REGIONAAL BOUWEN AAN HUMAN CAPITAL

Timber Floor Vibrations Test Procedure

Product

of the

"Trust in Timber" Project

Human Capital, Hub Noord

ir. Rozemarijn Veenstra[1] *and Dr. İhsan E. Bal*[2]

1. Scope and Content

Trust in Timber project primarily aims increasing trust among the "human capital" for using timber materials for structural purposes. In order to increase the impact of the bio-based materials in the overall construction industry, larger and taller structures need to be built using timber. When doing that, structural components, other than columns and beams, should also be built using timber. Only in this way a large sum of a new building can be made of timber, thus decreasing substantially the number of carbon-producing materials, such as steel and concrete, in a large structure.

During the consultations with several stakeholders, it became clear that one of the bottlenecks in building large timber structures was the timber floors. One reason for this is that the timber floors are light-weight as compared to their steel and concrete counterparts, and at the same time they have a smaller stiffness. This combination, although it does not create safety problems, may cause comfort issues such as large vibrations being felt by the user during a normal operation (i.e. when someone is walking and passing by). Critical factors in design of such floors, such as the damping, stiffness and the fundamental period of vibration, are yet not well established in the existing norms and standards, making it difficult for the structural engineers to precisely design and control the amount of user-felt vibrations on the timber floors.

This product is a result of multi-stakeholder efforts on defining the problem, design, and production of test floor, and finally performing tests in order to better understand the problem in hand.

[1] *Researcher in the Research Group of Structural Safety and Earthquakes, Research Centre Built Environment, Hanze University of Applied Sciences, Groningen, Netherlands (c.r.a.veenstra@pl.hanze.nl)*

[2] *Professor on Structural Safety and Earthquakes, Research Centre Built Environment, Hanze University of Applied Sciences, Groningen, Netherlands (i.e.bal@pl.hanze.nl)*

Version 1 – 29.03.2024

2. Method Development

After a preliminary search, several interested stakeholders were identified, coming both from design and production sides. Interested companies were involved for exchange of ideas and subsequently all of them decided to participate in-kind to develop the procedure reported in this document.

Lüning[3] was engaged as an expert in structural design with timber (see Appendix A for an example design). To effectively compare different floor types, key aspects were defined with them, such as:

- *Stiffness*
- *Vibration frequency*
- *Length and width*
- *Variable load*

Two producers were also interested in providing and sponsoring floors for testing. The first one was Posi-Tech[4], a Dutch representative of the international company MiTek[5]. Posi-tech produces metal-connected timber floor joists, a product extremely useful in due it its advantages, such as being light-weight, having larger flexural stiffness because of the beam-type form, and allowing the piping for HVAC systems within the floor (see Figure 1). Posi-tech relies on MiTek for the engineering calculations, which has and experienced engineering department and a state-of-the-art design software for floor vibrations (see Appendix B for an example output).

De Groot Vroomshoop[6] has also shown interest for their Kerto-Ripa type floors being tested in the same procedure. Lüning provided a re-design using Kerto-Ripa. De Groot Vroomshoop has produced two test floors using the design. Kerto-Ripa panel is a structural engineered wood element (see Figure 1), combining panels (horizontal) and ribs (vertical).

The last floor type for tests was Cross Laminated Timber (CLT) floors. CLT is a panel type element constructed gluing timber elements in cross laminated form, allowing the panel to have similar engineering properties in both in-plane directions (see Figure 1). The CLT panels in the project were procured from a vendor.

During the process of deciding "what to test" and "how to test", subsequent discussions ensued regarding the design and associated calculations, which provided dimensions and weights of the floor and screed. Following this, various productions commenced, the timeline of which depended on material delivery/storage, manufacturing time, factory scheduling, and BuildinG's timetable. Arrangements were made for delivery and transportation once the floors entered production.

Upon production and delivery confirmation, contacts were established with the supplier responsible for the mass screed layer production, delivery, and application. Another company, Bruil[7], agreed to sponsor the topping material production and delivery. Based on the calculated weight in the floor designs, the thickness of the screed layer could

---

[3] *Lüning Ingenieurs in Houtconstructies, https://luning.nl*
[4] PosiiTech posi-joists, https://posi-tech.nl
[5] MiTek France, https://www.mitek.fr
[6] De Groot Vroomshoop, Groots in Bouwen met Hout, https://degrootvroomshoop.nl
[7] Bruil, https://www.bruil.nl

be determined. The material of the layer could be determined later since only the weight was initially crucial for the floor calculations. Once determined, numerical tests will be scheduled, followed by workshops to share results.

Figure 1. Posi-Tech (top-left), Kerto-Ripa (top-right) and CLT (bottom) Systems

Lessons learned and experiences gained include:

- *It is better to have one person in charge of production and delivery rather than through intermediaries,*
- *A vast network can be formed in a short period because of the increasing interest in engineered timber construction,*
- *People are highly enthusiastic about testing and its effects, so a physical testing is a good way of mobilizing interested parties,*
- *Not everyone is interested in sponsoring, requiring extra time and measures to arrange funds and resources, especially from the sectors which feel saturation, such as CLT production,*
- *Some producers do not create their own design drawings and instead engage an external party to do this for them, which can have implications for time and efficiency,*

- *Occasionally, there are other individuals involved in discussing designs while another is responsible for production and delivery, which needs to be well organized by a person with a technical background.*

3. Floor Vibration Test Procedure

In order to establish the procedure, preliminary tests were conducted on a Posi-tech floor (number P2). The span of the floor is 6 meters, and the exact width of P2 is 1,22 meters. The floor is divided in directions: East (bottom of picture), West, North and South. The floor specimen was placed on two wooden supports at the two ends. The instrumentation of the floor consisted of 3 ultra-low-noise accelerometers, placed in vertical direction, and two potentiometers for measuring the vertical displacements in the middle of the floor (see Figure 2 for a specimen overview). The first tested specimen was without a topping material, making it lighter than the design. The very first test was done with the purpose of developing the test procedure, not actually for finding out the exact properties of the tested floor.

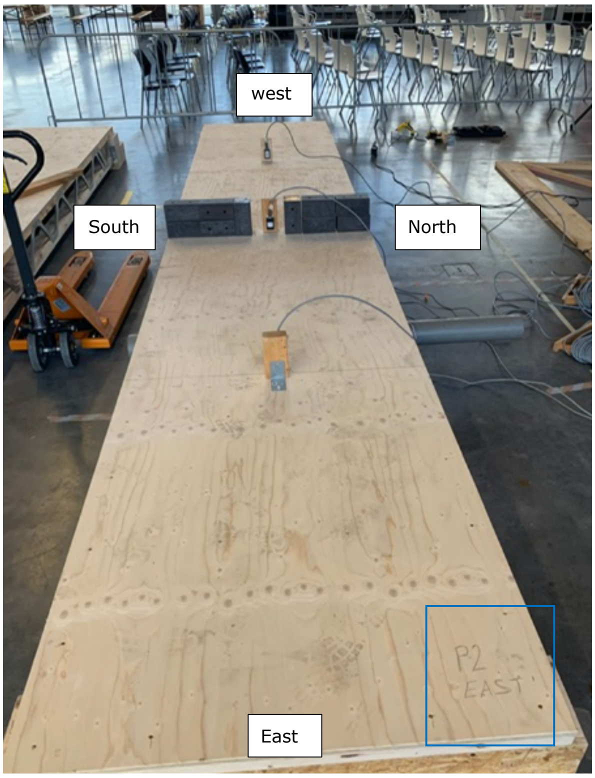


Figure 2. Test setup overview

Three accelerometers were attached to the middle of the floor. Accelerometer named 405 was placed on the east side, 435 in the middle, and 437 at the west side (see Figure 3 & 4). The accelerometers were screwed to timber pieces, which were screwed to steel 90-degree angles. All of the sensors were attached to a datalogger (see Figure 5, producer TDG[8]). The datalogger was connected via an ethernet cable to a PC, using the data acquisition software of the producer. Small potentiometers were placed against the

[8] *Specifications of the datalogger:* *https://tdg.com.tr/en/products/digitizers---daqs/testbox2010-rack*

concrete floor of the test hall (Figure 6). Gradual stating loading tests were performed using steel chunks, and then people stepping on the floor were also involved in the tests (Figure 7).

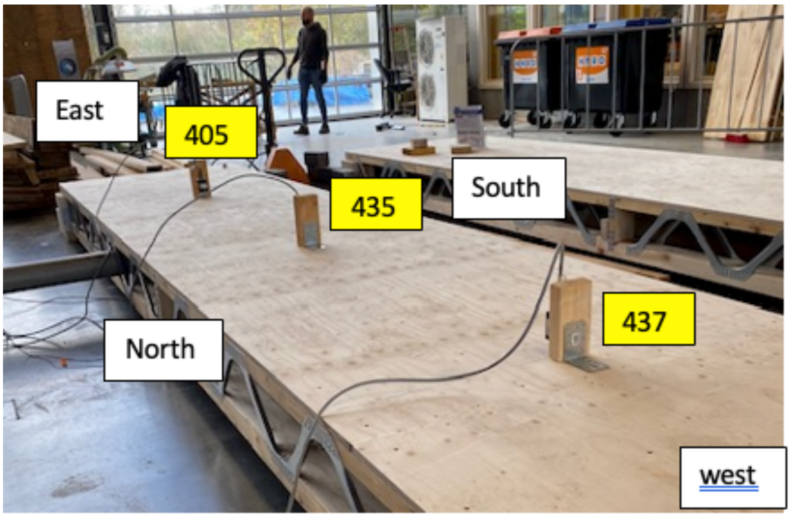


Figure 3. The accelerometer locations and the directions assumed for the specimen

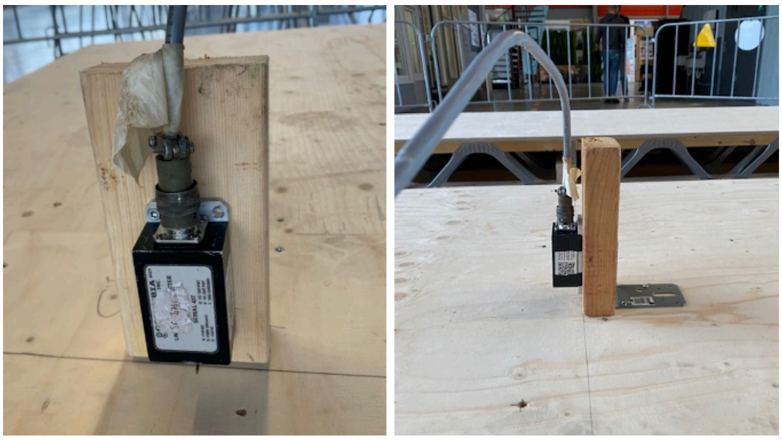


Figure 4. Accelerometer close-up view

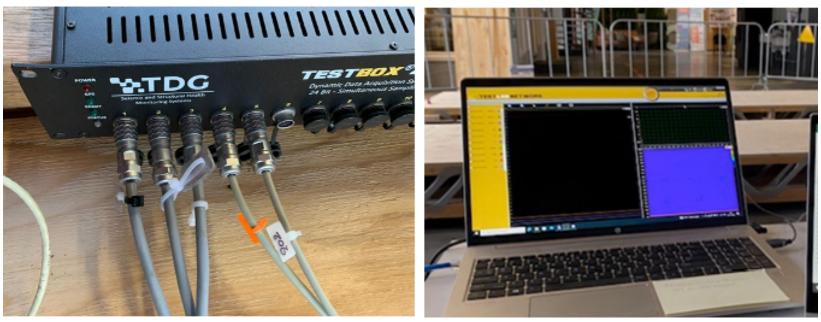


Figure 5. Datalogger (left) and the data acquisition software (right)

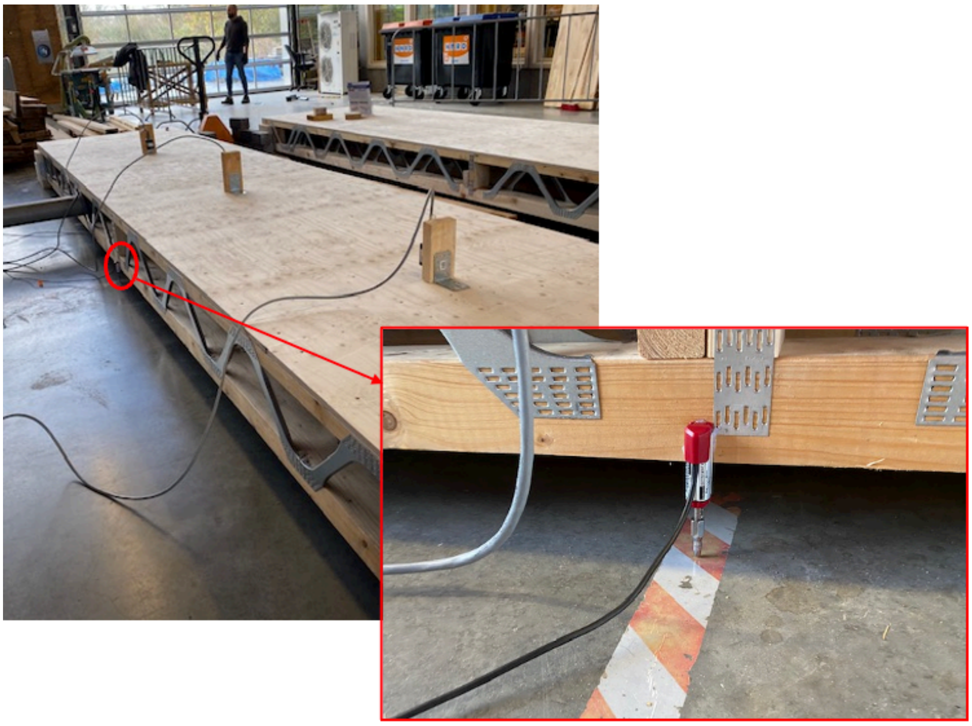


Figure 6. Displacement sensor (potentiometer) in the middle of the floor specimen

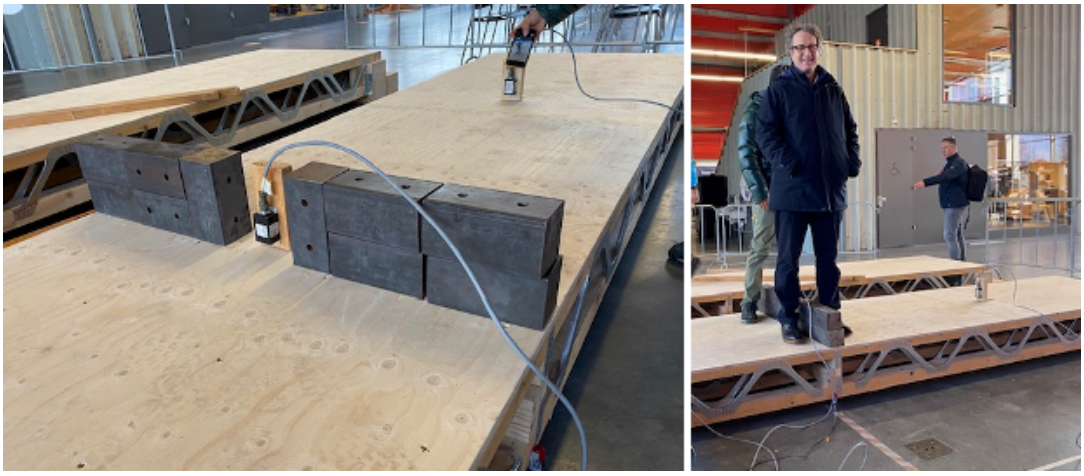


Figure 7. Loading test with steel chunk weights (left) and walking people (right)

Two tests were performed:

- *Test_1: Static Loading Test*
- *Test_2: Drop-weight Test*

Test_1 actions:

For the weight test, weight pieces were placed in the middle of the floor (see Figure 7), 10 pieces in total, 5 on each side. Every piece has a weight of 16 kg each. The time versus action is listed in Table 1.

