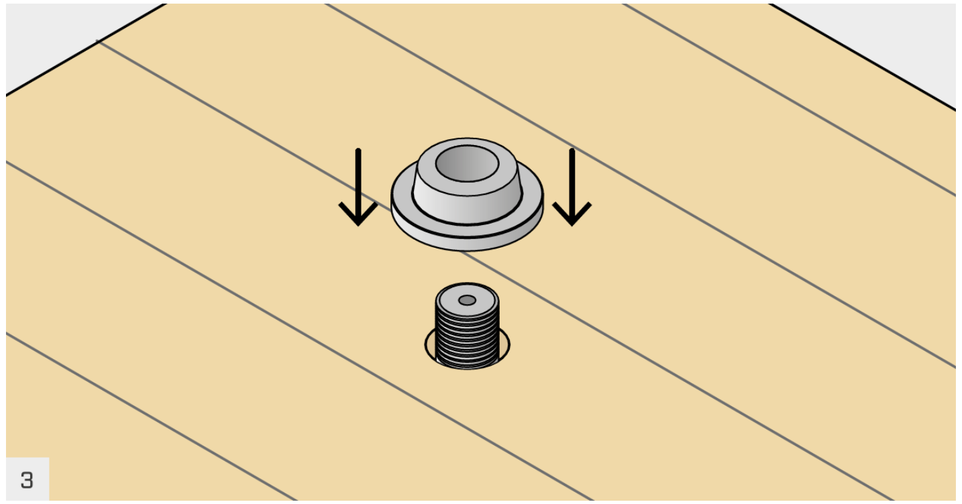
SPIDER WITH PLATE FLOOR

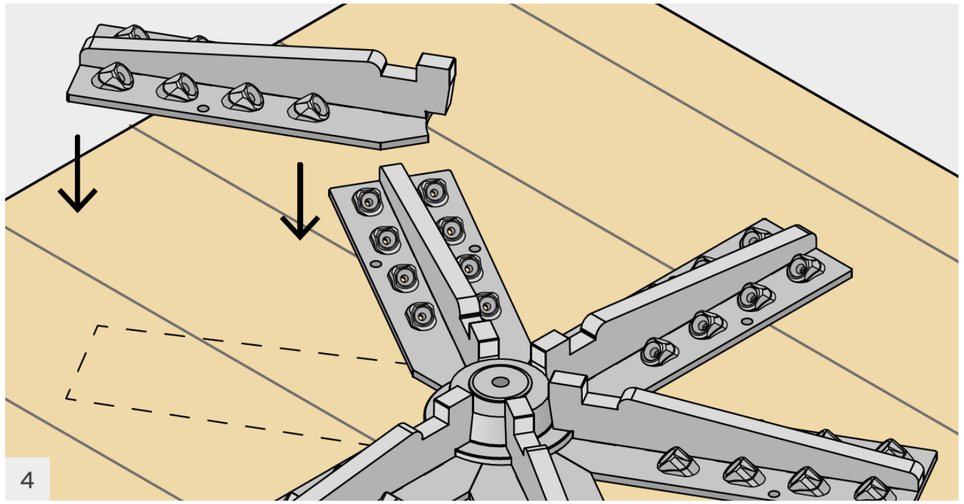


SPIDER CONNECTION – ASSEMBLAGGIO

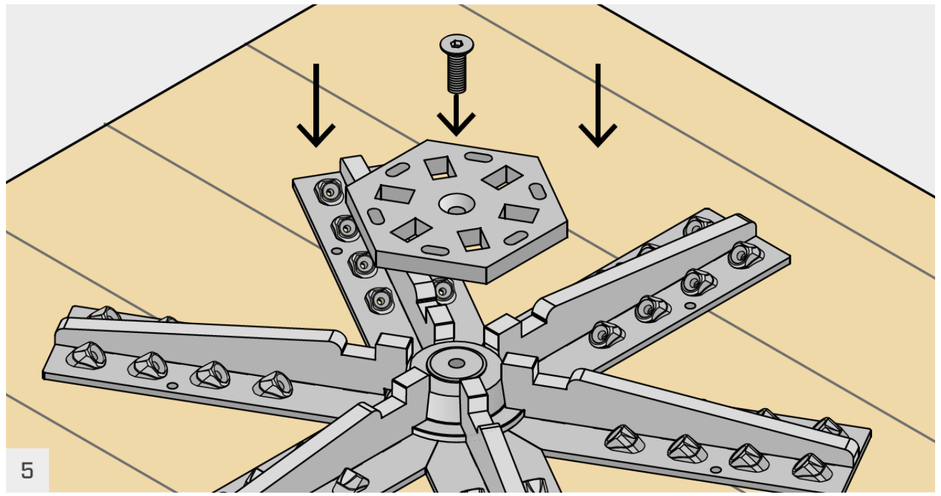








SPIDER CONNECTION – ASSEMBLAGGIO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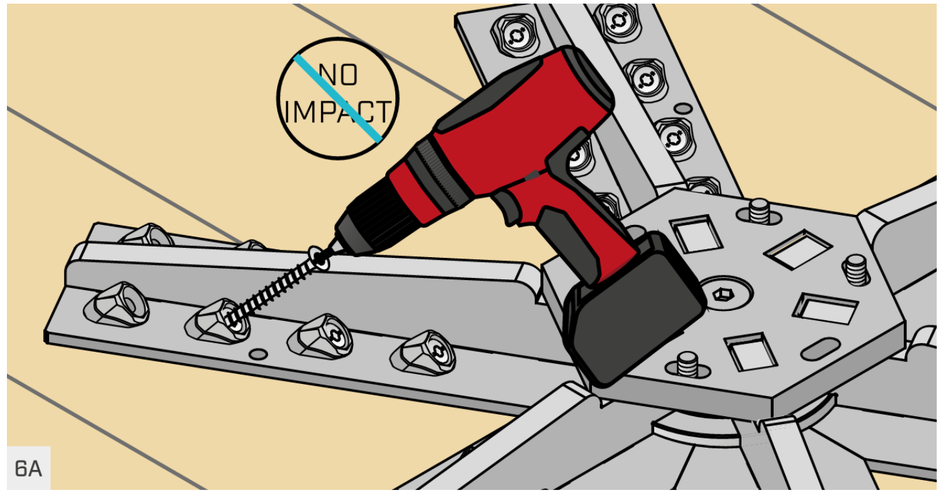
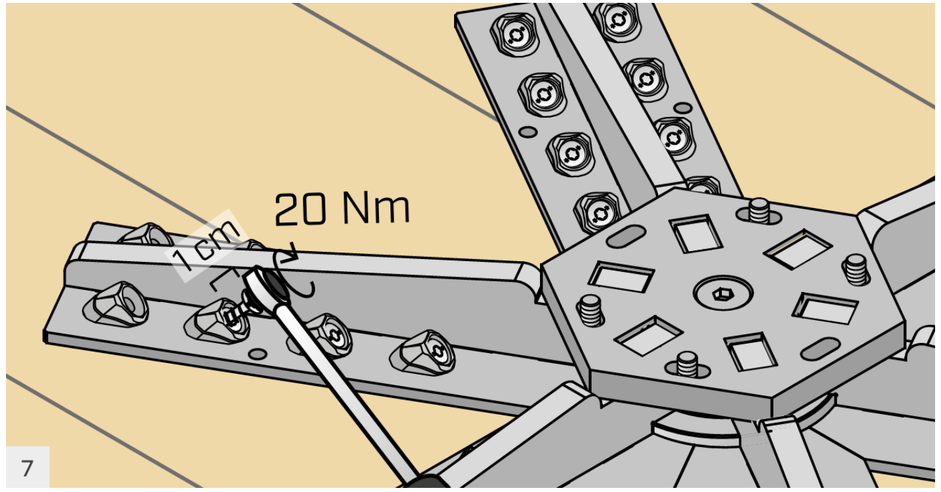
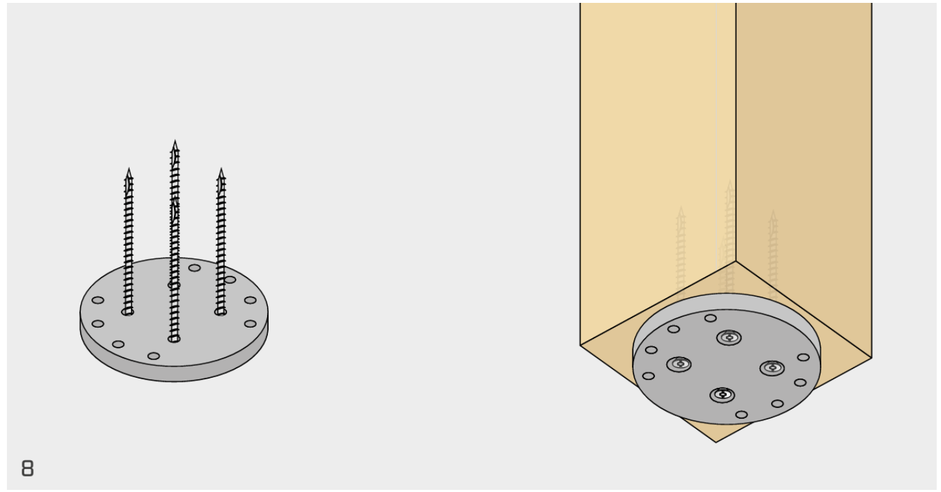


