Snimak stanja stare krovne konstrukcije i prijedlog sanacije

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SVEUČILIŠTE U ZAGREBU

GRAĐEVINSKI FAKULTET ZAGREB

ZAVRŠNI RAD

SNIMAK STANJA STARE KROVNE KONSTRUKCIJE I PRIJEDLOG SANACIJE

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ZAVRŠNI RAD

SNIMAK STANJA STARE KROVNE KONSTRUKCIJE I PRIJEDLOG SANACIJE

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Zagreb, 2023.

Sažetak:

Ponašanje drvenih konstrukcija u potresu, opis metoda potresnog proračuna konstrukcija i bitne značajke drva kao materijala vezanih uz potresnu otpornost.

Vizualni pregled krovišta Stare gradske vijećnice u Zagrebu, Ćirilometodska ul. 5, 10000, Zagreb, zajedno sa provođenjem nerazornih ispitivanja vlagomjerima i rezistografima. Izrada statičkog modela krovišta u programu Dlublal RFEM 6 te statički proračun istog. Proračun se sastoji od provjere graničnih stanja nosivosti i uporabljivosti prema Eurokodu 5: Projektiranje drvenih konstrukcija te prema hrvatskim nacionalnim dodacima za projektiranje drvenih konstrukcija.

Ključne riječi: drvene konstrukcije, drvo, potres, statički proračun, krovište

Summary:

The behaviour of timber structures during earthquakes, description of methods used for seismic analysis of structures and important features of wood as a material related to seismic resistance.

Visual inspection of the roof of the Old City Assembly of the City of Zagreb, Ćirilometodska Street 5, 10000, Zagreb, with conducting non-destructive tests using hygrometers and resistographs. Creating a structural model of the roof in the Dlublal RFEM 6 software and performing the static analysis of the same. The analysis includes checking the ultimate limit state and serviceability limit state according to Eurocode 5: Design of timber structures and according to Croatian national annex for the design of timber structures.

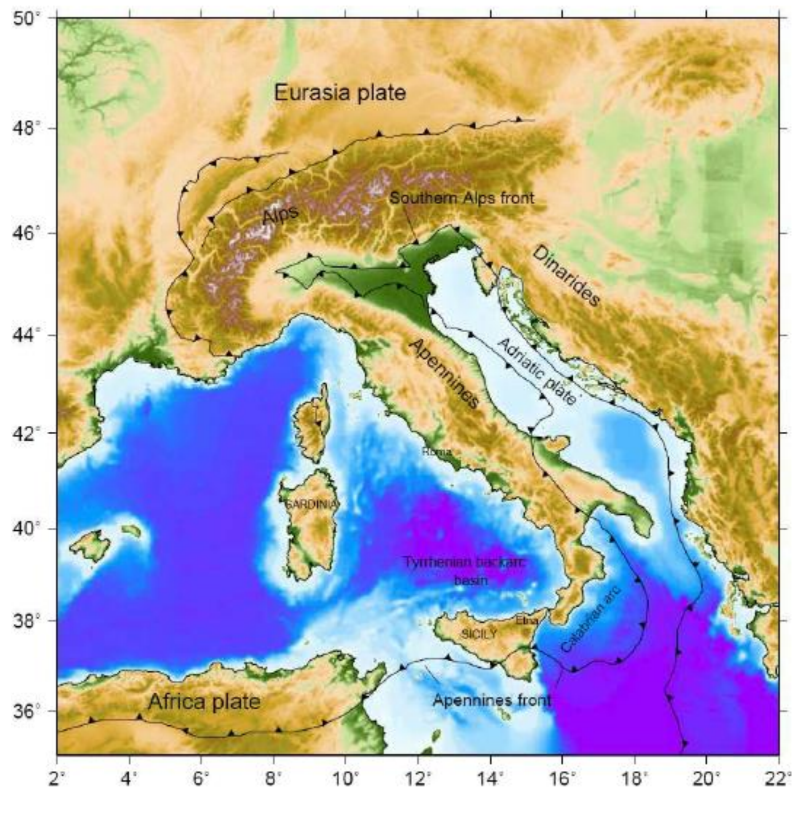
Key words: timber structures, timber, earthquake, statical analysis, roof

SADRŽAJ

1. Uvodni dio: Ponašanje drvenih konstrukcija u potresu

1.1. Potresno djelovanje

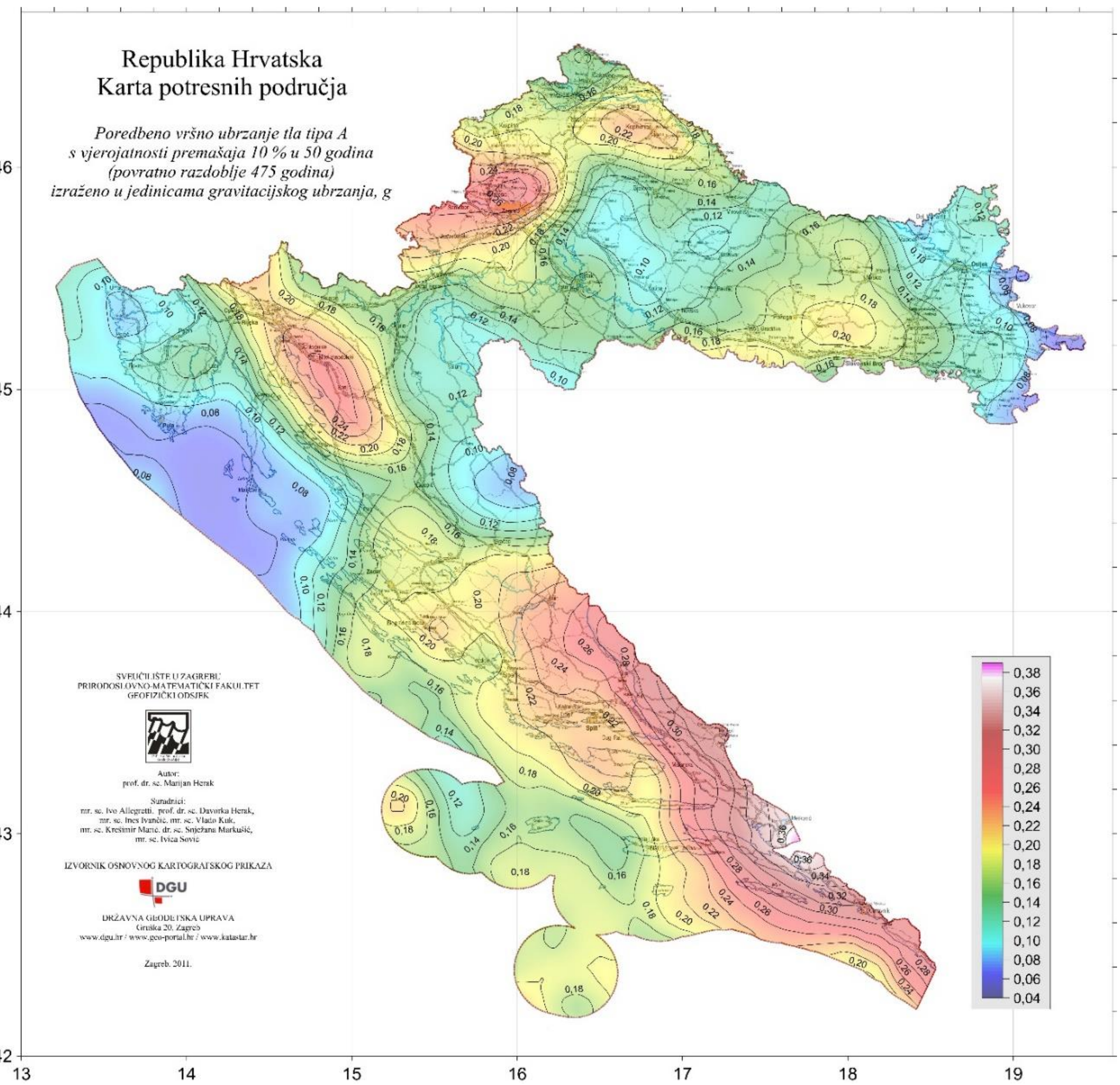
Potres je pojava koja se javlja zbog različitih promjena i pomaka u Zemljinoj kori, a karakteriziran je svojom vjerojatnošću pojavljivanja jer je po svojoj prirodi to "slučajna" pojava koja može imati značajne i razorne posljedice na građevinske objekte. Uzrocima nastanka, te izučavanjem posljedica i fizikalnim opisivanjem potresa bavi se geofizika, odnosno seizmologija, te strukturna geologija. Uzroci potresa su različiti, a najznačajniji potresi sa gledišta projektiranja konstrukcija su tektonski potresi, odnosno oni kod kojih dolazi do pomaka, točnije smicanja tektonskih ploča. Kako se Hrvatska nalazi upravo između područja smicanja Euroazijske i Afričke tektonske ploče, na njenom području dolazi do češćih podrhtavanja tla nego u sjevernijim Europskim državama, te mogućnosti potresa značajnih veličina. [1] [2]



Slika 1 Interakcija Euroazijske i Afričke tektonske ploče

Potresno djelovanje na konstrukcije i njihovo određivanje definirano je normom HRN ENV 1998-1-1 (Eurokod 8: Projektiranje potresne otpornosti konstrukcija, dio 1-1: Opća pravila – Potresna djelovanja i opći zahtjevi za konstrukcije).

Osnova za određivanje potresnog djelovanja je proračunsko ubrzanje tla, a_g [m/s^2], koje se izražava potresnim kartama (Slika 2) prema različitim potresnim zonama, a za Hrvatsku razlikujemo područja intenziteta 6, 7, 8 i 9 za koje su dane različite vrijednosti proračunskog ubrzanja tla, ovisno o potresnoj zoni, povratnog perioda 95, 225 ili 475 godina. Potres se definira povratnim periodom, odnosno sagledavamo vjerojatnost njegovog pojavljivanja u odnosu na vijek trajanja neke građevine, čime se procjenjuje rizik od pojave potresa određenog intenziteta. Prema normi HRN ENV 1998-1-1 razlikujemo 3 razreda tla: A, B i C, dok europska norma EN 1998-1-1 još dodaje razrede D, E i F. Eurokod 8 također razlikuje i 2 tipa elastičnih spektara odziva čime se opisuje površinsko seizmičko gibanje promatrane točke tla. [3]



Slika 2 Karta potresnih područja RH

1.2. Proračuni kostrukcija na potres

Kroz povijest su se za projektiranje konstrukcija na potresna opterećenja koristile metode temeljene na silama, odnosno koristila se horizontalna potresna sila koja je ekvivalenta potresnom djelovanju, te u direktnoj vezi sa masom objekta. U današnje vrijeme, za projektiranje drvenih konstrukcija i ostalih duktilnih konstrukcija na potres koriste se metode pod nazivom "performance based design" – to su metode koje se zasnivaju na pomacima, te su sastavni dio Eurokoda 8. Metoda pomaka se koristi prikazom spektra odziva i kapaciteta nosivosti (pushover krivulja) na istom grafu čime se omogućuje uspoređivanje stvarne i zahtjevane nosivosti konstrukcije, te stvarnog i zahtjevanog deformacijskog kapaciteta konstrukcije. Primjenjuje se za konstrukcije kojima je izraženo elasto-plastično ponašanje poput drvenih konstrukcija, a daje bolje rezultate od metode sila jer se na konstrukciju tijekom potresa prenose pomaci koji izazivaju unutarnje sile, a ne sile. Ovom metodom nije moguće procijeniti razinu oštećenja konstrukcije u slučaju potresa sa pretpostavljenim pomacima, stoga za to koristimo tzv. metodu temeljenu na stupnju oštećenja – "performance based engineering". Metoda se temelji na stupnju oštećenja konstrukcije nakon potresa koji je izražen kao linearna kombinacija deformacija izazvanih potresom i energije disipirane tijekom potresa u konstrukciji. [6]

1.3. Ponašanje drvenih konstrukcija u potresu

Temelj seizmičke otpornosti konstrukcije na potres predstavlja nosivost konstrukcije u odnosu na horizontalne sile i deformabilnost, tj. duktilnost konstrukcije. Drvene konstrukcije su po svojoj prirodi izrazito duktilne, ne samo zbog same prirode elastičnosti materijala, već i zbog niza spojeva u njima. Duktilnost je sposobnost materijala da se deformira, tj. da razvije velike plastične deformacije bez da dođe do sloma. [7] [8]

Ostale fizikalno-mehaničke karakteristike vezane uz potresnu otpornost drva i materijala na bazi drva su mala zapremninska težina, što uvjetuje malu vlastitu težinu konačne konstrukcije koja je u izravnoj vezi sa potresom, elastičnost materijala, te relativno visoka čvrstoća. Sve su te osobitosti vezane uz samu anatomsku građu drva i njenu vlaknastu strukturu. [9] [10]

Gradnja visokih drvenih konstrukcija uglavnom se sastoji od 2 tipa elemenata: zidni elementi izvedeni od okvira punog drva te zidni elementi od križnog lameliranog drva

(CLT – cross laminated timber) kao novijeg načina izvedbe drvenih nosivih elemenata. Zidovi izvedeni kao okvirni sustavi od punog drva pokazuju svojstva visoke duktilnosti i mogućnosti disipacije energije za monotona, kao i za ciklička opterećenja poput potresa, što omogućuje visoku seizmičku otpornost. S druge strane, masivni CLT elementi, tj. masivni elementi od križnog lameliranog drva ne pokazuju mogućnosti disipacije energije, odnosno takvi elementi su izvedeni kako bi podnjeli samo elastična naprezanja (ne ulaze u plastično područje deformacija). Disipaciju energije kod takvih sustava omogućava projektiranje spojeva elemenata te njihove sposobnosti popuštanja na određena opterećenja. Unatoč tome, mogućnosti disipacije energije bit će veće kod klasičnih drvenih okvirnih sustava, ali ukupni pomak konstrukcije od CLT elemenata nakon potresa će biti manji. [11]

Slika 3 Mjøstårnet, Norveška (visina: 85.4 m)

Drvene konstrukcije pokazale su visoku otpornost na seizmička djelovanja i kroz praktičku upotrebu, ali i kroz pokuse provođene s ciljem razvitaka drvenih konstruktivnih sistema u odnosu na njihove potresne karakteristike. Jedan od takvih pokusa proveden od strane NHERI TallWood Project koja se bavi upravo razvojem visokih drvenih konstrukcija otpornih na seizmičku aktivnost. Test je proveden na drvenoj zgradi visine od 10 katova, sistema takvog da distribuira silu pomoću pomaka zgrade koja se nakon prestanka djelovanja opterećenja centrira. Zgrada je ispitana na potrese magnituta 6.7 i 7.6 po Richterovoj ljestvici u samo jednom danu, a nakon ispitivanja nisu postojala vidljiva oštećenja primarnih nosivih elemenata, kao ni nenosivih elemenata. [13]

Slika 4 Detalj spoja sa senzorom za pomak

Slika 5 Potresno ispitivanje NHERI TallWood Project zgrade

1.4. Zaključak

Drvene konstrukcije i današnji moderni sustavi njihovog dizajniranja i projektiranja mogu ostvariti, a ponekad čak i premašiti potresnu otpornost materijala poput armiranog betona. Zbog sve veće primjene drva u graditeljstvu kao posljedice ekološkog osvještavanja, provode se i ispituju i ostale karakteristike drva, razvijaju se novi sistemi i novi materijali, te razmatraju kompozitni sustavi koji dodatno poboljšavaju svojstva drvenih materijala.

2. Projektni dio: Pregled i provjera drvenog krovišta Stare gradske vijećnice u Zagrebu

2.1. Uvod

Temeljni dio ovog završnog rada sastojao se od pregleda krovišta Stare gradske vijećnice u Zagrebu, te provođenje nekoliko nerazornih ispitivanja u svrhu utvrđivanja stanja u kojem se krovište nalazi. Provođena su ispitivanja vlagomjerima, čime je utvrđeno da je drvo klase uporabljivosti 1, te ispitivanja rezistografom. Krovište je podijeljeno u 5 zona, a nakon pregleda je slijedila izrada statičkog modela krovišta po zonama u programu Dlublal RFEM 6 te provjera po graničnim stanjima nosivosti i uporabljivosti prema Eurokodu 5 za proračun drvenih konstrukcija, uz primjenu hrvatskih normi za dimenzioniranje drvenih konstrukcija. Cilj provjera bio je provjeriti zadovoljava li trenutno stanje krovišta projektne uvjete te, ukoliko ne zadovoljava, predložiti rješenje sanacije. U nastavku su dani grafički prilozi krovišta i rezultata mjerenja, te završni statički izvještaj izrađen u programu Dlublal RFEM 6. Iz rezultata je vidljivo kako model zadovoljava kriterije graničnih stanja nosivosti i uporabljivosti s obzirom na postavljene uvjete.

2.2. Grafički prilozi

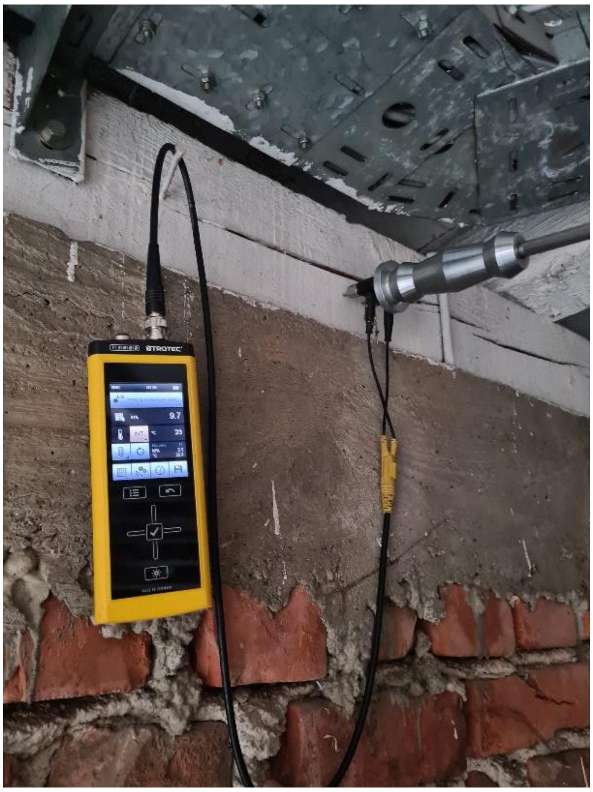
2.2.1. **Krovište** – zona 3

2.2.2. Mjerenja vlagomjerom – zona 3

1. mjerenje: 11.9% vlage

2. mjerenje: 11.7% vlage

3. mjerenje: 9.7% vlage



2.2.3. Detalji – zona 3



Structural Analysis

CLIENT

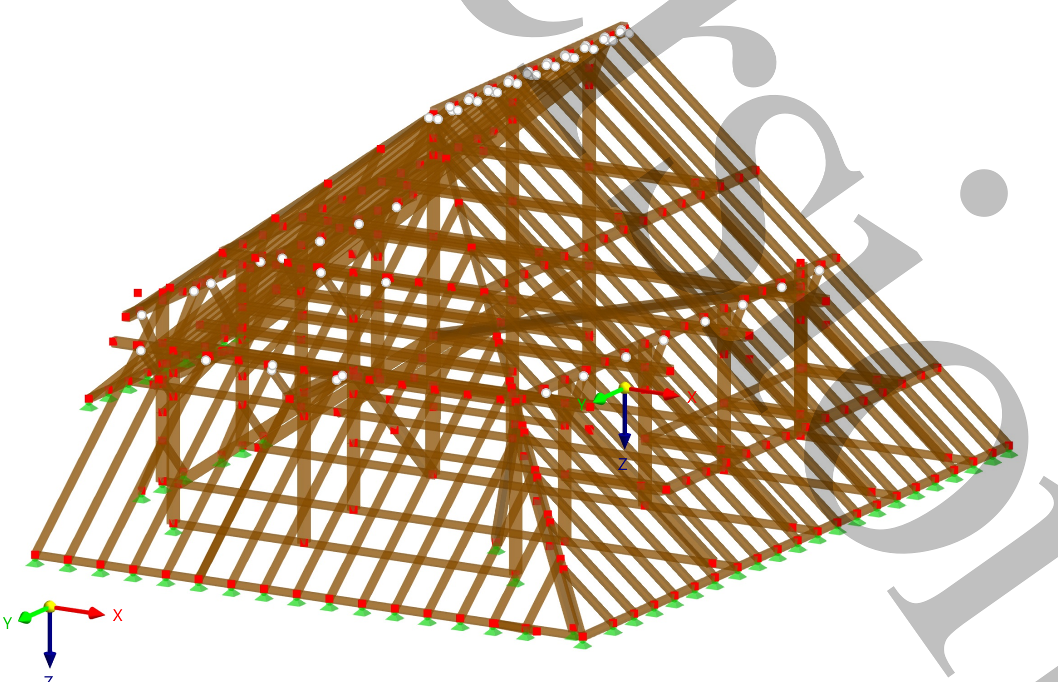
CREATED BY

PROJECT

Chapters

MODEL

In Axonometric Direction by Default



Trial Version

Trial Version

CONTENTS

A MODEL - LOCATION

Location			
	Country	:	Croatia
	Street	:	Ulica svetog Ćirila i Metoda
	Zip / Postal code	:	10000
	City	:	Zagreb
	State	:	
	Latitude	:	45.816 deg
	Longitude	:	15.973 deg
	Altitude	:	165.000 m