Table 1. The sequence of static weight loading

Time [hour]	Action [-]	Weight [kg]
13:29	Start recording	0
13:30	The pieces were placed alternately per side (10x16 kg total), started at the south side (figure 6)	160
13:30	All pieces + one man (100 kg) was standing on the north side	260
13:30	All pieces + one man on north + another man (82 kg) was standing on the south side (figure 7)	342
13:31	Man on south side went off	260
13:31	Man on north side went off	160
13:31	All pieces were taken off per side, started from the north side	0
13:31	Stop recording	0

In Figure 8, the deflection is shown related to the potentiometers. The orange line is potentiometer 201 on the north side and the blue line is the potetiometer 202 on the south side.

- Phase 1: the 5 pieces are being place per side;
- Phase 2: the man on the north side standing first and going off last
- Phase 3: the man on the south side standing at last and going off first;
- Phase 4: all pieces taken off per side.

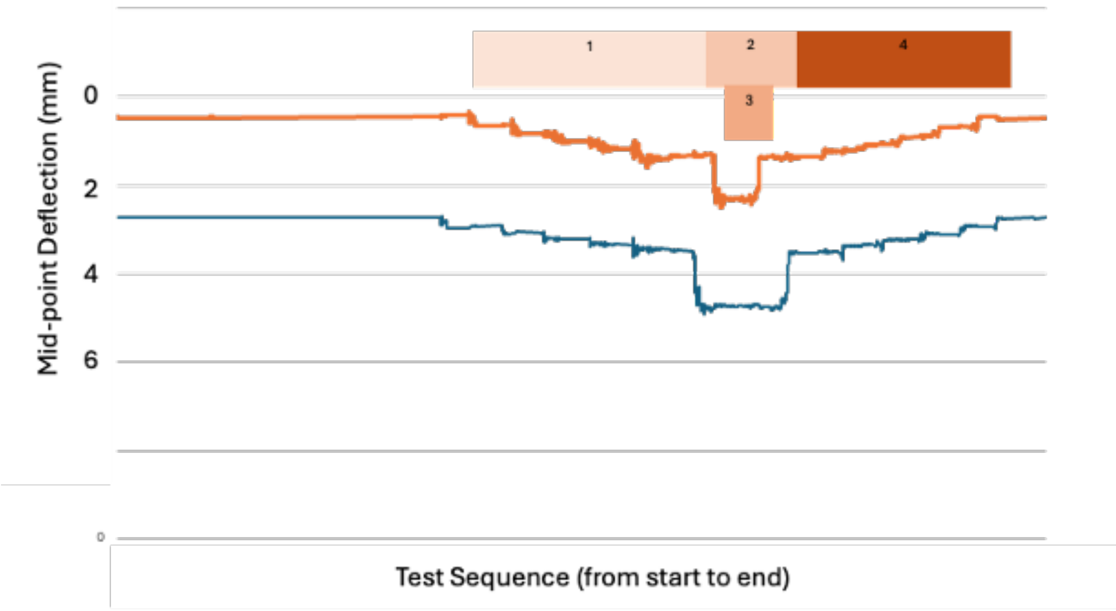
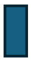


Figure 8. Mid-point deflection plot

For the drop weight test, one weight piece (16kg) was propped several times in the middle of the floor. A static weight of 100 kg was placed in the middle of the floor and dropped one piece of 16 kg from varying heights (see Table 2). In Table 2 below, the actions are given with the time and the drop height. The drop height is measured between the bottom of the piece and the top of the floor specimen. At the first three tests. The piece was hold horizontally when it was dropped, and in the last test the piece was hold vertically.

Table 2. Drop-weight test sequence

Time [hour]	Drop height [cm]	Piece direction	Distance from middle [mm]
13:51	57		7 cm to east side
13:53	50		7 cm to east side
13:53	66		7 cm to east side
13:53	63		7 cm to east side

4. Concluding Remarks

The purpose of this project was stimulating cooperation among different partners in the structural timber construction business. The best way of doing this is to identify a challenge, and via a physical testing to mobilize the interested parties around this challenge.

Preliminary tests were performed on one of the specimens in order to establish a procedure. The tests revealed a fundamental period of the floor as 8.4Hz, while the design was 11Hz. This is due to two possible reasons, first of all the topping is missing as opposed to the design, and second, the total weight (and hence mass) on the floor was smaller than what it was designed for.

The tests with all 6 floors will continue, and this product document will be updated as more results become available.

Acknowledgements

Special thanks are due to Rudi Roijakkers and Maria Felicita from Lüning, Arthur Tromp from Posi-tech, and Geert Ravenshorst from TU Delft for their valuable contribution to this project.

REGIONAAL BOUWEN AAN

HU MAN CAPITAL

Appendix A – Design by Lüning

Version 1 – 29.03.2024

datum:	17-10-2023
referentie:	
code:	
onderdeel:	

Berekening vloertrilling CLT platen volgens prEN en SBR

naam	norm artikel / formuke	symbool	eenheid	waarde
invoer vloer				
CLT type		-	-	L-240/7s
CLT merk		-	-	Derix
CLT dikte		d_{CLT}	mm	240
overspanningslengte		L_{CLT}	m	6,0
breedte vloer		B_{CLT}	m	1,2
overspanningsrichting				one-way
damping ratio	prEN 1995-1-1, art. 9.3.1 (3)	ζ	-	0,020
belastingen				
permanente belasting (exclusief eigen gewicht CLT)		$m_{G,k}$	kg/m²	140
veranderlijke belasting		$m_{Q,k}$	kg/m²	250
walking frequency	prEN 1995-1-1, art. 9.3.3 (2)	f_w	Hz	2,0
CEN-TC 250 N3489 prEN 1995-1-1				
resultaten				
maximum deflection due to a vertical static point-load F = 1 kN	prEN 1995-1-1, vgl (9.17)	w_{1kN}	mm	0,36
natural frequency	prEN 1995-1-1, vgl (9.12)	f_1	Hz	8,53
root mean square acceleration	prEN 1995-1-1, vgl (9.21)	a_{rms}	m/s²	0,360
root mean square velocity	prEN 1995-1-1, vgl (9.28)	v_{rms}	m/s	0,0025
controle				
acceleration response factor	prEN 1995-1-1, Tabel 9.1	R_a	-	72
velocity response factor	prEN 1995-1-1, Tabel 9.1	R_v	-	25
response factor	prEN 1995-1-1, Tabel 9.1	R	-	25
floor performance level	prEN 1995-1-1, Tabel 9.1	-	-	V
frequency criteria	prEN 1995-1-1, Tabel 9.1	-	-	ja
stiffness criteria	prEN 1995-1-1, Tabel 9.1	-		ja
SBR 539				
ES_RMS_90 value		$ES\text{-}RMS_{90}$	-	9,49
klasse		-	-	E
EC5				
stiffness check		*u.c.*	-	0,43
velocity check		u.c.	-	0,16

Appendix B – MiTek / Posi-Tech Design

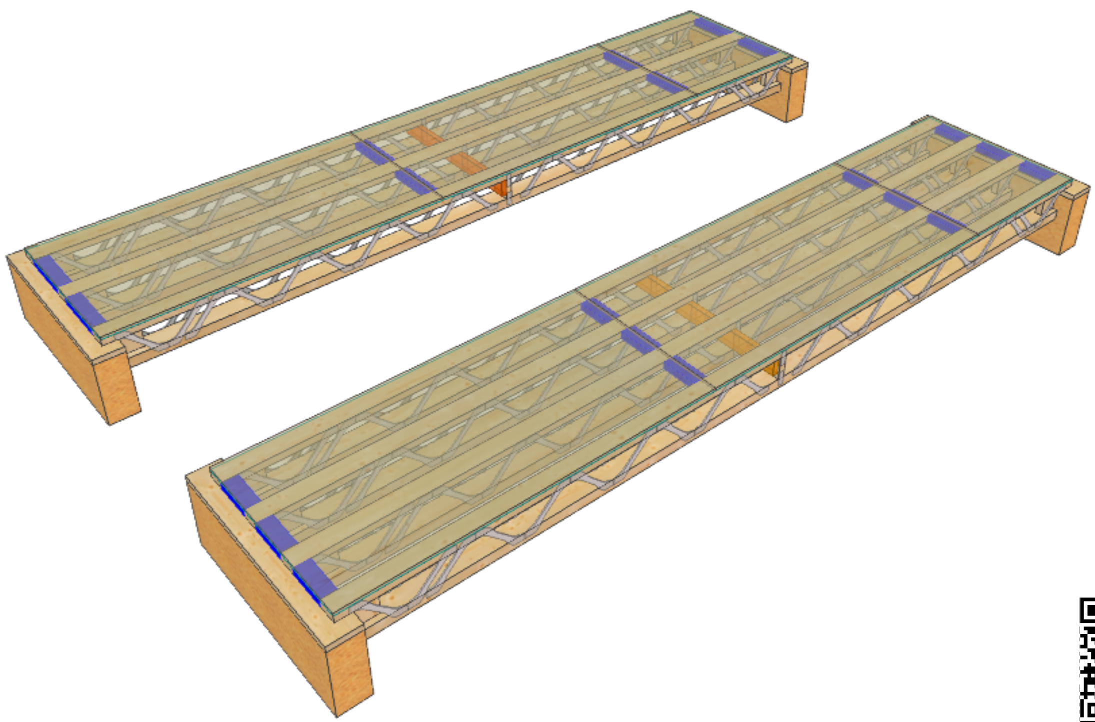
Posi-Tech

Adres:
Lenderinkweg 27 6733 AX Wekerom
Tel: 06-13 21 94 94 www.posi-tech.nl

Projectreferentie: **Opdrachtnummer: PT23-020** Date : 11/10/2023

Opdrachtgever	**: BuildinG**		
Projectnaam	: Trust in Timber		
Plaats Bouwlocatie	: Groningen	Kavel nummer	: N.V.T.
Straat	: Zernikelaan 17	Aantal x uitvoeren	: 1x

Default



Productie en leveringen:	
Productie :	Marcel Kok
Mail :	m.kok@posi-tech.nl
Telefoon :	06 132 194 94

Engineering:	
Getekend :	A. Tromp
Mail :	info@posi-tech.nl
Telefoon :	065 065 0065

Getekend akkoord productie: Datum :

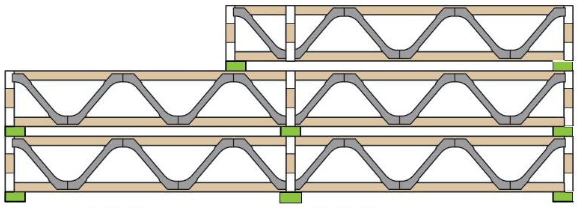
Voorschriften en details

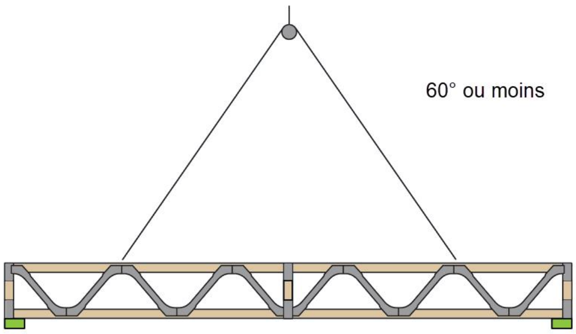
Verwerker,

Om een goede uitvoerig te garanderen gaan Mitek en de leverancier er vanuit dat de gene die dit product verwerkt goede kennis van zaken heeft en de bijgevoegde documenten uitvoerig heeft bestudeerd voordat zij hun werkzaamheden aanvangen.
Mitek en de leverancier kunnen dan ook niet aansprakelijk worden gesteld voor montagefouten op de bouwplaats.

Opslag

Tijdens opslag moet elk contact met de grond worden vermeden.
De beste manier van opslag is verticaal op klossen met een onderlinge afstand van maximaal 3 meter.
Bij langdurige opslag is het noodzakelijk de frames te beschermen tegen weersinvloeden door ze droog op te slaan en voldoende te ventileren.
Deze bescherming na aflevering is niet de verantwoordelijkheid van Mitek en of de leverancier.





Hijsen

Bij hijsen of verticaal transport houd altijd de veiligheid voorschriften in acht, bij voorkeur horizontaal met 2 bevestigingspunten met een tophoek van maximaal 60 graden (zie voorbeeld) en zorg voor een gelijke belasting op de twee hijspunten. Gebruik hijsbanden en geen kettingen en kabels dit om beschadiging te voorkomen. Hijs altijd met goedgekeurde en onbeschadigde hijsbanden.

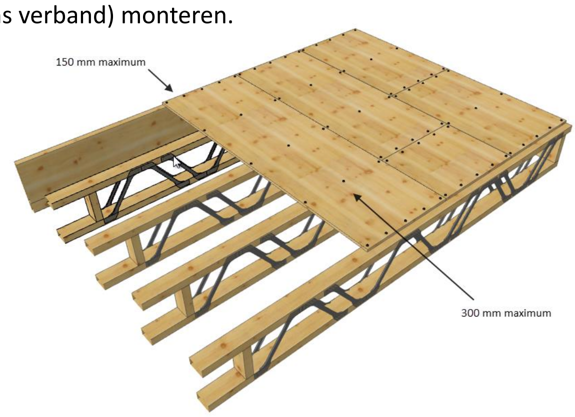
Bevestiging van de vloerdelen

Installatie van de vloerplaten of vloerdelen verspringend (zogenaamd halfsteens verband) monteren.

-De delen moeten minimaal op 3 steunpunten worden afgesteund.
-De lengteas van de delen staat loodrecht op de Posi-balken.
-De uiteinden van de delen moeten volledig worden ondersteund.

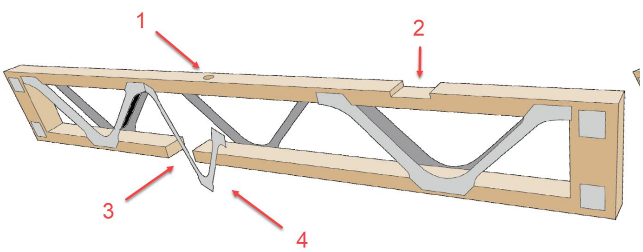
De delen worden vernageld of geschroefd op de houten liggers.
De tussenafstand is maximaal 300mm op de tussensteunpunten en maximaal 150mm op de uiteinden van de vloerdelen.

Als de vloerdelen een stabiliteitsfunctie hebben voor de gevel dient de bevestiging aldaar extra te worden berekend door een constructeur.
Mitek of de leverancier doen hier geen uitspraak over.



Waarschuwing!!

1. Maak geen gaten in de liggers.
2. Maak geen inkepingen in de liggers
3. Onderbreek nooit de houten delen.
4. Knip of verwijder de metalen V delen nooit



MiTek®

Posi-Tech

Adres:
Lenderinkweg 27 6733 AX Wekerom
Tel: 06-13 21 94 94   www.posi-tech.nl

Projectreferentie: **Opdrachtnummer :PT23-020** Date : 11/10/2023

Voorschriften :

NEN-EN 1990	Grondslag van het constructief ontwerpen
NEN-EN 1991	Belasting op constructies
NEN-EN 1992	Ontwerpen en berekening van beton-constructies
NEN-EN 1993	Ontwerpen en berekening van staal-constructies
NEN-EN 1994	Ontwerpen en berekening van Staal-beton-constructies
NEN-EN 1995	Ontwerpen en berekening van hout-constructies
NEN-EN 1996	Ontwerpen en berekening van metselwerk-constructies
NEN-EN 1997	Geotechnisch ontwerp
NEN-EN 1998	Aardbevings bestendige constructies

Toegepaste materialen :

Hout	Fijn bezaagd hout C24
Staal	Fe 250 staal 1mm dik gegalvaniceerd 275 g / m²

Belastingen volgens opgave hoofdconstructeur :

Gebruiksfunctie : 1 Woonfunctie **Gebruiksklasse :** CC1 **Gebruiksduur :** Klasse 3 50 jaar

Hoofd draag vloeren		**Zoldervloeren**		**Plat dak**	
Gebruiksbelasting :	2500 N/m²	Gebruiksbelasting :	N.V.T.	Sneeuw belasting :	N.V.T.
Dekvloer :	1530 N/m²	Dekvloer :	N.V.T.	Deklaag dak (plat):	N.V.T.
Bin wanden :	0 N/m²	Bin wanden :	N.V.T.	Zonnepanelen	N.V.T.
Plafond :	0 N/m²	Plafond :	N.V.T.	Plafond :	N.V.T.
Hartafstand :	610 mm	Hartafstand :	N.V.T.	Hartafstand :	N.V.T.