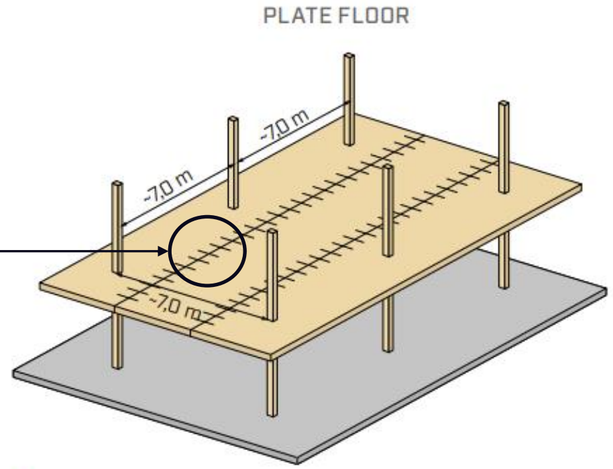
6A



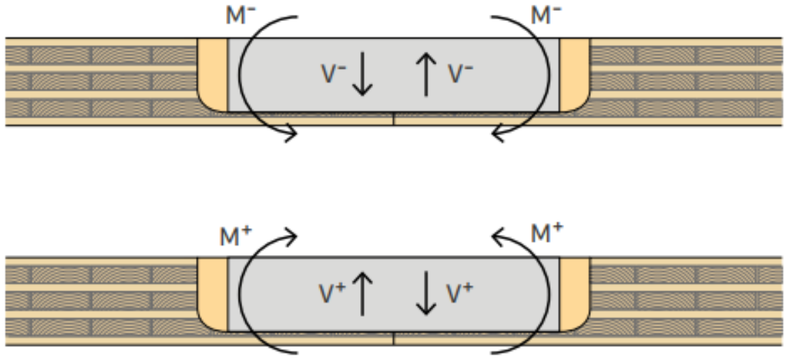
7


8

SPIDER CONNECTION

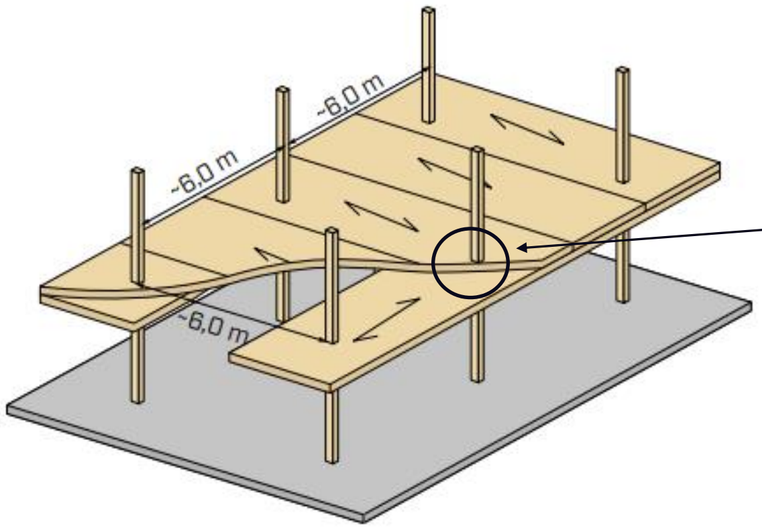


- maximum spacing between the columns
- it exploits the two-dimensional behaviour of the panel