1 Basic Objects

1.1 MATERIALS

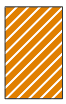
Legend
Stiffness modification

Material No.	Material Name	Material Type	Analysis Model	Options
1	C18 | Isotropic | Linear Elastic	Timber	Isotropic | Linear Elastic	%

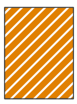
1.2 SECTIONS

R_M1 300/200

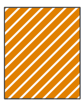
R_M1 200/320



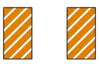
R_M1 180/240



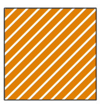
R_M1 140/170



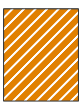
2R_M2 220/120/150/1



R_M1 150/150

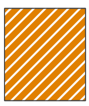


R_M1 220/270



R_M1 50/30

R_M1 150/170



Section No.	Material No.	Section Type	Manufacturing Type	I_t [cm⁴] / A [cm²]	I_y [cm⁴] / A_y [cm²]	I_z [cm⁴] / A_z [cm²]	Overall Dimensions b [mm]	h [mm]
1	R_M1 300/200 | 1 - C18							
	1	Parametric - Massive I		46953.09	20000.00	45000.00	300.0	200.0
				600.00	500.00	500.00		
2	R_M1 200/320 | 1 - C18							
	1	Parametric - Massive I		52160.58	54613.33	21333.33	200.0	320.0
				640.00	533.33	533.33		
3	R_M1 180/240 | 1 - C18							
	1	Parametric - Massive I		25192.30	20736.00	11664.00	180.0	240.0
				432.00	360.00	360.00		
4	R_M1 140/170 | 1 - C18							
	1	Parametric - Massive I		7791.19	5731.83	3887.33	140.0	170.0
				238.00	198.33	198.33		
5	2R_M2 220/120/150/1 | 1 - C18							
	1	Parametric - Massive II		16762.25	21296.05	102465.08	390.0	220.0
				528.00	0.00	441.43		
6	R_M1 150/150 | 1 - C18							
	1	Parametric - Massive I		7129.69	4218.75	4218.75	150.0	150.0
				225.00	187.50	187.50		
7	R_M1 220/270 | 1 - C18							
	1	Parametric - Massive I		48445.27	36085.50	23958.00	220.0	270.0
				594.00	495.00	495.00		
8	R_M1 50/30 | 1 - C18							
	1	Parametric - Massive I		28.17	11.25	31.25	50.0	30.0
				15.00	12.50	12.50		
9	R_M1 150/170 | 1 - C18							
	1	Parametric - Massive I		9030.75	6141.25	4781.25	150.0	170.0
				255.00	212.50	212.50		

Trial Version

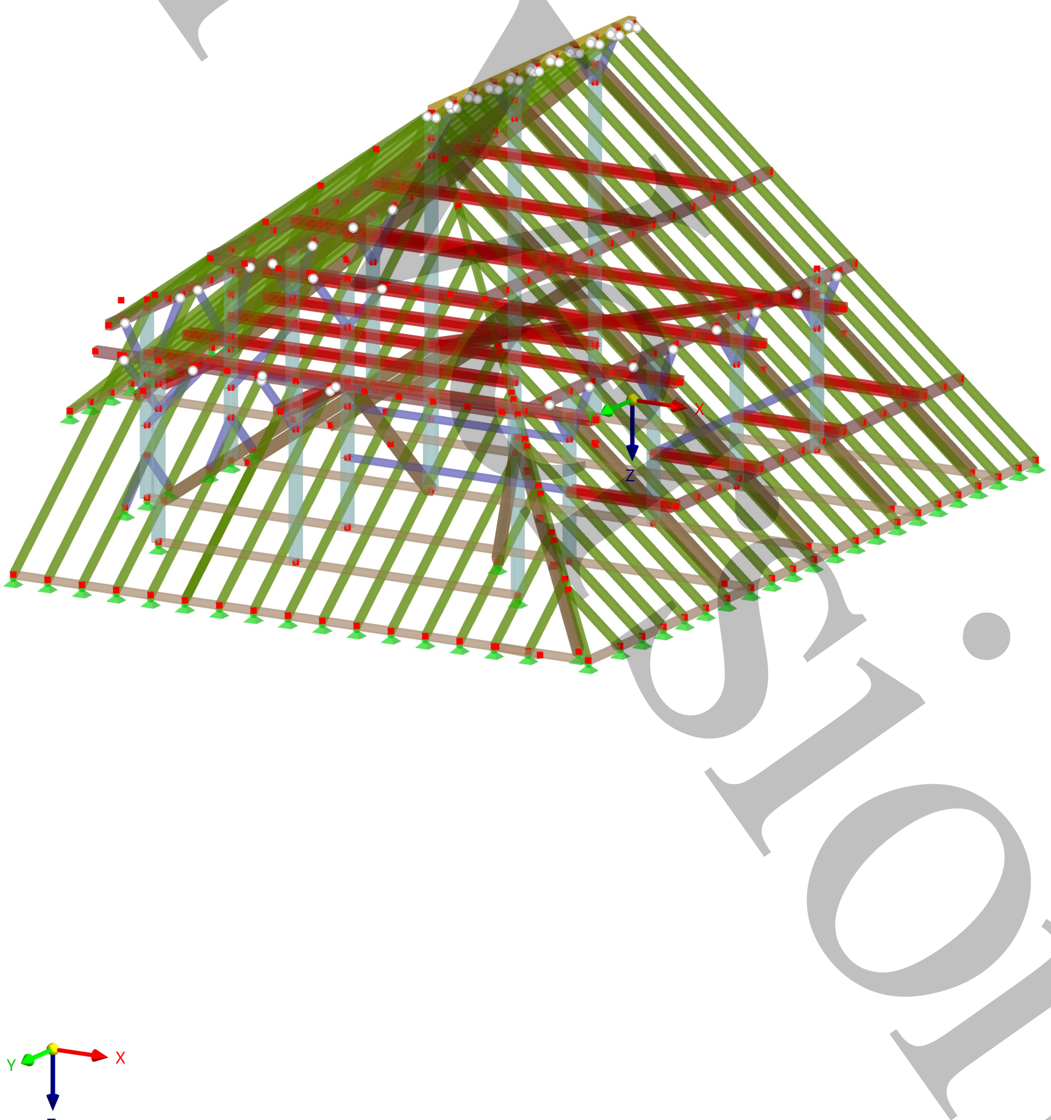
1.3 **CROSS SECTIONS** **Static Analysis**

CO15 - 1.60 * LC1 + 1.60 * LC4 + 0.50 * LC2 + LC3
Static Analysis

In Axonometric Direction by Default

Colors of Rendered Objects

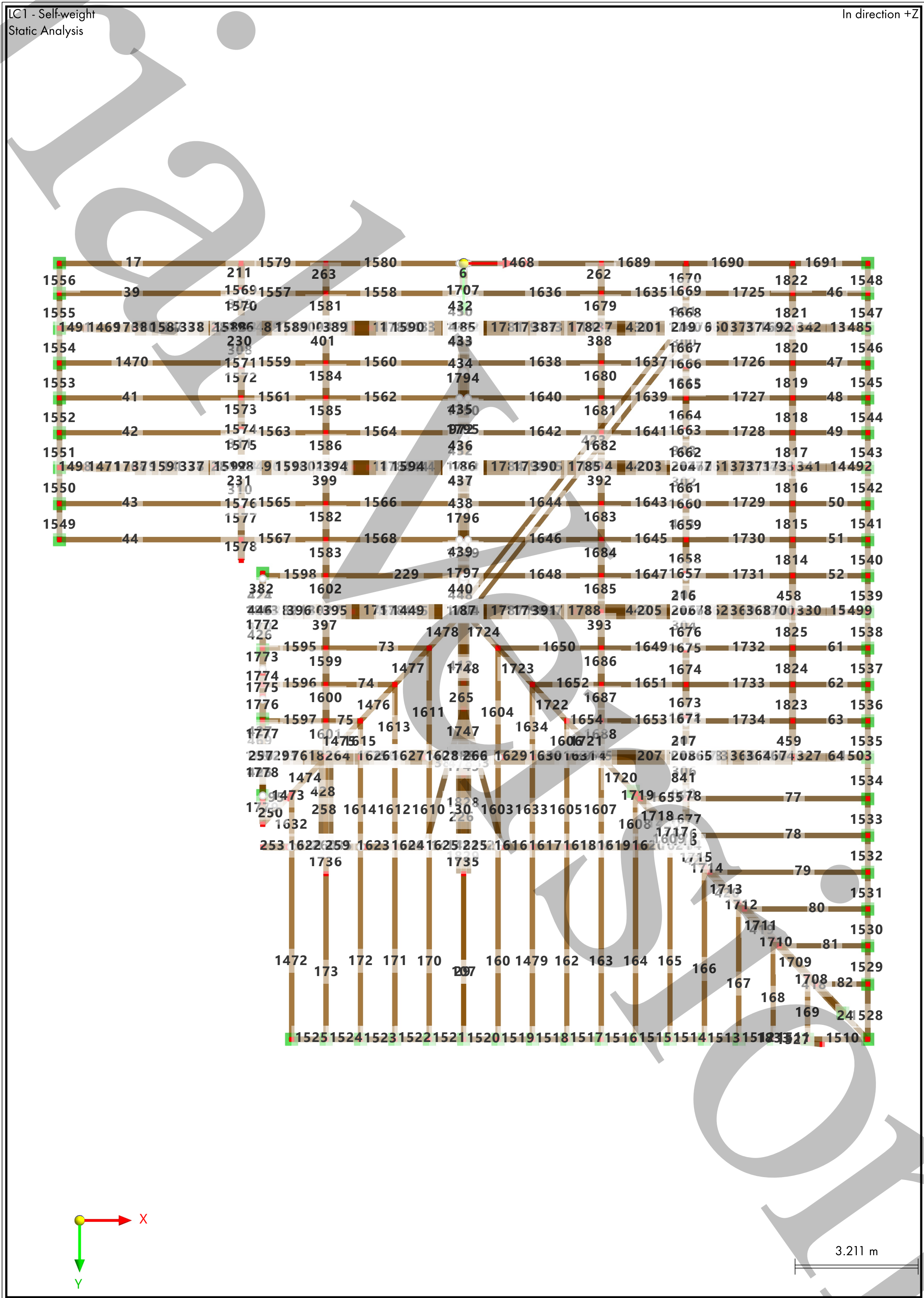
Node | Display Properties
Line | Display Properties
Member | Section
1 - R_M1 300/200
2 - R_M1 200/320
3 - R_M1 180/240
4 - R_M1 140/170
5 - 2R_M2 220/120/150/1
6 - R_M1 150/150
7 - R_M1 220/270
8 - R_M1 50/30
9 - R_M1 150/170



Trial Version

1.4 MEMBERS - NUMBERING

Static Analysis



Trial Version

2 Types for Nodes

2.1 NODAL SUPPORTS

Support No.	Nodes No.	Coordinate System	Translation Spring [kN/m] $C_{u,X}$	$C_{u,Y}$	$C_{u,Z}$	Rotation Spring [kNm/rad] $C_{\varphi,X}$	$C_{\varphi,Y}$	$C_{\varphi,Z}$
1	☑☑☑ ☐☐☑ | Hinged							
	12-14,17-22,32-42,55,57-61,79-84,219-233,350,352,516,545,566,572-575,1487	1 - Global XYZ	☒	☒	☒	☐	☐	☒

3 Types for Members

3.1 MEMBER HINGES

Hinge No.	Coordinate System	Translation Spring [kN/m] $C_{u,x}$	$C_{u,y}$	$C_{u,z}$	Rotation Spring [kNm/rad] $C_{\varphi,x}$	$C_{\varphi,y}$	$C_{\varphi,z}$
1	☐☐☐ ☐☑☑ | Local xyz						
	Local xyz	☐	☐	☐	☐	☒	☒

4 Types for Timber Design

4.1 SERVICE CLASSES

Class No.	Assigned to Members	Member Sets	Surfaces	Surface Sets	Service Class Type	Comment
1	Service Class 1 (Members : 6,13-15,17,24,29,30,39,41-44,46-52,61-64,73-82,95,107,160,162-173,185-188,196,198,201-208,211,216-219,225,226,229-231,250,253,257-260,262-266,276-278,280,282,283,285-287,289-311,314,327,328,330,335-342,347-349,351-353,355-357,359-375,377-380,382-397,399,401-403,406,407,409,412,413,418-421,423-428,430-459,464,468-471,473,474,476-478,840,841,972,1449,1468-1525,1527-1834)					
	6, 13-15,17,24,29, 30,39,41-44,46-52,61-64,73-82, 95,107,160,162-173,185-188,196,198,201-208,211,216-219,225, 226,229-231,250,253,257-260,262-266,276-278, 280,282,283,285-287,289-311,314,327,328,330, 335-342,347-349,351-353,355-357,359-375,377-380,382-397,399,401-403,406,407,409,412,413, 418-421,423-428,430-459,464,468-471,473,474, 476-478,840,841,972,1449,1468-1525,1527-1834				1 - Dry	

5 Load Cases & Combinations

Trial Version

Trial Version

5.1
LOAD CASES

LC No.	Settings	Value	Unit	To Solve
1	G Self-weight			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Action category	G Permanent		
	Self-weight - Factor in direction X	0.000	--	
	Self-weight - Factor in direction Y	0.000	--	
	Self-weight - Factor in direction Z	1.000	--	
	Load duration	Permanent		
2	Qs Snow			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Action category	Qs Snow/Ice loads - H <= 1000 m		
	Load duration	Short-term		
3	Qw Wind			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Action category	Qw Wind		
	Load duration	Short-term		
4	G dodatno stalno opterećenje			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Action category	G Permanent		
	Self-weight - Factor in direction X	0.000	--	
	Self-weight - Factor in direction Y	0.000	--	
	Self-weight - Factor in direction Z	1.000	--	
	Load duration	Permanent		

5.2
ACTIONS

Action No.	Settings	Value	Active
4	G Permanent		
	Action Category	G Permanent	☒
	Action Type	Simultaneously	
5	Qs Snow/Ice loads - H <= 1000 m		
	Action Category	Qs Snow/Ice loads - H <= 1000 m	☒
	Action Type	Alternatively	
6	Qw Wind		
	Action Category	Qw Wind	☒
	Action Type	Alternatively	

5.3
DESIGN SITUATIONS

DS No.	Settings	Value	Active
1	ULS ULS (STR/GEO) - Permanent and transient - Eq. 6.10		
	Design situation type	ULS ULS (STR/GEO) - Permanent and transient - Eq. 6.10	☒
	Combination wizard	2	
	Consider inclusive/exclusive load cases	☐	
2	S Ch SLS - Characteristic		
	Design situation type	S Ch SLS - Characteristic	☒
	Combination wizard	2	
	Consider inclusive/exclusive load cases	☐	
3	S Qp SLS - Quasi-permanent		
	Design situation type	S Qp SLS - Quasi-permanent	☒
	Combination wizard	2	
	Consider inclusive/exclusive load	☐	

Trial Version

5.3 DESIGN SITUATIONS

DS No.	Settings	Value	Active
	cases		

5.4 ACTION COMBINATIONS

AC No.	Settings	Value	Active
1	ULS 1.35 * A4		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	☒
	Generated load combinations	1	
	Generated by	Design Situation No. 1	
2	ULS 1.35 * A4 + 1.50 * A5		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	☒
	Generated load combinations	2	
	Generated by	Design Situation No. 1	
3	ULS 1.35 * A4 + 1.50 * A5 + 0.90 * A6		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	☒
	Generated load combinations	3	
	Generated by	Design Situation No. 1	
4	ULS 1.35 * A4 + 1.50 * A6		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	☒
	Generated load combinations	4	
	Generated by	Design Situation No. 1	
5	ULS 1.35 * A4 + 0.75 * A5 + 1.50 * A6		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	☒
	Generated load combinations	5	
	Generated by	Design Situation No. 1	
6	S Ch A4		
	Design Situation	S Ch DS2 - SLS - Characteristic	☒
	Generated load combinations	6	
	Generated by	Design Situation No. 2	
7	S Ch A4 + A5		
	Design Situation	S Ch DS2 - SLS - Characteristic	☒
	Generated load combinations	7	
	Generated by	Design Situation No. 2	
8	S Ch A4 + A5 + 0.60 * A6		
	Design Situation	S Ch DS2 - SLS - Characteristic	☒
	Generated load combinations	8	
	Generated by	Design Situation No. 2	
9	S Ch A4 + A6		
	Design Situation	S Ch DS2 - SLS - Characteristic	☒
	Generated load combinations	9	
	Generated by	Design Situation No. 2	
10	S Ch A4 + 0.50 * A5 + A6		
	Design Situation	S Ch DS2 - SLS - Characteristic	☒
	Generated load combinations	10	
	Generated by	Design Situation No. 2	
11	S Qp 1.60 * A4		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent	☒
	Generated load combinations	11	
	Generated by	Design Situation No. 3	
12	S Qp 1.60 * A4 + A5		

5.4 ACTION COMBINATIONS

AC No.	Settings	Value	Active
	Design Situation	S Qp DS3 - SLS - Quasi-permanent	☒
	Generated load combinations	12	
	Generated by	Design Situation No. 3	
13	S Qp 1.60 * A4 + A5 + 0.60 * A6		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent	☒
	Generated load combinations	13	
	Generated by	Design Situation No. 3	
14	S Qp 1.60 * A4 + A6		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent	☒
	Generated load combinations	14	
	Generated by	Design Situation No. 3	
15	S Qp 1.60 * A4 + 0.50 * A5 + A6		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent	☒
	Generated load combinations	15	
	Generated by	Design Situation No. 3	

5.5 LOAD COMBINATIONS

CO No.	Settings	Value	Unit	To Solve
1	ULS 1.35 * LC1 + 1.35 * LC4			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient -		
	Load duration	Permanent		
2	ULS 1.35 * LC1 + 1.35 * LC4 + 1.50 * LC2			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient -		
	Load duration	Short-term		
3	ULS 1.35 * LC1 + 1.35 * LC4 + 1.50 * LC2 + 0.90 * LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient -		
	Load duration	Short-term		
4	ULS 1.35 * LC1 + 1.35 * LC4 + 1.50 * LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient -		
	Load duration	Short-term		
5	ULS 1.35 * LC1 + 1.35 * LC4 + 0.75 * LC2 + 1.50 * LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	ULS DS1 - ULS (STR/GEO) - Permanent and transient -		
	Load duration	Short-term		
6	S Ch LC1 + LC4			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Ch DS2 - SLS - Characteristic		
7	S Ch LC1 + LC4 + LC2			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Ch DS2 - SLS - Characteristic		
8	S Ch LC1 + LC4 + LC2 + 0.60 * LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Ch DS2 - SLS - Characteristic		

Trial Version

5.5 LOAD COMBINATIONS

CO No.	Settings	Value	Unit	To Solve
9	S Ch LC1 + LC4 + LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Ch DS2 - SLS - Characteristic		
10	S Ch LC1 + LC4 + 0.50 * LC2 + LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Ch DS2 - SLS - Characteristic		
11	S Qp 1.60 * LC1 + 1.60 * LC4			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent		
12	S Qp 1.60 * LC1 + 1.60 * LC4 + LC2			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent		
13	S Qp 1.60 * LC1 + 1.60 * LC4 + LC2 + 0.60 * LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent		
14	S Qp 1.60 * LC1 + 1.60 * LC4 + LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent		
15	S Qp 1.60 * LC1 + 1.60 * LC4 + 0.50 * LC2 + LC3			
	Analysis type	Static Analysis		☒
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	S Qp DS3 - SLS - Quasi-permanent		