ETA Posi-Joist ETA-07/0161


Exova BMTRADA
Chiltern House
Stocking Lane
Hughenden Valley
High Wycombe
United Kingdom
Tel:+44 (0)1494 569700
Fax:+44 (0)1494 565487
enquiries@bmtrada.com
www.bmtrada.com

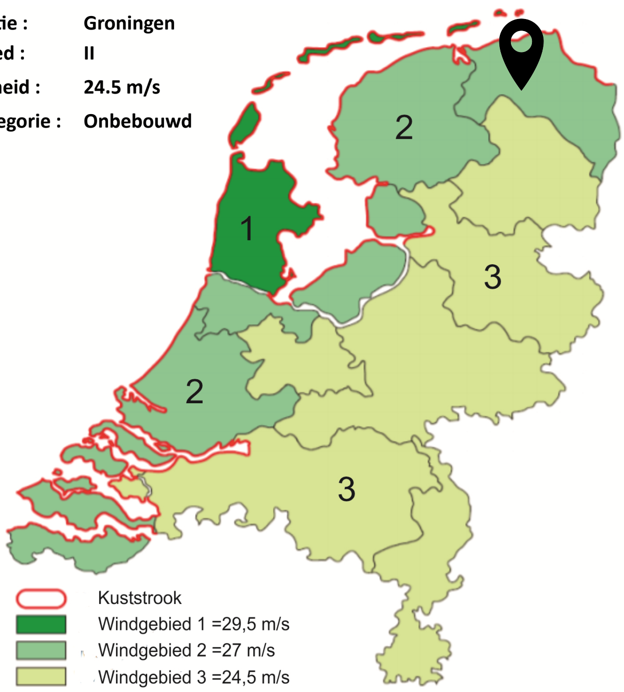
EOTA Member of www.eota.eu

European Technical Assessment **ETA-07/0161** **of 16/05/2018**

Technical Assessment Body Issuing the European Technical Assessment:	Exova BM TRADA
Trade Name of the Construction Product	Posi-Joist™, Posi-Joist™ (Staggered Web), Trim-It™, Posi-Stud™, & X-Rafter™
Product Family to which the Construction Product Belongs	EC PAC 13
Manufacturer	MiTek Industries Limited MiTek House Grazebrook Industrial Estate Peartree Lane Dudley West Midlands DY2 0XW
Manufacturing Plant(s)	As there are too many manufacturing plants to be listed on here, full details of manufacturers certified by Exova BM TRADA Certification are held on file by Exova BM TRADA Certification.
This European Technical Assessment Contains	39 pages including 6 Annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 130031-00-0304 Metal Web Beams and Columns
This Version Replaces	ETA 07/0161 Valid from 31 May 2013 to 30 May 2018

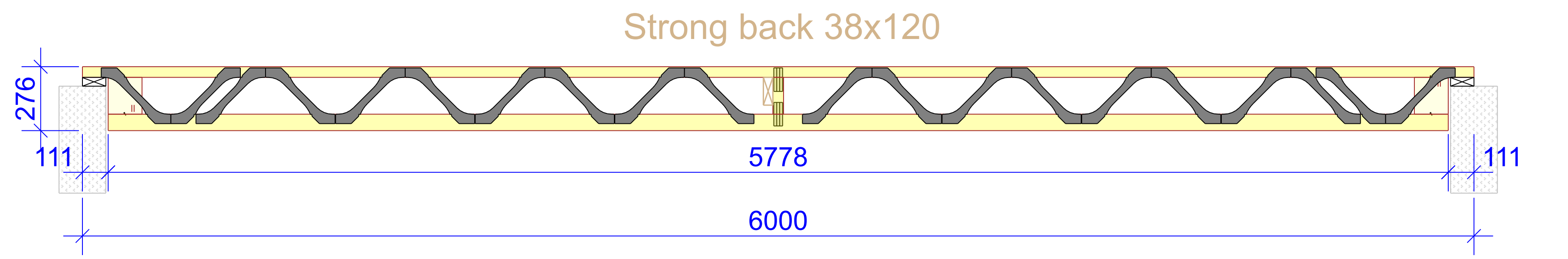
Windbelasting en locatie project

Bouwlocatie :	**Groningen**
Windgebied :	**II**
Windsnelheid :	**24.5 m/s**
Terreincategorie :	**Onbebouwd**

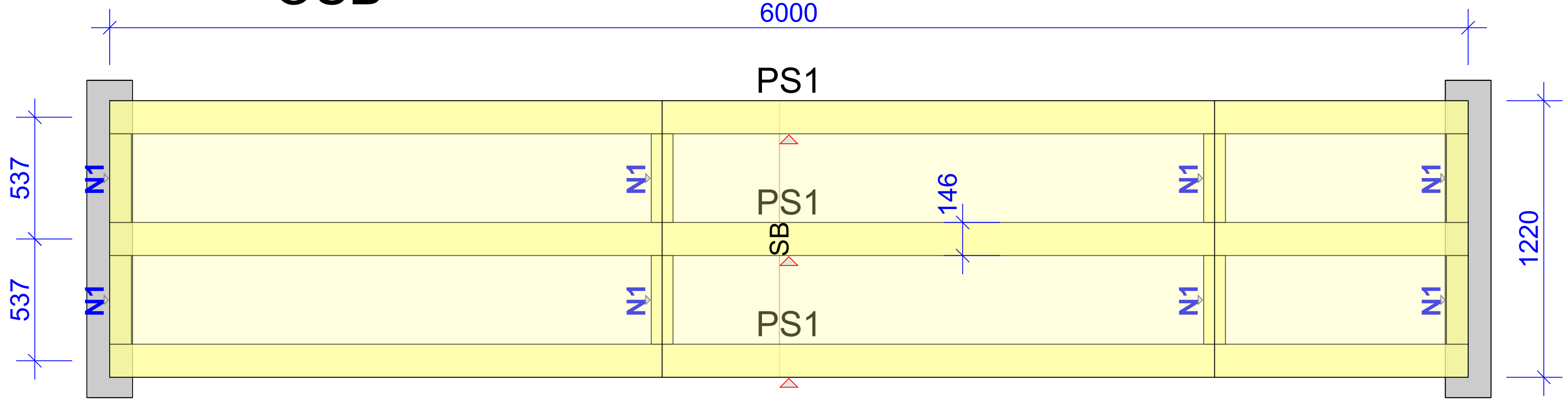


PS1 62 kg

Scan for 3D view



OSB



Uitgangspunten berekening vloer:

Windgebied II Terreincategorie Onbebouwd

Vloerbelasting permanent:

Plafond+leidingwerk : 0 N/m²

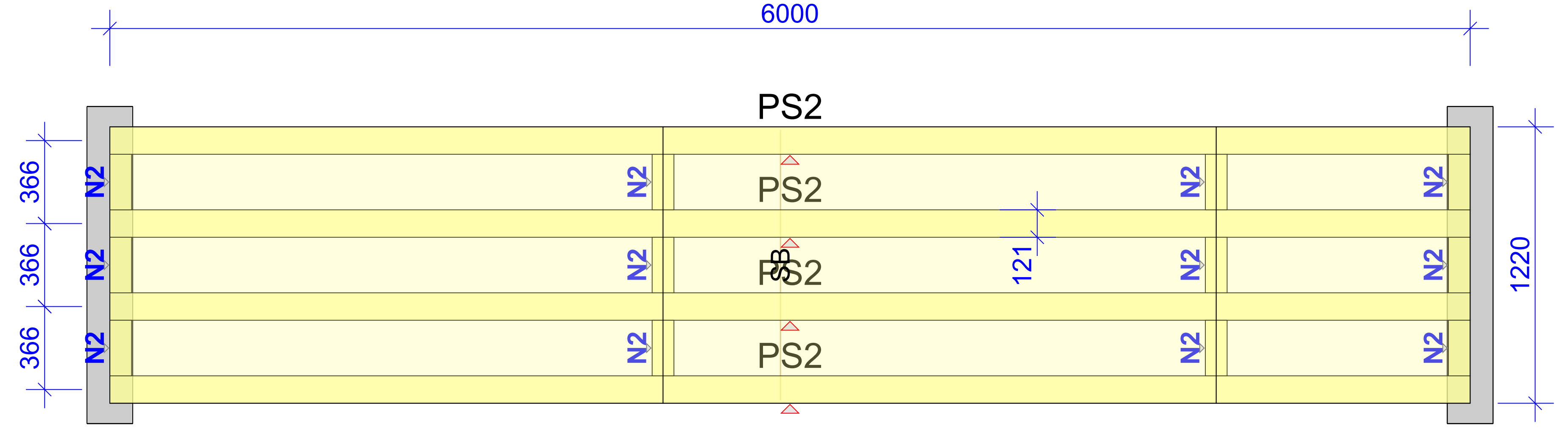
Vloerafwerking : 130 N/m²

Vloerbelasting variabel:

Variabele belasting : 2500 N/m²

Scheidingswanden : 0 N/m²

OSB & Anhydrite



Uitgangspunten berekening vloer:

Windgebied II Terreincategorie Onbebouwd

Vloerbelasting permanent:

Plafond+leidingwerk : 0 N/m²

Vloerafwerking : 1530 N/m²

Vloerbelasting variabel:

Variabele belasting : 2500 N/m²

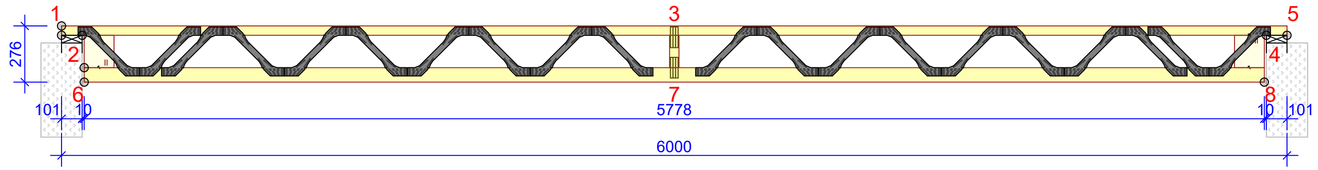
Scheidingswanden : 0 N/m²

Posi-Tech

Aannemer :	PT23-020				
Project :	Zernikelaan 17				
Project nr. :	PT23-020				**Versie :** 1
Gerekend door :	A. Tromp	**Datum:** 11/10/2023		**Schaal :** 1/75	**Pagina :** 1

PS1 - 3 no.

BRACINGS ACCORDING TO TIMBER TABLE AND STABILITY OF THE TRUSS SYSTEM SHALL BE DESIGNED SEPARATELY



GENERAL DIRECTIONS

THE STRUCTURE HAS BEEN CALCULATED USING
COMPUTER PROGRAM "MITEK PAMIR",
TCS Holdings - LICENSE: 19318
DESIGN CODE: NEN-EN 1995-1-1:2004
FULL DESIGN RESULTS AS PER CALC. PRINTOUT

GENERAL SETTINGS

TIMBER THICKNESS (mm):	146
TRUSS WEIGHT (kg/ply):	62
TRUSS CENTRES (mm):	537
LOAD SHARING FACTOR:	1.1
BUILDING CATEGORY:	Domestic
SERVICE CLASS:	1 = RH < 65%

BRACING: SEE TIMBER TABLE

LOADS (N/m²)

LIVE LOAD INSIDE ROOM:	2500
DEAD LOAD ON ATTIC FLOOR:	130

SELF-WEIGHT ADDED

SUPPORT REACTIONS (N) (ULTIMATE)

JOINT no	DIR.	LC P/L MAX	LC M MAX	LC S MAX	LC I MAX	LC I MIN	Charact. MAX / MIN	S-W mm
2	VER.	570	6611	0	0	0	10744 / 1235	10
4	VER.	570	6611	0	0	0	10744 / 1235	10

MAX DEFLECTION (mm) (SERVICEABILITY)

JOINT no	VER.	HOR.	LC NO.
2-3	17.2	-0.9	1006:2 (Wfin)
3-4	17.2	-0.9	1006:2 (Wfin)
4-5	-0.1	-1.8	1006:2 (Wfin)

FOR DEFLECTIONS AT OTHER POINTS - SEE CALC. PRINTOUT

POSI STRUT SIZE: PS-10+

TIMBER THICKNESS 146 mm

JOINT FR-TO	DEPTH mm	GRADE	BRACING mm/no.	CSI %
1-5	46!	C24	Sheeting	57
6-8	71!	C24	578	56
2-6	46x146	C24	None	1
4-8	46x146	C24	None	1
3-7	46	C24	None	1

FASTENERS - SPLICES EXCL

JOINT no	PLATE TYPE	WIDTH mm	LENGTH mm	CSI %
3	M20	38.1	101.6	3
7	M20	38.1	101.6	3

FASTENER LOCATION TOLERANCE: 10 mm

FASTENERS - SPLICES

JOINT no	PLATE TYPE	WIDTH mm	LENGTH mm	CSI %

Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

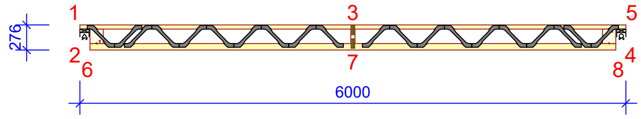
	MITEK PAMIR	DRAWN/CONSTR. BY		
11/10/2023 - 19:54	2023.2b (fe13ef1)	A. Tromp	SCALE 1:37	Page 1/36

Truss calculation performed with computer program MiTek Pamir

Version: 2023.2b (129896)
Program developed by: MiTek Europe

Project ID

Project code	:	PS1
Client	:	BuildinG
	:	Trust in Timber
	:	]Zernikelaan 17
	:	Groningen
Job number	:	PT23-020
Code type number	:	
Drawing number	:	



Calculation performed by

TCS Manufacturing

General project parameters

Basis of structural design	NEN-EN 1990:2002
Design of timber structures	NEN-EN 1995-1-1:2004
Dead load and live load	NEN-EN 1991-1-1:2002
Design for seismic forces	NEN-EN 1998-1

Manufacturing inspection	No
Design using rough sawn timber	No
Service class	1 = RH < 65%
Building category	Domestic
Humidity	20 %
Deflection factor (kDef)	0.6
Load sharing factor	1.1
Spacing	537 mm
Number of plies	1

Deviating parameters that apply to this part of the truss are specified in the "Timber parameters" table.
The shape of the truss is shown in the accompanying drawing.
Forces are calculated according to first order deflection theory.
Effect of shear deformation has been taken into account.
Vibration check calculated according to "prEN 1995-1-1: Vibrations"

Standard loads

Dead load

Floor 130 N/m²

Self-weight has been added

Live load

ID	Type	Value N/m²	Joint Number	Offset mm	Joint Number	Offset mm	Distribution mm
LL3	Inside room	2500	1	0	5	0	6000

Seismic loads

Acceleration, Se(T)	4.00 m/s²
Ductility, q	1.5

Point load in each load combination (ultimate)

