

Snimak stanja stare krovne konstrukcije i prijedlog sanacije

Klanac, Enia

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Sveučilište u Zagrebu

GRAĐEVINSKI FAKULTET

Enia Klanac

**SNIMAK STANJA STARE KROVNE
KONSTRUKCIJE I PRIJEDLOG SANACIJE**

ZAVRŠNI ISPIT

Zagreb, 2024.



Sveučilište u Zagrebu

GRAĐEVINSKI FAKULTET

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**SNIMAK STANJA STARE KROVNE
KONSTRUKCIJE I PRIJEDLOG SANACIJE**

ZAVRŠNI ISPIT

Mentor: prof. dr. sc. Vlatka Rajčić

Komentor: dr. sc. Nikola Perković

Zagreb, 2024.



University of Zagreb

FACULTY OF CIVIL ENGINEERING

Enia Klanac

**ASSESSMENT OF THE OLD ROOF STRUCTURE
AND SANATION PROPOSAL**

FINAL EXAM

Supervisor: prof. dr. sc. Vlatka Rajčić

Commentator: dr. sc. Nikola Perković

Zagreb, 2024.

SAŽETAK

U ovom radu je prikazan način snimka stanja stare krovne konstrukcije i prijedlog sanacije na primjeru Stare gradske vijećnice u Zagrebu, Ćirilometodska ul. 5, 10000 Zagreb u njenoj zoni 1. Poseban naglasak je stavljen na vizualni pregled te nerazorna ispitivanja vlagomjerom i rezistografom. Rezultati su korišteni za izradu statičkog modela u programu DLUBAL RFEM 6 te proračun konstrukcije prema Eurokodu 5: Projektiranje drvenih konstrukcija i hrvatskim nacionalnim dodacima za projektiranje drvenih konstrukcija, osiguravajući sigurnost i trajnost konstrukcije.

Ključne riječi: drvene konstrukcije; krovšte; nerazorna ispitivanja; statički proračun; prijedlog sanacije

SUMMARY

In this paper, the method for recording the condition of an old roof structure and the proposed remediation is demonstrated using the example of the Old City Hall in Zagreb, Ćirilometodska Street 5, 10000 Zagreb, in its Zone 1. Special emphasis is placed on visual inspection as well as non-destructive testing with a moisture meter and resistograph. The results were used to create a static model in the DLUBAL RFEM 6 software and to calculate the structure according to Eurocode 5: Design of Timber Structures and Croatian national annexes for the design of timber structures, ensuring the safety and durability of the structure.

Key words: timber structures; roofing; non-destructive testing; structural analysis; remediation proposal

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1. UVOD

Tema i cilj ovog rada je prikazati način snimka stanja stare krovne konstrukcije i prijedlog sanacije na primjeru Stare gradske vijećnice u Zagrebu, Ćirilometodska ul. 5, 10000 Zagreb. Na krovu Stare gradske vijećnice u Zagrebu, proveden je vizualni pregled uz korištenje nerazornih metoda ispitivanja. Upotrebom vlagomjera i rezistografa izvršena je analiza stanja drvene konstrukcije s posebnim naglaskom na detekciju vlage i ocjenu mehaničkih svojstava elemenata krovišta. Ovi podaci poslužili su kao temelj za daljnje projektne aktivnosti. Na osnovi prikupljenih mehaničkih i geometrijskih karakteristika, izrađen je statički model krovišta pomoću softverskog alata DLUBAL RFEM 6. Statički proračun obuhvaćao je provjeru graničnih stanja nosivosti i uporabljivosti drvene konstrukcije u skladu s Eurokodom 5 koji definira smjernice za projektiranje drvenih konstrukcija. Prilikom analize korišteni su i hrvatski nacionalni dodaci kako bi proračun bio usklađen s lokalnim standardima. Na kraju ovisno o rezultatima proračuna predlaže se prijedlog sanacije ako je sanacija potrebna.