5.6 STATIC ANALYSIS SETTINGS

Settings No.	Description	Symbol	Value	Unit
1	Geometrically linear			
	Analysis type		Geometrically linear	
	Modify standard precision and tolerance settings		☐	
	Modify loading by multiplier factor		☐	
	Displacements due to member load of type 'Pipe internal pressure' (Bourdon effect)		☐	
	Method for equation system		Direct	
	Plate bending theory		Mindlin	
	Activate mass conversion to load		☐	
	Asymmetric direct solver		☒	
	Equilibrium for undeformed structure		☐	

5.7 COMBINATION WIZARDS

Wizard No.	Settings	Value
1	Load combinations | ??	
	Assigned to	
	Generate combinations	Load combinations (non-linear analysis)
	Static analysis settings	??
	Consider imperfection case	☒
	Consider initial state	☐
	Structure modification enabled	☐
	Generate same load combinations without imperfection case	☐
	Consider construction stages	☐

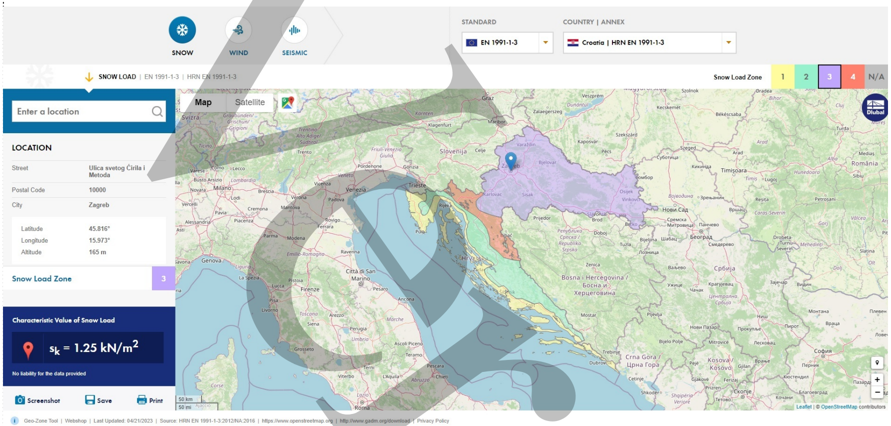
Trial Version

5.7 **COMBINATION WIZARDS**

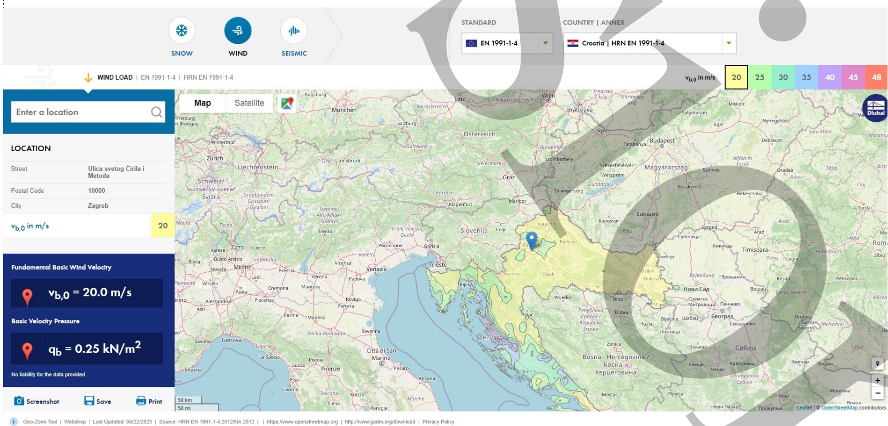
Wizard No.	Settings	Value
	User-defined action combinations	☐
	Favorable permanent actions	☐
	Reduce number of generated combinations	☐
2	Load combinations | SA1 - Geometrically linear	
	Assigned to	DS 1-3
	Generate combinations	Load combinations (non-linear analysis)
	Static analysis settings	SA1 - Geometrically linear
	Consider imperfection case	☐
	Consider initial state	☐
	Structure modification enabled	☐
	Consider construction stages	☐
	User-defined action combinations	☐
	Favorable permanent actions	☐
	Reduce number of generated combinations	☐

6 Loads

6.1 SNOW DLUBLAL.JPG



6.2 WIND DLUBLAL.JPG



Trial version

Trial version

6.3 LOADING

ANALIZA OPTEREĆENJA – Gradska vijećnica

Pozicija			**Zona 3**		
Opis pozicije			**Krov**		
Stalno opterećenje (g)		Sloj	Zapremninska težina [kg/m^3]	Debljina sloja [cm]	Iznos površinskog opterećenja [kN/m^2]
	1	Biber crijep			0.5
	2	Dodatno stalno			0.1
		Ukupno:			0.6
Promjenjivo opterećenje (q)	s	Snijeg	1		[kN/m^2]
	w	Vjetar	Software		

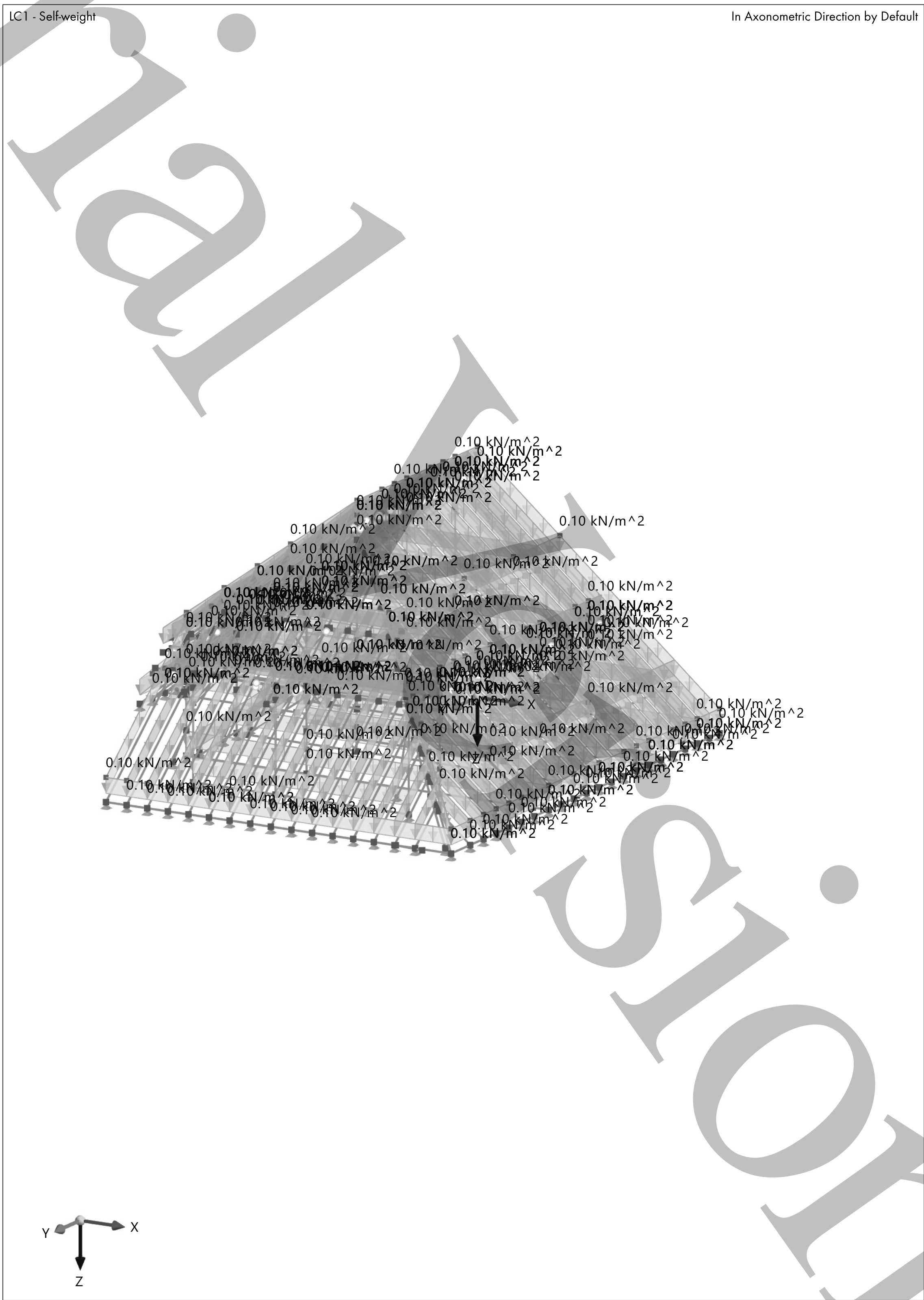
Snijeg (s)

Područje:	3	kontinentalna Hrvatska	
Nadmorska visina:	122	[m.n.m.]	
α =	32	°	
s_k =	1.25	[kn/m2]	karakteristična vrijednost opterećenja snijegom na tlu
$\mu_{1(\alpha)}$ =	0.8		koeficijent oblika opterećenja snijegom
C_e =	1		koeficijent izloženosti
C_t =	1		toplinski koeficijent
s_d =	$\mu_{1(\alpha)} * C_e * C_t * s_k$		
s_d =	1	[kn/m2]	

Vjetar (w)

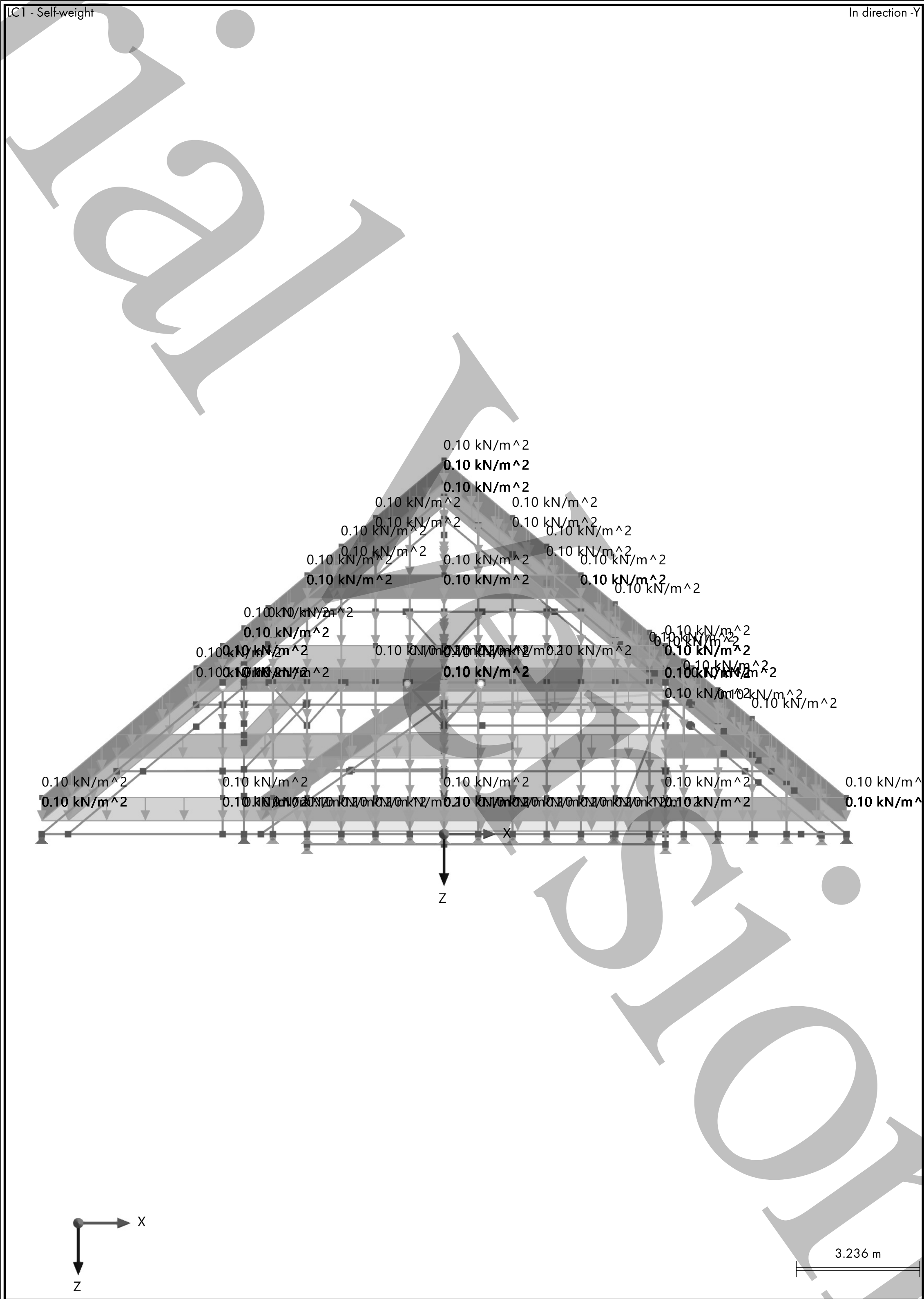
c_{dir} =	1		koeficijent smjera vjetra
c_{season} =	1		koeficijent godišnjeg doba
$v_{b,0}$ =	20	[m/s]	fundamentalna vrijednost osnovne brzine vjetra
v_b =	$c_{dir} \cdot c_{season} \cdot v_{b,0}$		osnovna brzina vjetra
v_b =	**20**	[m/s]	
ρ =	1.25	[kg/m^3]	gustoća zraka
*kategorija terena:	III		
$c_e(z)$ =	1.9		koeficijent izloženosti
q_b =	$½ * \rho * v_b^2$	[kN/m^2]	osnovni pritisak vjetra
q_b =	**0.25**	[kN/m^2]	
$c_{pe}(H)$ =	-0.96	[m^2]	koeficijent vanjskog pritiska
$c_{pe}(I)$ =	-0.76	[m^2]	koeficijent vanjskog pritiska
c_{pi} =	0.2	[m^2]	koeficijent unutarnjeg pritiska
$w_e (H) = q_b \cdot c_e(z) \cdot c_{pe}$	-0.55	[kN/m^2]	opterećenje vjetrom uključujući i unutarnji pritisak
$w_e (H) = q_b \cdot c_e(z) \cdot c_{pe}$	-0.46	[kN/m^2]	opterećenje vjetrom bez unutarnjeg pritiska
$w_e (I) = q_b \cdot c_e(z) \cdot c_{pe} \cdot$	-0.46	[kN/m^2]	opterećenje vjetrom uključujući i unutarnji pritisak
$w_e (I) = q_b \cdot c_e(z) \cdot c_{pe} \cdot$	-0.36	[kN/m^2]	opterećenje vjetrom bez unutarnjeg pritiska

