

# 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**

Lea Schiller

SVEUČILIŠTE U ZAGREBU  
GRAĐEVINSKI FAKULTET ZAGREB

**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 Dlubal 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 Dlubal 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

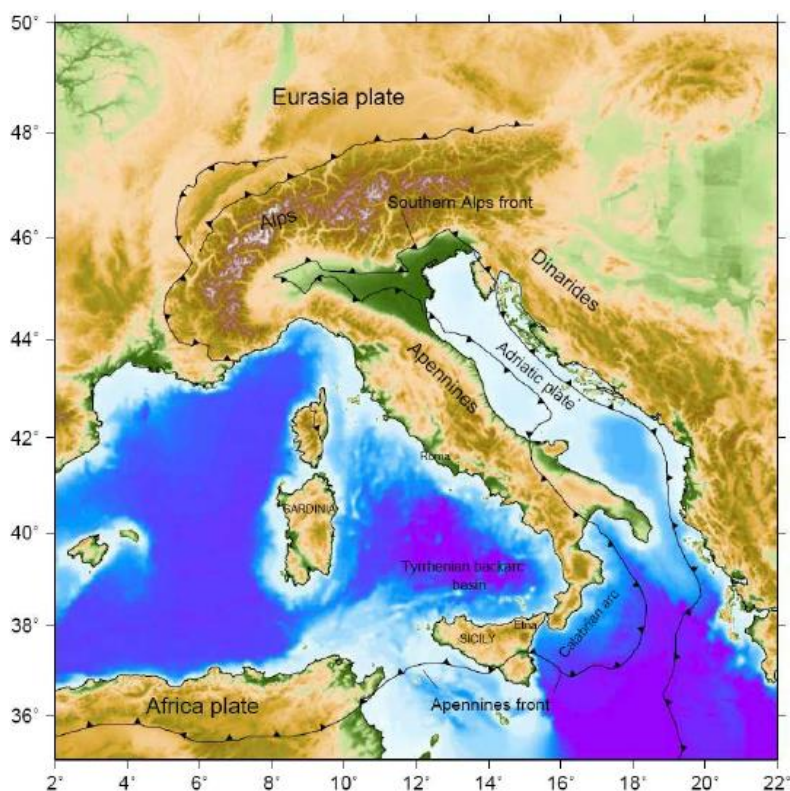
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# 1. Uvodni dio: Ponašanje drvenih konstrukcija u potresu

## 1.1. Potresno djelovanje

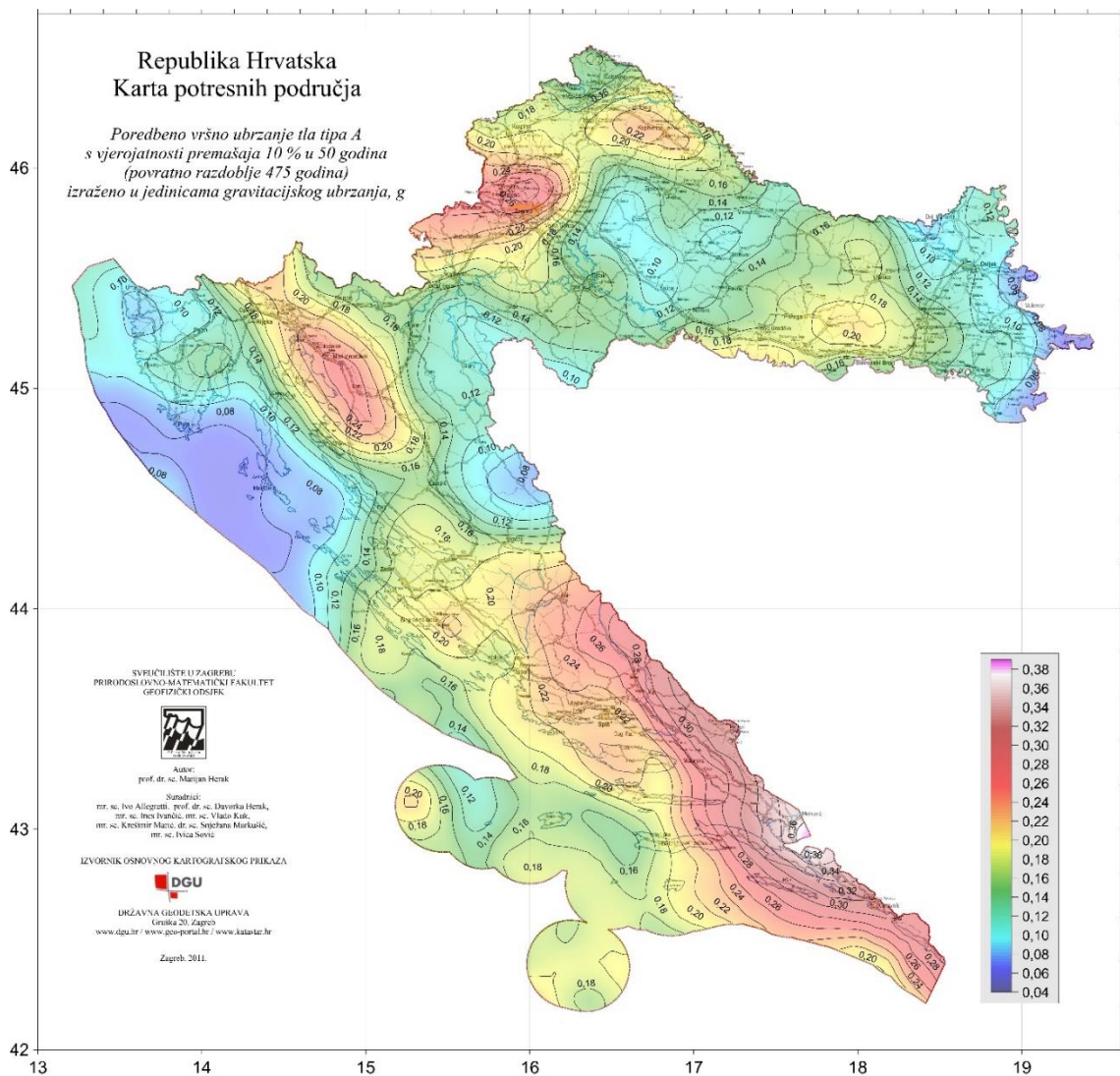
Potres je pojava koja se javlja zbog različitih promjena i pomaka u Zemljinoj kori, a karakteriziran je svojom vjerojatnošću pojavljivanja jer je po svojoj prirodi to “slučajna” pojava koja može imati značajne i razorne posljedice na građevinske objekte. Uzrocima nastanka, te izučavanjem posljedica i fizikalnim opisivanjem potresa bavi se geofizika, odnosno seizmologija, te strukturalna 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 konstrukcija 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 ekvivalentna 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 magnituda 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 Dlubal 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 Dlubal 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

Empty text box for client information.

## CREATED BY

Empty text box for creator information.

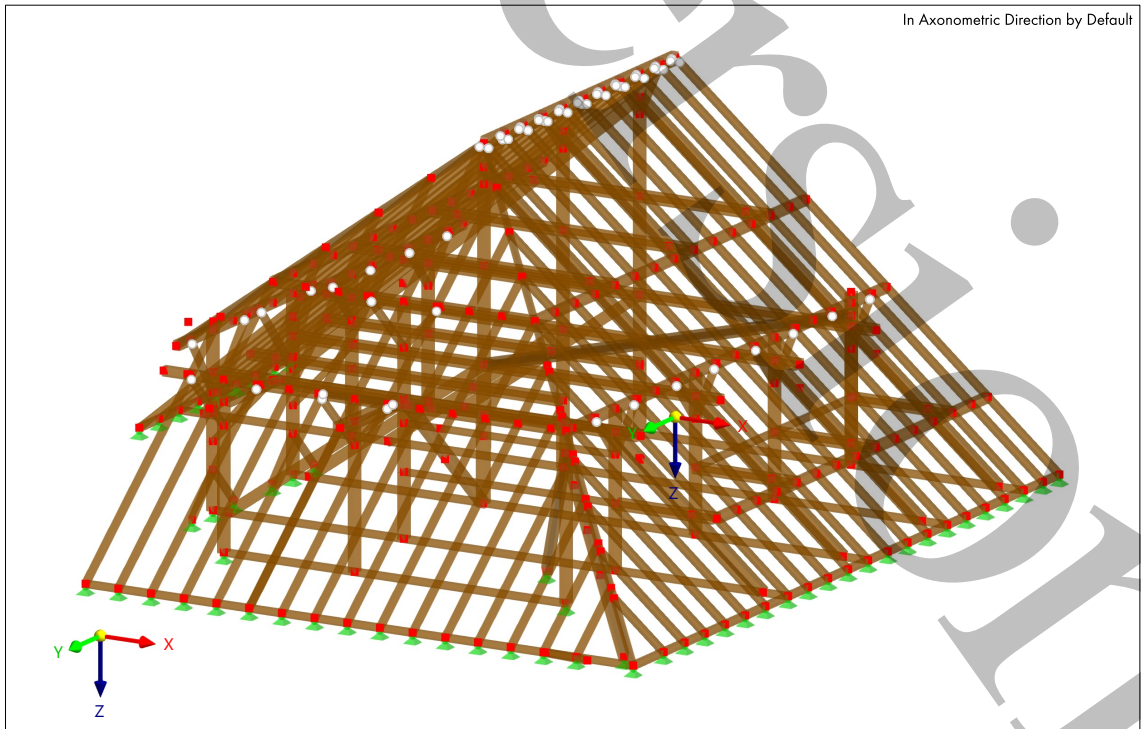
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## PROJECT

Empty text box for project information.

## MODEL





## MODEL

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MODEL

A MODEL - LOCATION

<b>Location</b>	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 <sub>x</sub> [cm <sup>4</sup> ]	I <sub>y</sub> [cm <sup>4</sup> ]	I <sub>z</sub> [cm <sup>4</sup> ]	Overall Dimensions	
				A [cm <sup>2</sup> ]	A <sub>y</sub> [cm <sup>2</sup> ]	A <sub>z</sub> [cm <sup>2</sup> ]	b [mm]	h [mm]
1	1	R_M1 300/200   1 - C18 Parametric - Massive I	1 - C18	46953.09	20000.00	45000.00	300.0	200.0
				600.00	500.00	500.00		
2	1	R_M1 200/320   1 - C18 Parametric - Massive I	1 - C18	52160.58	54613.33	21333.33	200.0	320.0
				640.00	533.33	533.33		
3	1	R_M1 180/240   1 - C18 Parametric - Massive I	1 - C18	25192.30	20736.00	11664.00	180.0	240.0
				432.00	360.00	360.00		
4	1	R_M1 140/170   1 - C18 Parametric - Massive I	1 - C18	7791.19	5731.83	3887.33	140.0	170.0
				238.00	198.33	198.33		
5	1	2R_M2 220/120/150/1   1 - C18 Parametric - Massive II	1 - C18	16762.25	21296.05	102465.08	390.0	220.0
				528.00	0.00	441.43		
6	1	R_M1 150/150   1 - C18 Parametric - Massive I	1 - C18	7129.69	4218.75	4218.75	150.0	150.0
				225.00	187.50	187.50		
7	1	R_M1 220/270   1 - C18 Parametric - Massive I	1 - C18	48445.27	36085.50	23958.00	220.0	270.0
				594.00	495.00	495.00		
8	1	R_M1 50/30   1 - C18 Parametric - Massive I	1 - C18	28.17	11.25	31.25	50.0	30.0
				15.00	12.50	12.50		
9	1	R_M1 150/170   1 - C18 Parametric - Massive I	1 - C18	9030.75	6141.25	4781.25	150.0	170.0
				255.00	212.50	212.50		