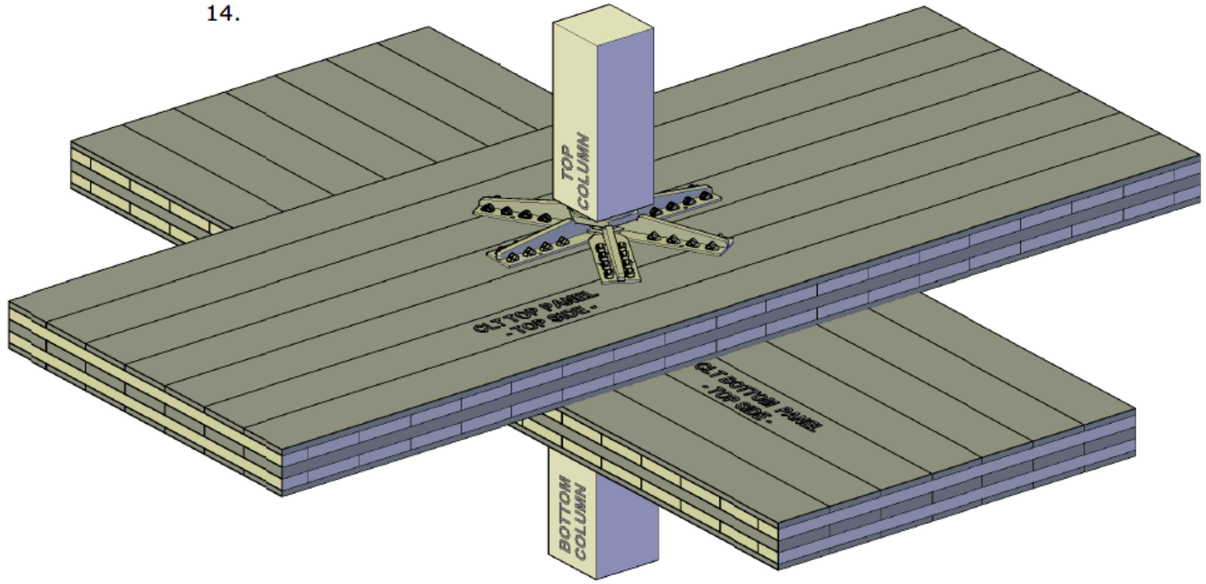


SPIDER CONNECTION

CROSSED PANELS

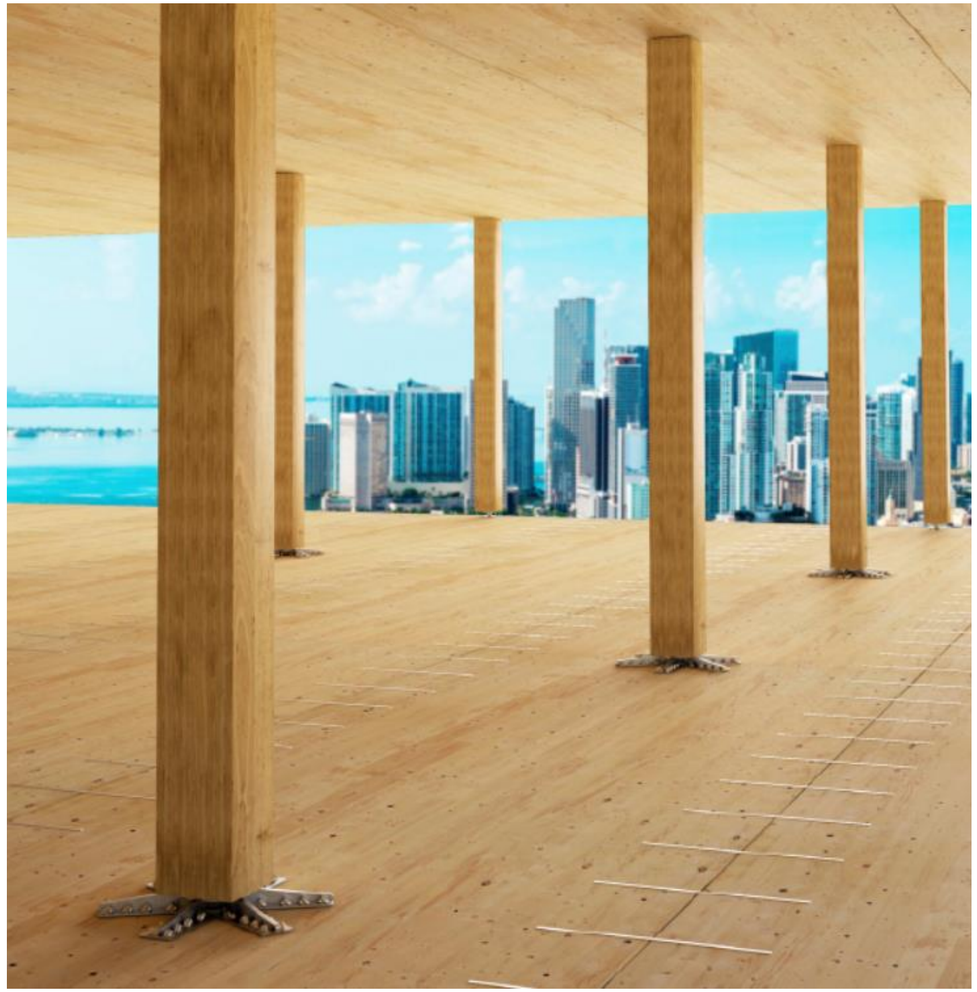


14.



- ✓ services duct at the bottom of beam
- ✓ no moment connections

SPIDER CONNECTION – TIME SAVING



- Risparmio di denaro e tempo su tutti i collegamenti delle strutture secondarie

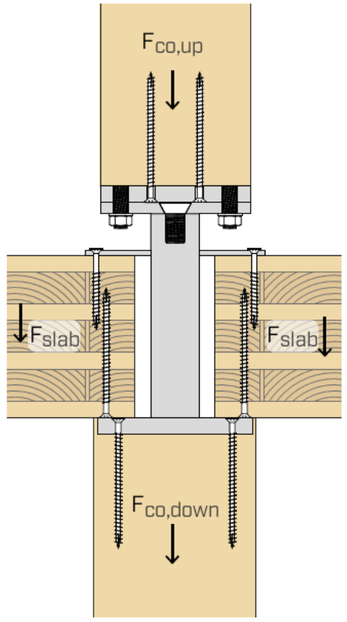
- Risparmio di metri cubi di edificio (piano extra)