6.4.1 LC1: LOADING, IN AXONOMETRIC DIRECTION BY DEFAULT



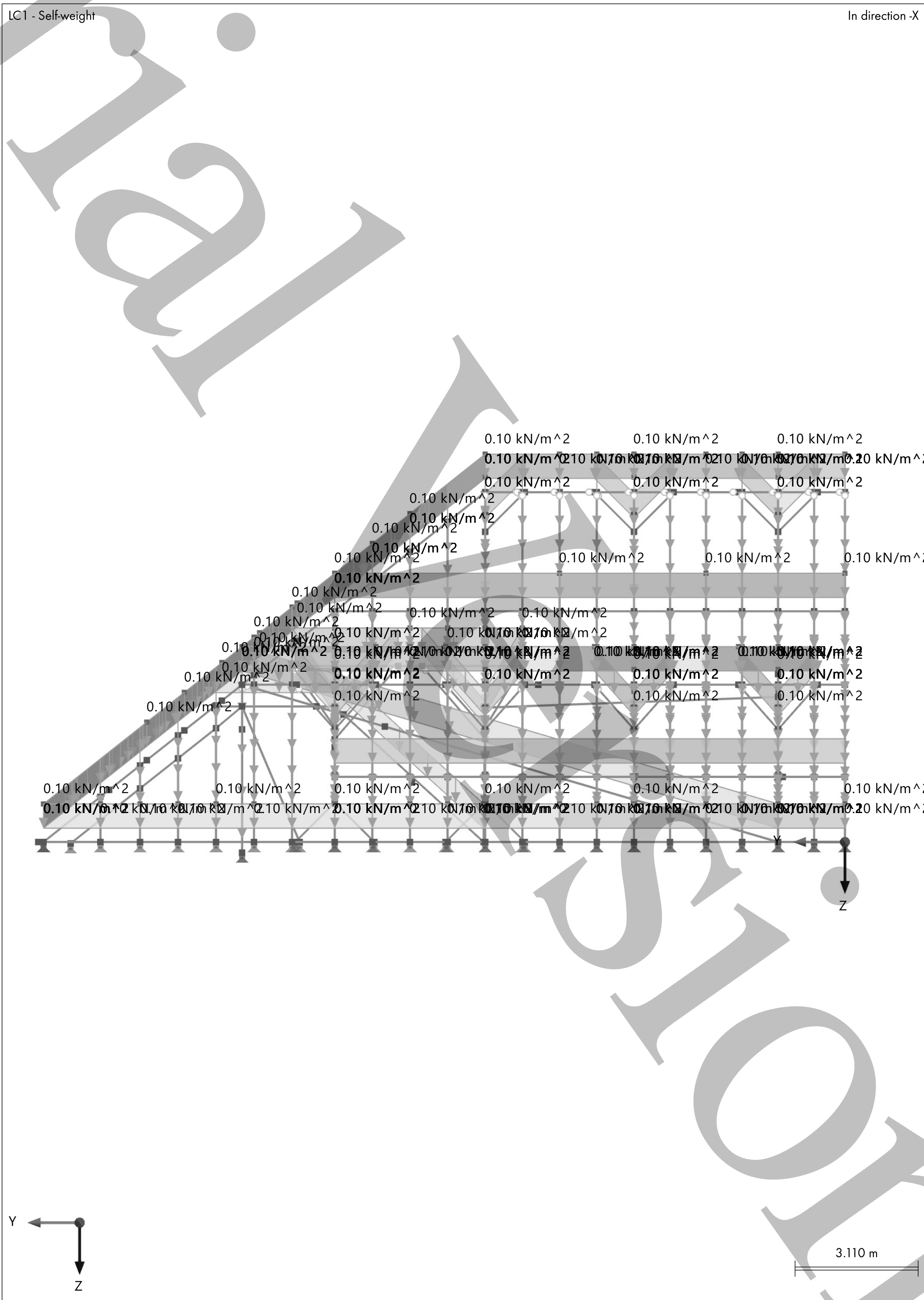
Trial Version

6.4.2 LC1: LOADING, IN DIRECTION -Y



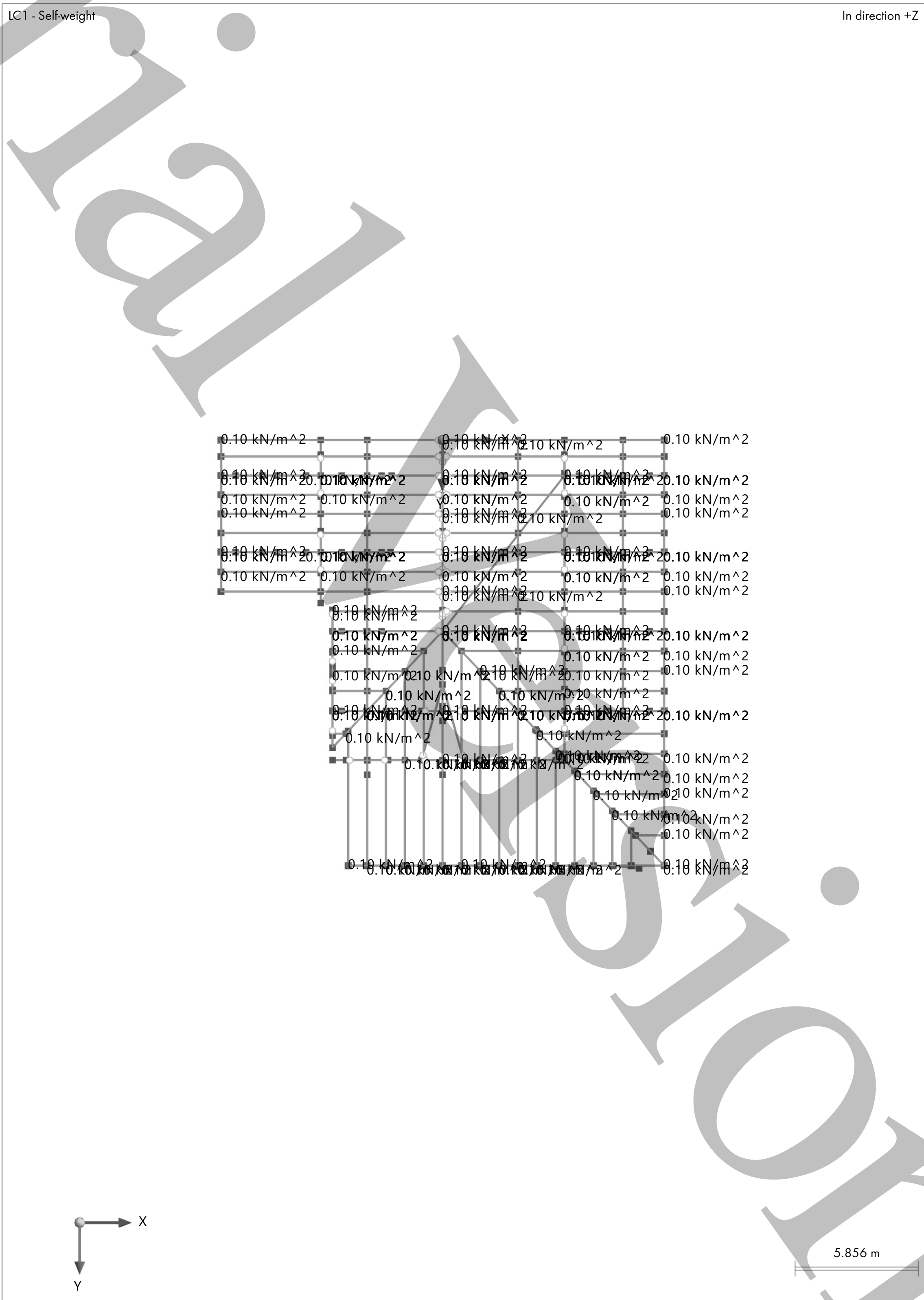
Trial Version

6.4.3 **LC1: LOADING, IN DIRECTION -X**



Trial Version

6.4.4 LC1: LOADING, IN DIRECTION +Z

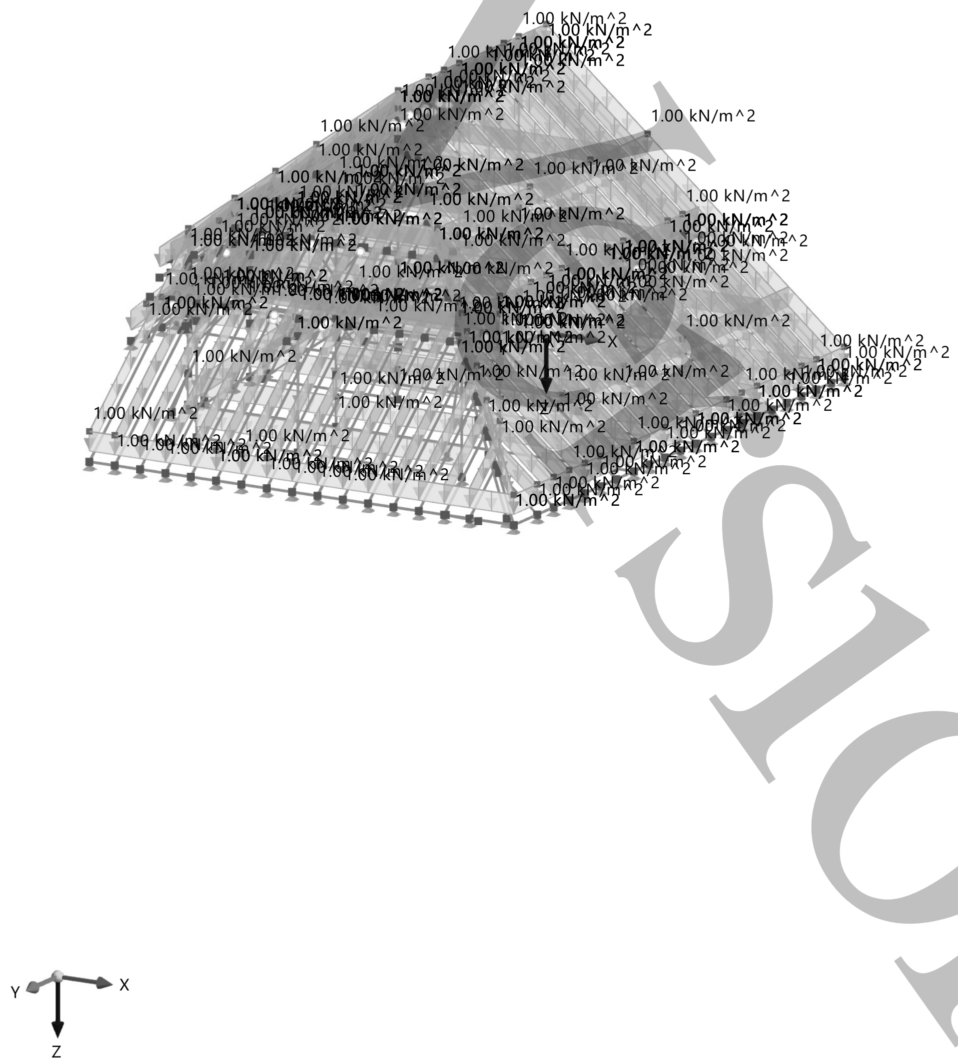


Trial Version

6.5.1 LC2: LOADING, IN AXONOMETRIC DIRECTION BY DEFAULT

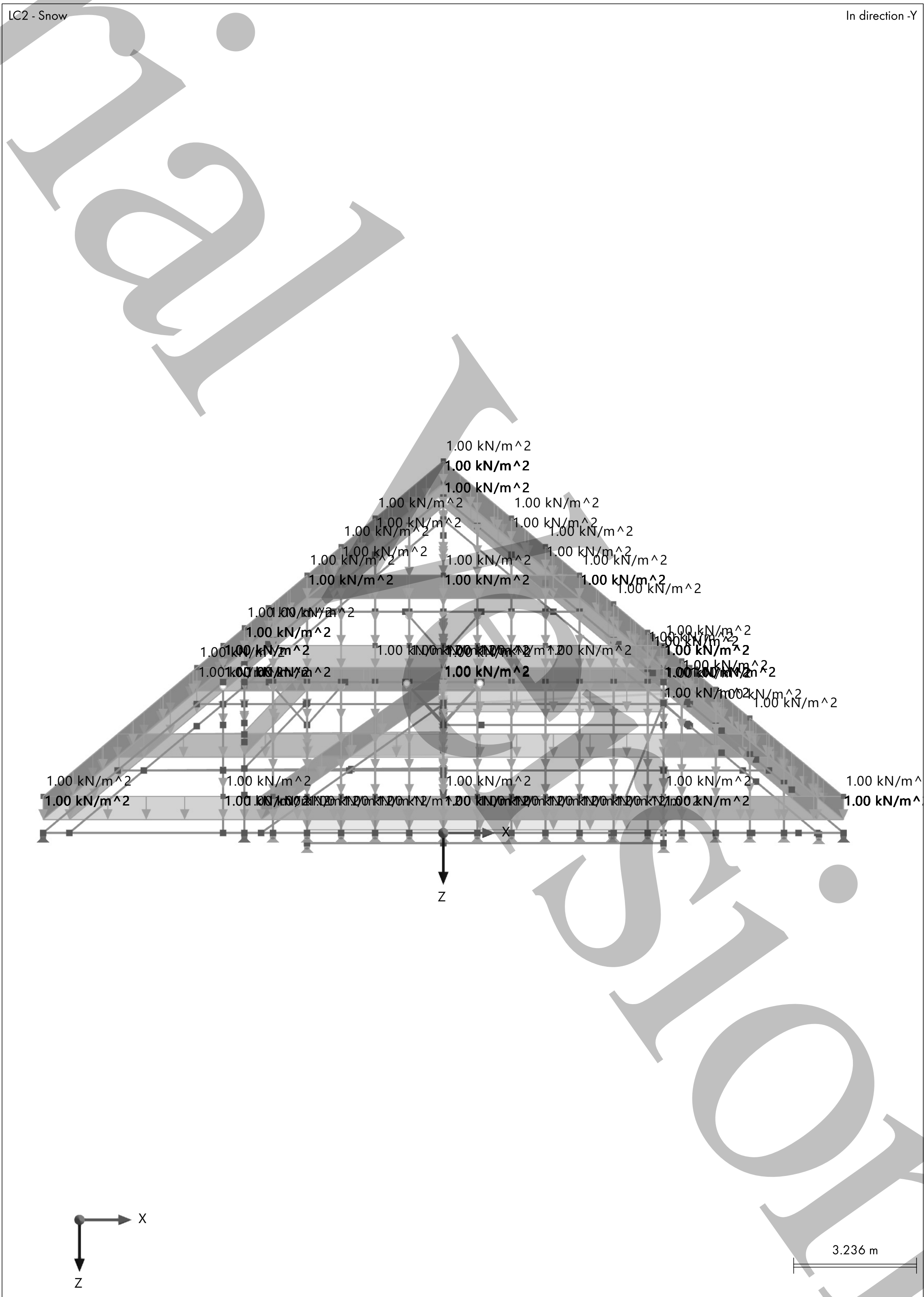
LC2 - Snow

In Axonometric Direction by Default



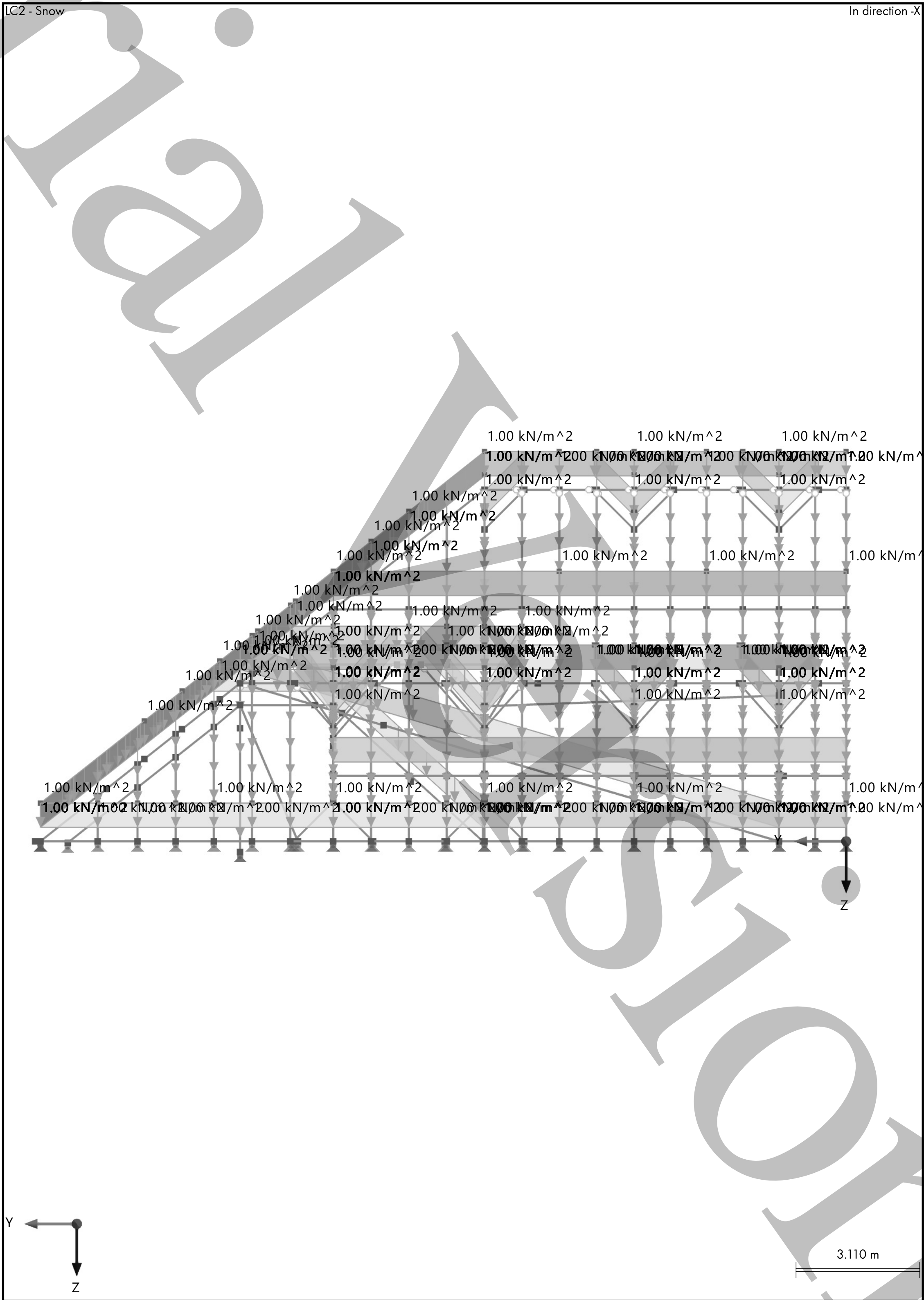
Trial Version

6.5.2 LC2: LOADING, IN DIRECTION -Y



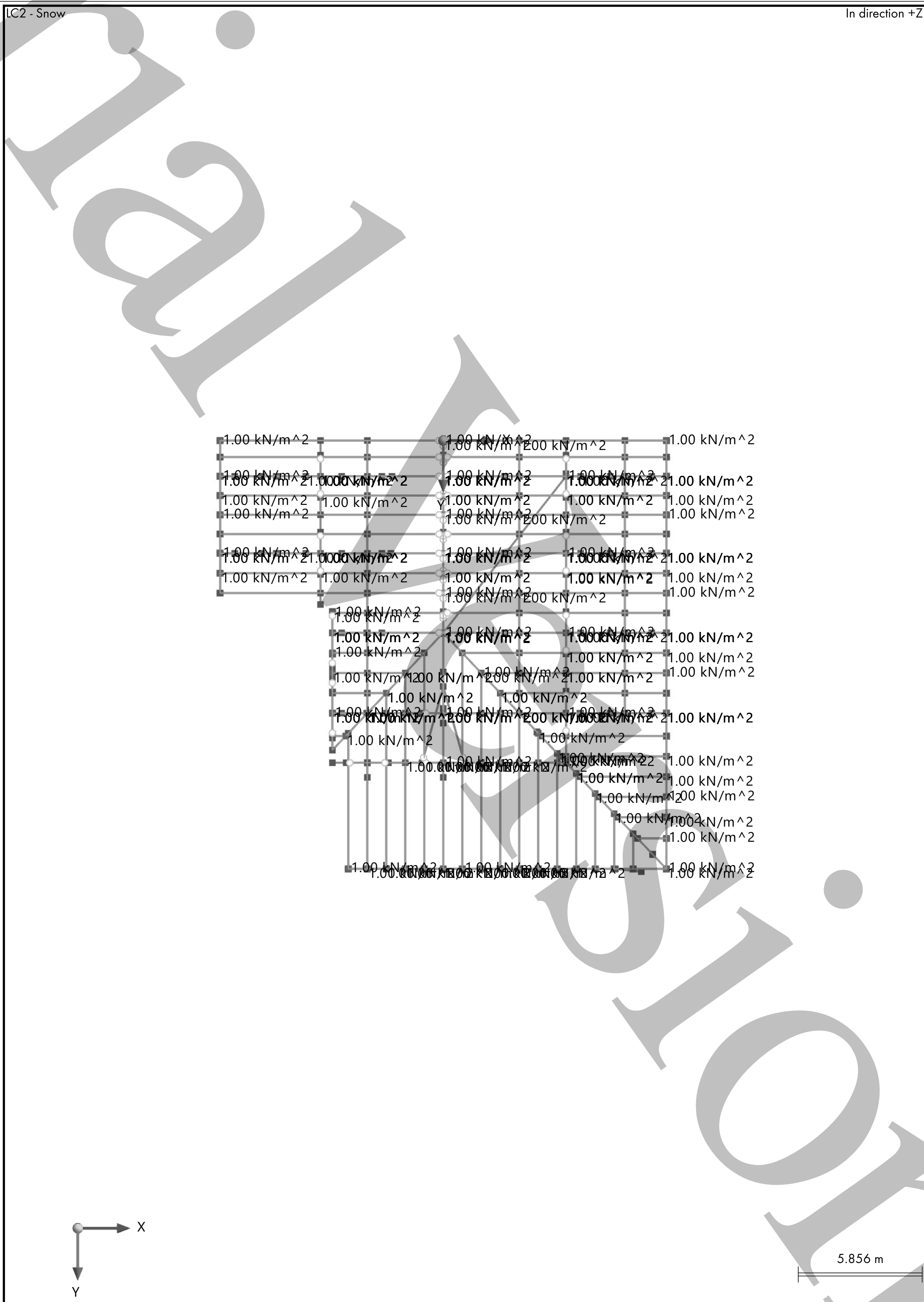
Trial Version

6.5.3 LC2: LOADING, IN DIRECTION -X



Trial Version

6.5.4 LC2: LOADING, IN DIRECTION +Z

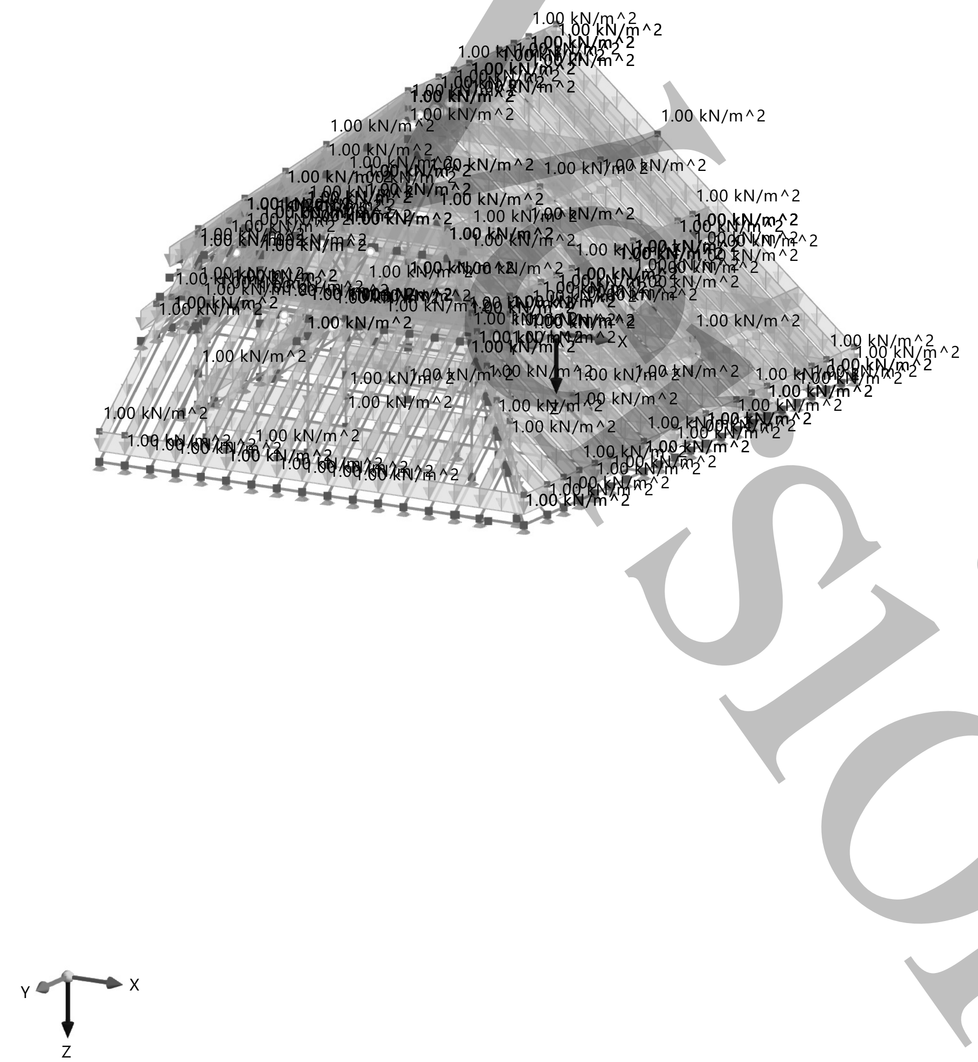


Trial Version

6.6.1 LC3: LOADING, IN AXONOMETRIC DIRECTION BY DEFAULT

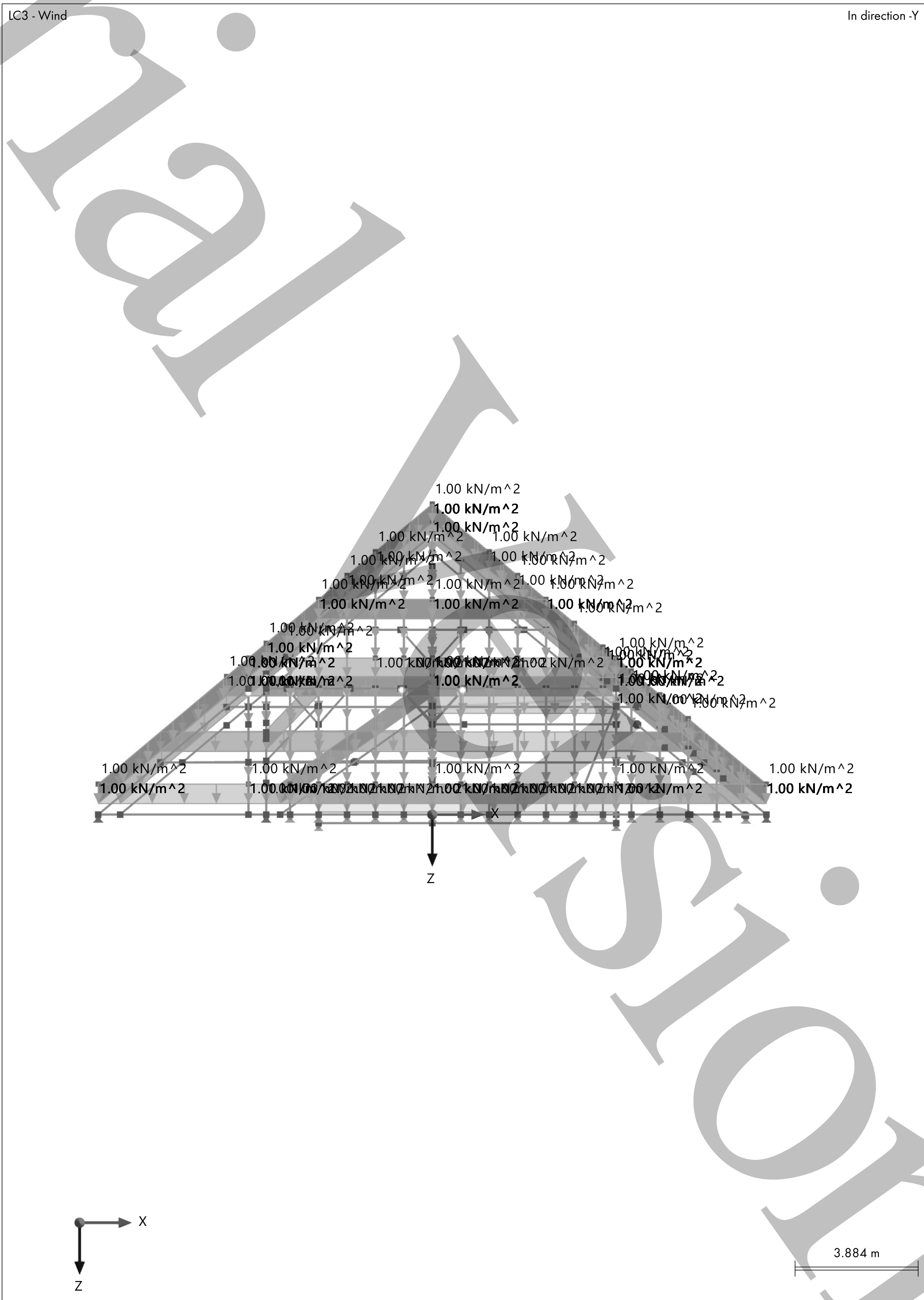
LC3 - Wind

In Axonometric Direction by Default



Trial Version

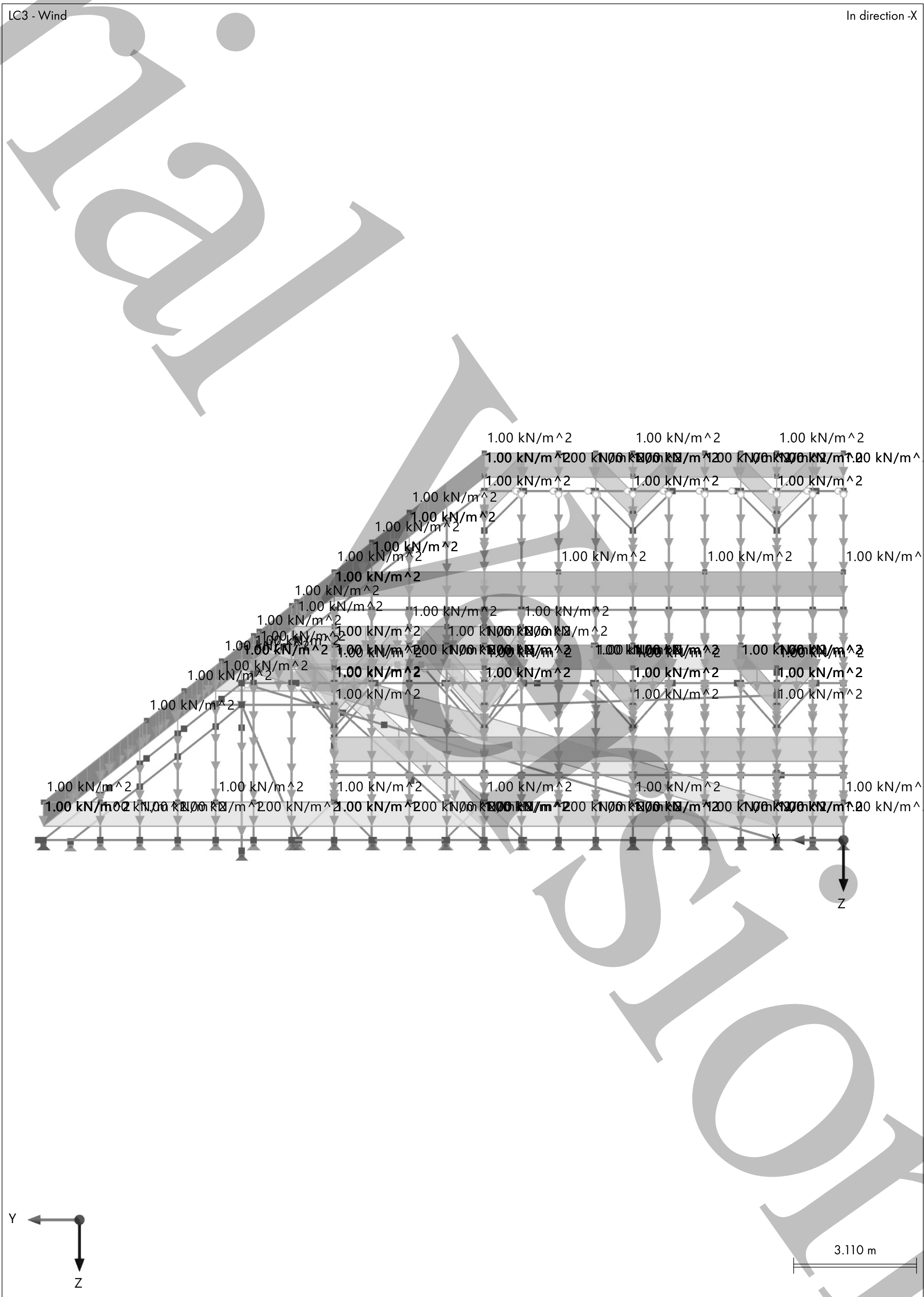
6.6.2 LC3: LOADING, IN DIRECTION -Y



Trial Version

Trial Version

6.6.3 LC3: LOADING, IN DIRECTION -X



6.6.4 LC3: LOADING, IN DIRECTION +Z

Trial Version

7 Guide Objects

7.1 COORDINATE SYSTEMS

System No.	Type	Coordinates Symbol	Coordinates Value	Coordinates Unit	Rotation Sequence	Rotation Symbol	Rotation Value	Rotation Unit	Comment