MODEL

1.3 CROSS SECTIONS

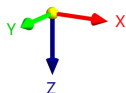
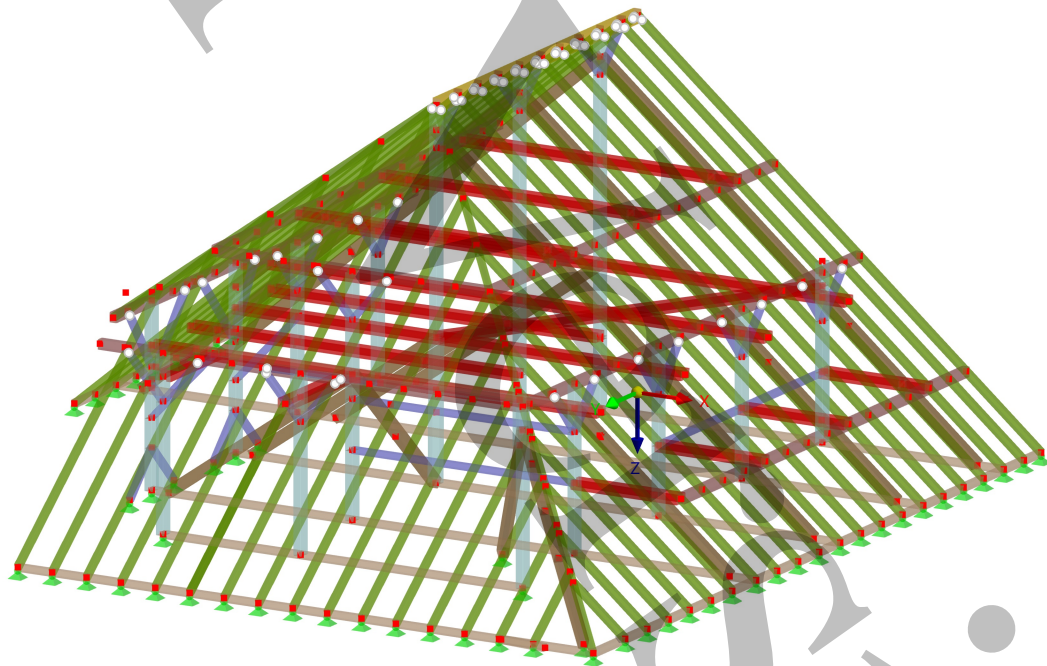
Static Analysis

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

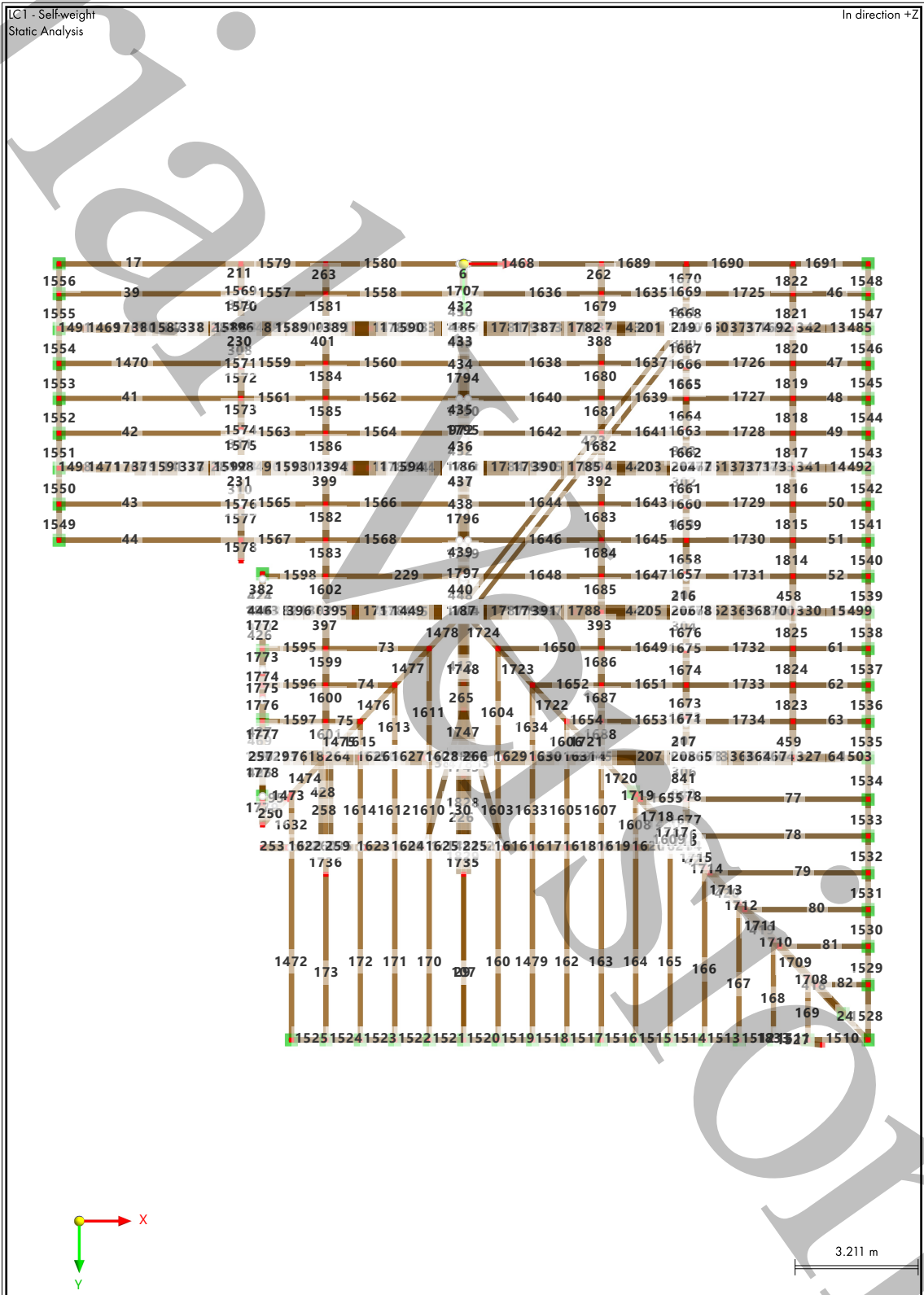




MODEL

1.4 MEMBERS - NUMBERING

Static Analysis





**MODEL**

**2 Types for Nodes**

**2.1 NODAL SUPPORTS**

Support No.	Nodes No.	Coordinate System	Translation Spring [kN/m]			Rotation Spring [kNm/rad]		
			C <sub>u,x</sub>	C <sub>u,y</sub>	C <sub>u,z</sub>	C <sub>φ,x</sub>	C <sub>φ,y</sub>	C <sub>φ,z</sub>
1	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>   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	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

**3 Types for Members**

**3.1 MEMBER HINGES**

Hinge No.	Coordinate System	Translation Spring [kN/m]			Rotation Spring [kNm/rad]		
		C <sub>u,x</sub>	C <sub>u,y</sub>	C <sub>u,z</sub>	C <sub>φ,x</sub>	C <sub>φ,y</sub>	C <sub>φ,z</sub>
1	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>   Local xyz Local xyz	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

**4 Types for Timber Design**

**4.1 SERVICE CLASSES**

Class No.	Members	Assigned to			Service Class Type	Comment
		Member Sets	Surfaces	Surface Sets		
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**



**LOADS**

5.1 **LOAD CASES**

LC No.	Settings	Value	Unit	To Solve
1	<b>Self-weight</b>			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Action category	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	<b>Snow</b>			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Action category	Snow/Ice loads - H <= 1000 m		
Load duration	Short-term			
3	<b>Wind</b>			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Action category	Wind		
Load duration	Short-term			
4	<b>dodatno stalno opterećenje</b>			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Action category	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	<b>Permanent</b>		
	Action Category	Permanent	<input checked="" type="checkbox"/>
	Action Type	Simultaneously	
5	<b>Snow/Ice loads - H &lt;= 1000 m</b>		
	Action Category	Snow/Ice loads - H <= 1000 m	<input checked="" type="checkbox"/>
	Action Type	Alternatively	
6	<b>Wind</b>		
	Action Category	Wind	<input checked="" type="checkbox"/>
	Action Type	Alternatively	

5.3 **DESIGN SITUATIONS**

DS No.	Settings	Value	Active
1	<b>ULS (STR/GEO) - Permanent and transient - Eq. 6.10</b>		
	Design situation type	ULS (STR/GEO) - Permanent and transient - Eq. 6.10	<input checked="" type="checkbox"/>
	Combination wizard	2	
	Consider inclusive/exclusive load cases	<input type="checkbox"/>	
2	<b>SLS - Characteristic</b>		
	Design situation type	SLS - Characteristic	<input checked="" type="checkbox"/>
	Combination wizard	2	
	Consider inclusive/exclusive load cases	<input type="checkbox"/>	
3	<b>SLS - Quasi-permanent</b>		
	Design situation type	SLS - Quasi-permanent	<input checked="" type="checkbox"/>
	Combination wizard	2	
	Consider inclusive/exclusive load cases	<input type="checkbox"/>	



## MODEL

5.3

## DESIGN SITUATIONS

DS No.	Settings	Value	Active
	cases		

5.4

## ACTION COMBINATIONS

AC No.	Settings	Value	Active
1	<b>ULS</b> 1.35 * A4 Design Situation	<b>ULS</b> DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	1 Design Situation No. 1	
2	<b>ULS</b> 1.35 * A4 + 1.50 * A5 Design Situation	<b>ULS</b> DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	2 Design Situation No. 1	
3	<b>ULS</b> 1.35 * A4 + 1.50 * A5 + 0.90 * A6 Design Situation	<b>ULS</b> DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	3 Design Situation No. 1	
4	<b>ULS</b> 1.35 * A4 + 1.50 * A6 Design Situation	<b>ULS</b> DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	4 Design Situation No. 1	
5	<b>ULS</b> 1.35 * A4 + 0.75 * A5 + 1.50 * A6 Design Situation	<b>ULS</b> DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	5 Design Situation No. 1	
6	<b>SCh</b> A4 Design Situation	<b>SCh</b> DS2 - SLS - Characteristic	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	6 Design Situation No. 2	
7	<b>SCh</b> A4 + A5 Design Situation	<b>SCh</b> DS2 - SLS - Characteristic	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	7 Design Situation No. 2	
8	<b>SCh</b> A4 + A5 + 0.60 * A6 Design Situation	<b>SCh</b> DS2 - SLS - Characteristic	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	8 Design Situation No. 2	
9	<b>SCh</b> A4 + A6 Design Situation	<b>SCh</b> DS2 - SLS - Characteristic	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	9 Design Situation No. 2	
10	<b>SCh</b> A4 + 0.50 * A5 + A6 Design Situation	<b>SCh</b> DS2 - SLS - Characteristic	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	10 Design Situation No. 2	
11	<b>SQp</b> 1.60 * A4 Design Situation	<b>SQp</b> DS3 - SLS - Quasi-permanent	<input checked="" type="checkbox"/>
	Generated load combinations Generated by	11 Design Situation No. 3	
12	<b>SQp</b> 1.60 * A4 + A5		





**MODEL**

5.4 **ACTION COMBINATIONS**

AC No.	Settings	Value	Active
	Design Situation	<b>S Co p</b> DS3 - SLS - Quasi-permanent	<input checked="" type="checkbox"/>
	Generated load combinations	12	
	Generated by	Design Situation No. 3	
13	<b>S Co p</b> $1.60 * A4 + A5 + 0.60 * A6$		
	Design Situation	<b>S Co p</b> DS3 - SLS - Quasi-permanent	<input checked="" type="checkbox"/>
	Generated load combinations	13	
14	<b>S Co p</b> $1.60 * A4 + A6$		
	Design Situation	<b>S Co p</b> DS3 - SLS - Quasi-permanent	<input checked="" type="checkbox"/>
	Generated load combinations	14	
15	<b>S Co p</b> $1.60 * A4 + 0.50 * A5 + A6$		
	Design Situation	<b>S Co p</b> DS3 - SLS - Quasi-permanent	<input checked="" type="checkbox"/>
	Generated load combinations	15	
	Generated by	Design Situation No. 3	

5.5 **LOAD COMBINATIONS**

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



**MODEL**

5.5 **LOAD COMBINATIONS**

CO No.	Settings	Value	Unit	To Solve
9	<b>SCh</b> LC1 + LC4 + LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	<b>SCh</b> DS2 - SLS - Characteristic		
10	<b>SCh</b> LC1 + LC4 + 0.50 * LC2 + LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	<b>SCh</b> DS2 - SLS - Characteristic		
11	<b>SOp</b> 1.60 * LC1 + 1.60 * LC4			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	<b>SOp</b> DS3 - SLS - Quasi-permanent		
12	<b>SOp</b> 1.60 * LC1 + 1.60 * LC4 + LC2			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	<b>SOp</b> DS3 - SLS - Quasi-permanent		
13	<b>SOp</b> 1.60 * LC1 + 1.60 * LC4 + LC2 + 0.60 * LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	<b>SOp</b> DS3 - SLS - Quasi-permanent		
14	<b>SOp</b> 1.60 * LC1 + 1.60 * LC4 + LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	<b>SOp</b> DS3 - SLS - Quasi-permanent		
15	<b>SOp</b> 1.60 * LC1 + 1.60 * LC4 + 0.50 * LC2 + LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
	Static analysis settings	SA1 - Geometrically linear		
	Design Situation	<b>SOp</b> 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		<input type="checkbox"/>	
	Modify loading by multiplier factor		<input type="checkbox"/>	
	Displacements due to member load of type 'Pipe internal pressure' (Bourdon effect)		<input type="checkbox"/>	
	Method for equation system		Direct	
	Plate bending theory		Mindlin	
	Activate mass conversion to load		<input type="checkbox"/>	
	Asymmetric direct solver		<input checked="" type="checkbox"/>	
	Equilibrium for undeformed structure		<input type="checkbox"/>	