- Nessun problema di impianti che passano attraverso le travi

- Ottima finitura architettonica

PILLAR CONNECTION

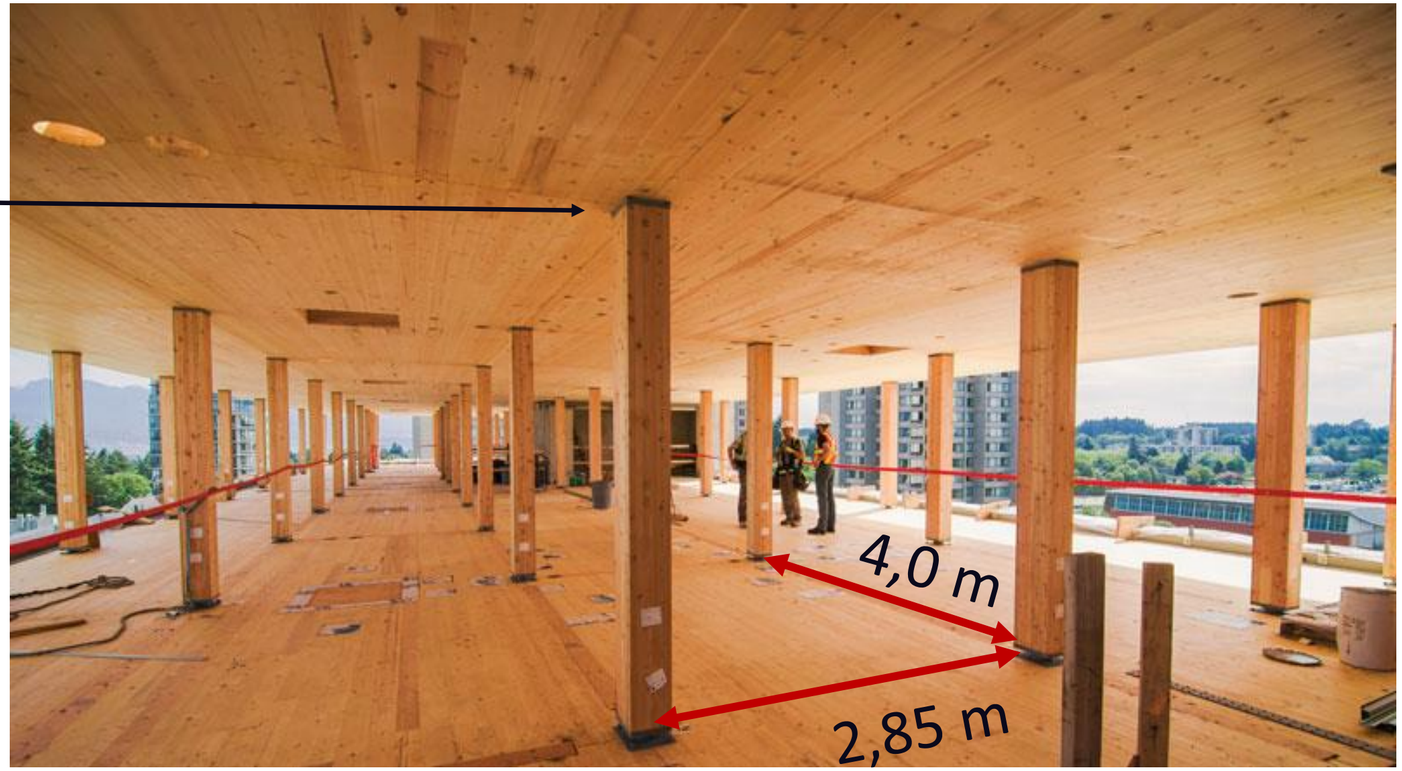
NEW 2019 ETA-19/0700 NEW 2019



PILLAR CONNECTION - CONCEPT

CONNESSIONE A DISEGNO

Acton Ostry Architects Inc. and Fast & Epp Engineers

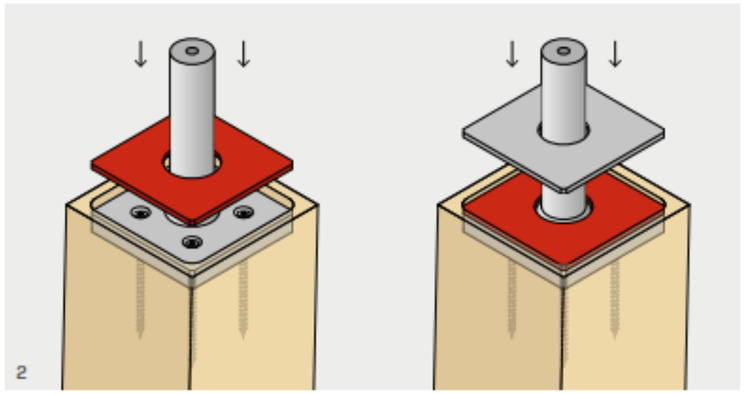


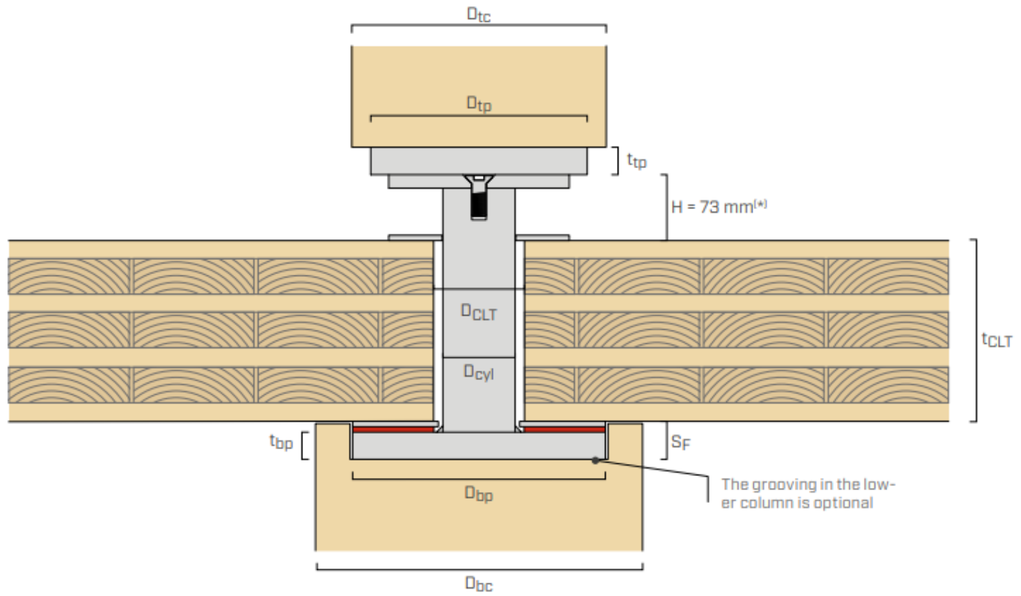
U.B.C. Brock commons
(Vancouver 2017)