1	Global XYZ								

8 Static Analysis Results

Trial Version

Lea Schiller

Model:
Gradska vijecnica, kroviste - ZONA 3 (Schiller)

Date 5.6.2023 Page 36
Sheet 1

MODEL

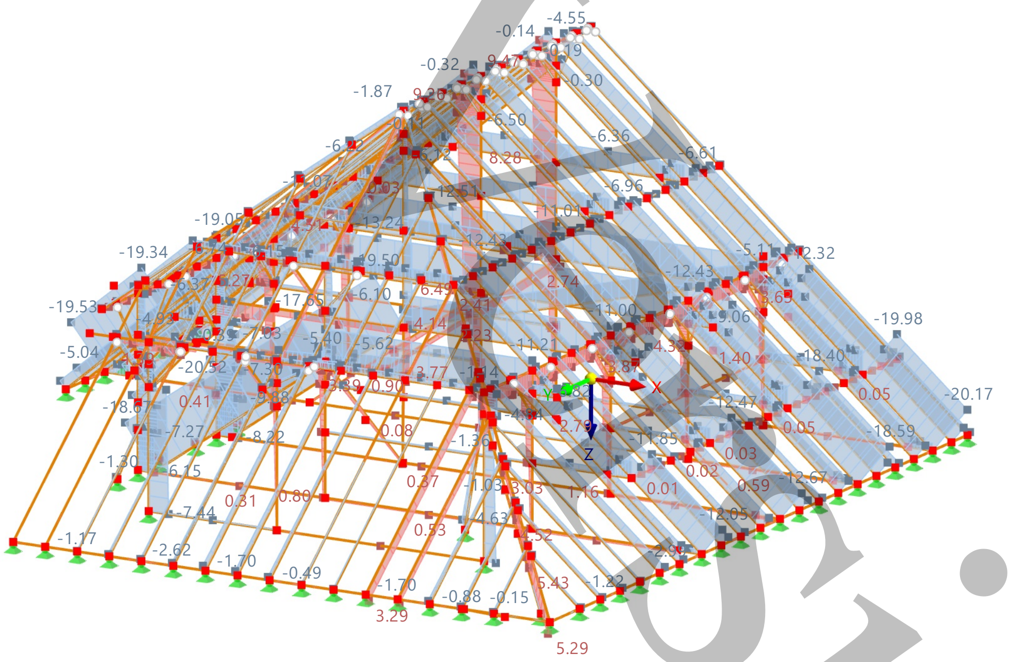
8.1

DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES N, IN AXONOMETRIC DIRECTION BY DEFAULT

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces N [kN]

In Axonometric Direction by Default



max N : 9.47 | min N : -20.52 kN

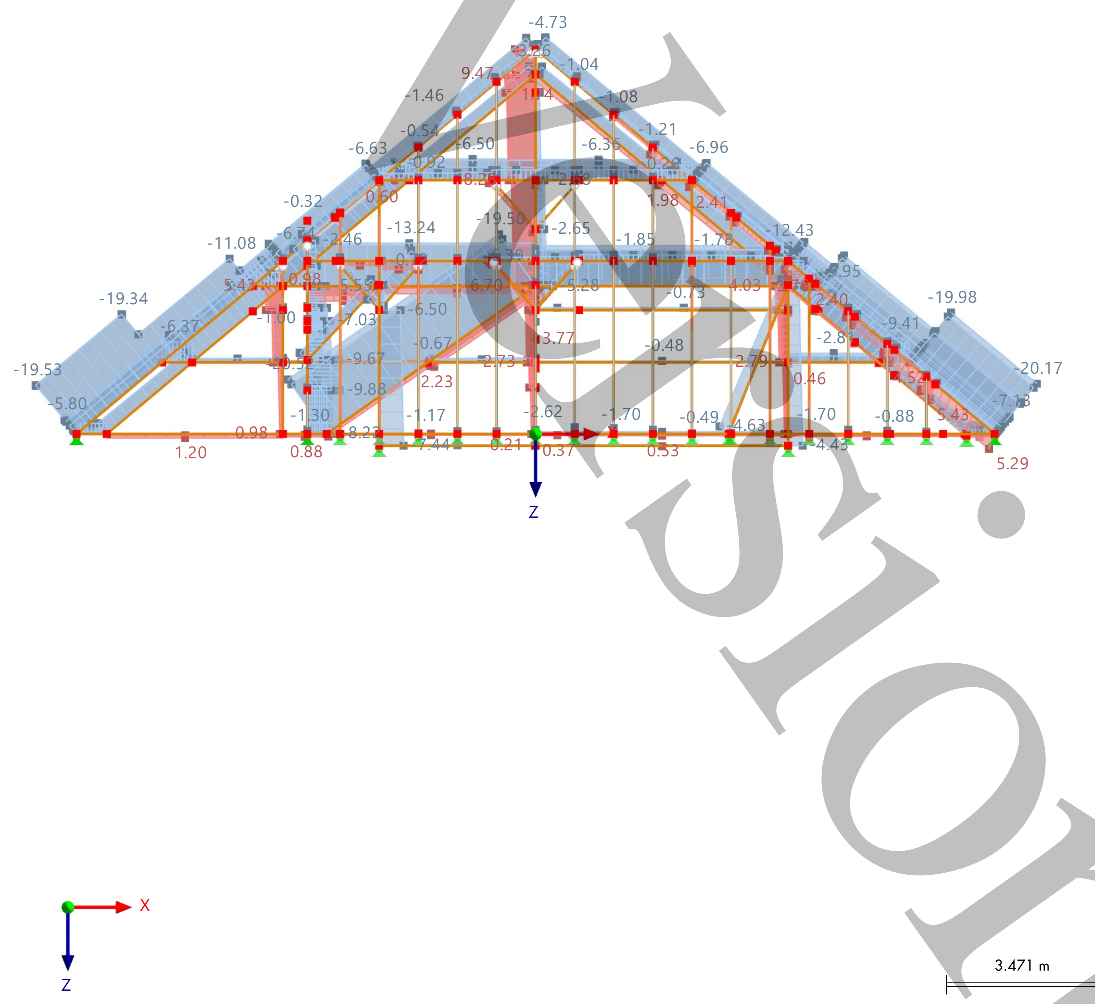
Trial Version

8.2 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES N, IN DIRECTION -Y

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces N [kN]

In direction -Y



max N : 9.47 | min N : -20.52 kN

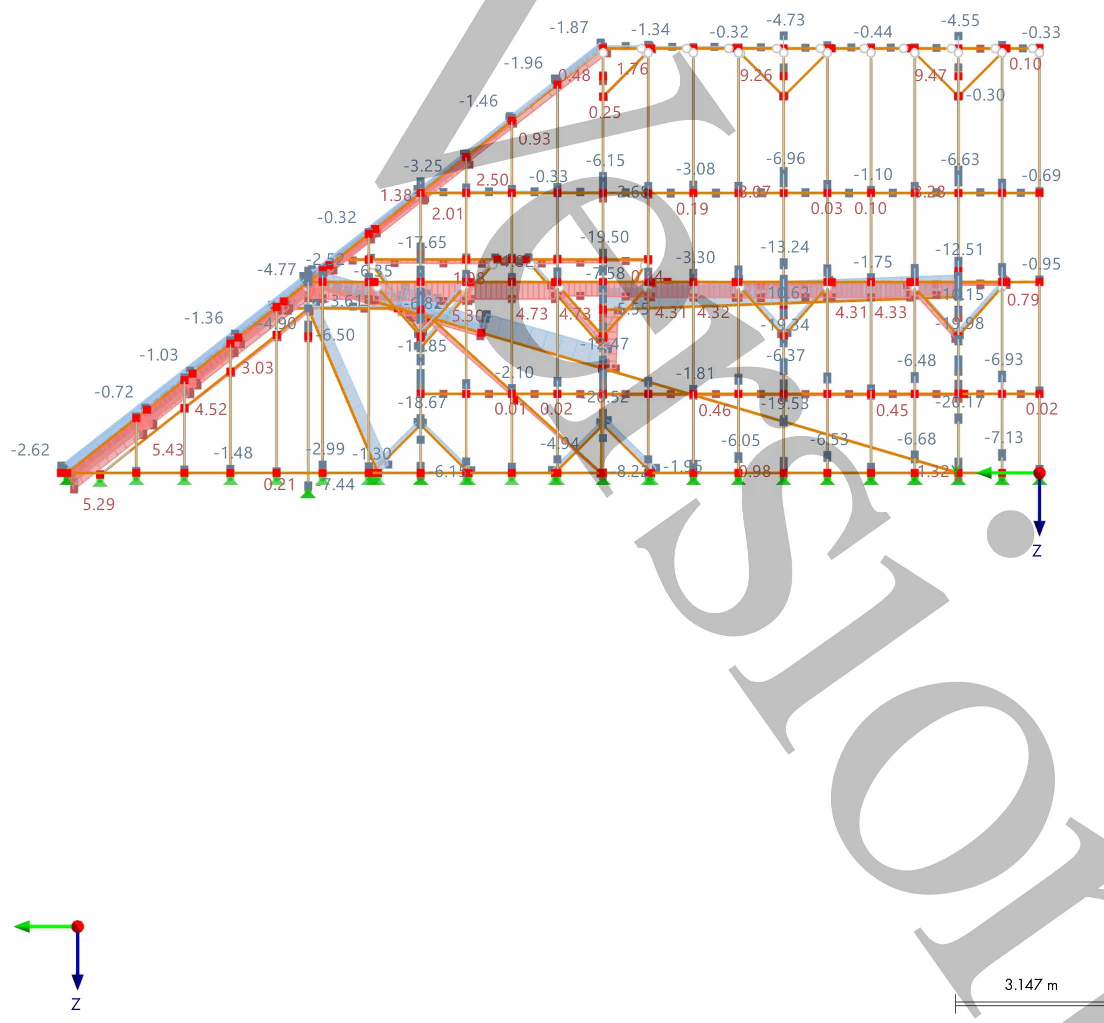
Trial Version

8.3 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES N, IN DIRECTION -X

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces N [kN]

In direction -X



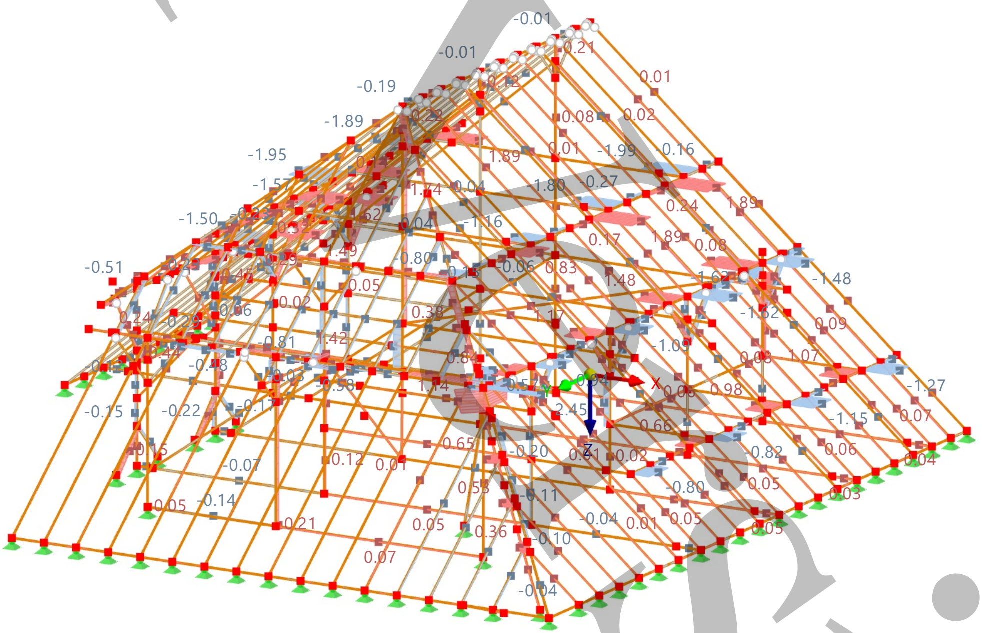
max N : 9.47 | min N : -20.52 kN

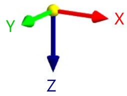
Trial Version

8.4 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES V_y, IN AXONOMETRIC DIRECTION BY DEFAULT** **Static Analysis**

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces V_y [kN]