Joint Number	LC No	Timber group	Offset mm	Vert. N	Hori. N	Moment kNm	Load type
1	2000	Top chord	3000	1000			Vibration

Load combinations

ID	Load duration	Name
Ultimate limit state		
1	Permanent	1.35*Dead
13	Medium-term	1.35*Dead + 1.50*LL3
Serviceability limit state		
1000:2	Permanent	1.00*Dead: Wfin

Load combinations

ID	Load duration	Name
1000:5	Permanent	1.00*Dead: Wfin – WGinst
1006:2	Medium-term	1.00*(LL3 + Dead): Wfin
1006:4	Medium-term	1.00*LL3: WQinst
1006:5	Medium-term	1.00*(LL3 + Dead): Wfin – WGinst

Accidental

801	Instantaneous	1.00*Dead + 0.30*LL3 + 0.27*Seismic left
802	Instantaneous	1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Vibrational

2000	Instantaneous	1.00*Vibration

Material values

Grade	E0,mean N/mm²	Gmean N/mm²	fm,k N/mm²	ft,0,k N/mm²	ft,90,k N/mm²	fc,0,k N/mm²	fc,90,k N/mm²	fv,k N/mm²	ρk kg/m³	γM
C24	11000	690	24	14.5	0.4	21	2.5	4	350	1.3

Anchorage plate values

Plate	fa0,0 N/mm²	fa90,90 N/mm²	k1	k2	Alpha0 °	kSer N/mm³	fax N/mm²	γM
M20	2.82	1.5	-0.0061	0.0169	59.43	14.7	10	1.3

Steel plate values

Plate	fc0 N/mm	fc90 N/mm	ft0 N/mm	ft90 N/mm	fv0 N/mm	fv90 N/mm	Gamma0 °	kv	γM
M20	76	88	148	136	69	43	-2.1	0.87	1.25

Support data

Joint Number	Y N/mm	X N/mm	RZ kNm/rad	Type
2	Fixed	Fixed	Free	Wall plate
4	Fixed	Free	Free	Wall plate

Deflection check limits

Load case type: Combined

Situation	Check	Global	Local	Unit
Wfin	Horizontal Support	-	-	mm
Wfin	Horizontal	-	-	L/x
Wfin	Bottom chord non attic	200	200	L/x
Wfin	Vertical	200	200	L/x
WQinst	Bottom chord non attic	300	300	L/x
WQinst	Vertical	300	300	L/x
Wfin – WGinst	Bottom chord non attic	350	350	L/x

Max deflections

Load case type: Combined

Situation	LC	Length mm	Allowed L/X	mm	Actual L/X	mm
Wfin	1006:2	5778	200	28.9	344	16.8
Wfin	1006:2	-	-	29.1	-	-17.2
Wfin – WGinst	1006:5	5778	350	16.5	374	15.5
WQinst	1006:4	5778	300	19.3	459	12.6
WQinst	1006:4	-	-	19.4	-	-12.9

Timber parameters

Timber group	Joints	Actual size mm	Design size mm	Grade	Bracing mm/no.	SSI %	LC No	CSI %	LC No	CSI Type
Top chord Left	1-5	46x146	45x143	C24	Sheeting	8	13	57	13	Max. combined CSI
Bottom chord	6-8	71x146	70x143	C24	578	5	13	56	13	Max. combined CSI
End vertical Right	4-8	46x146	45x143	C24	None	1	801	1	13	Max. combined CSI
End vertical Left	2-6	46x146	45x143	C24	None	1	801	1	13	Max. combined CSI
Web	3-7	46x146	45x143	C24	None	1	801	1	13	Max. combined CSI

Partial results from design in worst load combination

Member Joints	Load comb.	Dist. mm	Dist. %	Depth mm	kh	Grade	kmod	γM	Buckling length mm	Torsion length mm	Lateral buckling factor	kv	kc	kcr	Moment kNm	Axial force N	Shear force N	Bending CSI %	Axial CSI %	Shear CSI %	Torsion CSI %	Equ.	Max CSI %
1-2	13	95	100	45	1.27	C24	0.8	1.3	101y	101	1	-	1	1	-0.09	-8025	-5618	0.8	8.8	0.0	9.5	6.35	9.5
	2000	0	0		-		1.1	1.3	101x	101	-	-	-	-	0	0	0	0.0	0.0	0.0	0.0	-	0.0
2-3	13	2243	77	45	1.27	C24	0.8	1.3	482x	330	1	-	0.91y	1	0.1	-38507	-85	10.5	46.3	0.8	43.1	6.23	56.8
	13	6	0		1.27		0.8	1.3	0	-	1	1	-	1	-0.08	-8025	980	0.7	8.8	7.6	9.4	6.13	7.6
3-4	13	660	23	45	1.27	C24	0.8	1.3	482x	330	1	-	0.91y	1	0.1	-38507	85	10.5	46.3	0.8	43.1	6.23	56.8
	13	2896	100		1.27		0.8	1.3	0	-	1	1	-	1	-0.08	-8025	-980	0.7	8.8	7.6	9.4	6.13	7.6
4-5	13	0	0	45	1.27	C24	0.8	1.3	101y	101	1	-	1	1	-0.09	-8025	5618	0.8	8.8	0.0	9.5	6.35	9.5
	2000	0	0		-		1.1	1.3	101x	101	-	-	-	-	-0.01	-682	460	0.0	0.0	0.0	0.0	-	0.0
6-2	13	159	100	143	1.01	C24	0.8	1.3	159x	159	-	1	-	1	0	143	0	0.0	0.3	0.0	0.0	6.1	0.3
	802	159	100		1.01		1.1	1	0	-	-	1	-	1	0	34	-1	0.0	0.1	0.1	0.0	6.13	0.1
6-7	13	2889	100	70	1.17	C24	0.8	1.3	105x	520	-	-	-	1	-0.3	41014	284	13.8	41.6	0.0	0.0	6.17	55.4
	13	270	9		1.17		0.8	1.3	0	-	1	1	-	1	0.24	17405	888	10.9	17.7	5.0	10.9	6.13	5.0
7-3	13	27	17	45	1.27	C24	0.8	1.3	159y	159	1	-	1	1	0	-566	0	0.0	0.7	0.0	0.7	6.35	0.7
	801	124	78		1.27		1.1	1	0	-	1	1	-	1	0	-127	0	0.0	0.1	0.1	0.1	6.13	0.1
7-8	13	0	0	70	1.17	C24	0.8	1.3	105x	520	-	-	-	1	-0.3	41014	-284	13.8	41.6	0.0	0.0	6.17	55.4
	13	2619	91		1.17		0.8	1.3	0	-	1	1	-	1	0.24	17405	-888	10.9	17.7	5.0	10.9	6.13	5.0
8-4	13	159	100	143	1.01	C24	0.8	1.3	159x	159	-	1	-	1	0	143	0	0.0	0.3	0.0	0.0	6.1	0.3
	802	159	100		1.01		1.1	1	0	-	-	1	-	1	0	42	-1	0.0	0.1	0.1	0.0	6.13	0.1

Partial results from Posi-Strut design in worst load combination

Load comb.: 13 | kmod: 0.8 | Type: PS-10+ | Design of Posi Joists: ETA-20/1169 (15/12/2020)

Joint:index	Distance	Sides	Doubled	Axial force N	Anchorage CSI %	Buckling csi %	Max CSI %
2:1	81	Both	No	9681	97.2	-	97.2
2:2	381	Both	Yes	-10469	70.3	51.6	70.3
2:3	789	Both	No	6082	85.8	-	85.8
2:4	1091	Both	No	-7322	84.1	58.2	84.1
2:5	1391	Both	No	4878	68.8	-	68.8
2:6	1693	Both	No	-4700	54.0	37.4	54.0
2:7	1993	Both	No	2446	34.5	-	34.5
2:8	2295	Both	No	-2609	30.0	20.8	30.0
2:9	2595	Both	No	413	5.9	-	5.9
3:1	3105	Both	No	413	5.9	-	5.9
3:2	3405	Both	No	-2609	30.0	20.8	30.0
3:3	3707	Both	No	2446	34.5	-	34.5
3:4	4007	Both	No	-4700	54.0	37.4	54.0
3:5	4309	Both	No	4878	68.8	-	68.8
3:6	4609	Both	No	-7322	84.1	58.2	84.1
3:7	4911	Both	No	6082	85.8	-	85.8
3:8	5211	Both	Yes	-10469	70.3	51.6	70.3
3:9	5619	Both	No	9681	97.2	-	97.2

Fastener

Fastener Type	Make	Standard Approval Certificate
M20	MiTek United Kingdom	TRADA TE//F08550-M20 V1

Max tolerance for fastener position: 10 mm

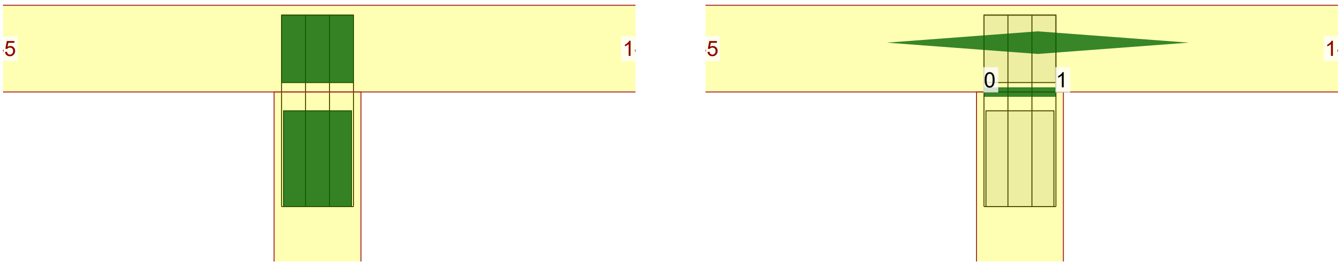
Joint Number	Fastener Type	Size Width	Length	CSI %
3	M20	38.1	101.6	3
7	M20	38.1	101.6	3

Nailed joints

Joint Number	
2	2 x Screwshank nails 3.3 * 98
4	2 x Screwshank nails 3.3 * 98
6	2 x Screwshank nails 3.3 * 98
8	2 x Screwshank nails 3.3 * 98

Result from design of fasteners in joints

Joint - 3   M20 410   Nail plate



Anchorage check

Member From-To	LC	Aef mm²	WP cm³	Force N	Angle °	Moment kNm	Fa,α,β,d N/mm²	Fa,0,0,d N/mm²	α °	β °	CSI %
1-5	13	983	12.01	28	-90	0.00	1.02	1.91	0	90	3
7-3	13	1104	14.33	28	90	0.00	1.91	1.91	0	0	2

Single gap check

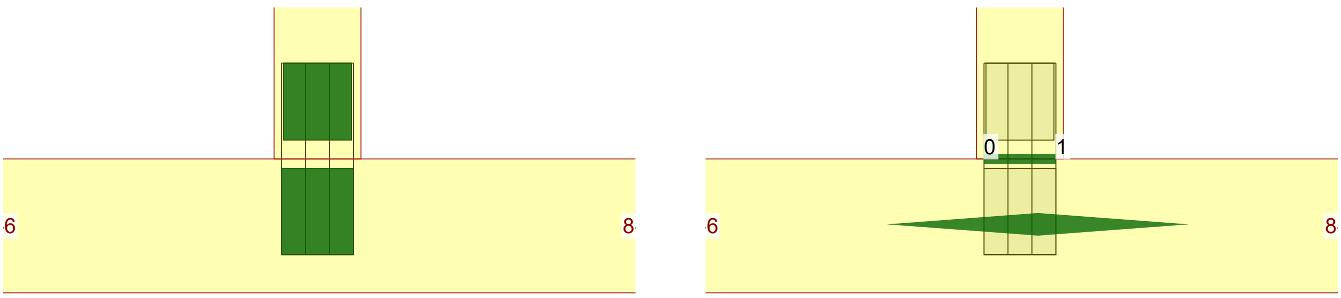
Points involved See image	LC	Lef mm	Force N	Angle °	Moment kNm	fx,Ed N/mm	fy,Ed N/mm	fx,Rd N/mm	fy,Rd N/mm	γ °	CSI %
0 -> 1	13	38	28	180	0	-0.75	0	66.88	37.84	90	2

Tension perpendicular check

Member From-To	LC	he mm	wpl mm	Fv,Ed N	F90,Rd N	CSI %
1-5	13	26	0	0	15408	1

Result from design of fasteners in joints

Joint - 7 M20 410 Nail plate



Anchorage check

Member From-To	LC	Aef mm²	WP cm³	Force N	Angle °	Moment kNm	Fa,α,β,d N/mm²	Fa,0,0,d N/mm²	α °	β °	CSI %
8-6	13	1364	19.07	28	90	0.00	1.02	1.91	0	90	3
7-3	13	833	9.13	28	-90	0.00	1.91	1.91	0	0	2

Single gap check

Points involved See image	LC	Lef mm	Force N	Angle °	Moment kNm	fx,Ed N/mm	fy,Ed N/mm	fx,Rd N/mm	fy,Rd N/mm	γ °	CSI %
0 -> 1	13	38	28	180	0	-0.76	0	66.88	37.84	90	2

Tension perpendicular check

Member From-To	LC	he mm	wpl mm	Fv,Ed N	F90,Rd N	CSI %
8-6	13	35	0	0	16275	1

Max/Min support reactions (ultimate)

Joint Number	Dir.		Perm. N	LC	Long N	LC	Medium N	LC	Short N	LC	Inst. N	LC	Capacity* N
2	VER.	Max	570	1	0	-	6611	13	0	-	0	-	10744
		Min	570	1	0	-	6611	13	0	-	0	-	1235
4	VER.	Max	570	1	0	-	6611	13	0	-	0	-	10744
		Min	570	1	0	-	6611	13	0	-	0	-	1235

* Minimum required connector characteristic capacity

Frame

Joint Number	Actual mm	Req. width mm	LC	Req. effective area mm²	kc90	fc,k N/mm²	Timber resistance N	CSI %
2	101	10	13	4380	1.50	2.5	48551	13.7
4	101	10	13	4380	1.50	2.5	48551	13.7

Max/Min support reactions (accidental)

Joint Number	Dir.		Perm. N	LC	Long N	LC	Medium N	LC	Short N	LC	Inst. N	LC	Capacity* N
2	HOR.	Max	0	-	0	-	0	-	0	-	887	801	1048
		Min	0	-	0	-	0	-	0	-	-887	802	-1048
2	VER.	Max	0	-	0	-	0	-	0	-	1633	802	1930
		Min	0	-	0	-	0	-	0	-	1628	801	1924
4	VER.	Max	0	-	0	-	0	-	0	-	1633	801	1930
		Min	0	-	0	-	0	-	0	-	1628	802	1924

* Minimum required connector characteristic capacity

Frame

Joint Number	Actual mm	Req. width mm	LC	Req. effective area mm²	kc90	fc,k N/mm²	Timber resistance N	CSI %
2	101	10	802	4380	1.50	2.5	86784	1.9
4	101	10	801	4380	1.50	2.5	86784	1.9

Support reactions by load case - Horizontal

Load case	2 N
Dead	0
LL3	0
Seismic left	-3261
Seismic left (modified by seismic factor)	-887
Seismic right	3261
Seismic right (modified by seismic factor)	887
Vibration	0

Support reactions by load case - Vertical

Load case	2 N	4 N
Dead	422	422
LL3	4028	4028
Seismic left	-9	9
Seismic left (modified by seismic factor)	-3	3
Seismic right	9	-9
Seismic right (modified by seismic factor)	3	-3
Vibration	500	500

Vibration check

Floor performance level	V
Interacting strut wall	No
Interacting bottom floor sheet	Yes
Interacting ceiling	No
Floor width	1200 mm
Max side length of room	6000 mm