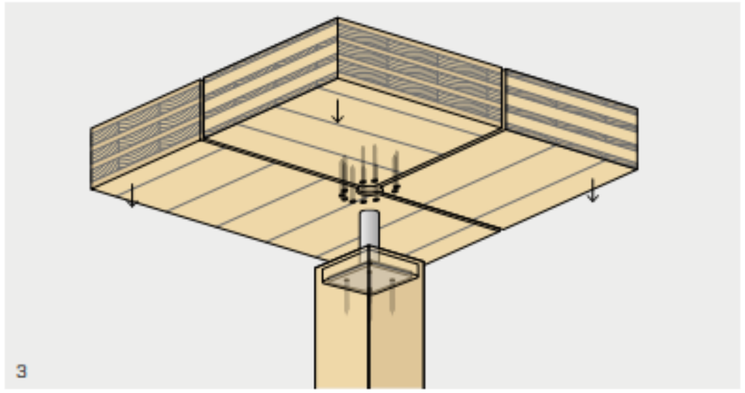
LUCI
2,85x4,00 m

Per luci maggiori:
Problemi di punzonamento/compressione

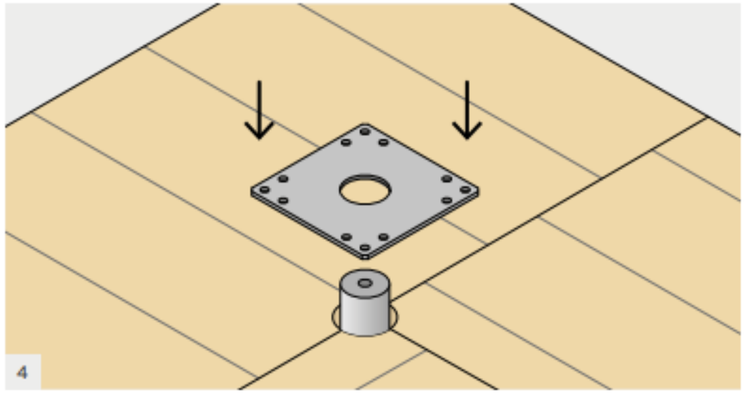
PILLAR CONNECTION





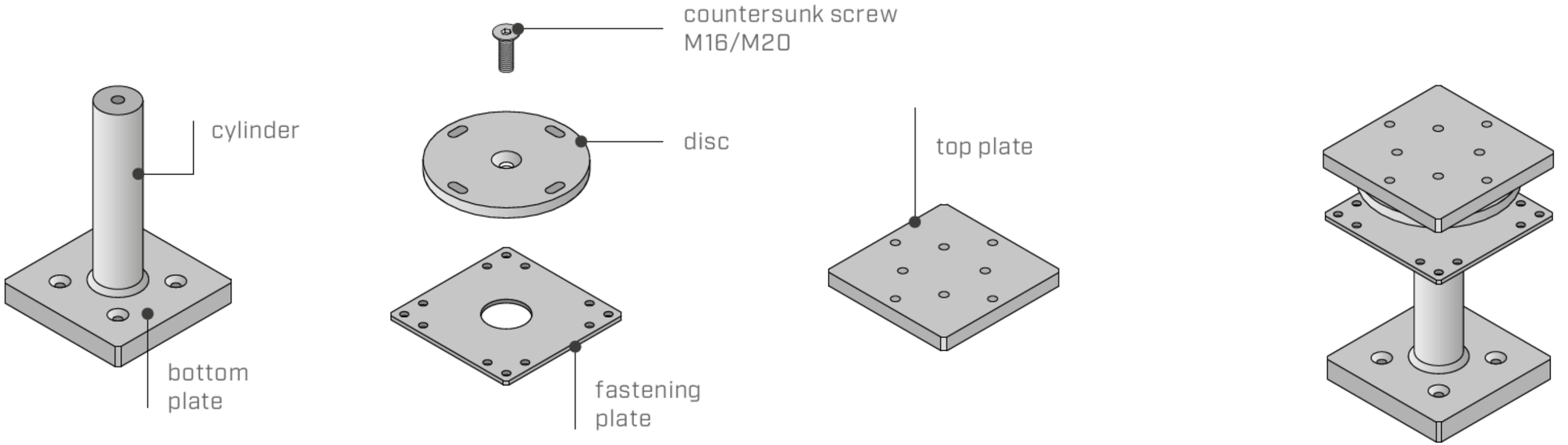


Fit pre-drilled CLT panels with a circular hole of D_{CLT} diameter onto the cylinder. A compression reinforcement can be provided to the panel bottom of beam to increase strength.

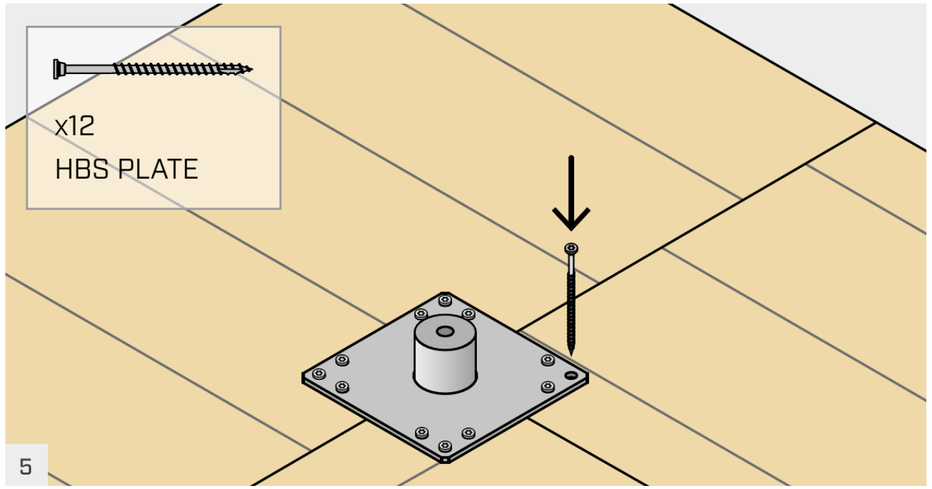


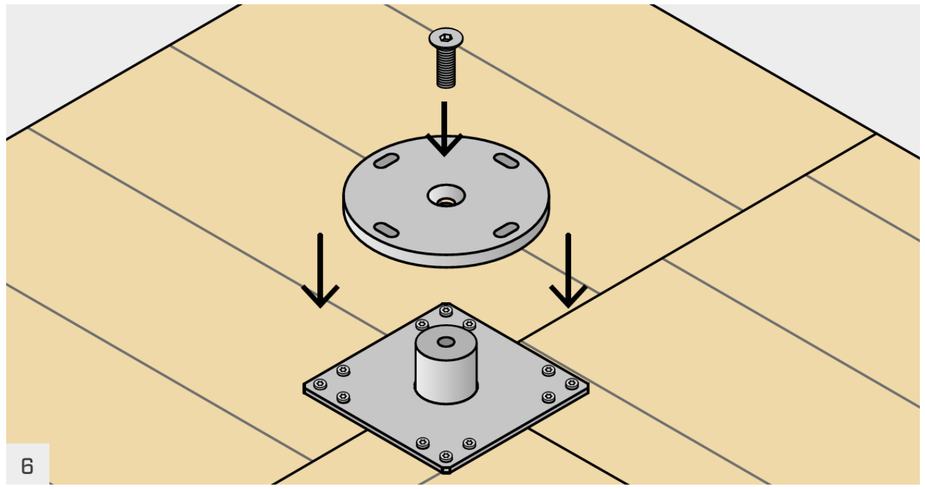
Insert the FASTENING PLATE onto the cylinder.