In Axonometric Direction by Default





max V_y : 1.89 | min V_y : -2.45 kN

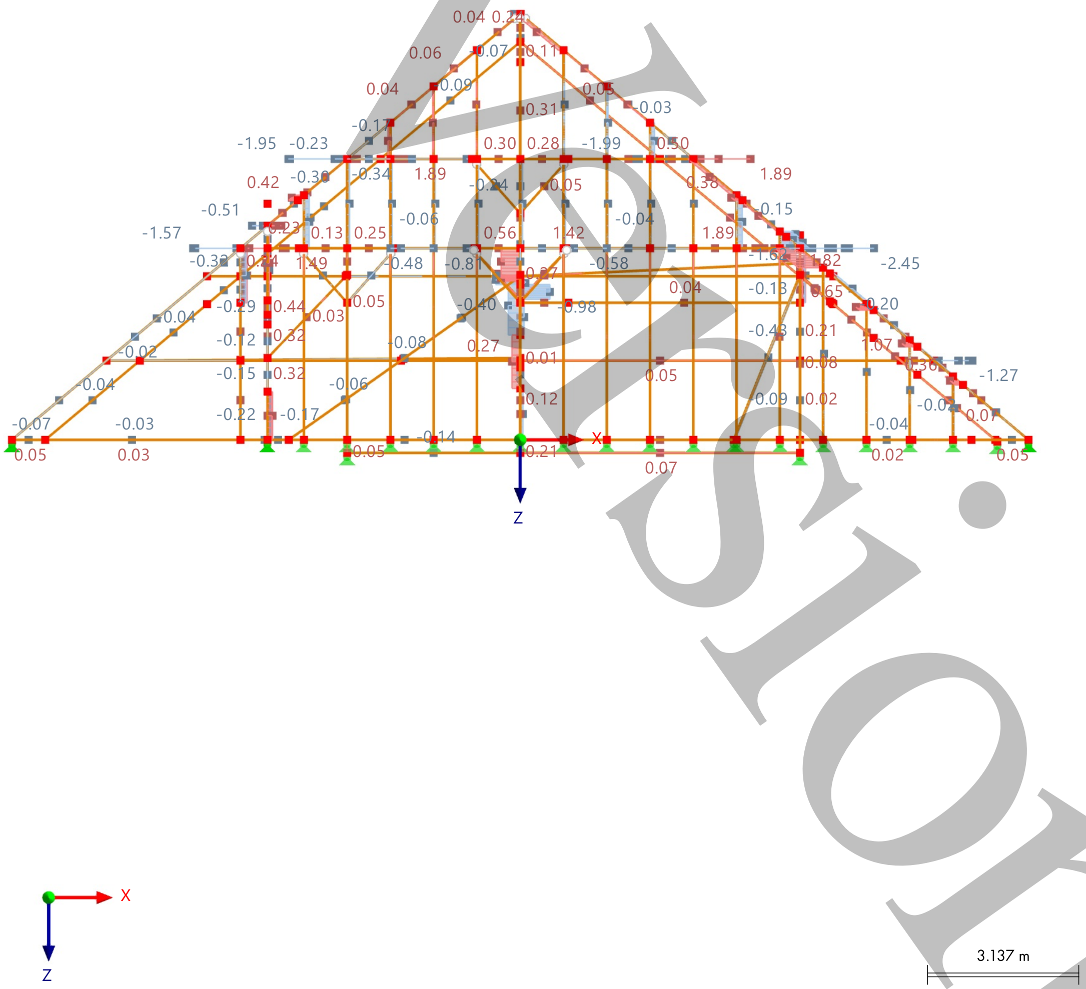
Trial Version

8.5 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES V_y, IN DIRECTION -Y

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces V_y [kN]

In direction -Y



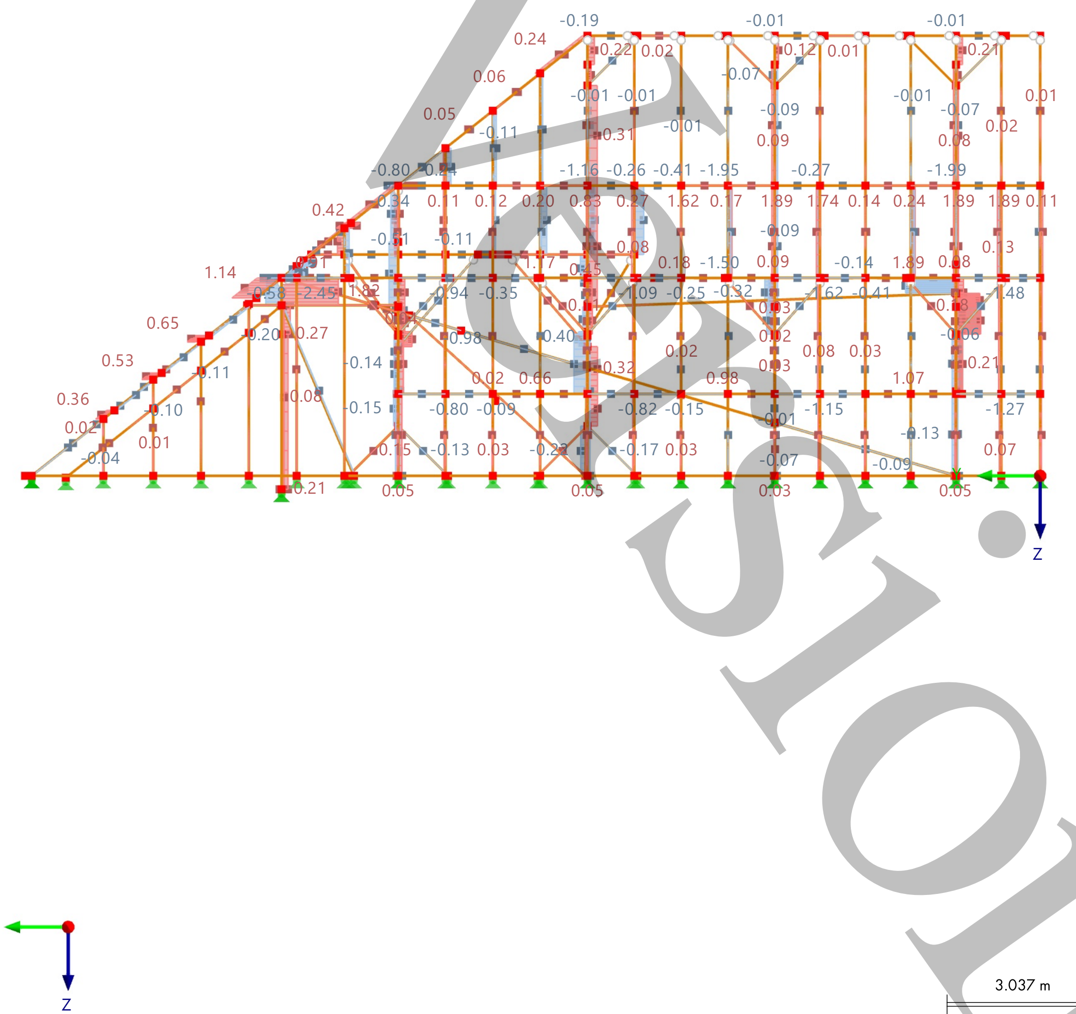
max V_y : 1.89 | min V_y : -2.45 kN

Trial Version

8.6 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES V_y, IN DIRECTION -X** **Static Analysis**

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces V_y [kN]

In direction -X



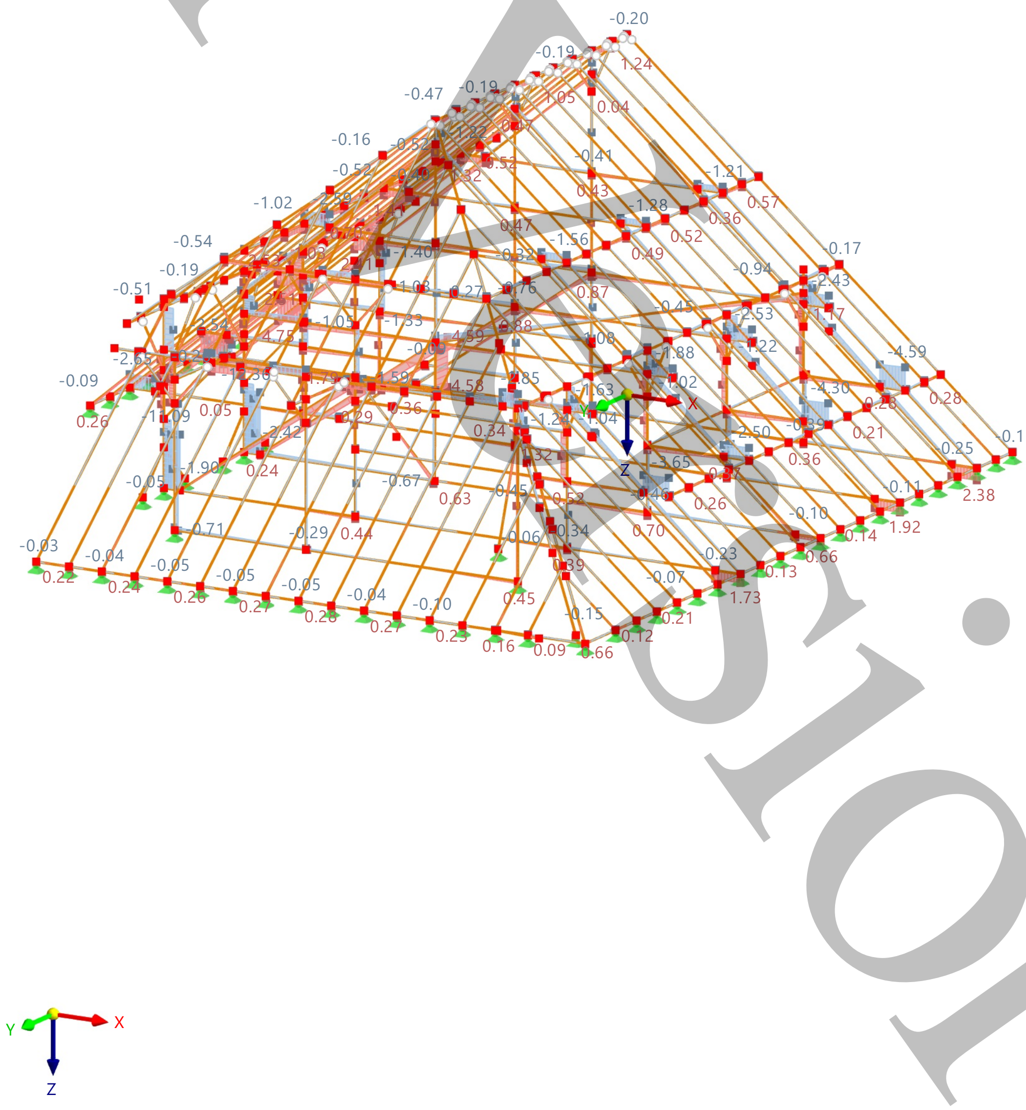
max V_y : 1.89 | min V_y : -2.45 kN

Trial Version

8.7 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES V_z, IN AXONOMETRIC DIRECTION BY DEFAULT — Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces V_z [kN]

In Axonometric Direction by Default



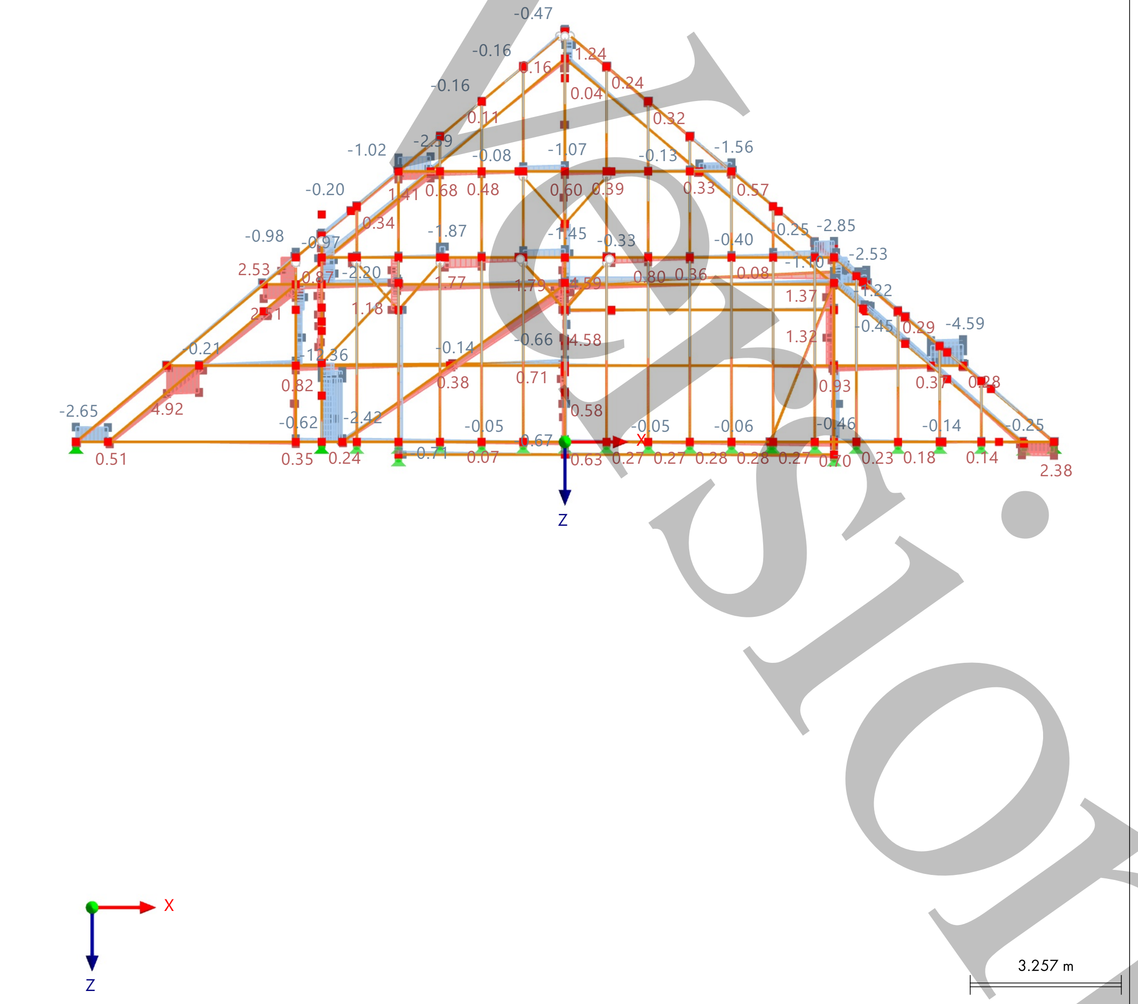
max V_z : 4.92 | min V_z : -12.36 kN

Trial Version

8.8 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES V_z, IN DIRECTION -Y** **Static Analysis**

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces V_z [kN]

In direction -Y



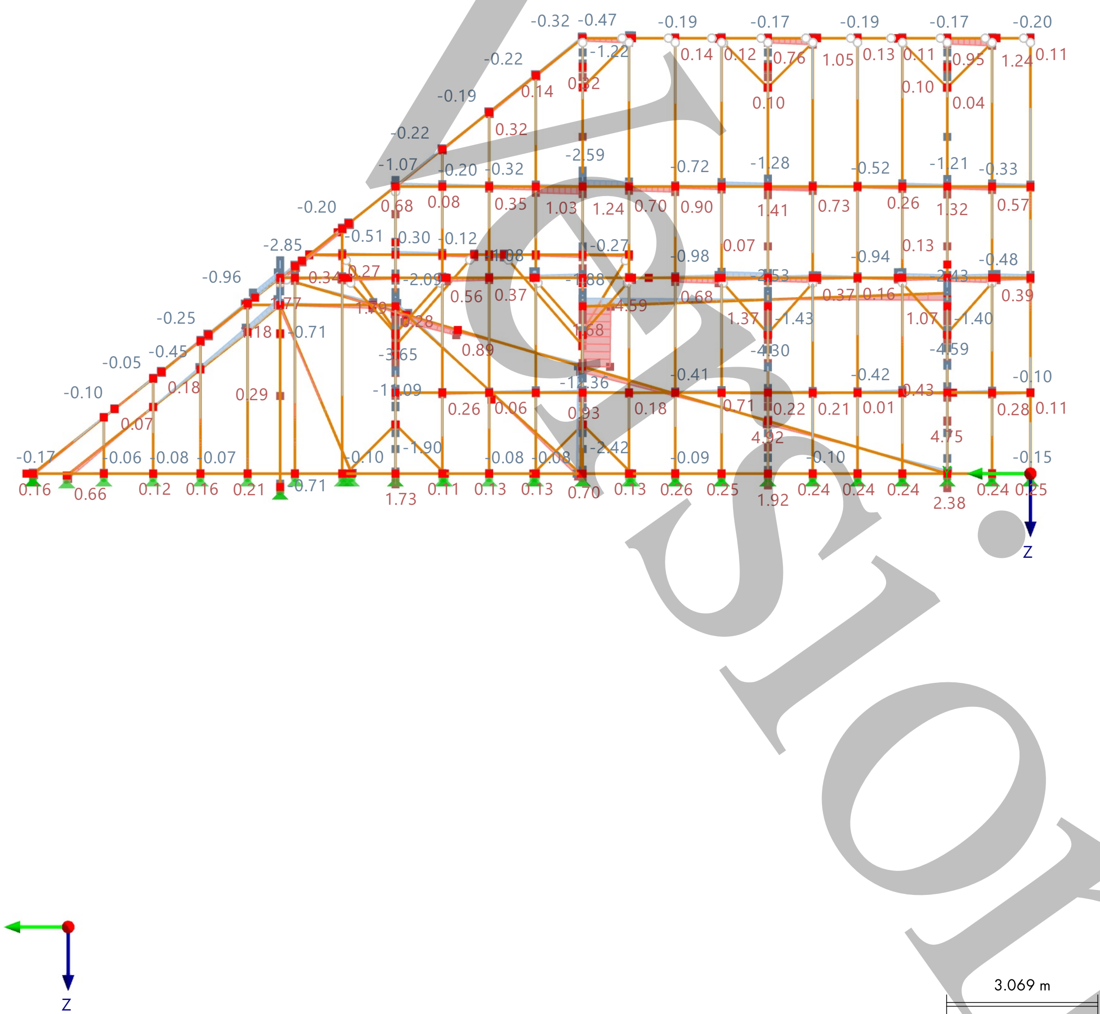
max V_z : 4.92 | min V_z : -12.36 kN

Trial Version

8.9 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES V_z, IN DIRECTION -X** **Static Analysis**

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Forces V_z [kN]

In direction -X



max V_z : 4.92 | min V_z : -12.36 kN

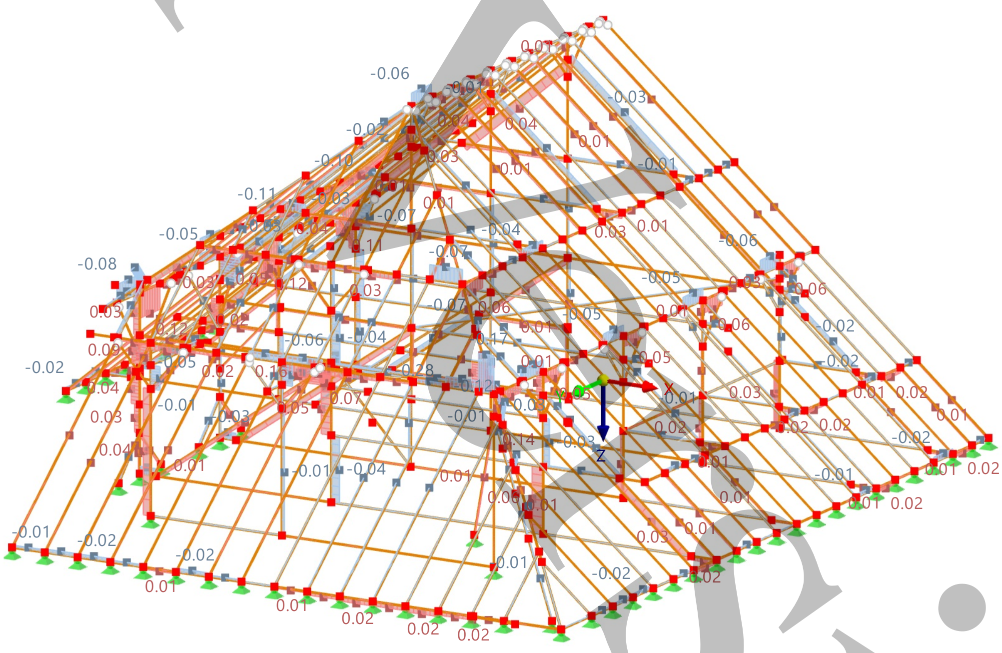
Trial Version

8.10 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_T, IN AXONOMETRIC DIRECTION BY DEFAULT

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_T [kNm]