Materials

Type	Material	Thickness mm	Ec N/mm²	E0 N/mm²	E90 N/mm²
Top floor sheet	None	0	0	0	0
Middle floor sheet	None	0	0	0	0
Bottom floor sheet	OSB 3 22mm	22	3500	3500	3500
Ceiling	13 mm Gypsum	13	0	0	0

Span

Free span mm	Continous floor	Span type	Floor joist height mm	Grade	Size mm	Spacing mm	Floor height mm	Extra weight kg/m²	Total weight kg/m²	Modal mass kg	Modal damping ratio	Effective floor width mm
5798	No	Simply supported	276	C24	146 x 46	537	311	0	52.08	90.59	0.03	1200

Fundamental frequency Hz	Allowed Minimum Fundamental frequency Hz	Deflection under a 1kN point load mm	Allowed Maximum Deflection mm	Effective strongback quantity	Strongest strongback size/grade	Acceleration m/s²	Allowed Maximum Acceleration m/s²	Velocity mm/s	Allowed velocity mm/s	Vibration result
21.77	4.5	0.86	0.93	1	38 x 120 C24	-	-	2.18	3.60	Passed

Global deflection span

Load case type: Combined | Member Joints: 6-8 | Length mm: 5778

Situation	LC	Allowed L/X	Absolute mm	Ratio L/X	Deflection mm	Ratio %
Wfin	1006:2	200	28.9	344	16.8	58.1
Wfin – WGinst	1006:5	350	16.5	374	15.5	93.6
WQinst	1006:4	300	19.3	459	12.6	65.4

Local deflection span

Load case type: Combined | Length mm: 601 | Absolute mm: 3

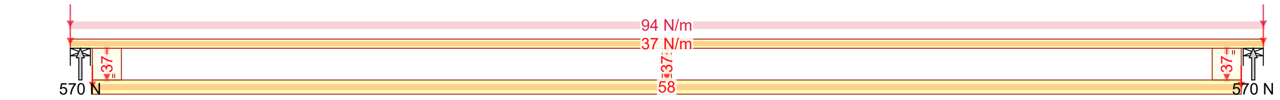
Situation	Member Joints	LC	Allowed L/X	Relative L/X	Deflection mm	Ratio %
Wfin	7-8	1006:2	200	3094	0.2	6.5
Wfin	6-7	1006:2	200	3094	0.2	6.5
Wfin – WGinst	7-8	1006:5	350	3374	0.2	6.0
Wfin – WGinst	6-7	1006:5	350	3374	0.2	6.0
WQinst	7-8	1006:4	300	4155	0.1	4.9
WQinst	6-7	1006:4	300	4155	0.1	4.9

Node deflection

Load case type: Combined

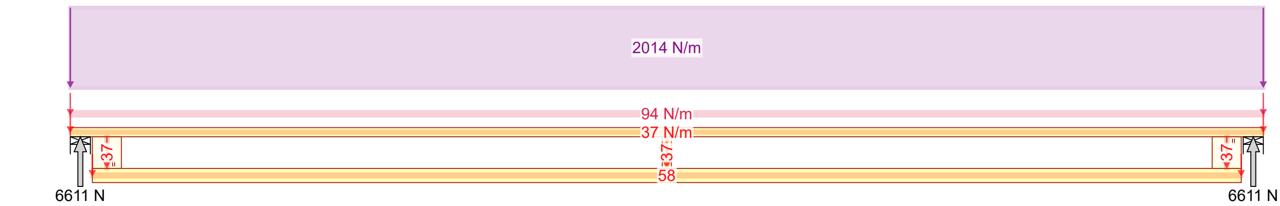
Situation	Joints	Support	Direction	LC	Absolute mm	Negative deflection mm	Ratio %	LC	Positive deflection mm	Ratio %
Wfin	3	No	Vertical	1006:2	29.1	-17.2	59.2			
Wfin	7	No	Vertical	1006:2	29.1	-17.2	59.1			
Wfin	2	Yes	Horizontal		6			1000:2	-	-
Wfin	4	Yes	Horizontal	1006:2	6	-1.8	30.5			
WQinst	3	No	Vertical	1006:4	19.4	-12.9	66.6			
WQinst	7	No	Vertical	1006:4	19.4	-12.9	66.5			

Ultimate limit state - Permanent



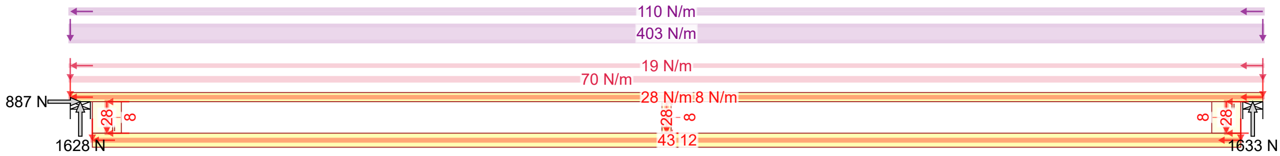
1 - 1.35*Dead

Ultimate limit state - Medium-term



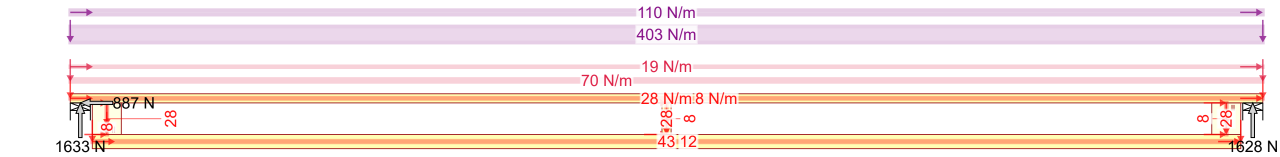
13 - 1.35*Dead + 1.50*LL3

Accidental



801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

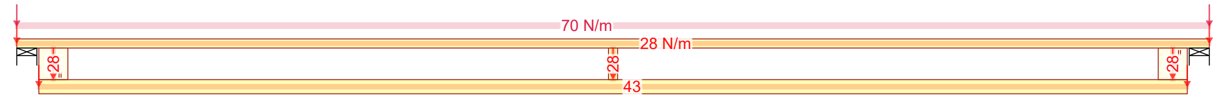
Accidental



802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

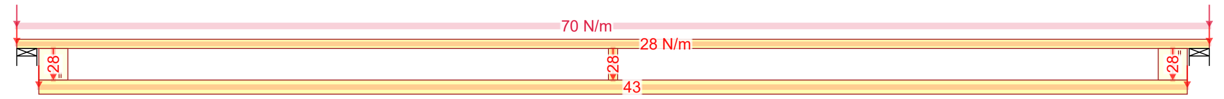
Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen	
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp

Serviceability limit state - Wfin



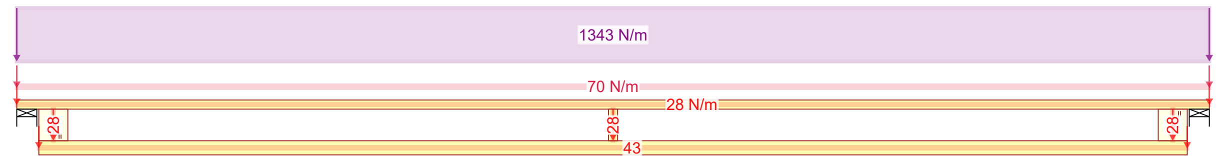
1000:2 - 1.00*DeadWfin

Serviceability limit state - Wfin – WGinst



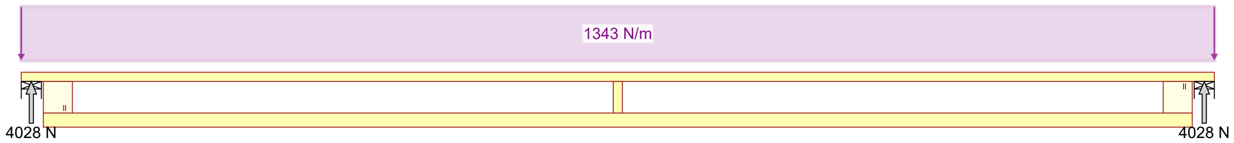
1000:5 - 1.00*DeadWfin – WGinst

Serviceability limit state - Wfin



1006:2 - 1.00*(LL3 + Dead)Wfin

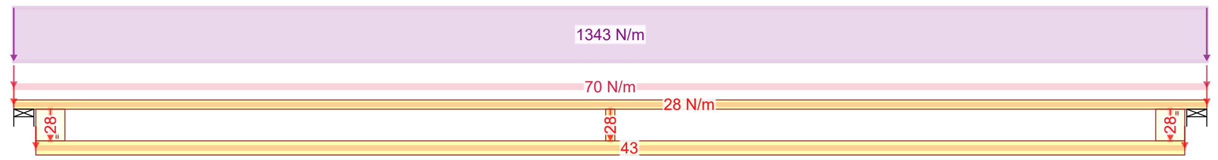
Serviceability limit state - WQinst



1006:4 - 1.00*LL3WQinst

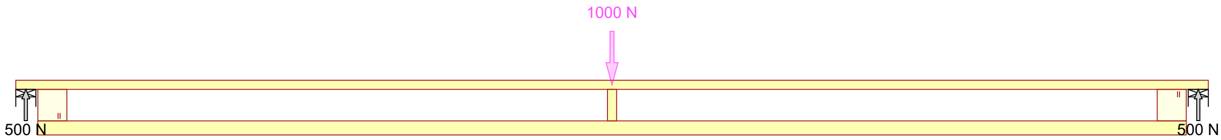
Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen	
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 9/36

Serviceability limit state - Wfin – WGinst



1006:5 - 1.00*(LL3 + Dead)Wfin – WGinst

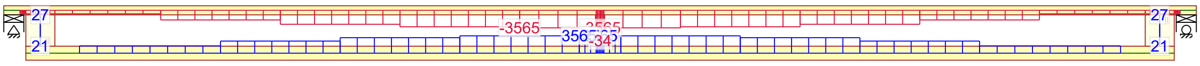
Vibrational



2000 - Vibration

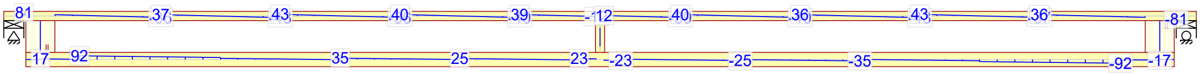
Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1) / DRAWN/CONSTR. BY A. Tromp / Page 10/36

Axial force



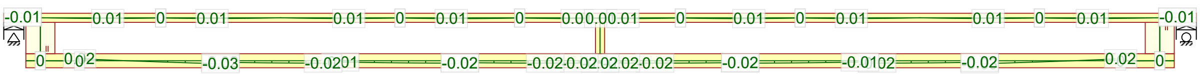
1 - 1.35*Dead

Shear force



1 - 1.35*Dead

Moment



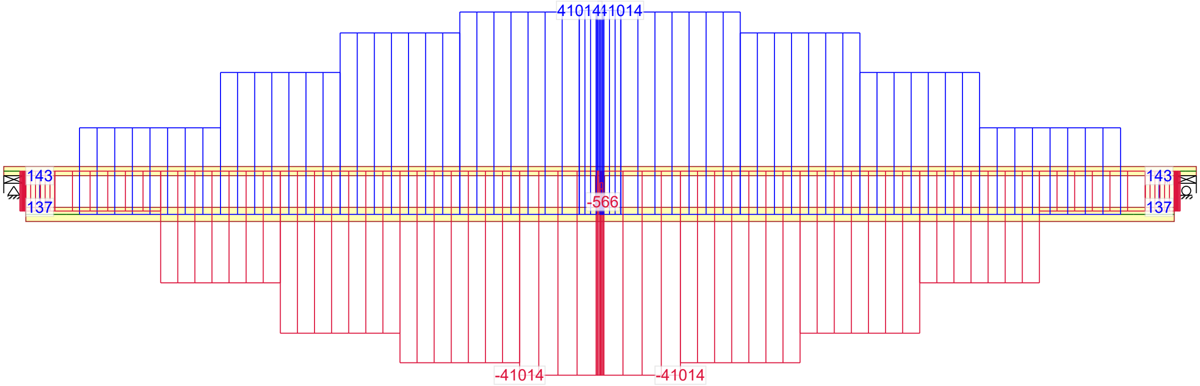
1 - 1.35*Dead

Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

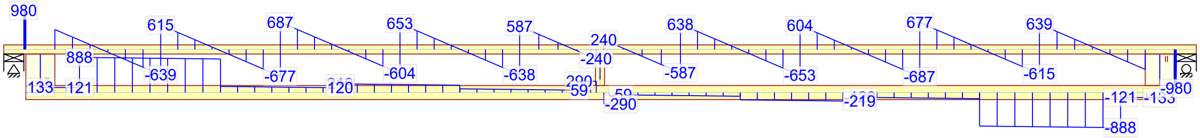
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp		Page 11/36

Axial force



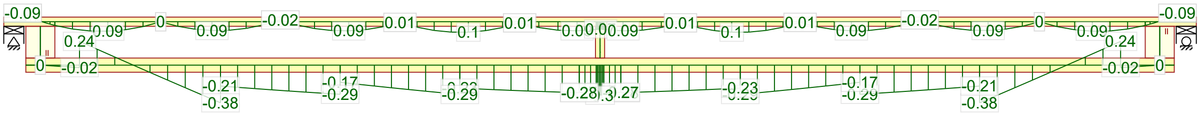
13 - 1.35*Dead + 1.50*LL3

Shear force



13 - 1.35*Dead + 1.50*LL3

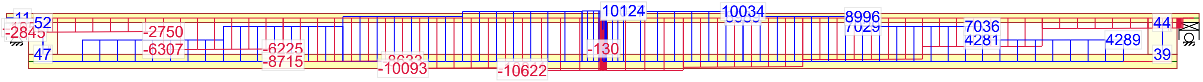
Moment



13 - 1.35*Dead + 1.50*LL3

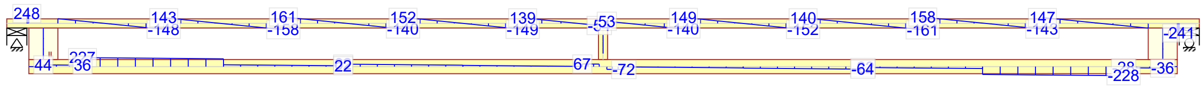
Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen	
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp

Axial force



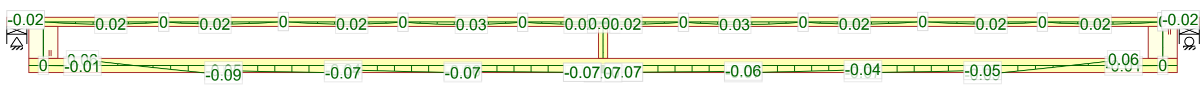
801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

Shear force



801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

Moment

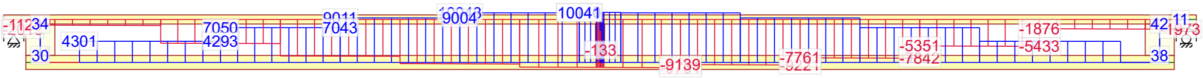


801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen	

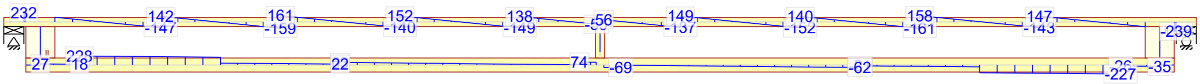
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 13/36

Axial force



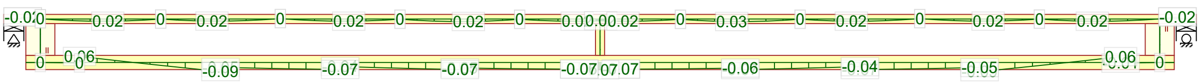
802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Shear force