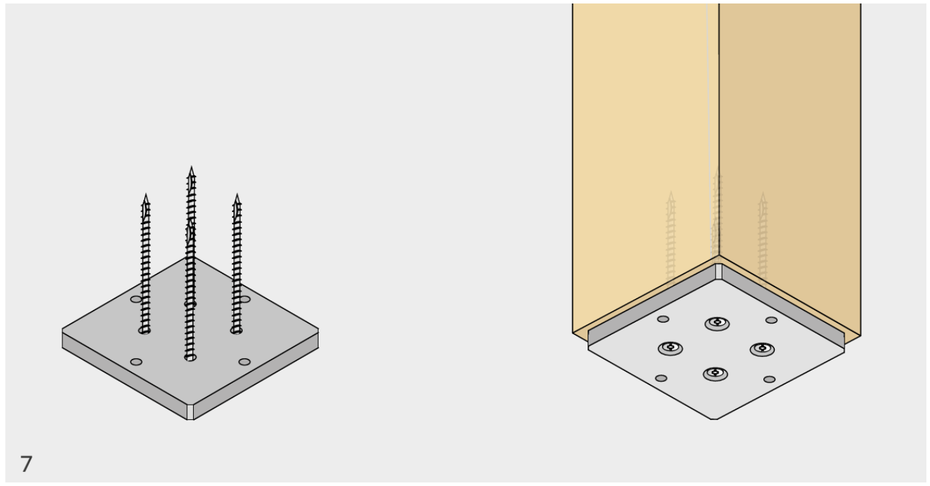
PILLAR CONNECTION – COMPONENTI

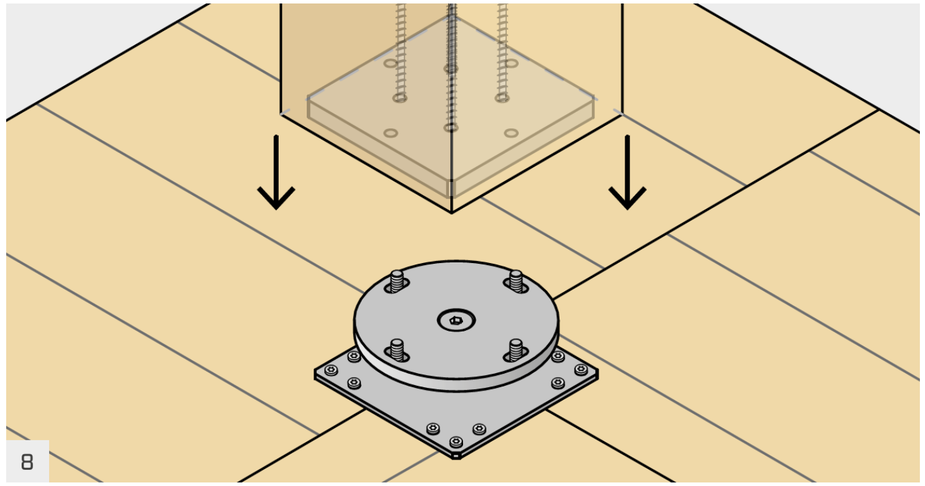


PILLAR CONNECTION – ASSEMBLAGGIO





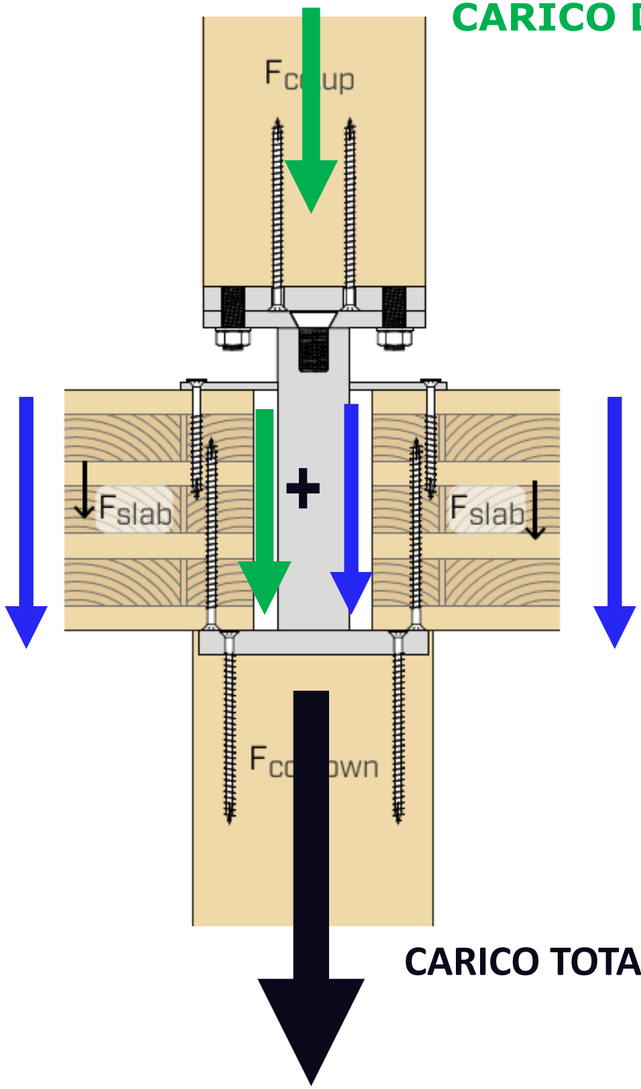




PILLAR CONNECTION – TRASMISSIONE DEI CARICHI

CARICO DAI PIANI SUOPERIORI

CARICO DAL SOLAIO

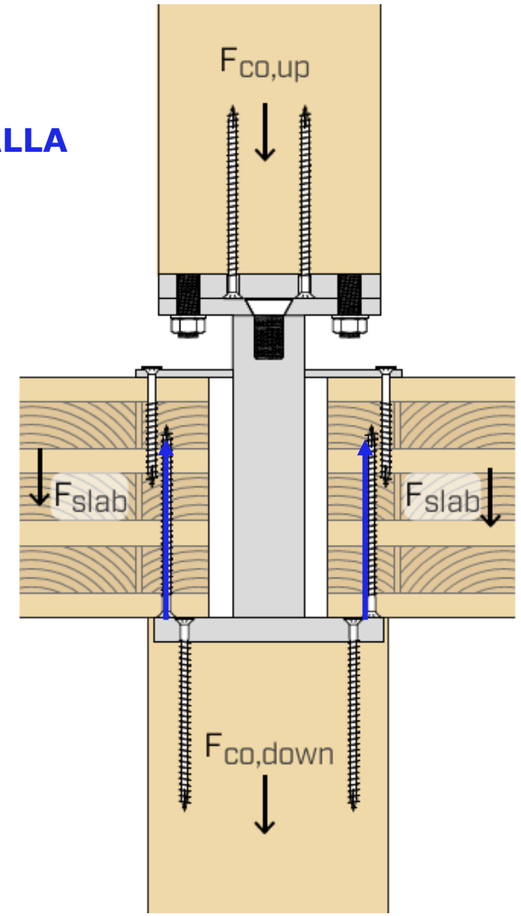


CARICO DAL SOLAIO

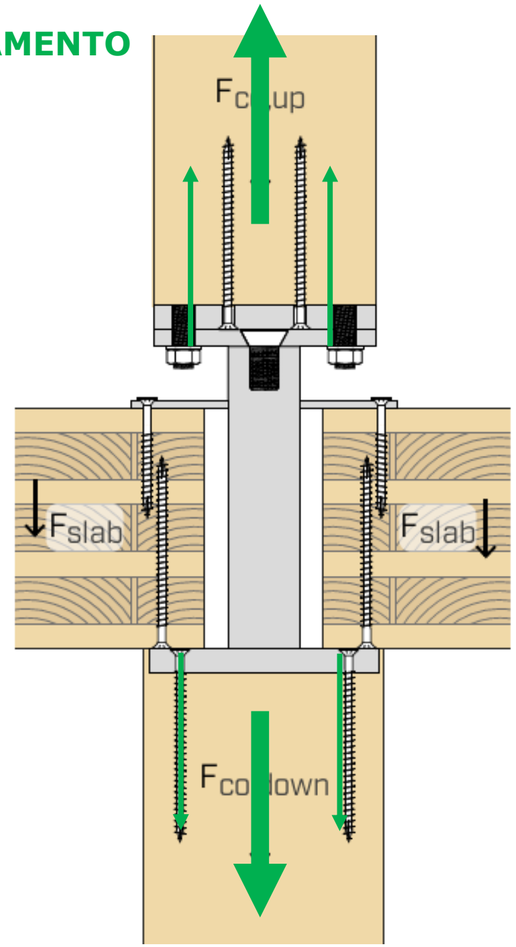
CARICO TOTALE = SOLAI + PIANI SUPERIORI

PILLAR CONNECTION – TRASMISSIONE DEI CARICHI

RINFORZO A COMPRESSIONE PERPENDICOLARE ALLA FIBRA

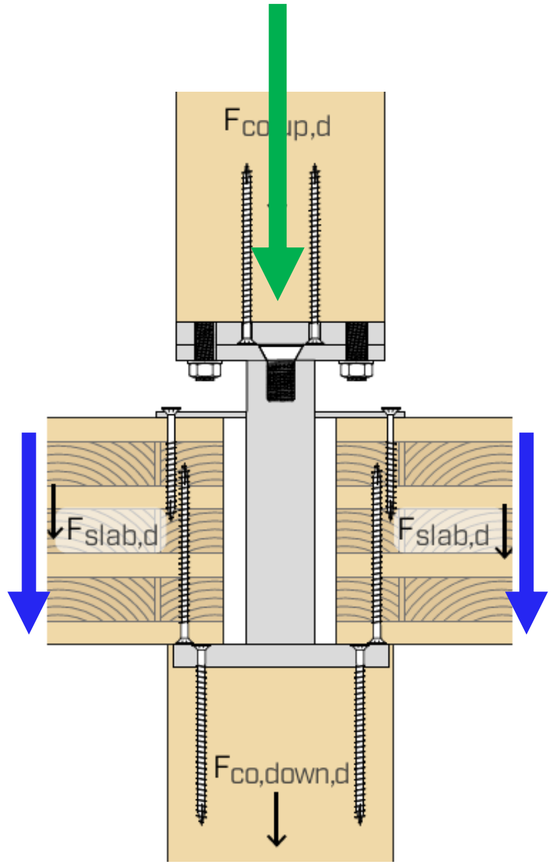


REISTENZA A SOLLEVAMENTO

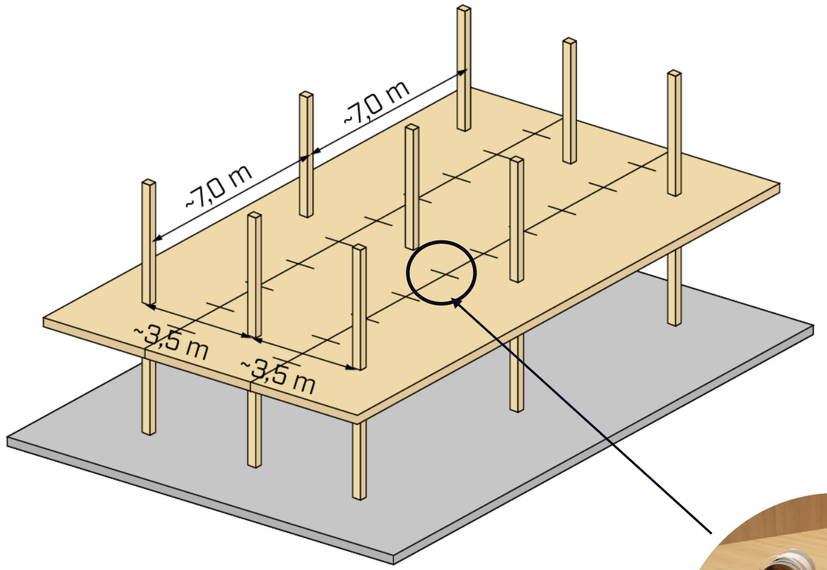


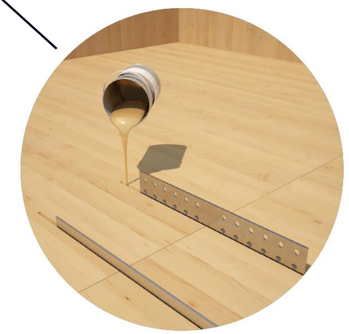
PILLAR CONNECTION – RESISTENZA DI CALCOLO