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	<input checked="" type="checkbox"/>
	Consider initial state	<input type="checkbox"/>
	Structure modification enabled	<input type="checkbox"/>
	Generate same load combinations without imperfection case	<input type="checkbox"/>
	Consider construction stages	<input type="checkbox"/>



**MODEL**

5.7 COMBINATION WIZARDS

Wizard No.	Settings	Value
	User-defined action combinations	<input type="checkbox"/>
	Favorable permanent actions	<input type="checkbox"/>
	Reduce number of generated combinations	<input type="checkbox"/>
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	<input type="checkbox"/>
	Consider initial state	<input type="checkbox"/>
	Structure modification enabled	<input type="checkbox"/>
	Consider construction stages	<input type="checkbox"/>
	User-defined action combinations	<input type="checkbox"/>
	Favorable permanent actions	<input type="checkbox"/>
	Reduce number of generated combinations	<input type="checkbox"/>

6 Loads

6.1 SNOW DLUBLAL.JPG

6.2 WIND DLUBLAL.JPG



6.3 **LOADING**

**ANALIZA OPTEREĆENJA – Gradska vijećnica**

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

Snijeg (s)	Područje:	3	kontinentalna Hrvatska
	Nadmorska visina:	122	[m.n.m.]
	$\alpha$ =	32	°
	$s_k$ =	1.25	[kn/m2]
	$\mu_{l(a)}$ =	0.8	
	$C_e$ =	1	koeficijent izloženosti
	$C_t$ =	1	toplinski koeficijent
	$s_d = \mu_{l(a)} * C_e * C_t * s_k$		
	$s_d$ =	1	[kn/m2]

Vjetar (w)	$C_{dir}$ =	1	koeficijent smjera vjetra
	$C_{season}$ =	1	koeficijent godišnjeg doba
	$V_{b,0}$ =	20	[m/s]
	$V_b = C_{dir} * C_{season} * V_{b,0}$		
	$V_b$ =	20	[m/s]
	$\rho$ =	1.25	[kg/m <sup>3</sup> ]
	*kategorija terena: III		
	$c_e(z)$ =	1.9	koeficijent izloženosti
	$q_b = \frac{1}{2} * \rho * v_b^2$ [kN/m <sup>2</sup> ]		
	$q_b$ =	0.25	[kN/m <sup>2</sup> ]
	$C_{pe}(H)$ =	-0.96	[m <sup>2</sup> ]
	$C_{pe}(l)$ =	-0.76	[m <sup>2</sup> ]
	$C_{pi}$ =	0.2	[m <sup>2</sup> ]
	$w_e(H) = q_b * c_e(z) * C_{pe}$	-0.55	[kN/m <sup>2</sup> ]
	$w_e(H) = q_b * c_e(z) * C_{pe}$	-0.46	[kN/m <sup>2</sup> ]
$w_e(l) = q_b * c_e(z) * C_{pe}$	-0.46	[kN/m <sup>2</sup> ]	
$w_e(l) = q_b * c_e(z) * C_{pe}$	-0.36	[kN/m <sup>2</sup> ]	
			osnovna brzina vjetra
			gustoća zraka
			osnovni pritisak vjetra
			koeficijent vanjskog pritiska
			koeficijent unutarnjeg pritiska
			opterećenje vjetrom uključujući i unutarnji pritisak
			opterećenje vjetrom bez unutarnjeg pritiska
			opterećenje vjetrom uključujući i unutarnji pritisak
			opterećenje vjetrom bez unutarnjeg pritiska