802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Moment

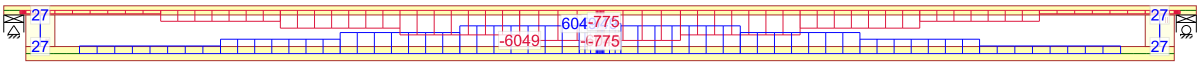


802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen	

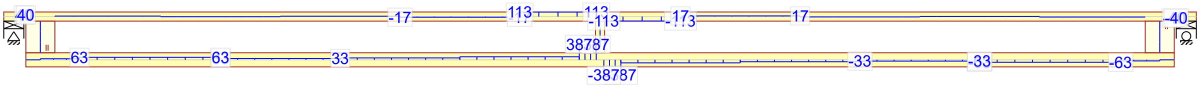
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 14/36

Axial force



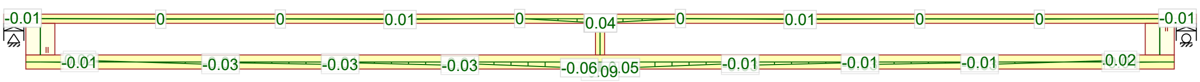
2000 - Vibration

Shear force



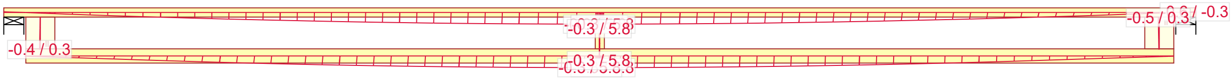
2000 - Vibration

Moment



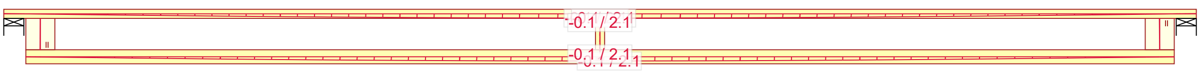
2000 - Vibration

Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen	
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp



801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

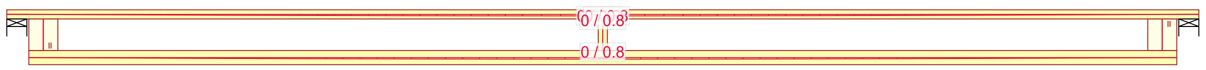


1000:2 - 1.00*Dead: Wfin

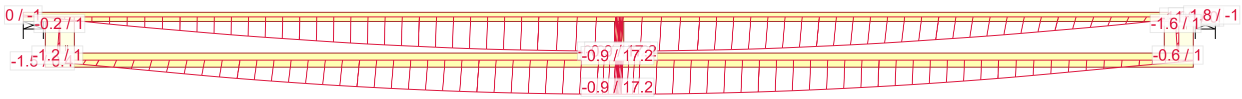
Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

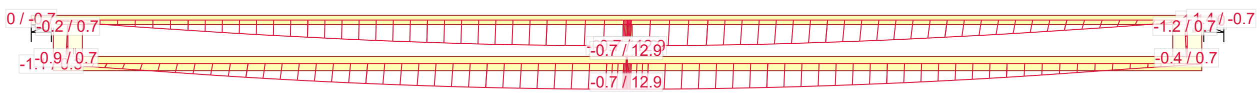
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 16/36



1000:5 - 1.00*Dead: Wfin – WGinst



1006:2 - 1.00*(LL3 + Dead): Wfin

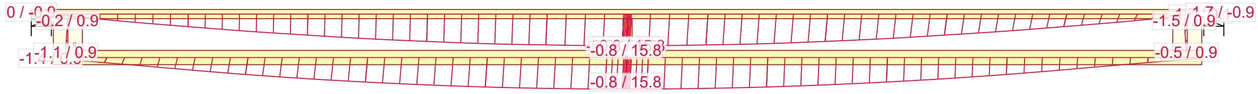


1006:4 - 1.00*LL3: WQinst

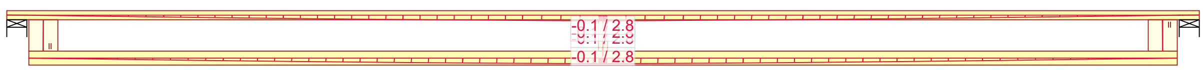
Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 17/36



1006:5 - 1.00*(LL3 + Dead): Wfin – WGinst



2000 - Vibration

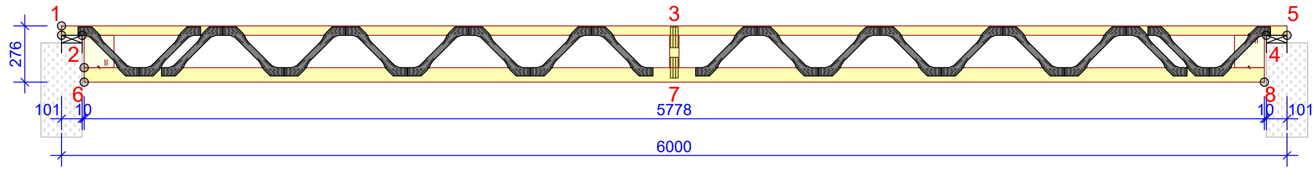
Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 18/36

PS2 - 4 no.

BRACINGS ACCORDING TO TIMBER TABLE AND STABILITY OF THE TRUSS SYSTEM SHALL BE DESIGNED SEPARATELY



GENERAL DIRECTIONS

THE STRUCTURE HAS BEEN CALCULATED USING
COMPUTER PROGRAM "MITEK PAMIR",
TCS Holdings - LICENSE: 19318
DESIGN CODE: NEN-EN 1995-1-1:2004
FULL DESIGN RESULTS AS PER CALC. PRINTOUT

GENERAL SETTINGS

TIMBER THICKNESS (mm):	121
TRUSS WEIGHT (kg/ply):	53
TRUSS CENTRES (mm):	366
LOAD SHARING FACTOR:	1.1
BUILDING CATEGORY:	Domestic
SERVICE CLASS:	1 = RH < 65%

BRACING: SEE TIMBER TABLE

LOADS (N/m²)

LIVE LOAD INSIDE ROOM:	2500
DEAD LOAD ON ATTIC FLOOR:	1530

SELF-WEIGHT ADDED

SUPPORT REACTIONS (N) (ULTIMATE)

JOINT no	DIR.	LC P/L MAX	LC M MAX	LC S MAX	LC I MAX	LC I MIN	Charact. MAX / MIN	S-W mm
2	VER.	2509	6630	0	0	0	10774 / 5437	10
4	VER.	2509	6630	0	0	0	10774 / 5437	10

MAX DEFLECTION (mm) (SERVICEABILITY)

JOINT no	VER.	HOR.	LC NO.
2-3	22.7	-1.3	1006:2 (Wfin)
3-4	22.7	-1.3	1006:2 (Wfin)
4-5	-0.2	-2.5	1006:2 (Wfin)

FOR DEFLECTIONS AT OTHER POINTS - SEE CALC. PRINTOUT

POSI STRUT SIZE: PS-10+

TIMBER THICKNESS 121 mm

JOINT FR-TO	DEPTH mm	GRADE	BRACING mm/no.	CSI %
1-5	46	C24	Sheeting	69
6-8	71	C24	578	65
2-6	46x146	C24	None	1
4-8	46x146	C24	None	1
3-7	46	C24	None	1

FASTENERS - SPLICES EXCL

JOINT no	PLATE TYPE	WIDTH mm	LENGTH mm	CSI %
3	M20	38.1	101.6	3
7	M20	38.1	101.6	3

FASTENER LOCATION TOLERANCE: 10 mm

FASTENERS - SPLICES

JOINT no	PLATE TYPE	WIDTH mm	LENGTH mm	CSI %

Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

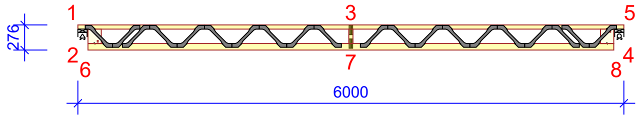
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	SCALE 1:37	Page 19/36

Truss calculation performed with computer program MiTek Pamir

Version: 2023.2b (129896)
Program developed by: MiTek Europe

Project ID

Project code	:	PS2
Client	:	BuildinG
	:	Trust in Timber
	:	]Zernikelaan 17
	:	Groningen
Job number	:	PT23-020
Code type number	:	
Drawing number	:	



Calculation performed by

TCS Manufacturing

General project parameters

Basis of structural design	NEN-EN 1990:2002
Design of timber structures	NEN-EN 1995-1-1:2004
Dead load and live load	NEN-EN 1991-1-1:2002
Design for seismic forces	NEN-EN 1998-1

Manufacturing inspection	No
Design using rough sawn timber	No
Service class	1 = RH < 65%
Building category	Domestic
Humidity	20 %
Deflection factor (kDef)	0.6
Load sharing factor	1.1
Spacing	366 mm
Number of plies	1

Deviating parameters that apply to this part of the truss are specified in the "Timber parameters" table.
The shape of the truss is shown in the accompanying drawing.
Forces are calculated according to first order deflection theory.
Effect of shear deformation has been taken into account.
Vibration check calculated according to "prEN 1995-1-1: Vibrations"

Standard loads

Dead load

Floor 1530 N/m²

Self-weight has been added

Live load

ID	Type	Value N/m²	Joint Number	Offset mm	Joint Number	Offset mm	Distribution mm
LL3	Inside room	2500	1	0	5	0	6000

Seismic loads

Acceleration, Se(T)	4.00 m/s²
Ductility, q	1.5

Point load in each load combination (ultimate)

Joint Number	LC No	Timber group	Offset mm	Vert. N	Hori. N	Moment kNm	Load type
1	2000	Top chord	3000	1000			Vibration

Load combinations

ID	Load duration	Name
Ultimate limit state		
1	Permanent	1.35*Dead
13	Medium-term	1.35*Dead + 1.50*LL3
Serviceability limit state		
1000:2	Permanent	1.00*Dead: Wfin

Load combinations

ID	Load duration	Name
1000:5	Permanent	1.00*Dead: Wfin – WGinst
1006:2	Medium-term	1.00*(LL3 + Dead): Wfin
1006:4	Medium-term	1.00*LL3: WQinst
1006:5	Medium-term	1.00*(LL3 + Dead): Wfin – WGinst

Accidental

801	Instantaneous	1.00*Dead + 0.30*LL3 + 0.27*Seismic left
802	Instantaneous	1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Vibrational

2000	Instantaneous	1.00*Vibration

Material values

Grade	E0,mean N/mm²	Gmean N/mm²	fm,k N/mm²	ft,0,k N/mm²	ft,90,k N/mm²	fc,0,k N/mm²	fc,90,k N/mm²	fv,k N/mm²	ρk kg/m³	γM
C24	11000	690	24	14.5	0.4	21	2.5	4	350	1.3

Anchorage plate values

Plate	fa0,0 N/mm²	fa90,90 N/mm²	k1	k2	Alpha0 °	kSer N/mm³	fax N/mm²	γM
M20	2.82	1.5	-0.0061	0.0169	59.43	14.7	10	1.3

Steel plate values

Plate	fc0 N/mm	fc90 N/mm	ft0 N/mm	ft90 N/mm	fv0 N/mm	fv90 N/mm	Gamma0 °	kv	γM
M20	76	88	148	136	69	43	-2.1	0.87	1.25

Support data

Joint Number	Y N/mm	X N/mm	RZ kNm/rad	Type
2	Fixed	Fixed	Free	Wall plate
4	Fixed	Free	Free	Wall plate

Deflection check limits

Load case type: Combined

Situation	Check	Global	Local	Unit
Wfin	Horizontal Support	-	-	mm
Wfin	Horizontal	-	-	L/x
Wfin	Bottom chord non attic	200	200	L/x
Wfin	Vertical	200	200	L/x
WQinst	Bottom chord non attic	300	300	L/x
WQinst	Vertical	300	300	L/x
Wfin – WGinst	Bottom chord non attic	350	350	L/x

Max deflections

Load case type: Combined

Situation	LC	Length mm	Allowed L/X	mm	Actual L/X	mm
Wfin	1006:2	5778	200	28.9	261	22.1
Wfin	1006:2	-	-	29.1	-	-22.7
Wfin – WGinst	1006:5	5778	350	16.5	375	15.4
WQinst	1006:4	5778	300	19.3	583	9.9
WQinst	1006:4	-	-	19.4	-	-10.2

Timber parameters

Timber group	Joints	Actual size mm	Design size mm	Grade	Bracing mm/no.	SSI %	LC No	CSI %	LC No	CSI Type
Top chord Left	1-5	46x121	45x119	C24	Sheeting	10	13	69	13	Max. combined CSI
Bottom chord	6-8	71x121	70x119	C24	578	6	13	65	13	Max. combined CSI
End vertical Right	4-8	46x146	45x143	C24	None	1	801	1	13	Max. combined CSI
End vertical Left	2-6	46x146	45x143	C24	None	1	801	1	13	Max. combined CSI
Web	3-7	46x121	45x119	C24	None	1	802	1	13	Max. combined CSI

Partial results from design in worst load combination

Member Joints	Load comb.	Dist. mm	Dist. %	Depth mm	kh	Grade	kmod	γM	Buckling length mm	Torsion length mm	Lateral buckling factor	kv	kc	kcr	Moment kNm	Axial force N	Shear force N	Bending CSI %	Axial CSI %	Shear CSI %	Torsion CSI %	Equ.	Max CSI %
1-2	13	94	100	45	1.27	C24	0.8	1.3	101y	101	1	-	1	1	-0.08	-8043	-5630	1.0	10.6	0.0	11.6	6.35	11.6
	2000	0	0		-		1.1	1.3	101x	101	-	-	-	-	0	0	0	0.0	0.0	0.0	0.0	-	0.0
2-3	13	2243	77	45	1.27	C24	0.8	1.3	482x	330	1	-	0.91y	1	0.1	-38693	-84	12.3	56.2	0.9	52.5	6.23	68.4
	13	7	0		1.27		0.8	1.3	0	-	1	1	-	1	-0.08	-8043	986	0.9	10.6	9.2	11.5	6.13	9.2
3-4	13	660	23	45	1.27	C24	0.8	1.3	482x	330	1	-	0.91y	1	0.1	-38693	84	12.3	56.2	0.9	52.5	6.23	68.4
	13	2896	100		1.27		0.8	1.3	0	-	1	1	-	1	-0.08	-8043	-986	0.9	10.6	9.2	11.5	6.13	9.2
4-5	13	0	0	45	1.27	C24	0.8	1.3	101y	101	1	-	1	1	-0.08	-8043	5630	1.0	10.6	0.0	11.6	6.35	11.6
	2000	0	0		-		1.1	1.3	101x	101	-	-	-	-	-0.01	-679	458	0.0	0.0	0.0	0.0	-	0.0
6-2	13	159	100	143	1.01	C24	0.8	1.3	159x	159	-	1	-	1	0	166	0	0.0	0.3	0.0	0.0	6.1	0.3
	802	159	100		1.01		1.1	1	0	-	-	1	-	1	0	56	-1	0.0	0.1	0.1	0.0	6.13	0.1
6-7	13	2889	100	70	1.17	C24	0.8	1.3	105x	520	-	-	-	1	-0.29	41215	286	16.0	48.6	0.0	0.0	6.17	64.6
	13	270	9		1.17		0.8	1.3	0	-	1	1	-	1	0.24	17565	856	13.0	20.7	5.8	13.0	6.13	5.8
7-3	13	27	17	45	1.27	C24	0.8	1.3	159y	159	1	-	1	1	0	-571	0	0.0	0.8	0.0	0.8	6.35	0.8
	802	124	78		1.27		1.1	1	0	-	1	1	-	1	0	-228	0	0.0	0.2	0.1	0.2	6.13	0.1
7-8	13	0	0	70	1.17	C24	0.8	1.3	105x	520	-	-	-	1	-0.29	41215	-286	16.0	48.6	0.0	0.0	6.17	64.6
	13	2619	91		1.17		0.8	1.3	0	-	1	1	-	1	0.24	17565	-856	13.0	20.7	5.8	13.0	6.13	5.8
8-4	13	159	100	143	1.01	C24	0.8	1.3	159x	159	-	1	-	1	0	166	0	0.0	0.3	0.0	0.0	6.1	0.3
	802	159	100		1.01		1.1	1	0	-	-	1	-	1	0	71	-1	0.0	0.1	0.1	0.0	6.13	0.1