2. OCJENA STANJA KONSTRUKCIJE

Drvo je prirodni materijal koji se ističe visokom ekološkom vrijednošću i tehničkom svestranošću te je u posljednjim godinama ponovno stekao značaj. Ključne mehaničke, fizičke i kemijske karakteristike drva su od presudne važnosti za njegovu široku primjenu u građevinskoj industriji. [1]

Prvi dio ovog završnog rada se sastojao od vizualnog pregleda krovišta Stare gradske vijećnice u Zagrebu te provođenja nerazornih ispitivanja kako bismo utvrdili stanje u kojem se krovište nalazi.

Najjednostavnija i najčešće korištena metoda nedestruktivnog ispitivanja drvenih konstrukcija je vizualni pregled. Ovo je prvi korak u ocjeni stanja konstrukcije jer pruža osnovne, ali važne informacije o vidljivim oštećenjima kao što su pukotine, truljenje, oštećenje vlakana, puzanje i ozbiljne raspukline. Vizualni pregled omogućava uočavanje prirodnih nedostataka i propadanja drva, koji mogu negativno utjecati na mehanička svojstva materijala. Biološki napadi često uzrokuju smanjenje gustoće drva i kemijske reakcije koje dovode do truljenja. [2] Vizualnim pregledom nismo uočili značajnija oštećenja drvene konstrukcije.

Jedan od ključnih čimbenika koji utječe na ponašanje i karakteristike drvene građe je vlažnost drva. Količina vode prisutne u drvetu značajno utječe na njegovu težinu, čvrstoću, obradivost, osjetljivost na biološke napade i dimenzijsku stabilnost elemenata. Udio vlage određuje se mjerenjem mase drva u vlažnom stanju i usporedbom s masom drva u suhom stanju, pri čemu se rezultat izražava u postocima ili kao u ovom slučaju, mjerenjem specifičnog električnog otpora drva vlagomjerom. [3]

Provođenjem ispitivanja vlagomjerom, utvrdili smo da se drvo nalazi u 1. razredu uporabljivosti.

Rezistograf je instrument koji služi za otkrivanje truljenja i šupljina u drveću i drvenim materijalima. Pomoću njega analiziramo unutarnju strukturu drva te omogućuje identifikaciju truleži, faze raspadanja, šuplja područja, pukotine i strukturu godova. Rezultati mjerenja prikazani su u obliku linija: ravna linija označava odsutnost otpora bušilici, što upućuje na šuplje ili trulo područje, dok nazubljena linija ukazuje na prisutnost otpora i čvrsto drvo [4]. Na kraju, naš rezultat je upravo bio takav – pokazao je čvrsto drvo.

U nastavku su prikazane slike krovišta i rezultata mjerenja.



Slika 1. Krovšte



Slika 2. Krovšte



Slika 3. Krovšte



Slika 4. Detalj krovišta



Slika 5. Detalj krovišta



Slika 6. Detalj krovišta



Slika 7. Prvo mjerenje vlagomjerom



Slika 8. Drugo mjerenje vlagomjerom



Slika 9. i Slika 10. Treće mjerenje vlagomjerom

3. STATIČKI PRORAČUN

Nakon vizualnog pregleda i nerazornih ispitivanja, ključno je bilo provesti proračun graničnih stanja nosivosti i uporabljivosti prema Eurokodu 5 za proračun drvenih konstrukcija, specifično u ovom radu za zonu 1 krovišta. Model krovišta izrađen je pomoću programa Dlubal RFEM 6, a cilj je bio utvrditi zadovoljava li postojeće stanje krovišta zahtjeve sigurnosti nosivih konstrukcija (GSN i GSU).[5,6] U proračun su uzeta u obzir sva relevantna opterećenja, uključujući vlastitu težinu konstrukcije, dodatna stalna opterećenja te opterećenja uzrokovana vjetrom i snijegom kako bi se osigurala sveobuhvatna analiza.