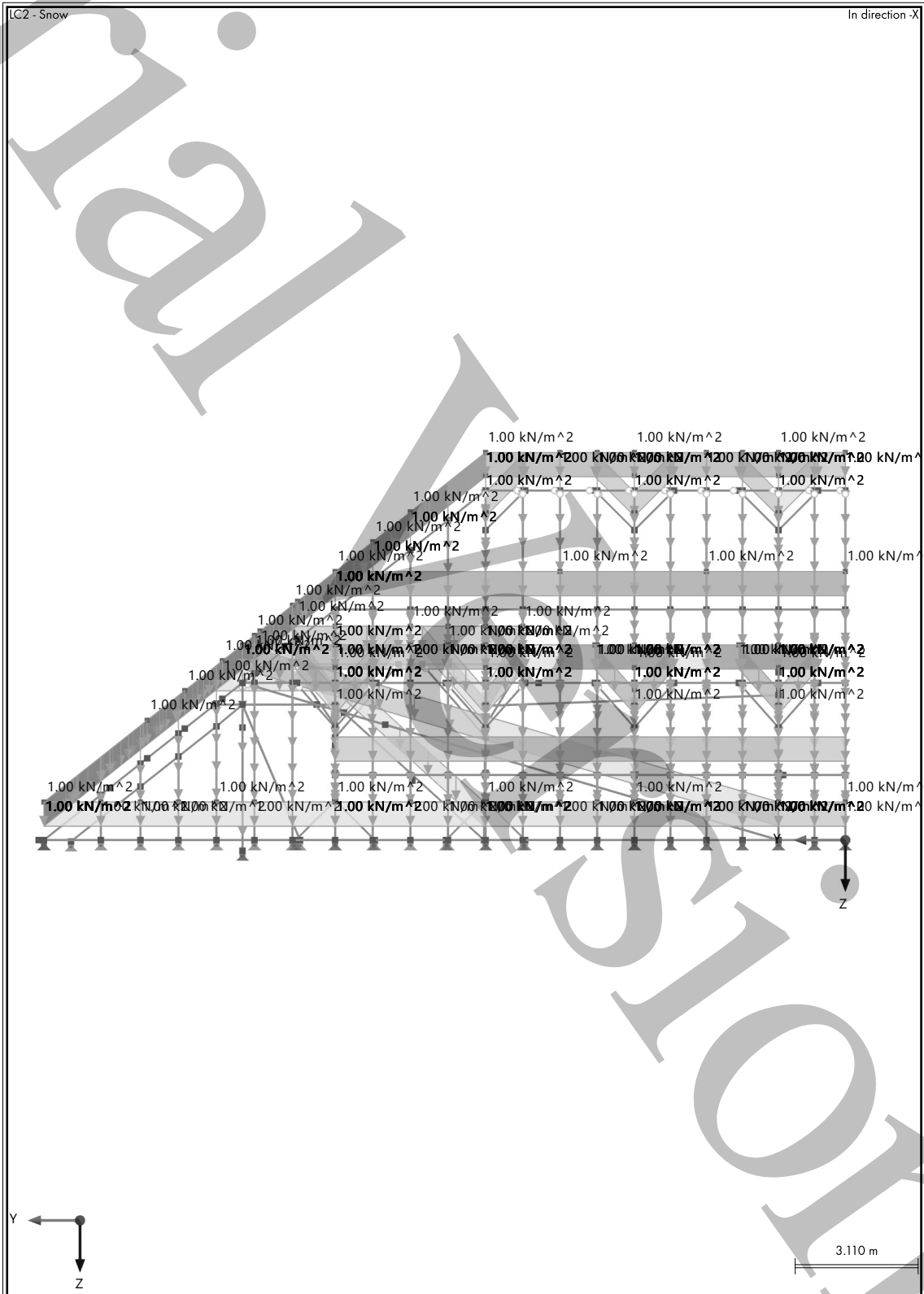






MODEL

6.5.3 LC2: LOADING, IN DIRECTION -X



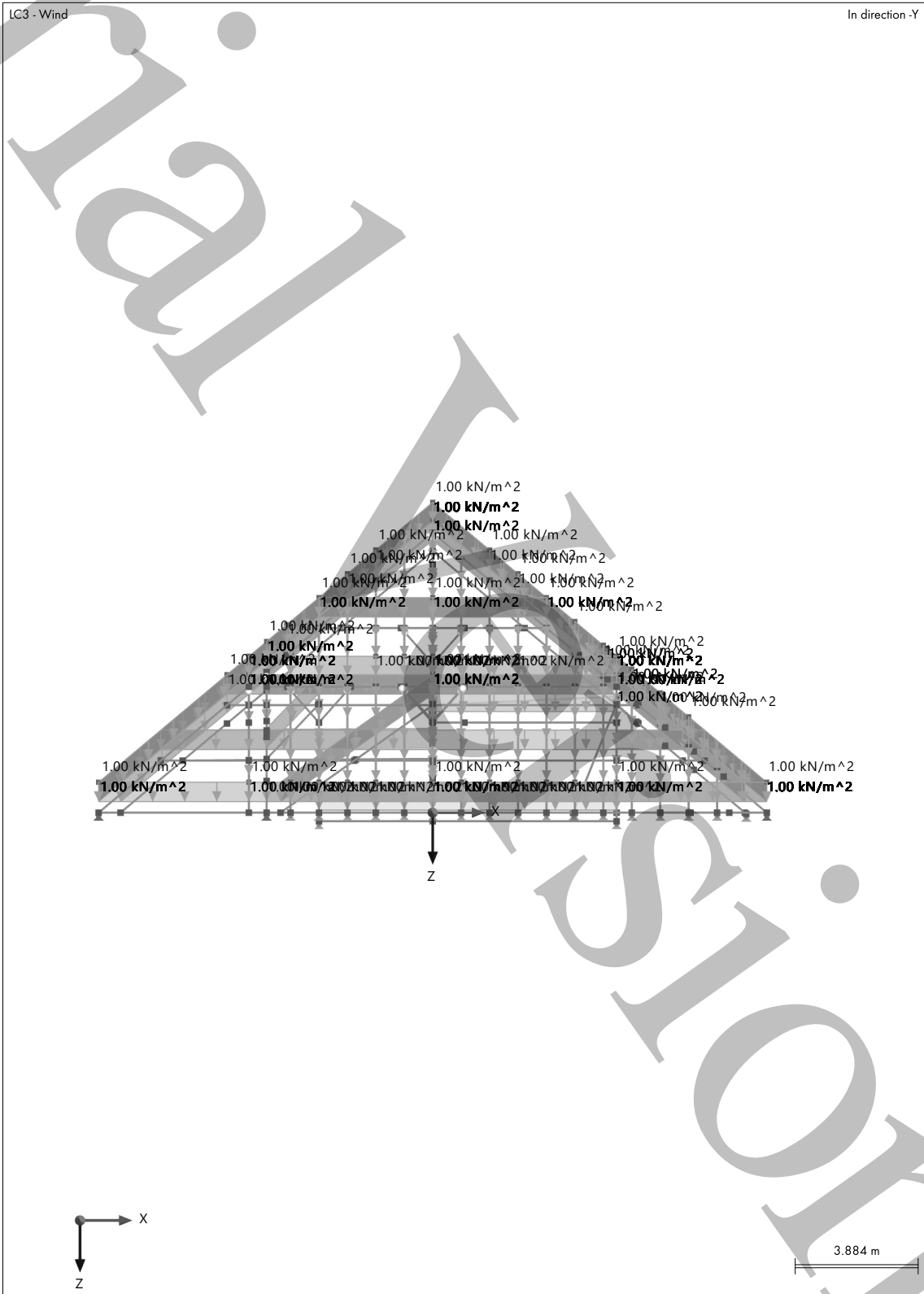






MODEL

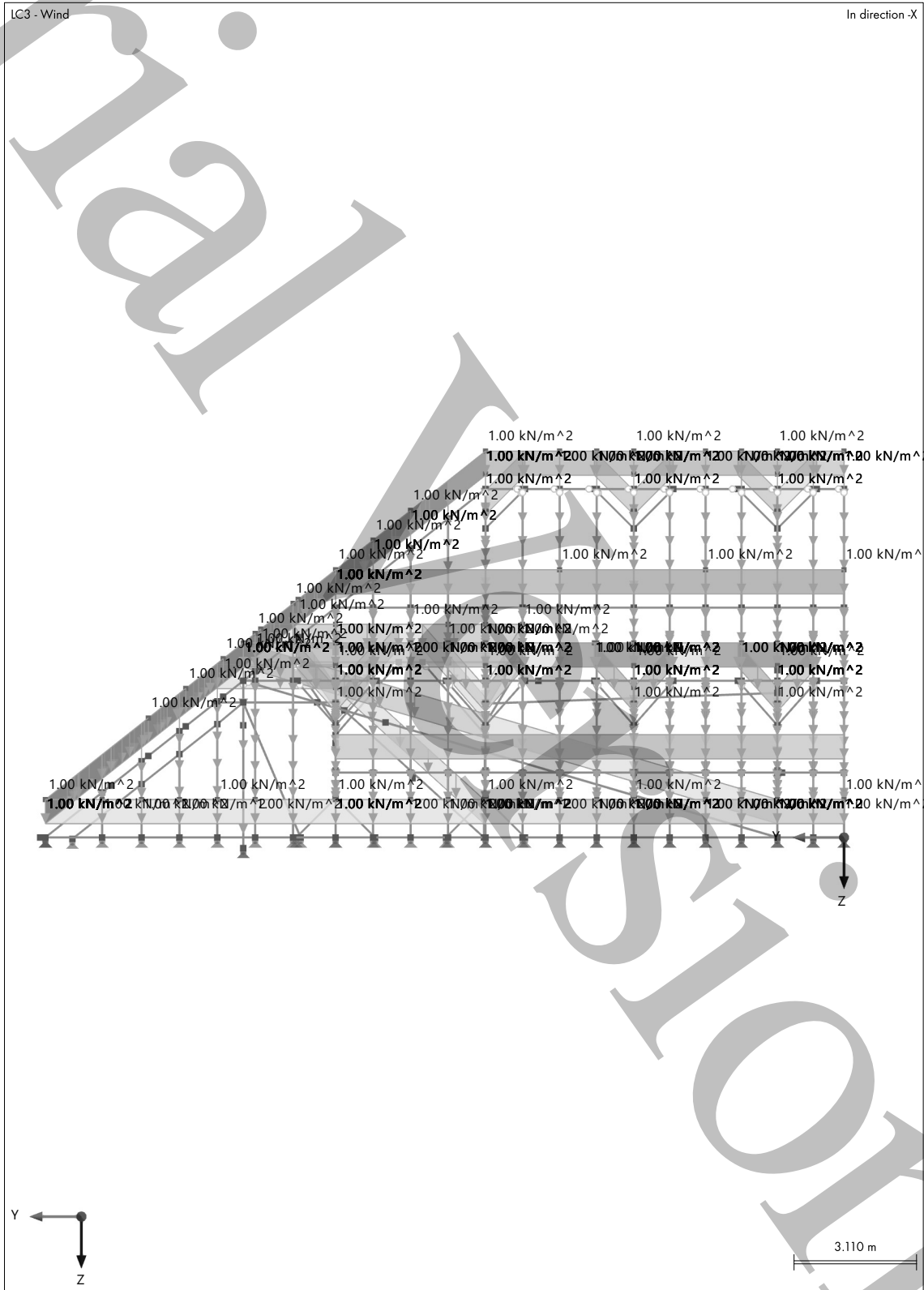
6.6.2 LC3: LOADING, IN DIRECTION -Y





**MODEL**

6.6.3 LC3: LOADING, IN DIRECTION -X









**MODEL**

**7 Guide Objects**

**7.1 COORDINATE SYSTEMS**

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

**8 Static Analysis Results**

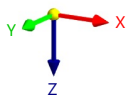
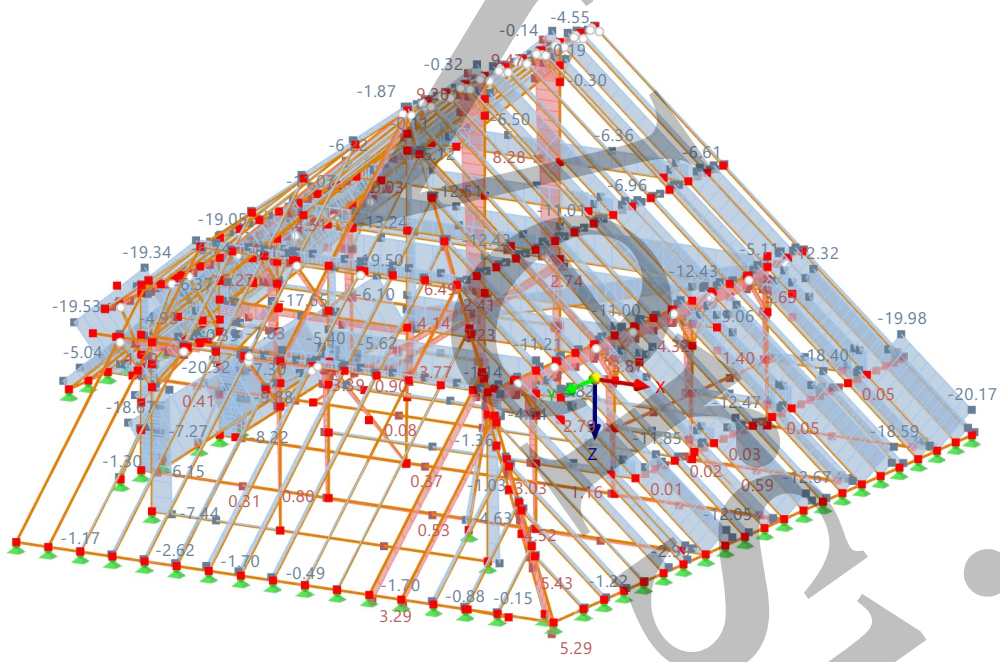


**MODEL**

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

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

In Axonometric Direction by Default



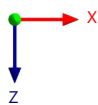
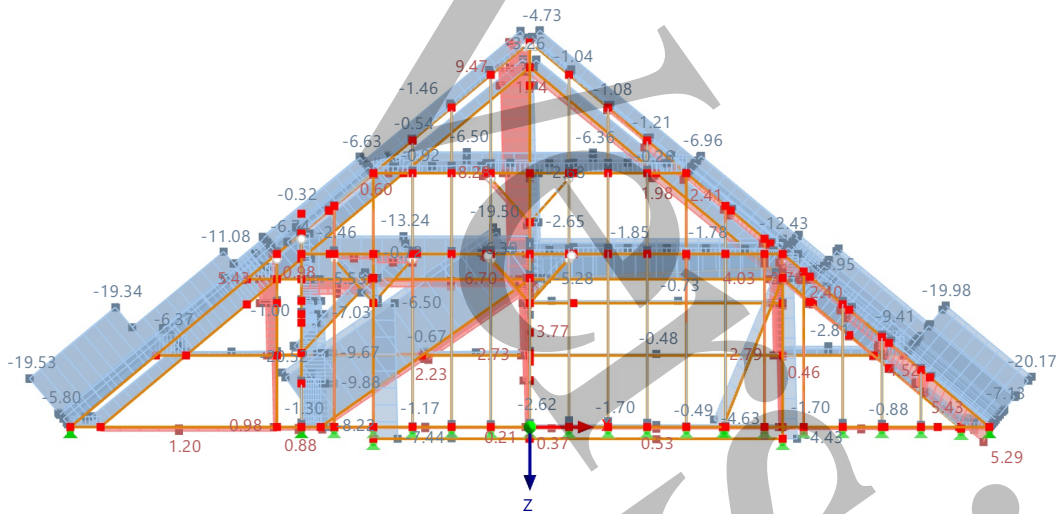
max N : 9.47 | min N : -20.52 kN



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

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

In direction -Y



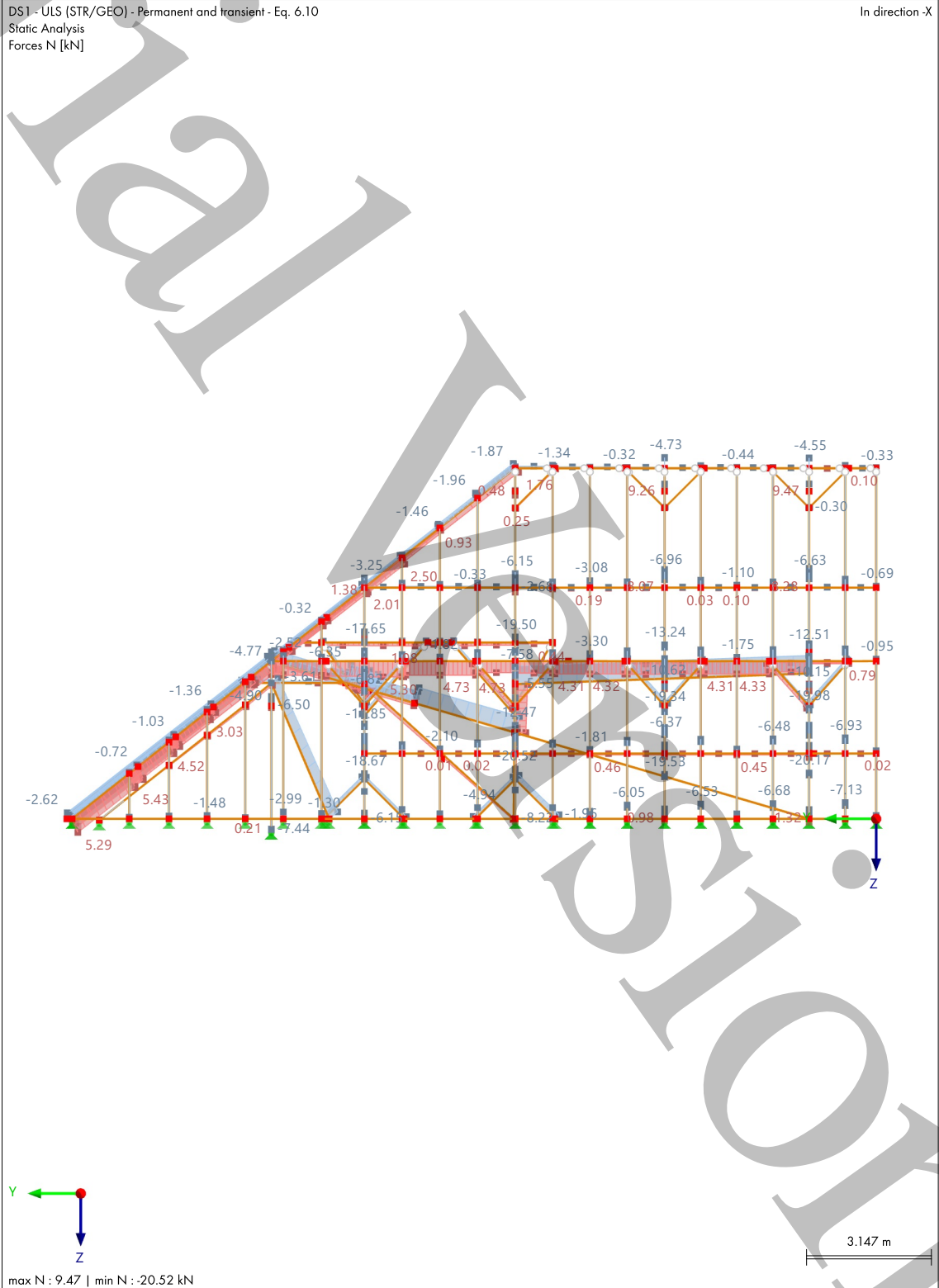
max N : 9.47 | min N : -20.52 kN

3.471 m



**MODEL**

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





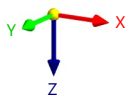
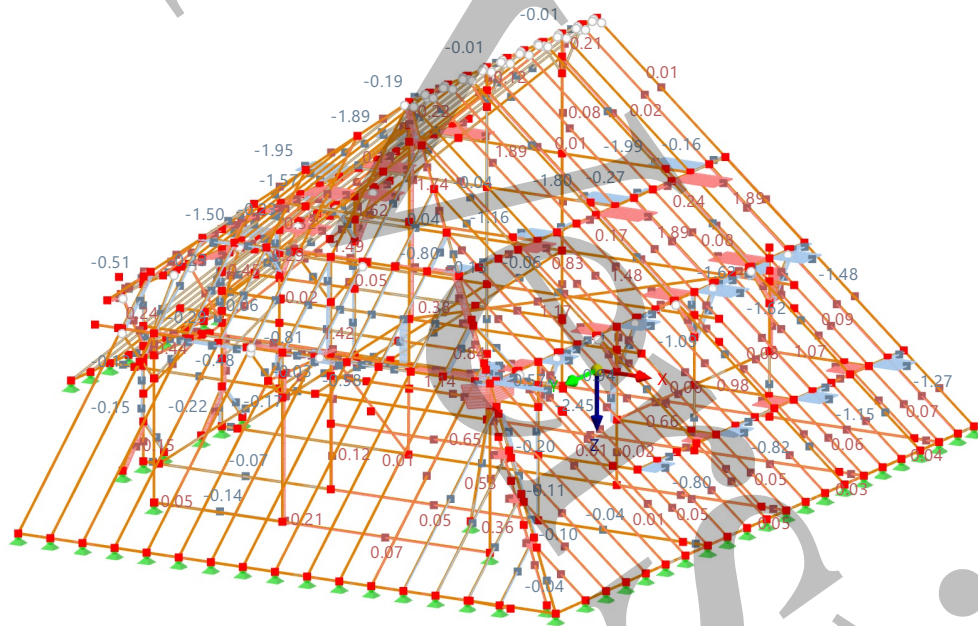
MODEL