Partial results from Posi-Strut design in worst load combination

Load comb.: 13 | kmod: 0.8 | Type: PS-10+ | Design of Posi Joists: ETA-20/1169 (15/12/2020)

Joint:index	Distance	Sides	Doubled	Axial force N	Anchorage CSI %	Buckling csi %	Max CSI %
2:1	81	Both	No	9703	97.5	-	97.5
2:2	381	Both	Yes	-10627	71.4	52.4	71.4
2:3	789	Both	No	6119	86.4	-	86.4
2:4	1091	Both	No	-7308	83.9	58.1	83.9
2:5	1391	Both	No	4883	68.9	-	68.9
2:6	1693	Both	No	-4717	54.2	37.5	54.2
2:7	1993	Both	No	2433	34.4	-	34.4
2:8	2295	Both	No	-2624	30.2	20.9	30.2
2:9	2595	Both	No	415	5.9	-	5.9
3:1	3105	Both	No	415	5.9	-	5.9
3:2	3405	Both	No	-2624	30.2	20.9	30.2
3:3	3707	Both	No	2433	34.4	-	34.4
3:4	4007	Both	No	-4717	54.2	37.5	54.2
3:5	4309	Both	No	4883	68.9	-	68.9
3:6	4609	Both	No	-7307	83.9	58.1	83.9
3:7	4911	Both	No	6119	86.4	-	86.4
3:8	5211	Both	Yes	-10627	71.4	52.4	71.4
3:9	5619	Both	No	9703	97.5	-	97.5

Fastener

Fastener Type	Make	Standard Approval Certificate
M20	MiTek United Kingdom	TRADA TE//F08550-M20 V1

Max tolerance for fastener position: 10 mm

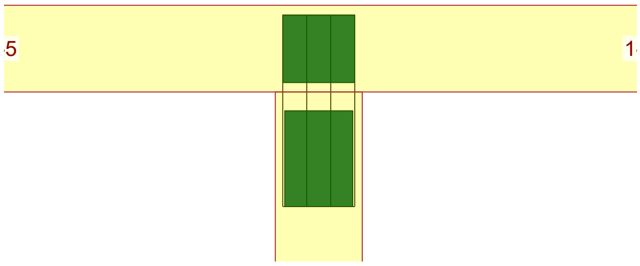
Joint Number	Fastener Type	Size Width	Length	CSI %
3	M20	38.1	101.6	3
7	M20	38.1	101.6	3

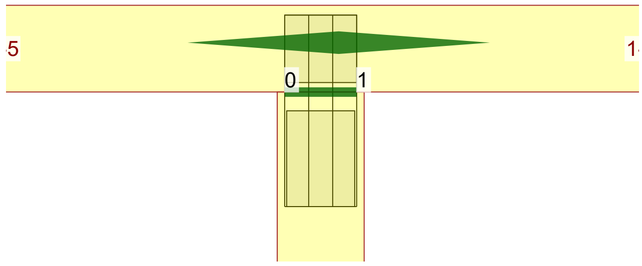
Nailed joints

Joint Number	
2	2 x Screwshank nails 3.3 * 98
4	2 x Screwshank nails 3.3 * 98
6	2 x Screwshank nails 3.3 * 98
8	2 x Screwshank nails 3.3 * 98

Result from design of fasteners in joints

Joint - 3   M20 410   Nail plate





Anchorage check

Member From-To	LC	Aef mm²	WP cm³	Force N	Angle °	Moment kNm	Fa,α,β,d N/mm²	Fa,0,0,d N/mm²	α °	β °	CSI %
1-5	13	983	12.01	28	-90	0.00	1.02	1.91	0	90	3
7-3	13	1104	14.33	28	90	0.00	1.91	1.91	0	0	2

Single gap check

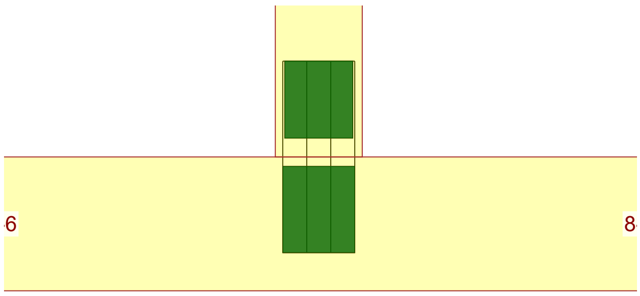
Points involved See image	LC	Lef mm	Force N	Angle °	Moment kNm	fx,Ed N/mm	fy,Ed N/mm	fx,Rd N/mm	fy,Rd N/mm	γ °	CSI %
0 -> 1	13	38	28	179.98	0	-0.76	0	66.88	37.84	90	2

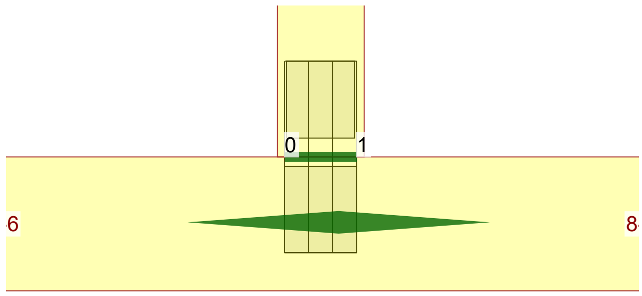
Tension perpendicular check

Member From-To	LC	he mm	wpl mm	Fv,Ed N	F90,Rd N	CSI %
1-5	13	26	0	0	12769	1

Result from design of fasteners in joints

Joint - 7 M20 410 Nail plate





Anchorage check

Member From-To	LC	Aef mm²	WP cm³	Force N	Angle °	Moment kNm	Fa,α,β,d N/mm²	Fa,0,0,d N/mm²	α °	β °	CSI %
8-6	13	1364	19.07	29	90	0.00	1.02	1.91	0	90	3
7-3	13	833	9.13	29	-90	0.00	1.91	1.91	0	0	2

Single gap check

Points involved See image	LC	Lef mm	Force N	Angle °	Moment kNm	fx,Ed N/mm	fy,Ed N/mm	fx,Rd N/mm	fy,Rd N/mm	γ °	CSI %
0 -> 1	13	38	29	179.98	0	-0.76	0	66.88	37.84	90	2

Tension perpendicular check

Member From-To	LC	he mm	wpl mm	Fv,Ed N	F90,Rd N	CSI %
8-6	13	35	0	0	13488	1

Max/Min support reactions (ultimate)

Joint Number	Dir.	Perm. N	LC	Long N	LC	Medium N	LC	Short N	LC	Inst. N	LC	Capacity* N
2	VER. Max	2509	1	0	-	6630	13	0	-	0	-	10774
	Min	2509	1	0	-	6630	13	0	-	0	-	5437
4	VER. Max	2509	1	0	-	6630	13	0	-	0	-	10774
	Min	2509	1	0	-	6630	13	0	-	0	-	5437

* Minimum required connector characteristic capacity

Frame

Joint Number	Actual mm	Req. width mm	LC	Req. effective area mm²	kc90	fc,k N/mm²	Timber resistance N	CSI %
2	101	10	13	3630	1.50	2.5	40237	16.5
4	101	10	13	3630	1.50	2.5	40237	16.5

Max/Min support reactions (accidental)

Joint Number	Dir.	Perm. N	LC	Long N	LC	Medium N	LC	Short N	LC	Inst. N	LC	Capacity* N
2	HOR.Max	0	-	0	-	0	-	0	-	1459	801	1724
	Min	0	-	0	-	0	-	0	-	-1459	802	-1724
2	VER.Max	0	-	0	-	0	-	0	-	2685	802	3173
	Min	0	-	0	-	0	-	0	-	2681	801	3168
4	VER.Max	0	-	0	-	0	-	0	-	2685	801	3173
	Min	0	-	0	-	0	-	0	-	2681	802	3168

* Minimum required connector characteristic capacity

Frame

Joint Number	Actual mm	Req. width mm	LC	Req. effective area mm²	kc90	fc,k N/mm²	Timber resistance N	CSI %
2	101	10	802	3630	1.50	2.5	71924	3.8
4	101	10	801	3630	1.50	2.5	71924	3.8

Support reactions by load case - Horizontal

Load case	2 N
Dead	0
LL3	0
Seismic left	-5366
Seismic left (modified by seismic factor)	-1459
Seismic right	5366
Seismic right (modified by seismic factor)	1459
Vibration	0

Support reactions by load case - Vertical

Load case	2 N	4 N
Dead	1859	1859
LL3	2747	2747
Seismic left	-8	8
Seismic left (modified by seismic factor)	-2	2
Seismic right	8	-8
Seismic right (modified by seismic factor)	2	-2
Vibration	500	500

Vibration check

Floor performance level	V
Interacting strut wall	No
Interacting bottom floor sheet	Yes
Interacting ceiling	No
Floor width	1200 mm
Max side length of room	6000 mm

Materials

Type	Material	Thickness mm	Ec N/mm²	E0 N/mm²	E90 N/mm²
Top floor sheet	None	0	0	0	0
Middle floor sheet	None	0	0	0	0
Bottom floor sheet	OSB 3 22mm	22	3500	3500	3500
Ceiling	13 mm Gypsum	13	0	0	0

Span

Free span mm	Continous floor	Span type	Floor joist height mm	Grade	Size mm	Spacing mm	Floor height mm	Extra weight kg/m²	Total weight kg/m²	Modal mass kg	Modal damping ratio	Effective floor width mm
5798	No	Simply supported	276	C24	121 x 46	366	311	0	197.71	343.89	0.03	1200

Fundamental frequency Hz	Allowed Minimum Fundamental frequency Hz	Deflection under a 1kN point load mm	Allowed Maximum Deflection mm	Effective strongback quantity	Strongest strongback size/grade	Acceleration m/s²	Allowed Maximum Acceleration m/s²	Velocity mm/s	Allowed velocity mm/s	Vibration result
11.57	4.5	0.71	0.93	1	38 x 120 C24	-	-	2.38	3.60	Passed

Global deflection span

Load case type: Combined | Member Joints: 6-8 | Length mm: 5778

Situation	LC	Allowed L/X	Absolute mm	Ratio L/X	Deflection mm	Ratio %
Wfin	1006:2	200	28.9	261	22.1	76.6
Wfin – WGinst	1006:5	350	16.5	375	15.4	93.4
WQinst	1006:4	300	19.3	583	9.9	51.5

Local deflection span

Load case type: Combined | Length mm: 601 | Absolute mm: 3

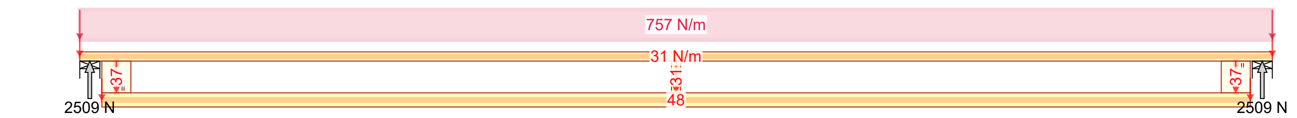
Situation	Member Joints	LC	Allowed L/X	Relative L/X	Deflection mm	Ratio %
Wfin	7-8	1006:2	200	2338	0.3	8.6
Wfin	6-7	1006:2	200	2338	0.3	8.6
Wfin – WGinst	7-8	1006:5	350	3365	0.2	6.0
Wfin – WGinst	6-7	1006:5	350	3365	0.2	6.0
WQinst	7-8	1006:4	300	5244	0.1	3.9
WQinst	6-7	1006:4	300	5244	0.1	3.9

Node deflection

Load case type: Combined

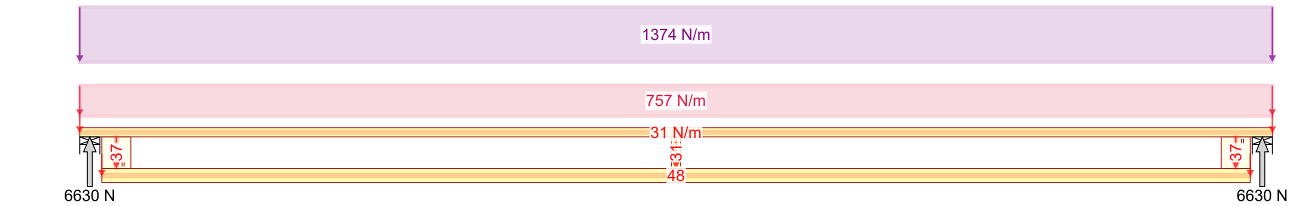
Situation	Joints	Support	Direction	LC	Absolute mm	Negative deflection mm	Ratio %	LC	Positive deflection mm	Ratio %
Wfin	3	No	Vertical	1006:2	29.1	-22.7	78.0			
Wfin	7	No	Vertical	1006:2	29.1	-22.6	78.0			
Wfin	2	Yes	Horizontal		6			1000:2	-	-
Wfin	4	Yes	Horizontal	1006:2	6	-2.5	42.1			
WQinst	3	No	Vertical	1006:4	19.4	-10.2	52.5			
WQinst	7	No	Vertical	1006:4	19.4	-10.1	52.4			

Ultimate limit state - Permanent



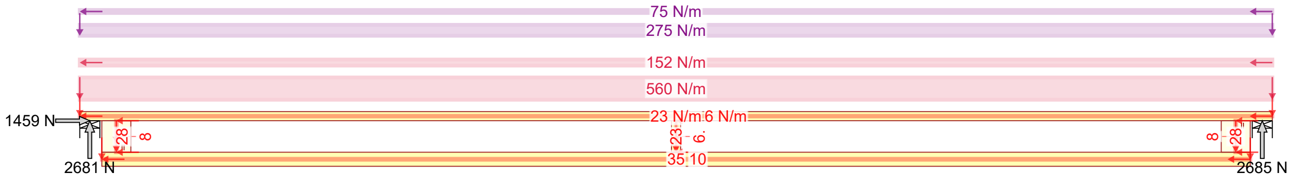
1 - 1.35*Dead

Ultimate limit state - Medium-term



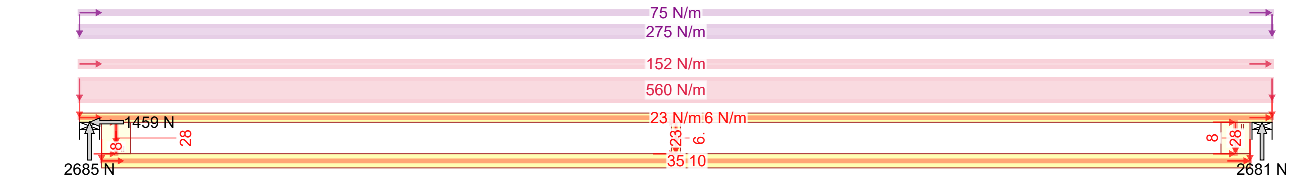
13 - 1.35*Dead + 1.50*LL3

Accidental



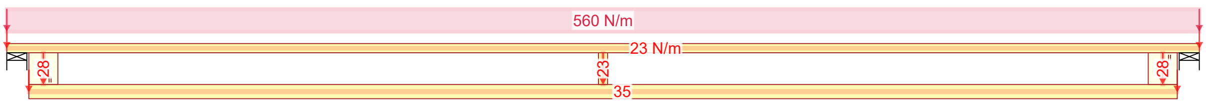
801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