Type	CLT FLOOR THICKNESS 160 [mm] $F_{co,up,d}$ [kN]	+ $F_{slab,d}$ [kN]	180 [mm] $F_{co,up,d}$ [kN]	+ $F_{slab,d}$ [kN]	200 [mm] $F_{co,up,d}$ [kN]	+ $F_{slab,d}$ [kN]	220 [mm] $F_{co,up,d}$ [kN]	+ $F_{slab,d}$ [kN]	240 [mm] $F_{co,up,d}$ [kN]	+ $F_{slab,d}$ [kN]	COLUMN
PIL 60 S	470	132	470	145	470	157	470	157	470	184	GL32h
PIL 80 S	815	167	815	181	815	195	815	195	815	225	
PIL 80 M	1.005	208	990	223	975	239	975	239	940	272	
PIL 80 L	1.325	208	1.310	223	1.295	239	1.295	239	1.265	272	
PIL 100 M	2.205	202	2.205	218	2.205	234	2.205	234	2.205	266	LVL GL75
PIL 120 M	3.200	196	3.185	211	3.170	227	3.170	227	3.140	260	
PIL 100 L	4.435	202	4.435	218	4.435	234	4.435	234	4.435	266	STEEL
PIL 120 L	5.480	196	5.480	211	5.480	227	5.480	227	5.480	260	