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

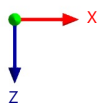
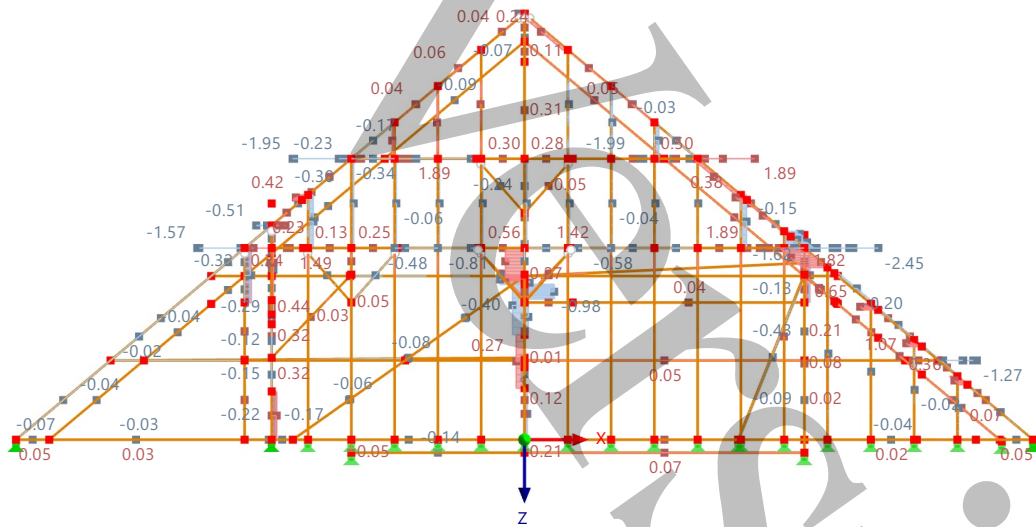


8.5 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES  $V_y$ , IN DIRECTION -Y

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

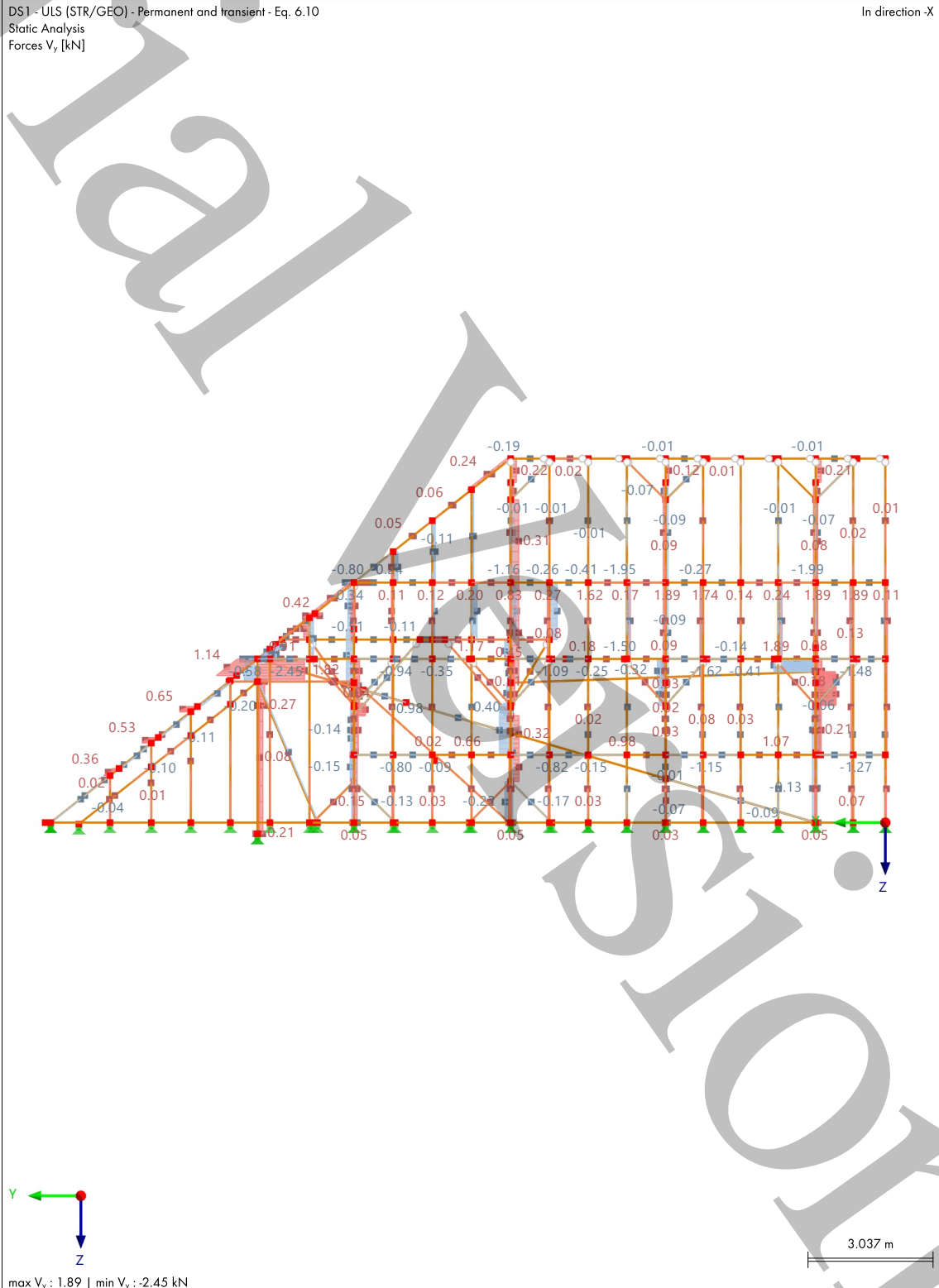
3.137 m



MODEL

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

Static Analysis



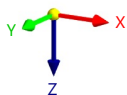
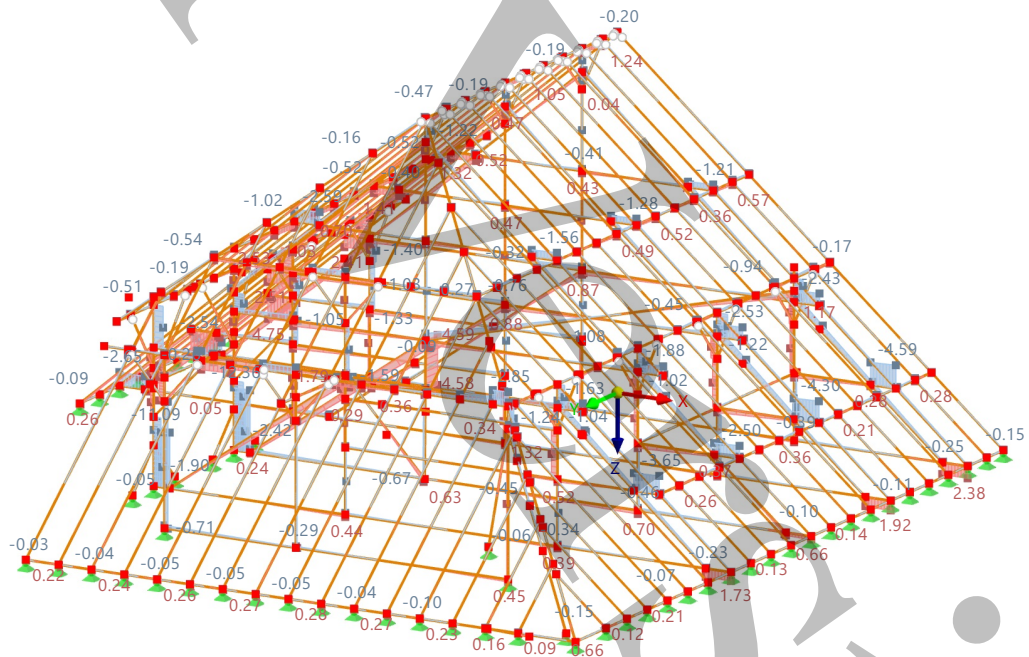


MODEL

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

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

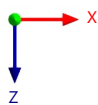
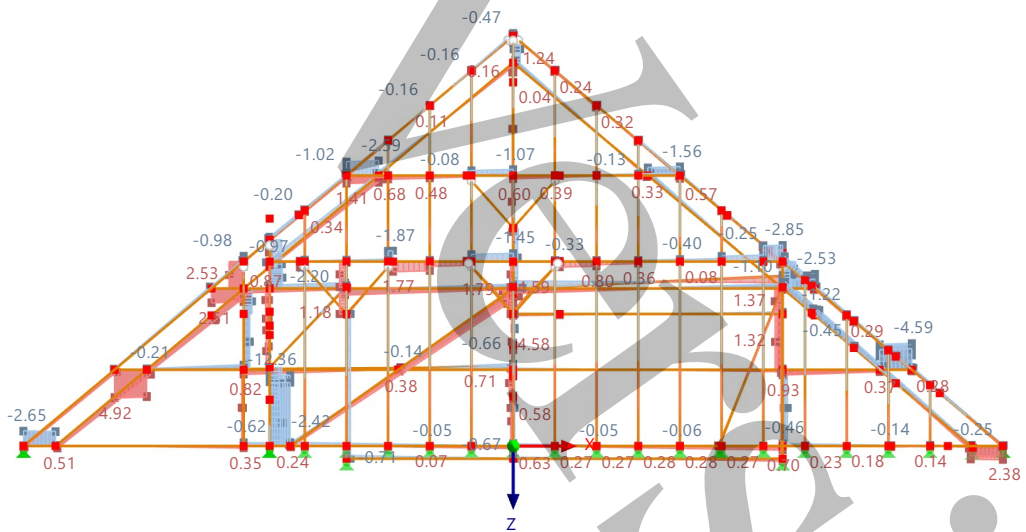




8.8 **DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES  $V_z$ , Static Analysis IN DIRECTION -Y**