Accidental



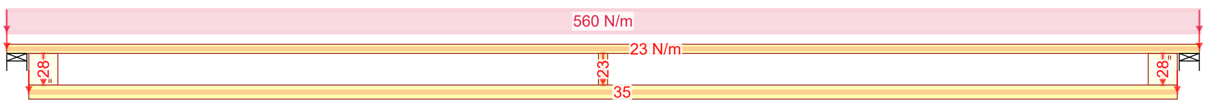
802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Serviceability limit state - Wfin



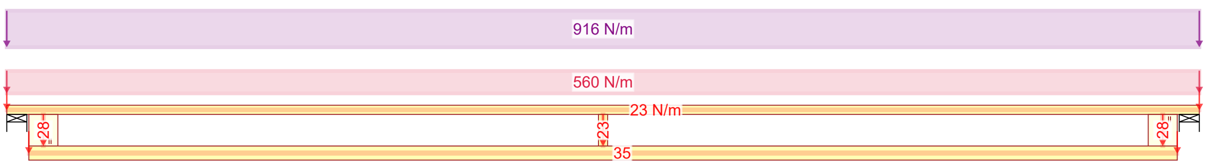
1000:2 - 1.00*DeadWfin

Serviceability limit state - Wfin – WGinst



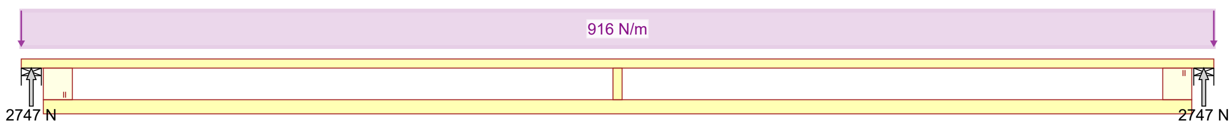
1000:5 - 1.00*DeadWfin – WGinst

Serviceability limit state - Wfin



1006:2 - 1.00*(LL3 + Dead)Wfin

Serviceability limit state - WQinst



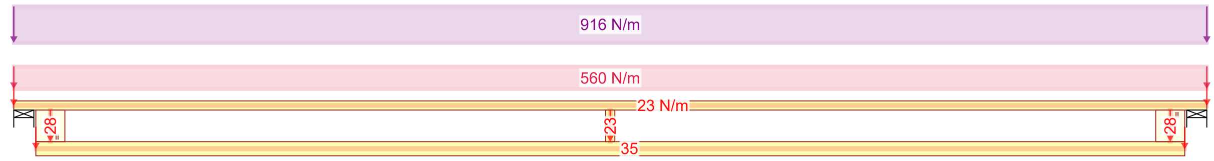
1006:4 - 1.00*LL3WQinst

Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

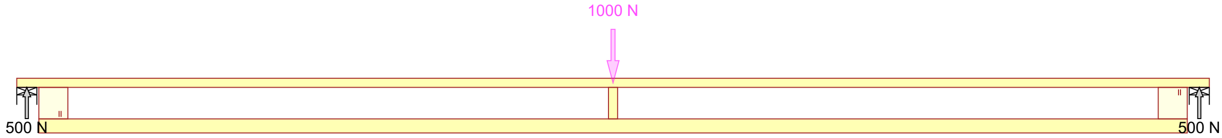
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 27/36

Serviceability limit state - Wfin – WGinst



1006:5 - 1.00*(LL3 + Dead)Wfin – WGinst

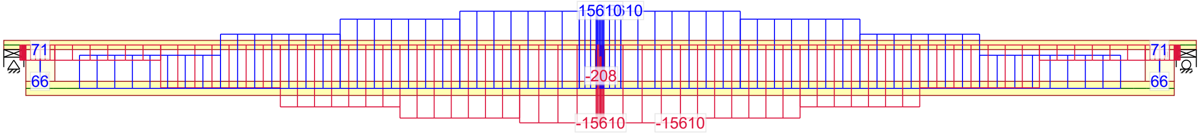
Vibrational



2000 - Vibration

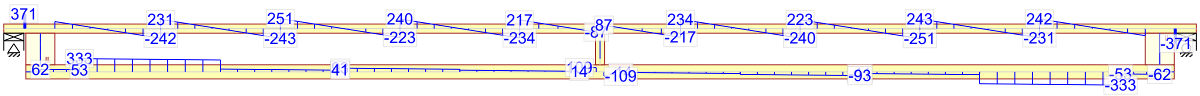
Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen	
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp
Page 28/36		

Axial force



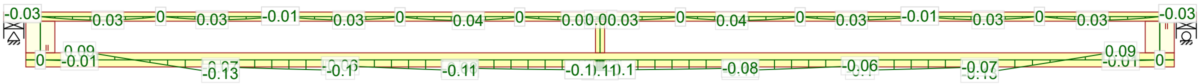
1 - 1.35*Dead

Shear force



1 - 1.35*Dead

Moment

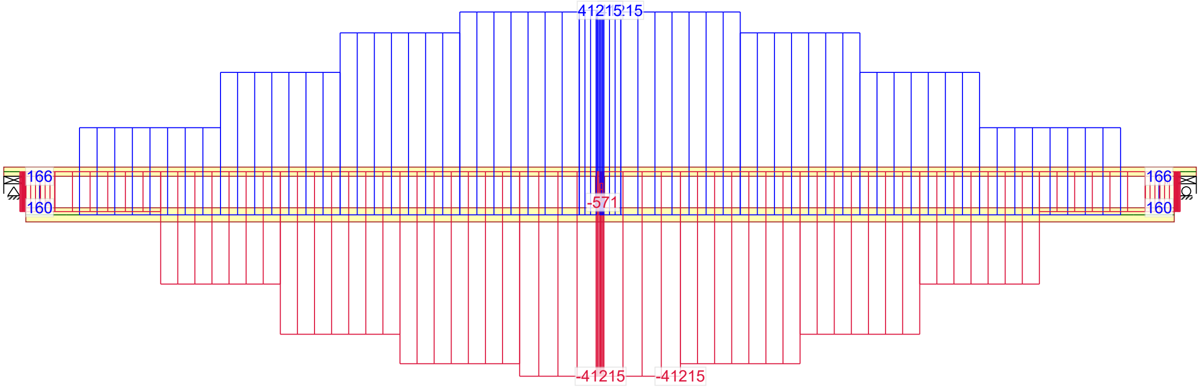


1 - 1.35*Dead

	Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen

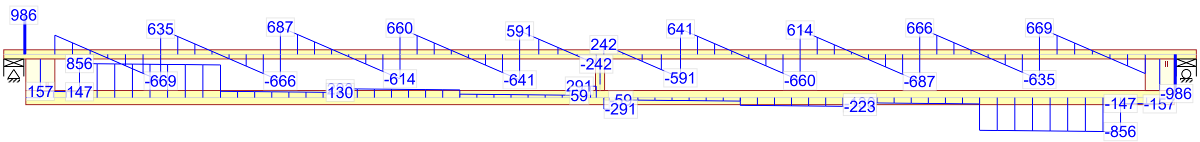
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 29/36

Axial force



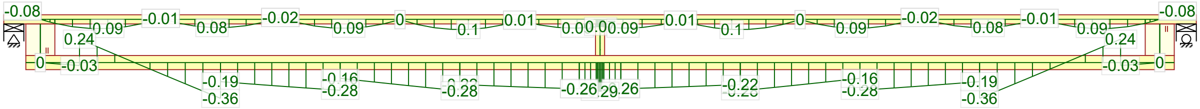
13 - 1.35*Dead + 1.50*LL3

Shear force



13 - 1.35*Dead + 1.50*LL3

Moment



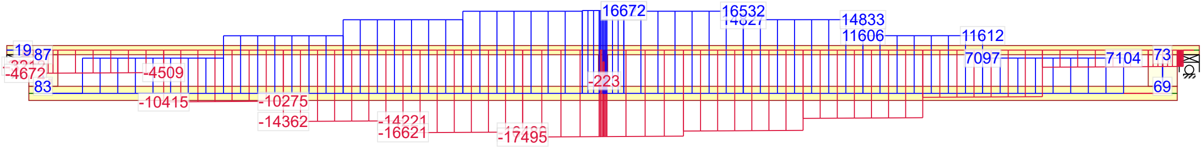
13 - 1.35*Dead + 1.50*LL3

Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

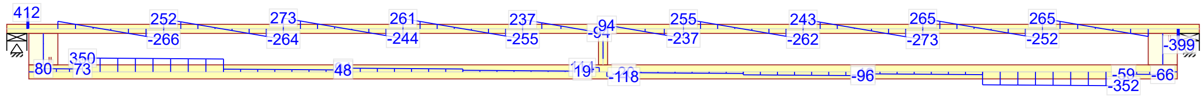
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 30/36

Axial force



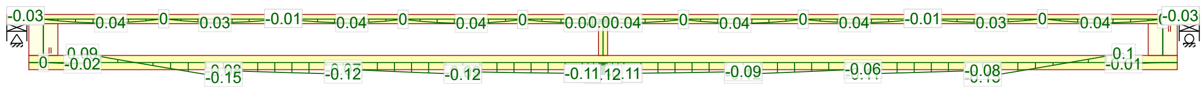
801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

Shear force



801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

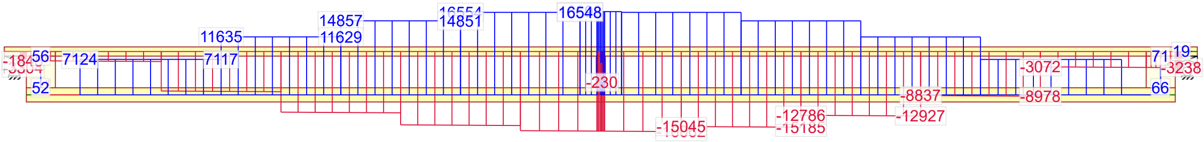
Moment



801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left

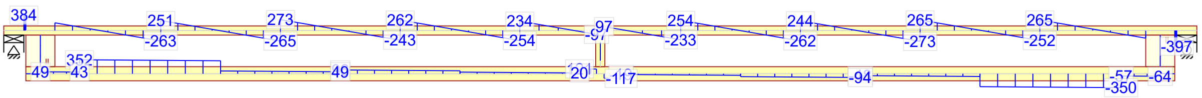
Posi-Tech	**JOB: PT23-020** BuildinG Trust in Timber]Zernikelaan 17 Groningen	
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp
		Page 31/36

Axial force



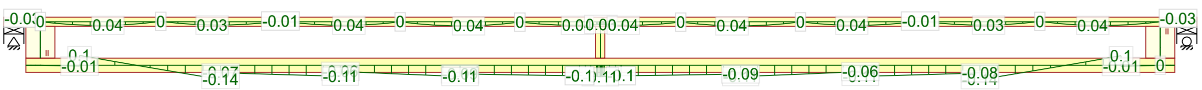
802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Shear force



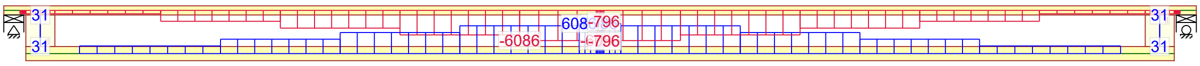
802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Moment



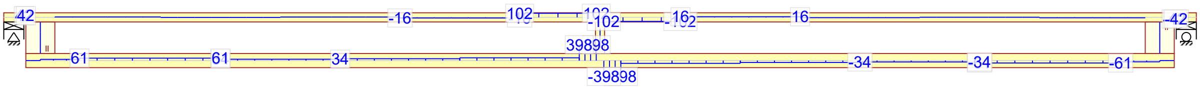
802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

Axial force



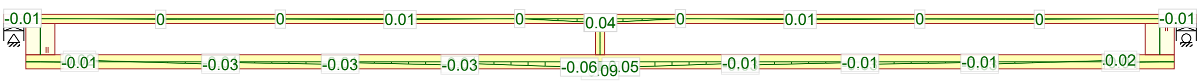
2000 - Vibration

Shear force



2000 - Vibration

Moment

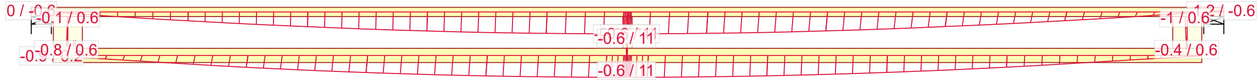


2000 - Vibration

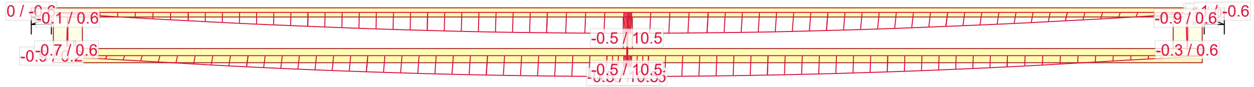
Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

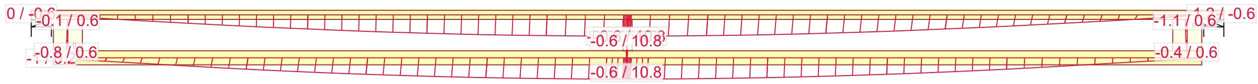
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 33/36



801 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic left



802 - 1.00*Dead + 0.30*LL3 + 0.27*Seismic right

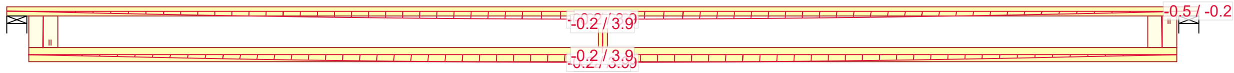


1000:2 - 1.00*Dead: Wfin

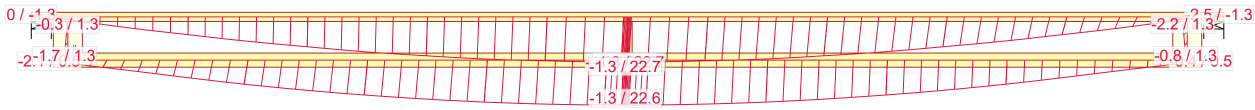
Posi-Tech

JOB: PT23-020
BuildinG
Trust in Timber
]Zernikelaan 17
Groningen

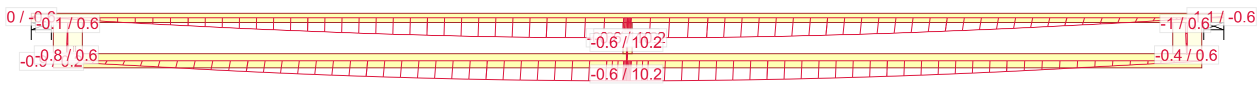
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp	Page 34/36



1000:5 - 1.00*Dead: Wfin – WGinst

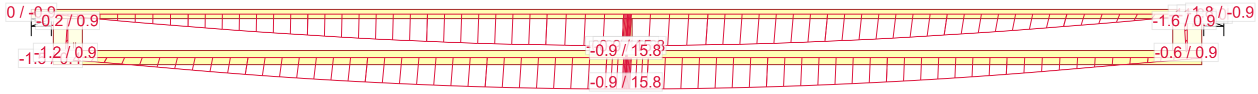


1006:2 - 1.00*(LL3 + Dead): Wfin

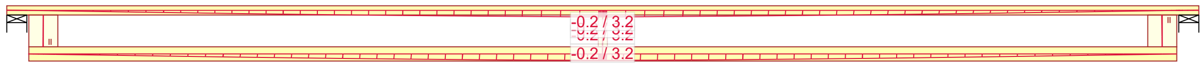


1006:4 - 1.00*LL3: WQinst

JOB: PT23-020 BuildinG Trust in Timber]Zernikelaan 17 Groningen				
11/10/2023 - 19:54	MITEK PAMIR 2023.2b (fe13ef1)	DRAWN/CONSTR. BY A. Tromp		Page 35/36



1006:5 - 1.00*(LL3 + Dead): Wfin – WGinst



2000 - Vibration