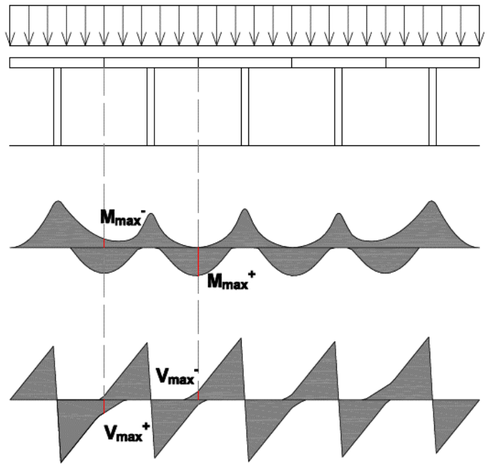


PILLAR CONNECTION – RESISTENZA DI CALCOLO

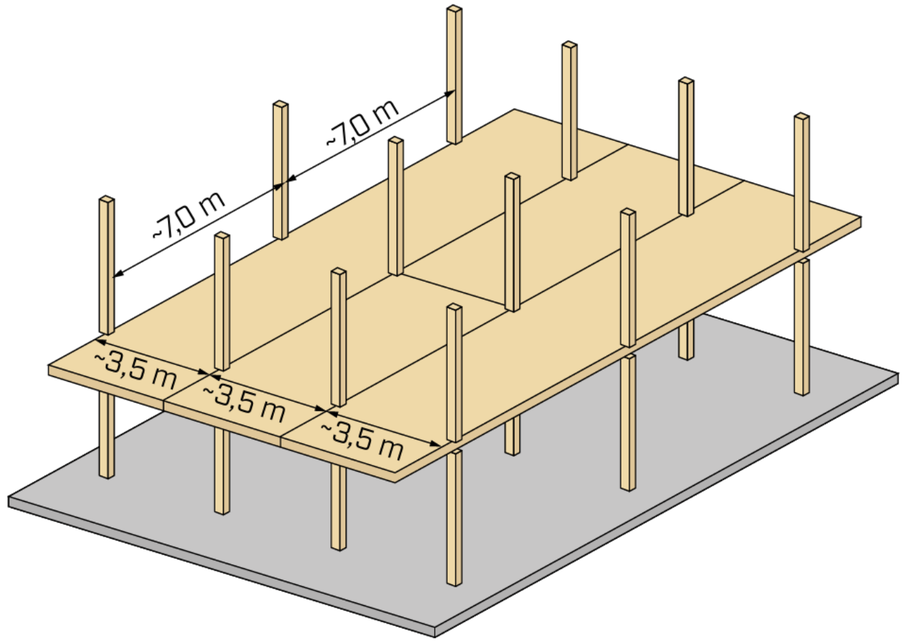




Connessioni a momento

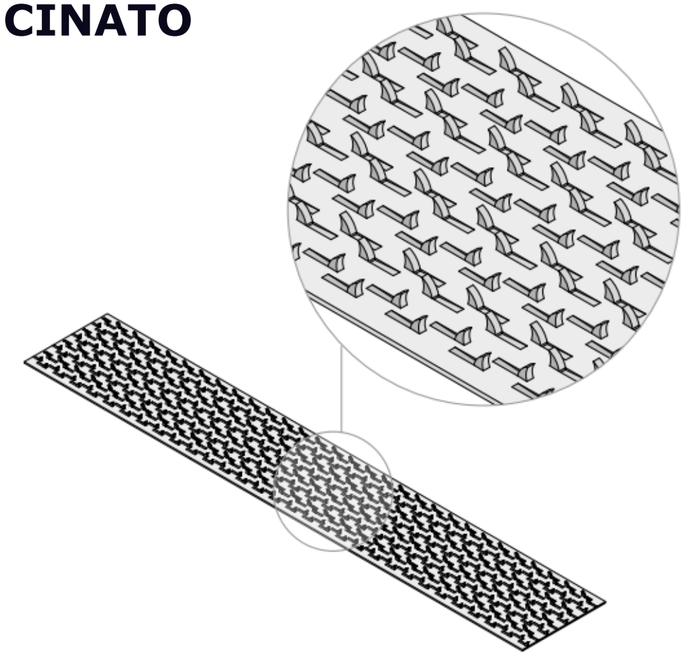


PILLAR CONNECTION – RESISTENZA DI CALCOLO



Nessuna connessione a momento

SHARP METAL – CONNETTORE A TAGLIO UNCINATO

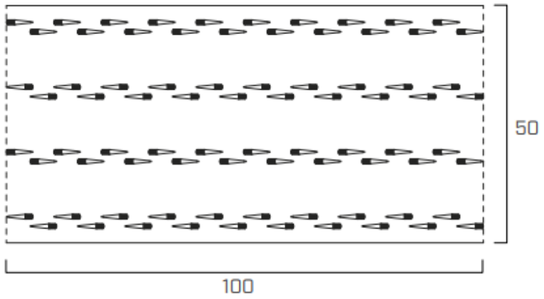


Le piastre uncinate consentono il trasferimento di sforzi di taglio tra due superfici di legno. Prestazioni paragonabili a quelle di un incollaggio.

SHARP METAL – CONNETTORE A TAGLIO UNCINATO

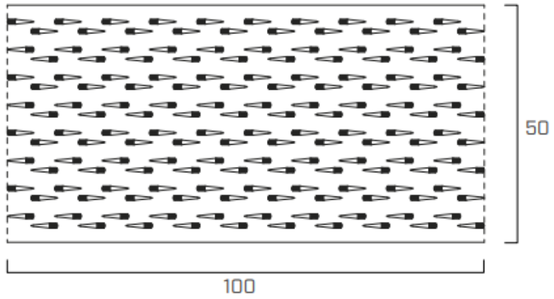
LOW DENSITY (LD)

SHARP501200
SHARP50



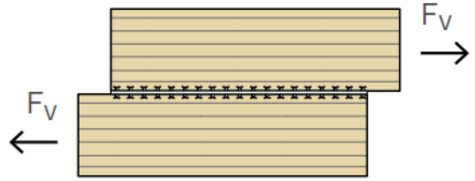
HIGH DENSITY (HD)

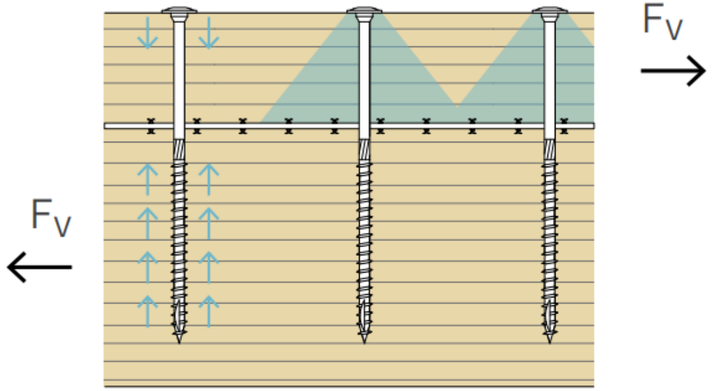
SHARP501200H
SHARP50H

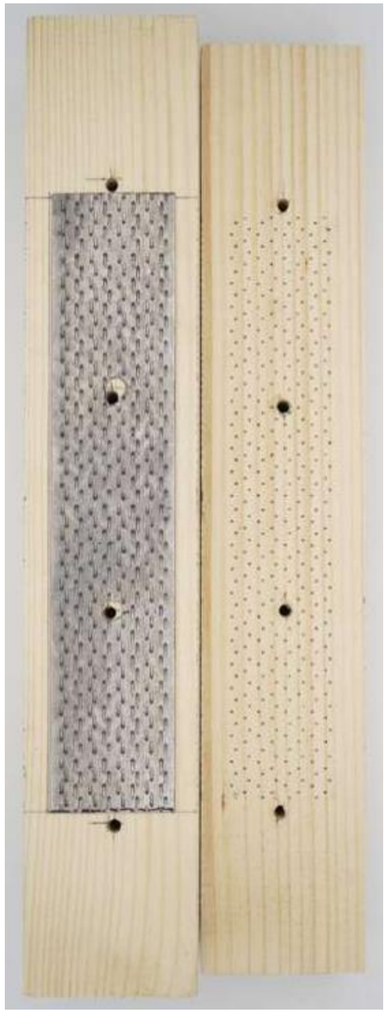


- necessità di pressioni ridotte per garantire l'ingranamento
- alte resistenze e rigidezze concentrate in dimensioni ridotte

SOLLECITAZIONI

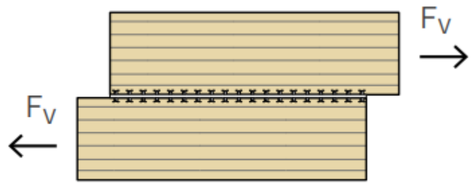






SHARP METAL – CONNETTORE A TAGLIO UNCINATO

SOLLECITAZIONI



Valori di resistenza caratteristica della connessione SHARP METAL CON VITI

tipo	$f_{v,0,k}$ [MPa]	$k_{ser,0,k}$ [N/mm]*[1/mm^2]	$f_{v,90,k}$ [MPa]	$k_{ser,90,k}$ [N/mm]*[1/mm^2]	$f_{v,EG,k}$ [MPa]	$k_{ser,EG,k}$ [N/mm]*[1/mm^2]
LD	2,02	3,13	2,11	0,65	1,92	4,19
HD	2,24	6,47	2,42	0,90	1,92	5,00

I valori in tabella corrispondono ai dati sperimentali con viti TBS 8x160 a passo 10d (80 mm) con spessore del legno sottotesta pari a 60 mm.
La rigidezza complessiva della connessione K_{ser} [N/mm] si determina moltiplicando il coefficiente k_{ser} per la superficie della piastra.

Ing. Matteo Andreottola
technical.consulting@rothoblaas.com

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