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

In direction -Y

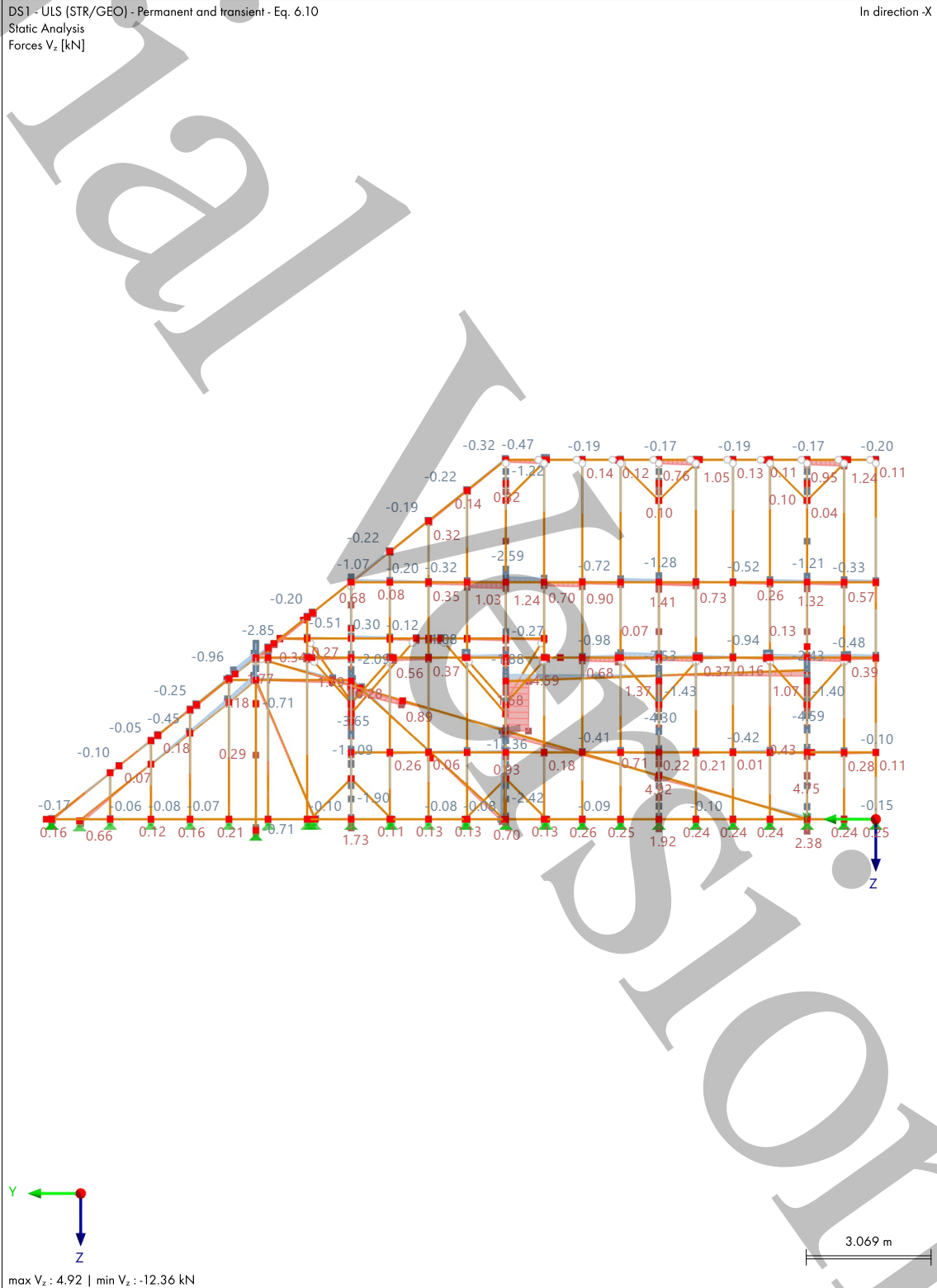


max  $V_z$ : 4.92 | min  $V_z$ : -12.36 kN



MODEL

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





**MODEL**

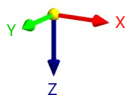
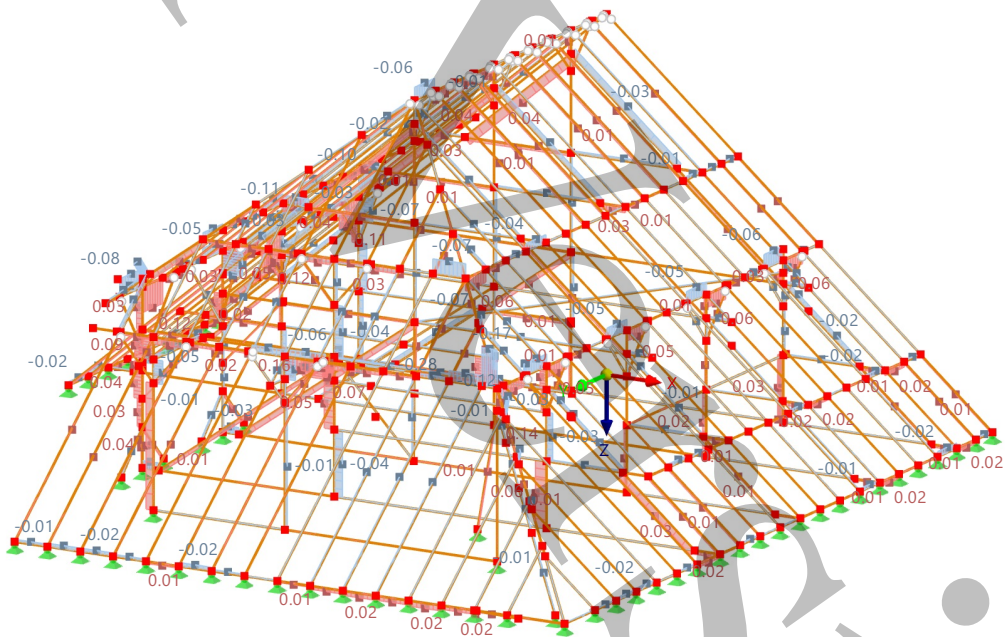
8.10

**DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES  
 $M_{Tr}$  IN AXONOMETRIC DIRECTION BY DEFAULT**

Static Analysis

DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10  
Static Analysis  
Moments  $M_{Tr}$  [kNm]

In Axonometric Direction by Default



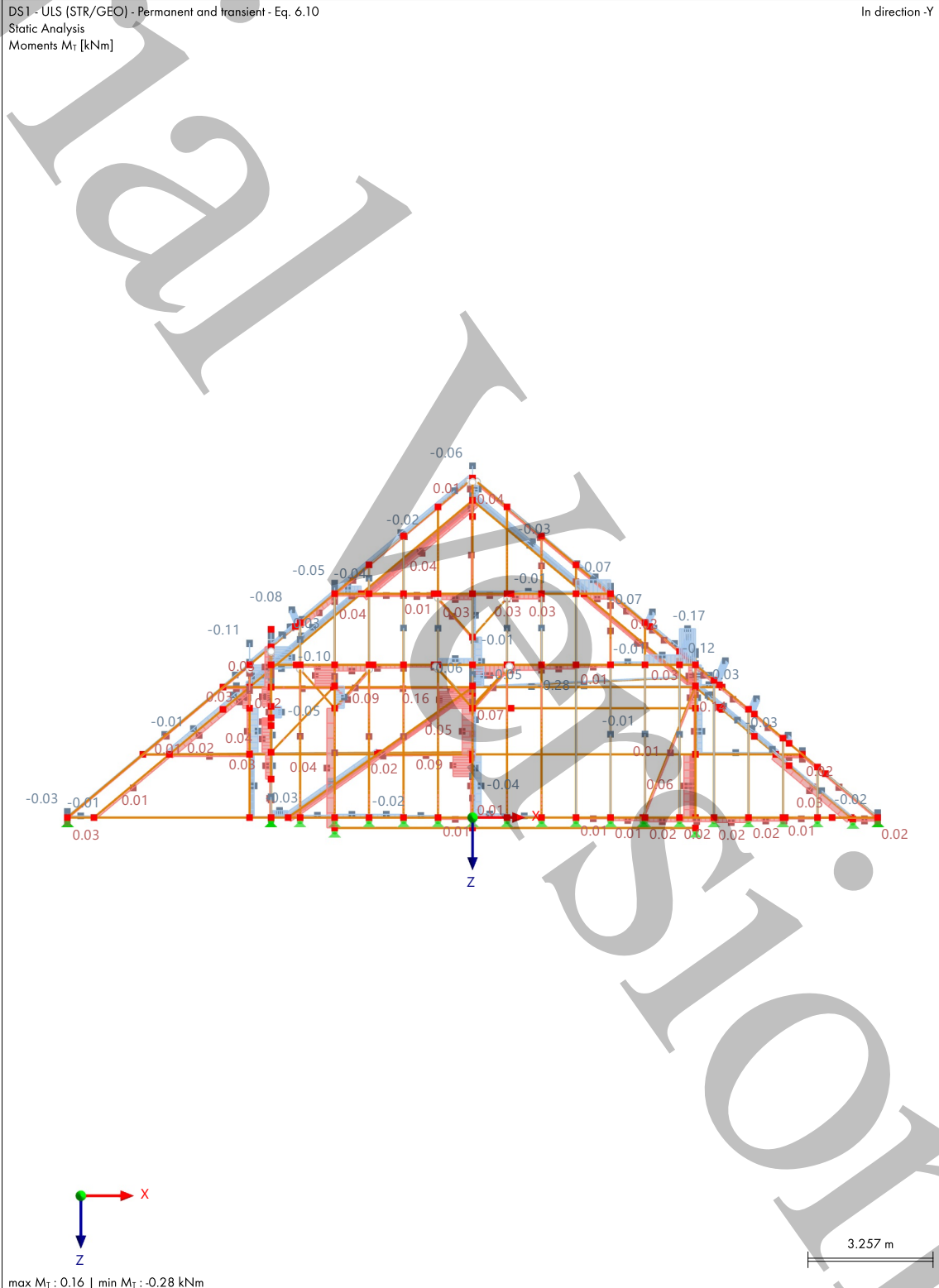
max  $M_{Tr}$  : 0.16 | min  $M_{Tr}$  : -0.28 kNm



MODEL

8.11 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES  
 $M_{Tr}$ , IN DIRECTION -Y