In Axonometric Direction by Default



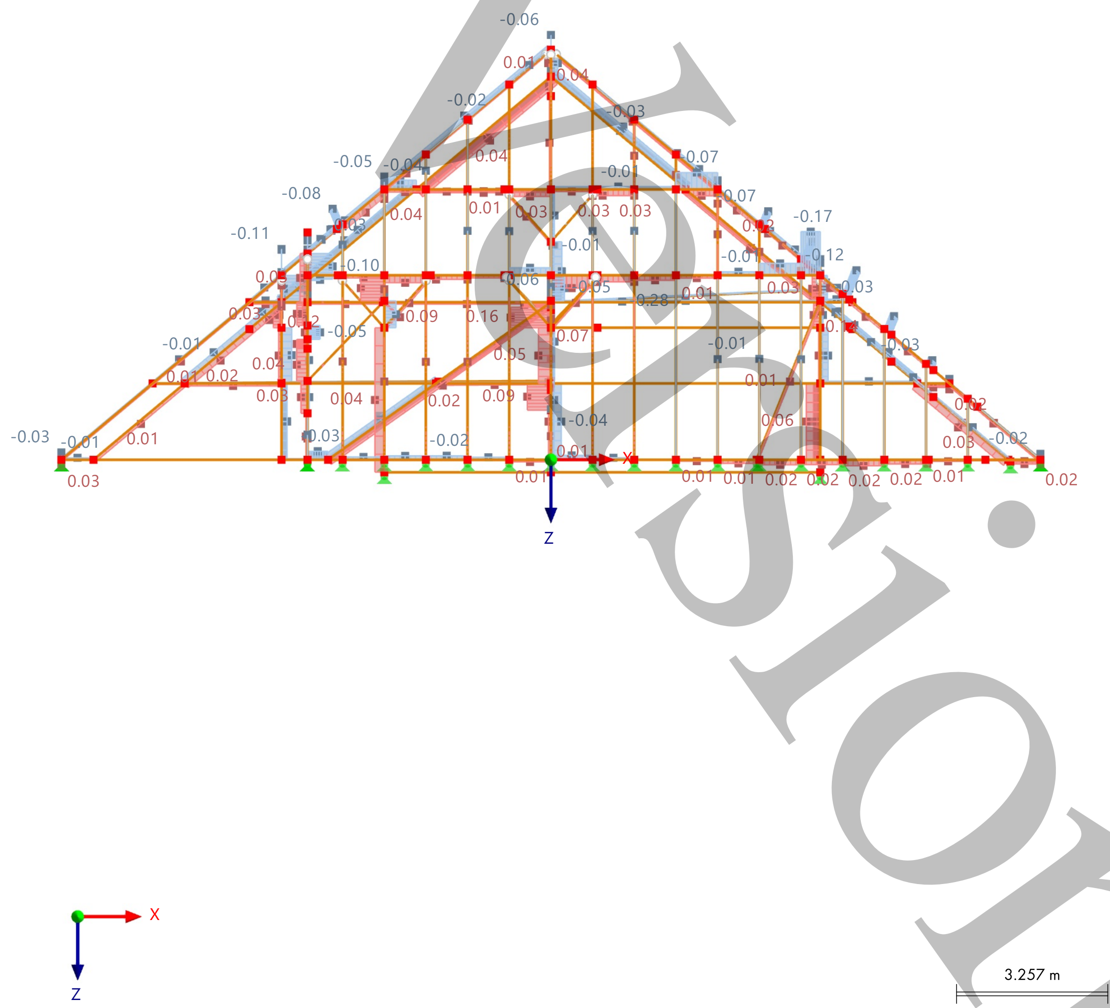
max M_T : 0.16 | min M_T : -0.28 kNm

Trial Version

8.11 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_T, IN DIRECTION -Y** **Static Analysis**

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_T [kNm]

In direction -Y



max M_T : 0.16 | min M_T : -0.28 kNm

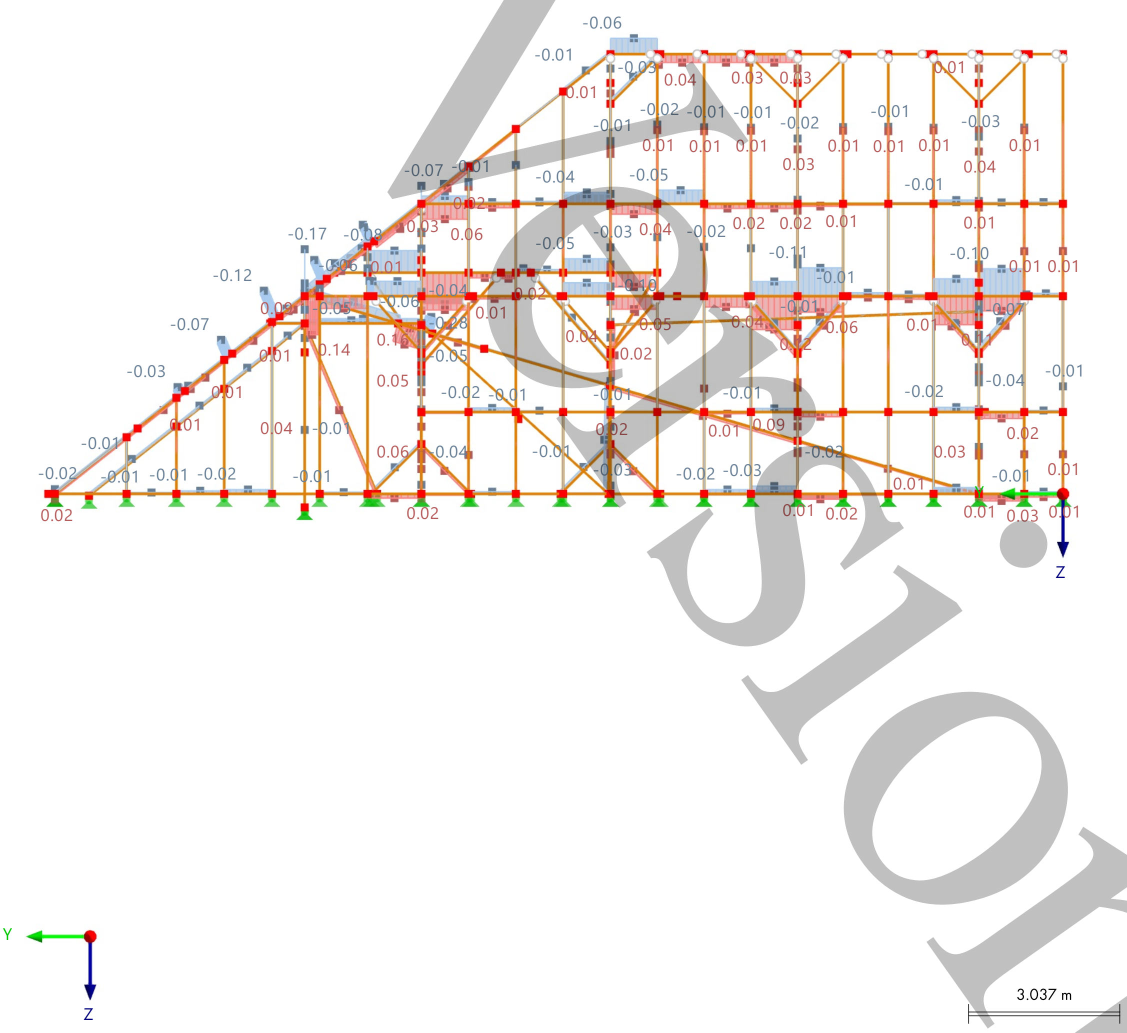
Trial Version

8.12 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_T, IN DIRECTION -X

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_T [kNm]

In direction -X



max M_T : 0.16 | min M_T : -0.28 kNm

Trial Version

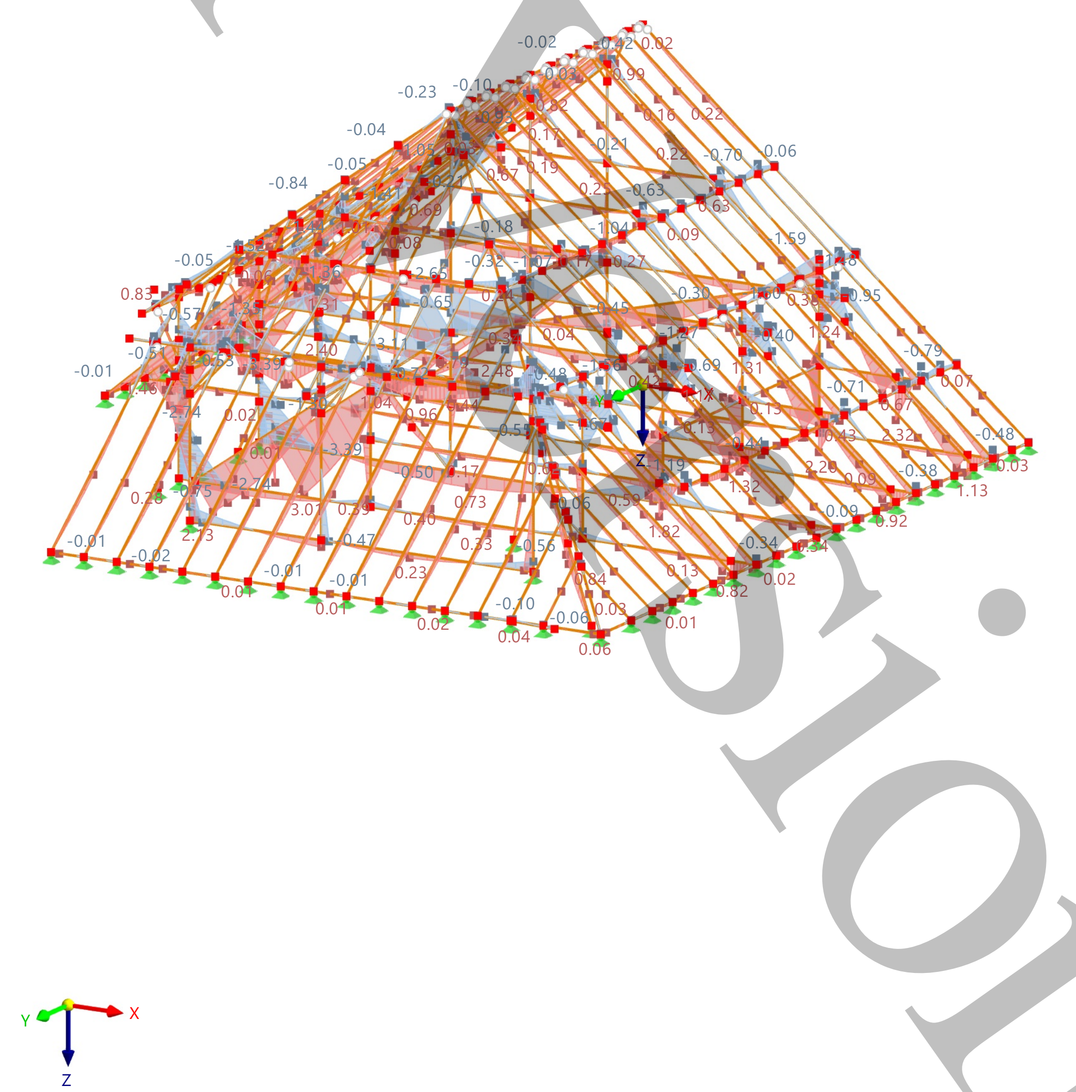
Trial Version

8.13 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_y, IN AXONOMETRIC DIRECTION BY DEFAULT

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_y [kNm]

In Axonometric Direction by Default

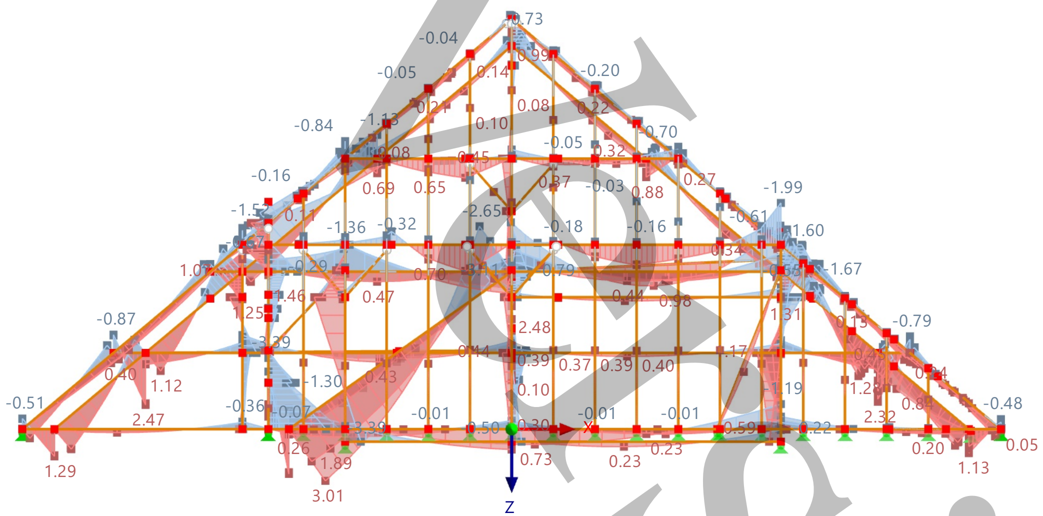


max M_y : 3.01 | min M_y : -3.39 kNm

8.14 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_y, IN DIRECTION -Y** **Static Analysis**

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_y [kNm]

In direction -Y



3.257 m

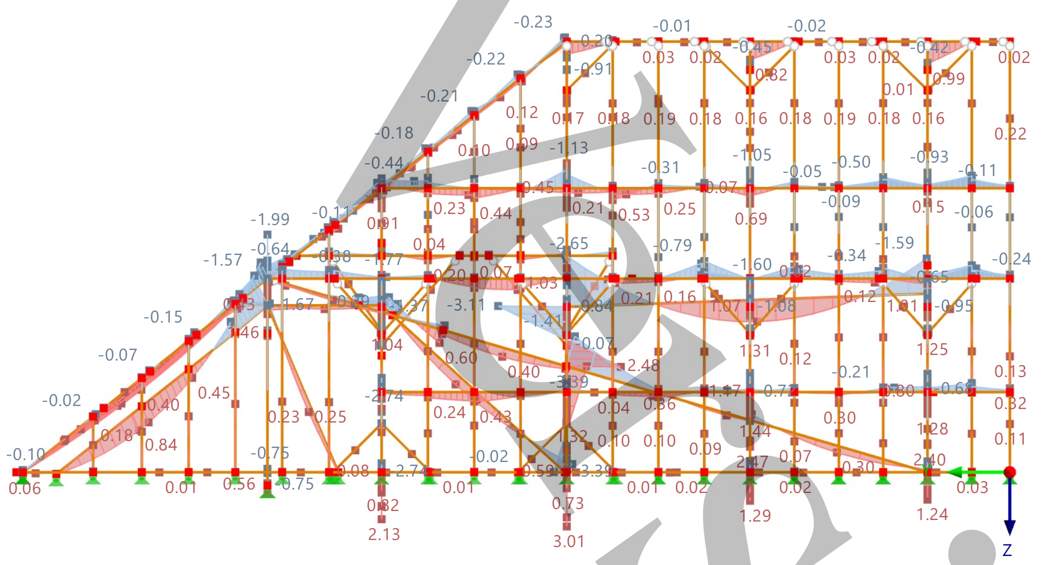
max M_y : 3.01 | min M_y : -3.39 kNm

Trial Version

8.15 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_y, IN DIRECTION -X** **Static Analysis**

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_y [kNm]

In direction -X



3.102 m

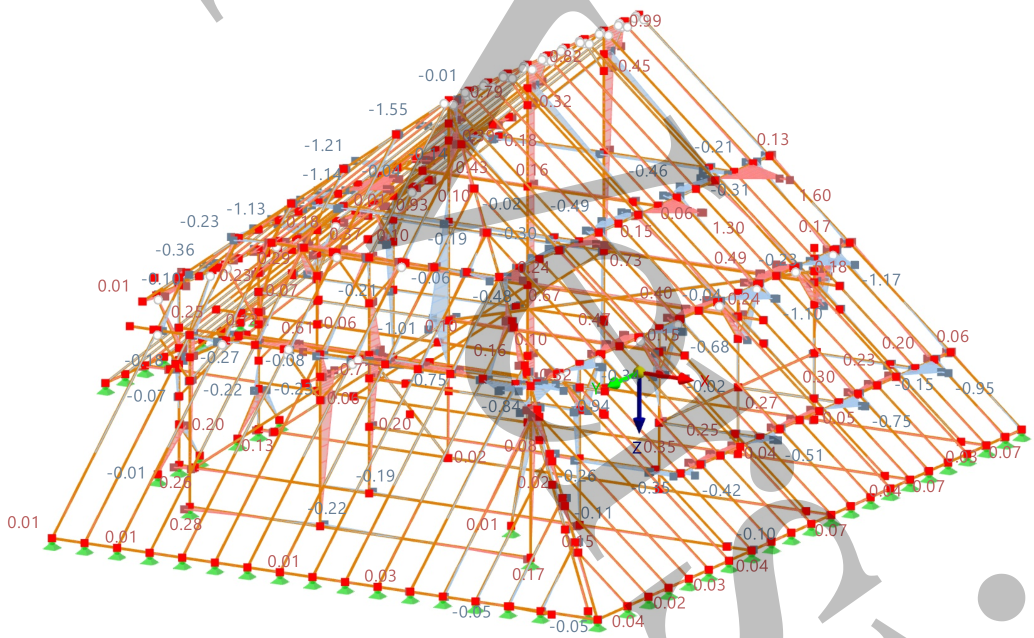
max M_y : 3.01 | min M_y : -3.39 kNm

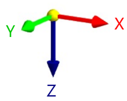
Trial Version

8.16 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_z, IN AXONOMETRIC DIRECTION BY DEFAULT** **Static Analysis**

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_z [kNm]

In Axonometric Direction by Default





max M_z : 1.60 | min M_z : -1.55 kNm

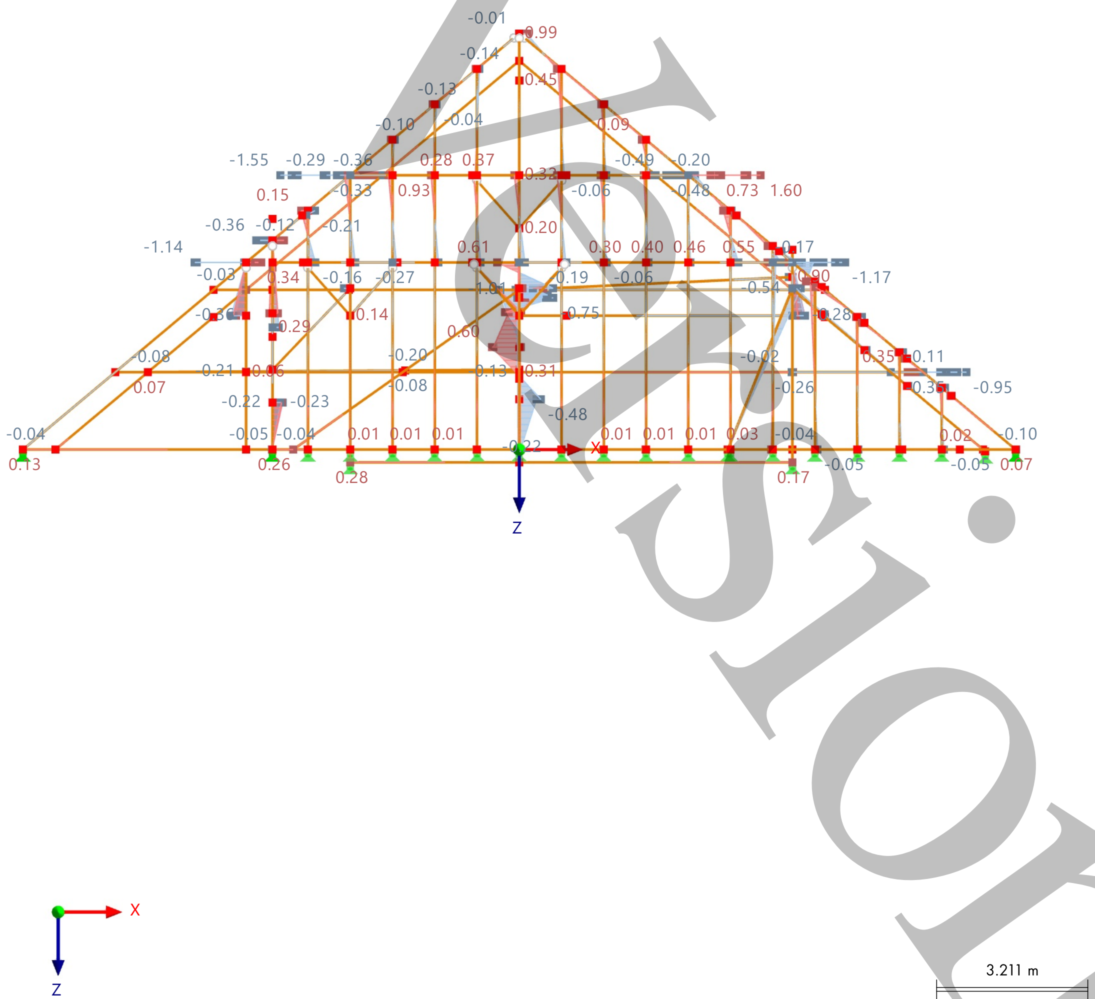
Trial Version

8.17 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_z, IN DIRECTION -Y

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_z [kNm]