U nastavku su prikazani rezultati završnog statičkog izvještaja izrađenog u programu Dlubal RFEM 6.

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Model:
Enia Klanec, I.zona krovitka - kopija (2)

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MODEL

Structural Analysis

CLIENT

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CREATED BY

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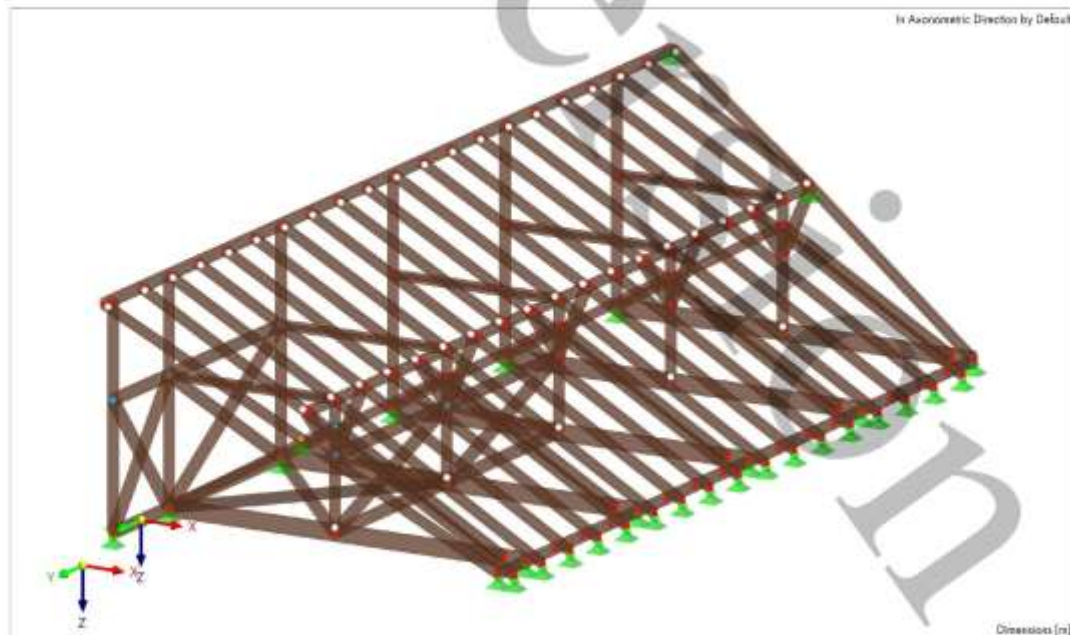
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PROJECT

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MODEL



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MODEL

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6.2	Vjatar	14	9.18 Member No. 29 DS1 CO2 0,000 m Stress Point No. 1 ST1300
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MODEL

MODEL - LOCATION

Location



Country	: Croatia
Street	: Zrinjevac 7
Zip / Postal code	: 10000
City	: Zagreb
State	:
Latitude	: deg
Longitude	: deg
Altitude	: 122.000 m