Static Analysis



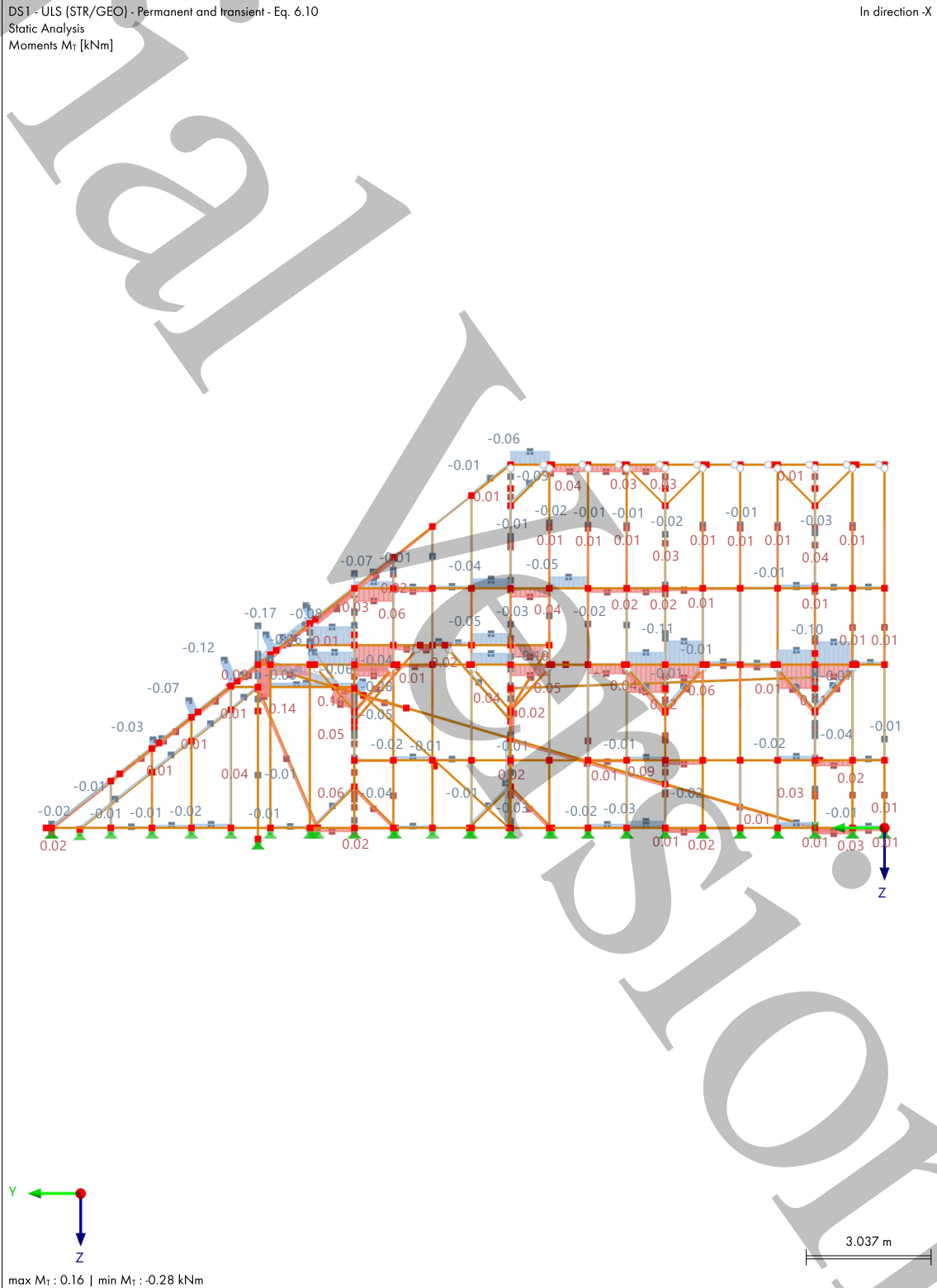


MODEL

8.12

**DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES**  
 **$M_{Tr}$  IN DIRECTION -X**

Static Analysis





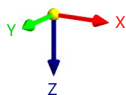
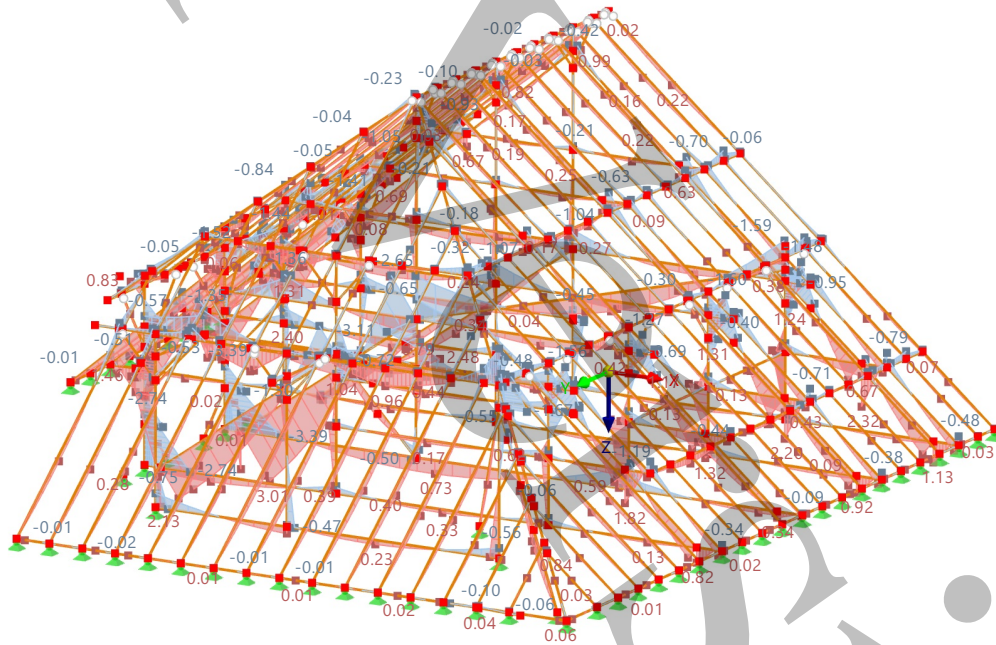
8.13

**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



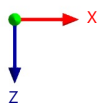
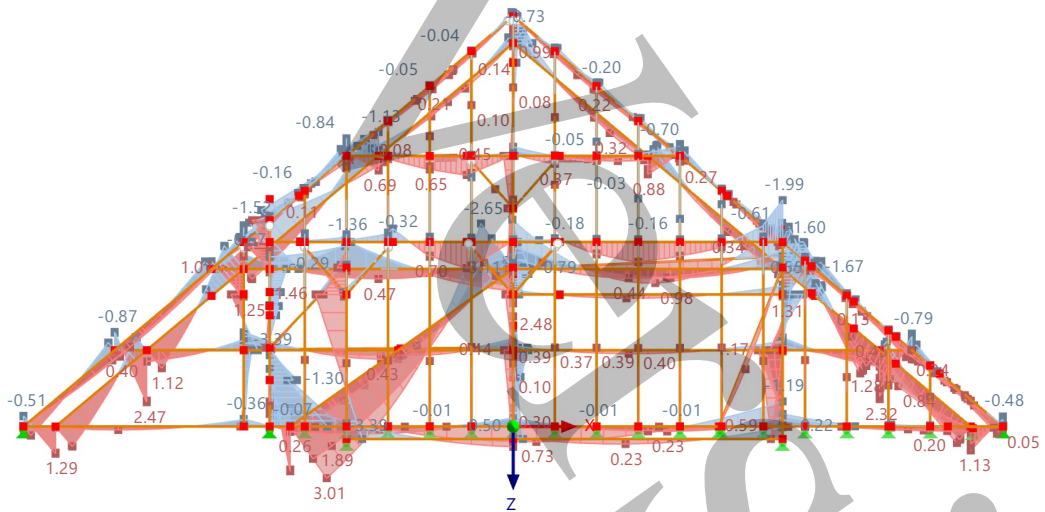
8.14

**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



max  $M_y$  : 3.01 | min  $M_y$  : -3.39 kNm



**MODEL**

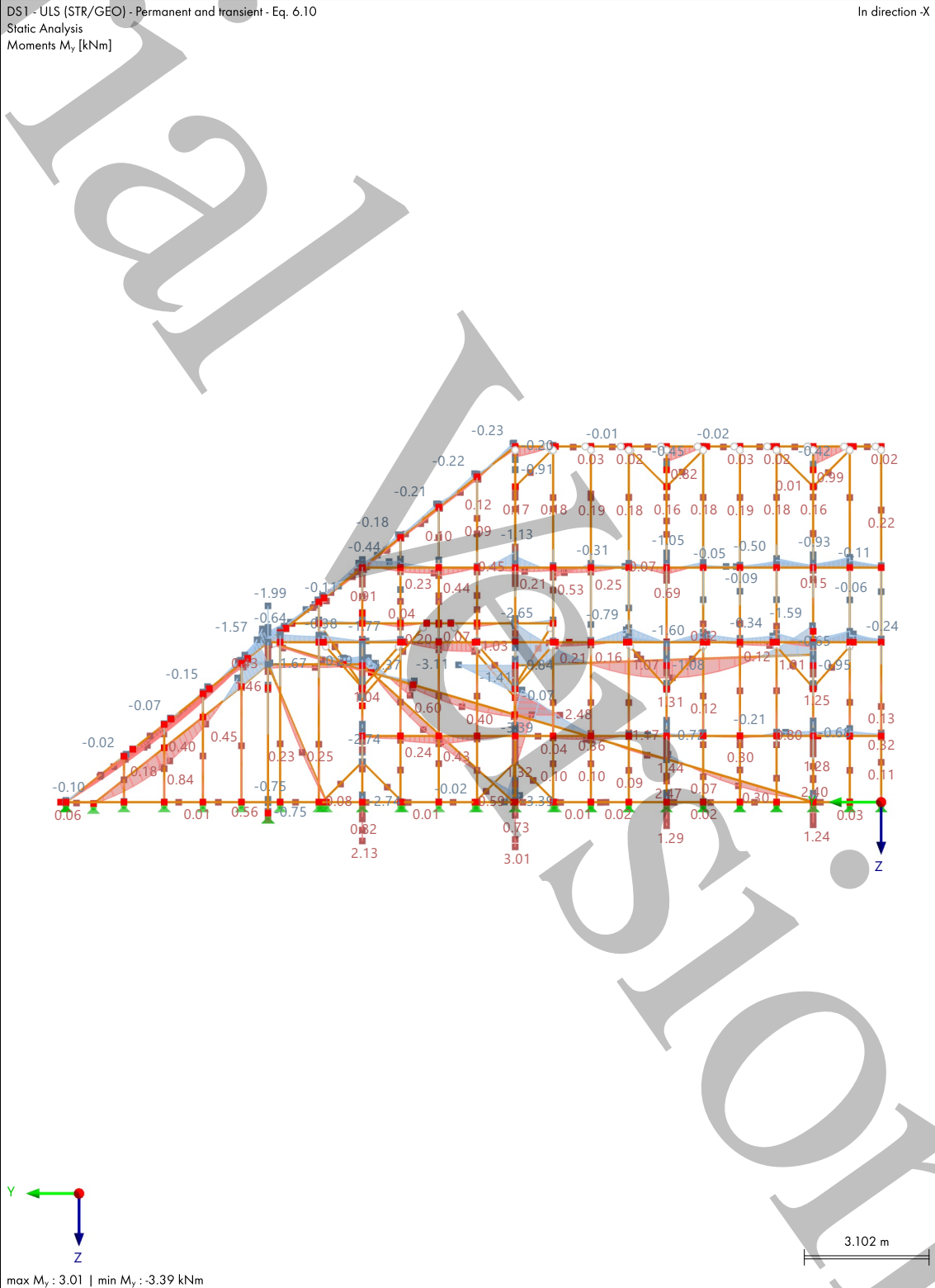
8.15

**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







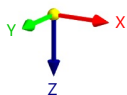
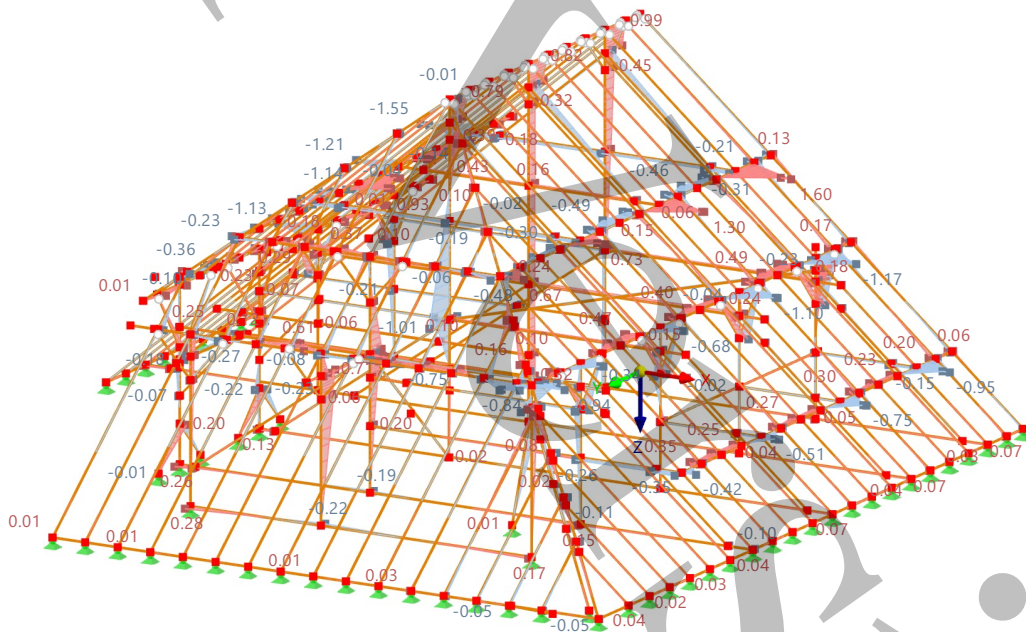
8.16