In direction -Y



max M_z : 1.60 | min M_z : -1.55 kNm

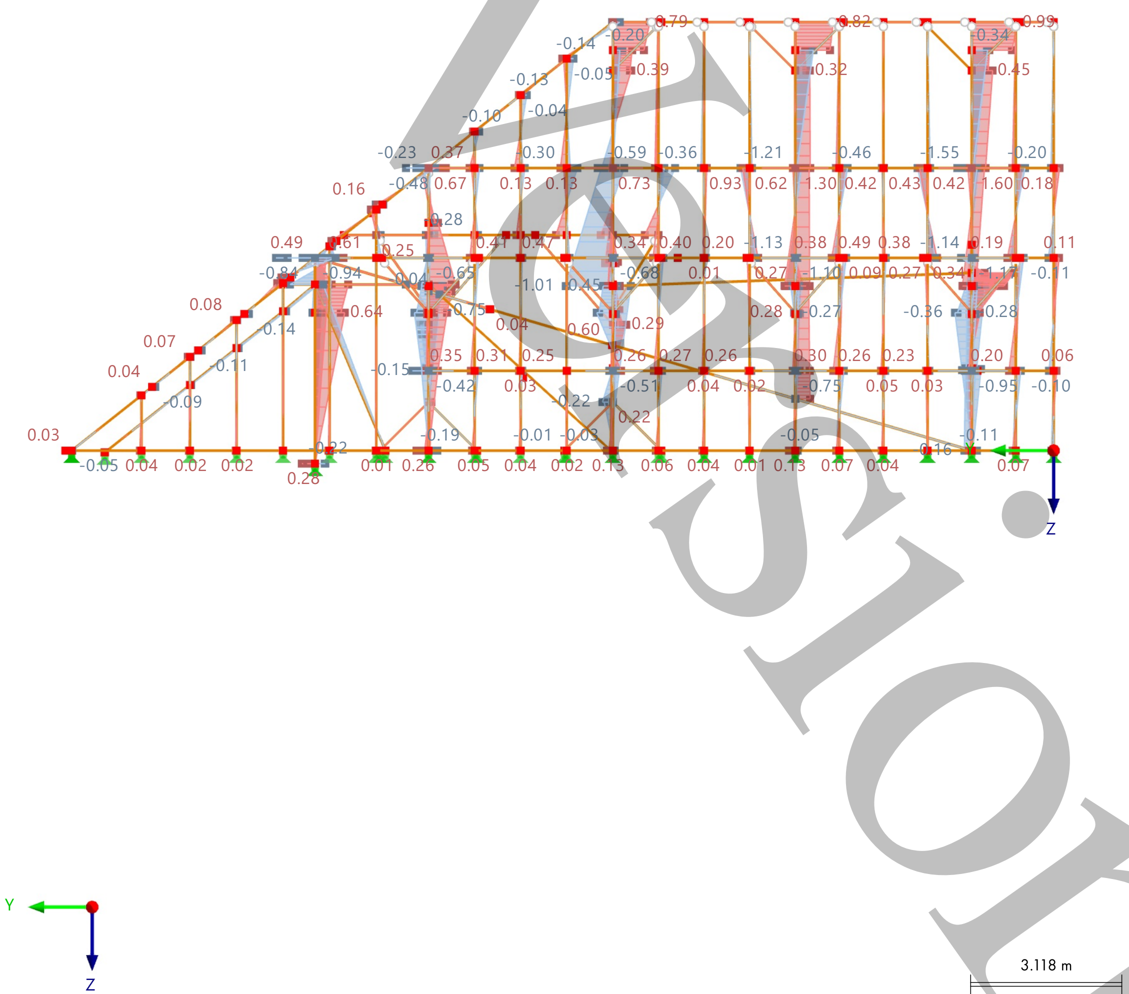
Trial Version

8.18 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES M_z, IN DIRECTION -X

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10
Static Analysis
Moments M_z [kNm]

In direction -X



max M_z : 1.60 | min M_z : -1.55 kNm

Trial Version

9 Timber Design

9.1 OBJECTS TO DESIGN

	Object Type	Design All	Objects to Design Selected	To Calculate	Removed	Not Valid / Deact	Comment
	Members	☒	6,13-15,17,24,29,30,39,41-44,46-52,61-64,73-82,95,107,160,162-173,185-188,196,198,201-208,211,216-219,225,226,229-231,250,253,257-260,262-266,276-278,280,282,283,285-287,289-311,314,327,328,330,335-342,347-349,351-353,355-357,359-375,377-380,382-397,399,401-403,406,407,409,412,413,418-421,423-428,430-459,464,468-471,473,474,476-478,840,841,972,1449,1468-1525,1527-1834	6,13-15,17,24,29,30,39,41-44,46-52,61-64,73-82,95,107,160,162-173,185-188,196,198,201-208,211,216-219,225,226,229-231,250,253,257-260,262-266,276-278,280,285,290,292,294,296,298,300-311,314,327,328,330,335-342,347-349,351-353,355-357,359,364-366,368,369,371,372,374,375,382-388,390-393,396,397,399,401-403,406,407,409,412,413,418-421,424-427,430-459,464,468-471,473,474,476,477,840,841,972,1449,1468-1525,1527-1691,1693,1694,1696-1754,1757,1758,1760,1761,1763,1765,1767-1769,1772-1779,1789-1827,1830-18		282,283,286,287,289,291,293,295,297,299,360-363,367,370,373,377-380,389,394,395,423,428,478,1692,1695,1755,1756,1759,1762,1764,1766,1770,1771,1780-1788,1828,1829,1834	

9.2 DESIGN SITUATIONS

DS No.	EN 1990 | Timber | CEN | 2010-(Design Situation Type	To Design	Active	EN 1995 | HRN | 2015-03 Design Situation Type	Combinations to Design for Enumeration Method
1	ULS ULS (STR/GEO) - Permanent and transient - Eq. 6.10	☒	☒	ULS ULS (STR/GEO) - Permanent and transient	All
2	S Ch SLS - Characteristic	☒	☒	S Ch SLS - Characteristic	All
3	S Qp SLS - Quasi-permanent	☒	☒	S Qp1 SLS - Quasi-permanent 1	All

9.3 MATERIALS

Material No.	Name	To Design	Material Type	Options	Comment
1	C18	☒	Timber	%	

Legend
% Stiffness modification

Trial Version

Trial Version

9.4
SECTIONS

Legend
Warping stiffness deactivated

Section No.	Name	Material	To Design	Section Type	Use Other Section for Design	Options
1	R_M1 300/200	1	☒	Parametric - Massive I	--	
2	R_M1 200/320	1	☒	Parametric - Massive I	--	
3	R_M1 180/240	1	☒	Parametric - Massive I	--	
4	R_M1 140/170	1	☒	Parametric - Massive I	--	
5	2R_M2 220/120/150/1	1	☒	Parametric - Massive II	--	
6	R_M1 150/150	1	☒	Parametric - Massive I	--	
7	R_M1 220/270	1	☒	Parametric - Massive I	--	
8	R_M1 50/30	1	☒	Parametric - Massive I	--	
9	R_M1 150/170	1	☒	Parametric - Massive I	--	

9.5
ULTIMATE CONFIGURATIONS

Config. No.	Name	Assigned to Members	Member Sets	Surfaces	Surface Sets
1	Default	All	All	All	All

9.5.1
ULTIMATE CONFIGURATIONS - SETTINGS - MEMBERS

Config. No.	Description	Symbol	Value	Unit
1	Default			
	General			
	☒ Perform stability design			
	Limit Values for Special Cases			
	Tension ($\sigma_{t,0,d}$ / $f_{t,0,d}$)	$\eta_{\sigma t,lim}$	0.001	--
	Compression ($\sigma_{c,0,d}$ / $f_{c,0,d}$)	$\eta_{\sigma c,lim}$	0.001	--
	Shear ($\tau_{xy,d}$ / $f_{v,d}$)	$\eta_{\tau xy,lim}$	0.001	--
	Shear ($\tau_{xz,d}$ / $f_{v,d}$)	$\eta_{\tau xz,lim}$	0.001	--
	Torsion ($\tau_{tor,d}$ / $f_{v,d}$)	$\eta_{\tau tor,lim}$	0.010	--
	Bending ($\sigma_{m,y,d}$ / $f_{m,d}$)	$\eta_{\sigma m,y,lim}$	0.001	--
	Bending ($\sigma_{m,z,d}$ / $f_{m,d}$)	$\eta_{\sigma m,z,lim}$	0.001	--
	Curved and Saddle Members			
	☒ Perpendicular tension design of curved members			
	☒ Perpendicular tension design of saddle members			
	Cut-to-Grain Angle Limit			
	Allow further design if angle does not exceed limit	$\|\alpha\| \leq$	24.00	deg
	System Strength Acc. to 6.6			
	☐ Consider system strength factor			
	Settings for Stability Design			
	Stiffness Reduction			
	☐ Reduction of stiffness with coefficient 1/(1+k_{def}) acc. to DIN EN 1995-1-1			
	Position of Positive Transverse Load Application			
	Vertical position			
	◉ On section edge (destabilizing effect)			
	○ At shear point			
	○ At center point			
	○ On section edge (stabilizing effect)			
	☐ Reduction of effective length by 0.5h acc. to Tab. 6.1 (stabilizing effect)			

Trial Version

9.6
SERVICEABILITY CONFIGURATIONS

Config. No.	Name	Assigned to Members	Member Sets	Surfaces	Surface Sets
1	Default	All	All	All	All

9.6.1
SERVICEABILITY CONFIGURATIONS - SETTINGS - MEMBERS

Config. No.	Description	Symbol	Value	Unit
1	Default			
	Serviceability Limits (Deflections) Acc. to 7.2			
	Beam limits			
	Characteristic	L /	300	--
	Quasi-permanent 1	L /	250	--
	Quasi-permanent 2	L /	150	--
	Cantilever limits			
	Characteristic	L_c /	150	--
	Quasi-permanent 1	L_c /	125	--
	Quasi-permanent 2	L_c /	75	--
	Vibration Design			
	Vibration design	$w_{inst,lim}$	5.0	mm

9.7
FIRE RESISTANCE CONFIGURATIONS

Config. No.	Name	Assigned to Members	Member Sets	Surfaces	Surface Sets
1	Default	All	All	All	All

9.7.1
FIRE RESISTANCE CONFIGURATIONS - SETTINGS - MEMBERS

Config. No.	Description	Symbol	Value	Unit
1	Default			
	Fire Design Settings			
	Required time of fire resistance	t	15	min
	Fire exposure (not for circular sections)			
	☒ Top (-z)			
	☒ Left (-y)			
	☒ Right (+y)			
	☒ Bottom (+z)			

10 Design Overview

10.1
DESIGN OVERVIEW

Design Overview

	Addon	Objects Type	No.	Location [m]	Design Situation	Loading No.	Design Check Ratio η [--]	Type	Description
	Timber Design	Member	1502	x: 0.440	DS1	CO3	36.352 ❗	ST3100.00	Stability | Bending about y-axis and compression acc. to 6.3.3
	Timber Design	Member	1502	x: 0.440	DS1	CO3	6.761 ❗	SP6300.00	Section Proof | Biaxial bending and compressive axial force acc. to 6.2.4
	Timber Design	Member	1502	x: 0.440	DS1	CO3	6.761 ❗	ST1600.03	Stability | Biaxial bending and compression with buckling about both axes acc. to 6.3.2
	Timber Design	Member	1502	x: 0.440	DS1	CO3	6.666 ❗	SP3100.00	Section Proof | Shear in z-axis acc. to 6.1.7 | Rectangular section
	Timber Design	Member	1501	x: 5.260	DS2	CO8	5.624 ❗	SE1200.01	Serviceability | Combination of actions 'Characteristic' | z-direction acc. to 7.2
	Timber Design	Member	1501	x: 5.260	DS3	CO13	5.068 ❗	SE1200.02	Serviceability | Combination of actions 'Quasi-permanent 1' | z-direction acc. to 7.2

10.1 DESIGN OVERVIEW

	Objects				Design	Loading	Design Check		
	Addon	Type	No.	Location [m]	Situation	No.	Ratio η [--]	Type	Description
	Timber Design	Member	1501	x: 0.000	DS1	CO3	4.139	SP5300.00	Section Proof | Biaxial bending and tensile axial force acc. to 6.2.3
	Timber Design	Member	1501	x: 0.000	DS1	CO3	4.054	ST2100.00	Stability | Flexural member without compression force | Bending about y-axis acc. to 6.3.3
	Timber Design	Member	1810	x: 0.800	DS1	CO3	1.969	ST1600.01	Stability | Bending about y-axis and compression with buckling about both axes acc. to 6.3.2
	Timber Design	Member	1810	x: 0.800	DS1	CO3	1.858	SP6100.00	Section Proof | Bending about y-axis and compressive axial force acc. to 6.2.4
	Timber Design	Member	1501	x: 9.636	DS1	CO3	1.633	SP5100.00	Section Proof | Bending about y-axis and tensile axial force acc. to 6.2.3
	Timber Design	Member	1714	x: 0.000	DS1	CO3	1.444	SP2100.00	Section Proof | Shear due to torsion acc. to 6.1.8
	Timber Design	Member	390	x: 4.684	DS1	CO3	1.068	ST1300.00	Stability | Axial compression with buckling about both axes acc. to 6.3.2
	Timber Design	Member	401	x: 0.000	DS1	CO3	1.042	SP4300.00	Section Proof | Biaxial bending acc. to 6.1.6
	Timber Design	Member	14	x: 1.792	DS1	CO2	1.034	ST1600.02	Stability | Bending about z-axis and compression with buckling about both axes acc. to 6.3.2
	Timber Design	Member	218	x: 0.000	DS1	CO3	0.951	SP3200.00	Section Proof | Shear in y-axis acc. to 6.1.7 | Rectangular section
	Timber Design	Member	1471	x: 2.560	DS1	CO3	0.911	SP1200.00	Section Proof | Compression along grain acc. to 6.1.4
	Timber Design	Member	1706	x: 2.435	DS1	CO3	0.589	ST3200.00	Stability | Bending about z-axis and compression acc. to 6.3.3
	Timber Design	Member	24	x: 2.286	DS1	CO3	0.542	SP1100.00	Section Proof | Tension along grain acc. to 6.1.2
	Timber Design	Member	1709	x: 0.225	DS1	CO3	0.529	SP5200.00	Section Proof | Bending about z-axis and tensile axial force acc. to 6.2.3
	Timber Design	Member	1706	x: 2.250	DS1	CO4	0.445	SP6200.00	Section Proof | Bending about z-axis and compressive axial force acc. to 6.2.4
	Timber Design	Member	187	x: 0.000	DS1	CO3	0.391	ST2200.00	Stability | Flexural member without compression force | Bending about z-axis acc. to 6.3.3
	Timber Design	Member	464	x: 1.933	DS2	CO8	0.326	SE1100.01	Serviceability | Combination of actions 'Characteristic' | y-direction acc. to 7.2
	Timber Design	Member	464	x: 1.933	DS3	CO13	0.302	SE1100.02	Serviceability | Combination of actions 'Quasi-permanent 1' | y-direction acc. to 7.2
	Timber Design	Member	1573	x: 0.164	DS1	CO3	0.272	SP4200.00	Section Proof | Bending about z-axis acc. to 6.1.6
	Timber Design	Member	163	x: 3.201	DS1	CO1	0.212	SP4100.00	Section Proof | Bending about y-axis acc. to 6.1.6
	Timber Design	Member	219,253,434,457,972,1527,1578,1827	x: 0.000	DS1	CO1	0.000	SP0100.00	Section Proof | Negligible internal forces
	Timber Design	Member	6, 13-15,17,24,29,30,39,41-44,46-52,61-64,73-82,95,107,160,162-173,185-188,196,198,201-208,211,216-219,225,226,229-231,25	x: 0.000	DS2	CO6	0.000	SE0100.01	Serviceability | Negligible deflection | Combination of actions 'Characteristic'

Trial Version

10.1 DESIGN OVERVIEW

	Addon	Objects Type	No.	Location [m]	Design Situation	Loading No.	Design Check Ratio η [--]	Type	Description
			0,253,257-260,262-266,276-278,280,285,290,292,294,296,298,300-311,314,327,328,330,335-342,347-349,351-353,355-357,359,364-366,368,369,371,372,374,375,382-388,390-393,396,397,399,401-403,406,407,409,412,413,418-421,424-427,430-459,464,468-471,473,474,476,477,840,841,972,1449,1468-1525,1527-1691,1693,1694,1696-1754,1757,1758,1760,1761,1763,1765,1767-1769,1772-1779,1789-182						
	Timber Design	Member	6,13-15,17,24,29,30,39,41-44,46-52,61-64,73-82,95,107,160,162-173,185-188,196,198,201-208,211,216-219,225,226,229-231,250,253,257-260,262-266,276-278,280,285,290,292,294,296,298,300-311,314,327,328,330,335-342,347-349,351-353,355-357,359,364-366,368,369,371,372,374,375,382-388,390-393,396,397,399,401-403,406,407,409,412,413,418-421,424-427,430-459,464,468-471,473,474,476,477,840,841,972,1449,1468-1525,1527-1691,1693,1694,1696-1754,1757,1758,1760,1761,1763,1765,1767-1769,1772-1779,1789-182	x: 0.000	DS3	CO11	0.000 ✓	SE0100.02	Serviceability | Negligible deflection | Combination of actions 'Quasi-permanent 1'

Trial Version

2.4. Zaključak

Statički proračun modela provođen je na temelju zadanih opterećenja snijegom, vjetrom, vlastite težine konstrukcije te dodatnog stalnog opterećenja, prema geometrijski linearnom proračunu konstrukcija. Iz rezultata je vidljivo kako su kriteriji graničnih stanja nosivosti i graničnih stanja uporabljivosti zadovoljeni s obzirom na postavljene uvjete prema zahtjevima Eurokoda 5 za projektiranje drvenih konstrukcija uz hrvatske nacionalne dodatke za projektiranje drvenih konstrukcija.

3. Popis slika

4. Literatura:

[1] Bačić, M., Ivšić, T., Kovačević, M. S.: Geotehnika kao nezaobilazan segment potresnog inženjerstva, *GRAĐEVINAR, 72* (2020) 10, pp. 923-936, doi: https://doi.org/10.14256/JCE.2968.2020

[2] Hršak, D.: Potres u Zagrebu i utjecaj potresa na građevinske objekte, završni rad, fakultet kemijskog inženjerstva i tehnologije Sveučilišta u Zagrebu, 2021.

[3] https://www.researchgate.net/figure/The-interaction-between-the-Africa-and-Eurasia-plates-generates-a-diffuse-area-of_fig1_271200275

[4] Šavor Z., Radić J., Mandić A.: Neke usporedbe hrvatskih i europskih norma za djelovanja, *GRAĐEVINAR, 58* (2006) 8, pp. 641-648

[5] http://seizkarta.gfz.hr/hazmap/karta.php

[6] Perić, Lj.: Nova paradigma dimenzioniranja na potresna djelovanja (Performance Based Seismic Engineering – PBSE) na primjeru nelinearnoga odziva zidova tipičnih drvenih konstrukcija, e-Zbornik, broj 16, prosinac 2018.

[7] Perić, Lj.: Proračun duktilnih konstrukcija na potresna djelovanja, *GRAĐEVINAR, 60* (2008) 10, pp. 867-875

[8] https://www.naturallywood.com/wood-performance/resilience/

[9] Rajčić V.: Svojstva drva kao materijala, predavanje, kolegij Drvene konstrukcije, Građevinski fakultet Sveučilišta u Zagrebu

[10] Bjelanović A., Rajčić V.: Drvene konstrukcije prema europskim normama, Zagreb, 2007.

[11] Seim W., Hummel J.: Earthquake design of timber structures – Remarks on force-based design procedures for different wall systems, Volume 76, 1 October 2014, Pages 124-137 https://doi.org/10.1016/j.engstruct.2014.06.037

[12] https://www.moelven.com/mjostarnet/

[13] https://www.fastcompany.com/90897645/wooden-high-rise-survived-earthquakes