**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



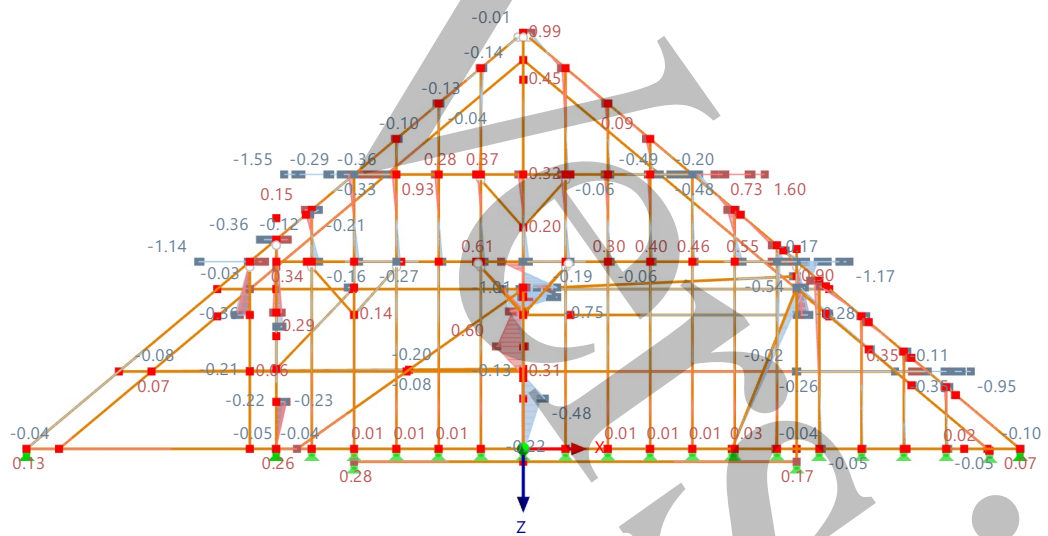
8.17

**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

3.211 m

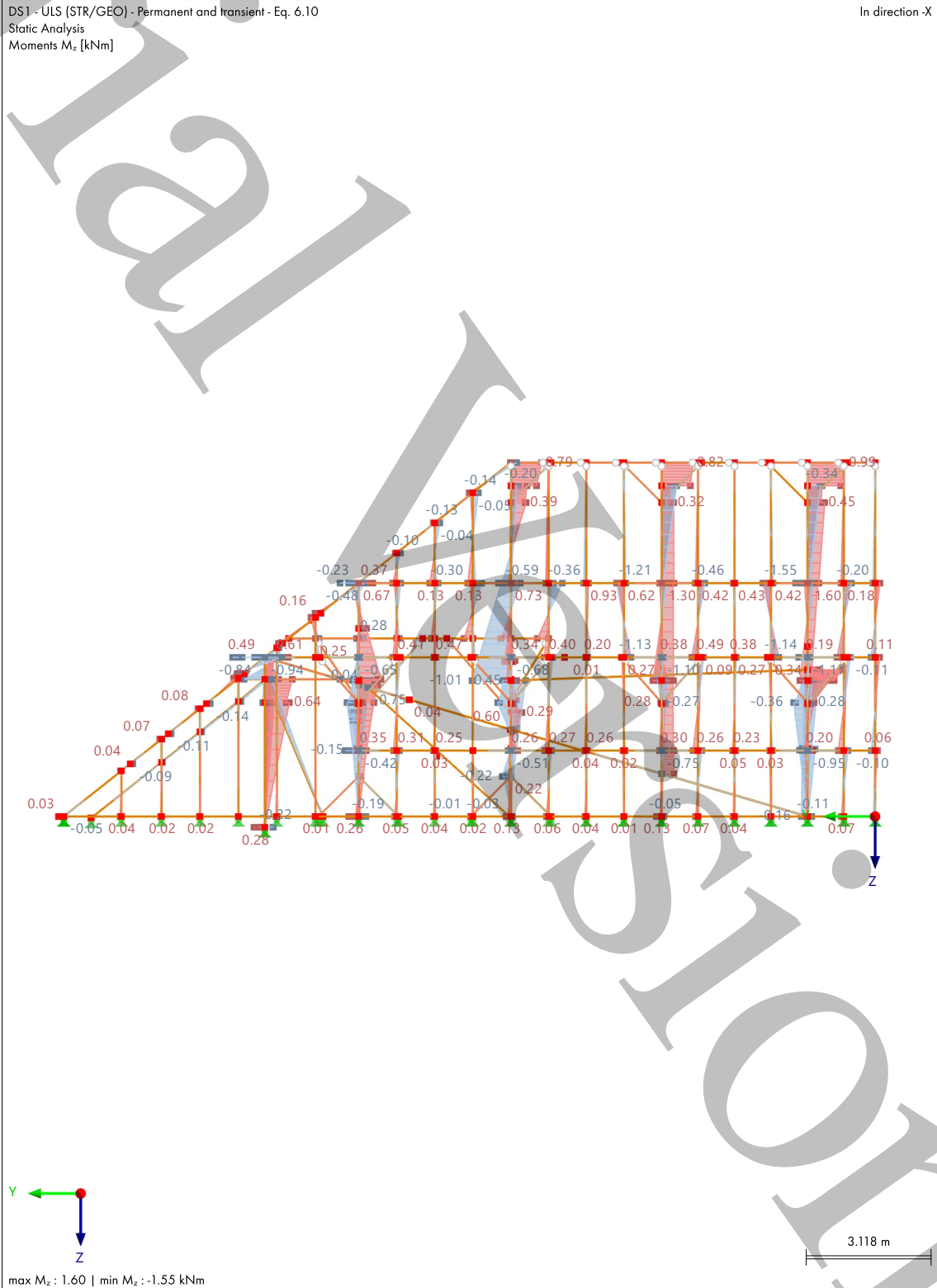


**MODEL**

8.18

**DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES**  
 **$M_{zr}$  IN DIRECTION -X**

Static Analysis





## 9 Timber Design

### 9.1 OBJECTS TO DESIGN

Object Type	Design All	Objects to Design				Comment
		Selected	To Calculate	Removed	Not Valid / Deact	
Members	<input checked="" type="checkbox"/>	6,	6,		282,283,286,2	
		13-15,17,24,2	13-15,17,24,2		87,289,291,29	
		9,30,39,41-44,	9,30,39,41-44,		3,295,297,299	
		46-52,61-64,7	46-52,61-64,7		,360-363,367,	
		3-82,95,107,1	3-82,95,107,1		370,373,377-3	
		60,162-173,18	60,162-173,18		80,389,394,39	
		5-188,196,198	5-188,196,198		5,423,428,478	
		,201-208,211,	,201-208,211,		,1692,1695,17	
		216-219,225,2	216-219,225,2		55,1756,1759,	
		26,229-231,25	26,229-231,25		1762,1764,17	
		0,253,257-260	0,253,257-260		66,1770,1771,	
		,262-266,276-	,262-266,276-		1780-1788,18	
		278,280,282,2	278,280,285,2		28,1829,1834	
		83,285-287,28	90,292,294,29			
		9-311,314,327	6,298,300-311			
		,328,330,335-	,314,327,328,			
		342,347-349,3	330,335-342,3			
		51-353,355-35	47-349,351-3			
		7,359-375,377	53,355-357,35			
		-380,382-397,	9,364-366,368			
		399,401-403,4	,369,371,372,			
		06,407,409,41	374,375,382-3			
		2,413,418-421	88,390-393,39			
		,423-428,430-	6,397,399,401			
		459,464,468-4	-403,406,407,			
		71,473,474,47	409,412,413,4			
		6-478,840,841	18-421,424-4			
		,972,1449,146	27,430-459,46			
		8-1525,1527-1	4,468-471,473			
		834	,474,476,477,			
			840,841,972,1			
			449,1468-152			
			5,1527-1691,1			
			693,1694,169			
			6-1754,1757,1			
			758,1760,176			
			1,1763,1765,1			
			767-1769,177			
			2-1779,1789-			
			1827,1830-18			

### 9.2 DESIGN SITUATIONS

DS No.	EN 1990   Timber   CEN   2010-0	To Design	Active	EN 1995   HRN   2015-03	Combinations to Design for Enumeration Method
1	<b>ULS</b> ULS (STR/GEO) - Permanent and transient - Eq. 6.10	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<b>ULS</b> ULS (STR/GEO) - Permanent and transient	All
2	<b>SCh</b> SLS - Characteristic	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<b>SCh</b> SLS - Characteristic	All
3	<b>SQp1</b> SLS - Quasi-permanent	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<b>SQp1</b> SLS - Quasi-permanent 1	All

### 9.3 MATERIALS

Legend  
 Stiffness modification

Material No.	Name	To Design	Material Type	Options	Comment
1	C18	<input checked="" type="checkbox"/>	Timber		



TIMBER

9.4 SECTIONS

Legend  
 Warping stiffness deactivated

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

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			
	<input checked="" type="checkbox"/> Perform stability design			
	Limit Values for Special Cases			
	Tension ( $\sigma_{t,0,d} / f_{t,0,d}$ )	$\eta_{t,lim}$	0.001	--
	Compression ( $\sigma_{c,0,d} / f_{c,0,d}$ )	$\eta_{c,lim}$	0.001	--
	Shear ( $T_{xy,d} / f_{v,d}$ )	$\eta_{xy,lim}$	0.001	--
	Shear ( $T_{xz,d} / f_{v,d}$ )	$\eta_{xz,lim}$	0.001	--
	Torsion ( $T_{tor,d} / f_{v,d}$ )	$\eta_{tor,lim}$	0.010	--
	Bending ( $\sigma_{m,y,d} / f_{m,d}$ )	$\eta_{m,y,lim}$	0.001	--
	Bending ( $\sigma_{m,z,d} / f_{m,d}$ )	$\eta_{m,z,lim}$	0.001	--
	Curved and Saddle Members			
	<input checked="" type="checkbox"/> Perpendicular tension design of curved members			
	<input checked="" type="checkbox"/> 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			
	<input type="checkbox"/> Consider system strength factor			
	Settings for Stability Design			
	Stiffness Reduction			
	<input type="checkbox"/> Reduction of stiffness with coefficient $1/(1+k_{def})$ acc. to DIN EN 1995-1-1			
	Position of Positive Transverse Load Application			
	Vertical position			
	<input checked="" type="radio"/> On section edge (destabilizing effect)			
	<input type="radio"/> At shear point			
	<input type="radio"/> At center point			
	<input type="radio"/> On section edge (stabilizing effect)			
	<input type="checkbox"/> Reduction of effective length by 0.5h acc. to Tab. 6.1 (stabilizing effect)			



TIMBER

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 <sub>c</sub> /	150	--
	Quasi-permanent 1	L <sub>c</sub> /	125	--
	Quasi-permanent 2	L <sub>c</sub> /	75	--
	Vibration Design			
	Vibration design	W <sub>instLim</sub>	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)			
	<input checked="" type="checkbox"/> Top (-z)			
	<input checked="" type="checkbox"/> Left (-y)			
	<input checked="" type="checkbox"/> Right (+y)			
	<input checked="" type="checkbox"/> Bottom (+z)			

10 Design Overview

10.1 DESIGN OVERVIEW

Design Overview

	Addon	Type	Objects		Design Situation	Loading No.	Design Check		Description
			No.	Location [m]			Ratio η [-]	Type	
	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



**RESULTS**

10.1 **DESIGN OVERVIEW**

**Design Overview**

Addon	Type	Objects		Location [m]	Design Situation	Loading No.	Design Check		Description
		No.					Ratio $\eta$ [-]	Type	
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	219,253,434,4 57,972,1527,1 578,1827		x: 0.000	DS1	CO1	0.000	SP0100.00	Section Proof   Negligible internal forces
Timber Design	Member	6, 13-15,17,24,2 9,30,39,41-44, 46-52,61-64,7 3-82,95,107,1 60,162-173,18 5-188,196,198 ,201-208,211, 216-219,225,2 26,229-231,25		x: 0.000	DS2	CO6	0.000	SE0100.01	Serviceability   Negligible deflection   Combination of actions 'Characteristic'



**RESULTS**

10.1 **DESIGN OVERVIEW**

**Design Overview**

Addon	Type	Objects		Location [m]	Design Situation	Loading No.	Design Check		Description
		No.					Ratio $\eta$ [-]	Type	
			0,253,257-260 ,262-266,276- 278,280,285,2 90,292,294,29 6,298,300-311 ,314,327,328, 330,335-342,3 47-349,351-35 3,355-357,359 ,364-366,368, 369,371,372,3 74,375,382-38 8,390-393,396 ,397,399,401- 403,406,407,4 09,412,413,41 8-421,424-427 ,430-459,464, 468-471,473,4 74,476,477,84 0,841,972,144 9,1468-1525,1 527-1691,169 3,1694,1696-1 754,1757,175 8,1760,1761,1 763,1765,176 7-1769,1772-1 779,1789-182						
Timber Design	Member	6,	13-15,17,24,2 9,30,39,41-44, 46-52,61-64,7 3-82,95,107,1 60,162-173,18 5-188,196,198 ,201-208,211, 216-219,225,2 26,229-231,25 0,253,257-260 ,262-266,276- 278,280,285,2 90,292,294,29 6,298,300-311 ,314,327,328, 330,335-342,3 47-349,351-35 3,355-357,359 ,364-366,368, 369,371,372,3 74,375,382-38 8,390-393,396 ,397,399,401- 403,406,407,4 09,412,413,41 8-421,424-427 ,430-459,464, 468-471,473,4 74,476,477,84 0,841,972,144 9,1468-1525,1 527-1691,169 3,1694,1696-1 754,1757,175 8,1760,1761,1 763,1765,176 7-1769,1772-1 779,1789-182	x: 0.000	DS3	CO11	0.000 ✓	SE0100.02	Serviceability   Negligible deflection   Combination of actions 'Quasi-permanent 1'



## **2.4. Zaključak**

Statički proračun modela proveden 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**

Slika 1: Interakcija Euroazijske i Afričke tektonske ploče [3]

Slika 2: Karta potresnih područja RH [5]

Slika 3: Mjøstårnet, Norveška (visina: 85.4 m) [12]

Slika 4: Detalj spoja sa senzorom za pomak [13]

Slika 5: Potresno ispitivanje NHERI TallWood Project zgrade [13]

## 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>

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