1 Basic Objects



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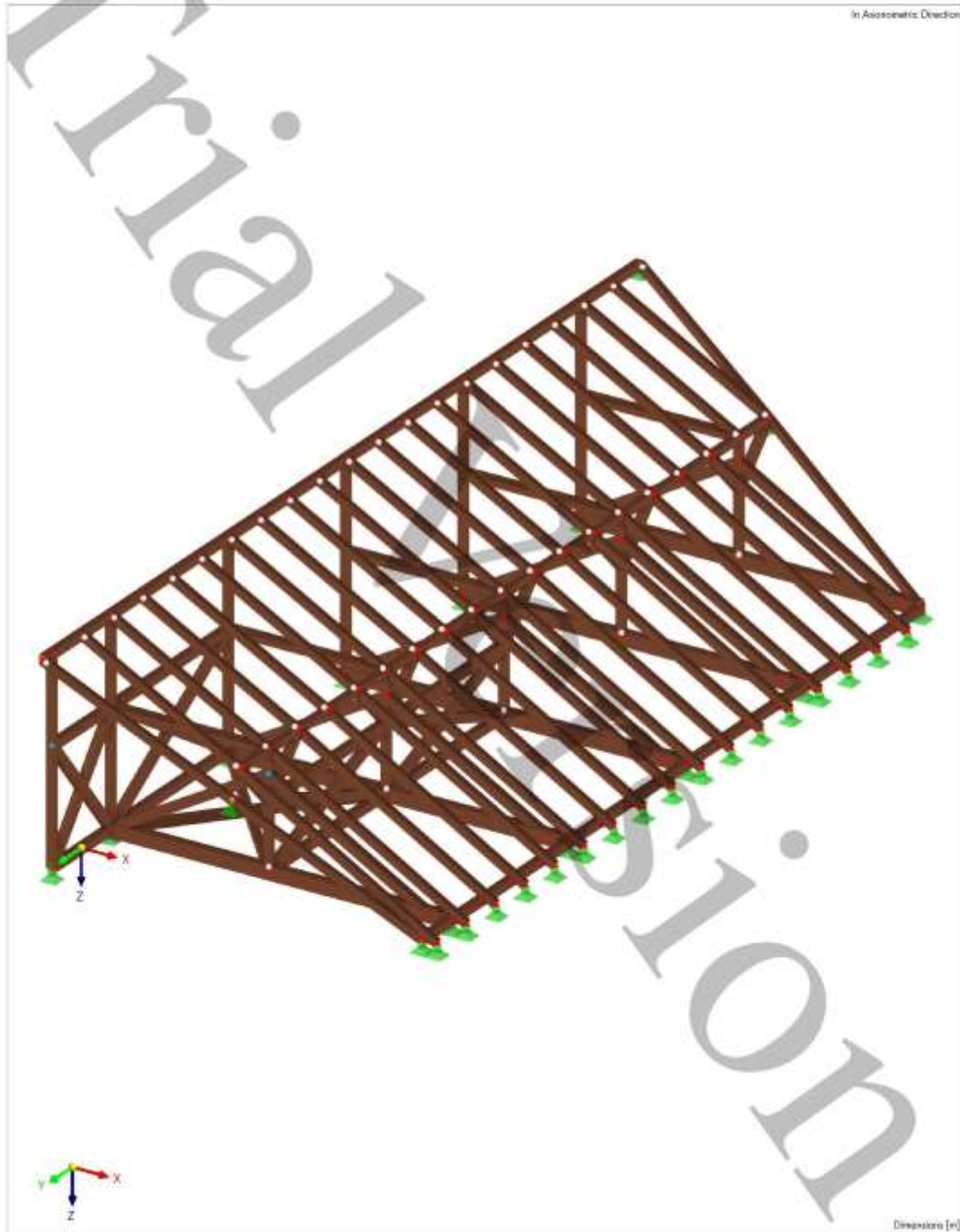


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MODEL

1.1 MODEL, IN AXONOMETRIC DIRECTION



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MODEL

1.3 MATERIALS

Legend
[Symbol] Stress modification

Material No.	Material Name	Material Type	Analysis Model	Options
1	D50 Isotropic Linear Elastic	Timber	Isotropic Linear Elastic	[Symbol]

1.3 SECTIONS

Section No.	Material No.	Section Type	Manufacturing Type	I_y [cm ⁴]	I_z [cm ⁴]	I_{yz} [cm ⁴]	Overall Dimensions b [mm]	h [mm]
1	1	R_M1 160x220 1 - D50 Parametric - Massive I		16096.63	14197.33	7506.33	160.0	220.0
2	1	R_M1 160x160 1 - D50 Parametric - Massive I		9229.65	5461.33	5461.33	160.0	160.0
3	1	R_M1 150x150 1 - D50 Parametric - Massive I		7129.69	4218.75	4218.75	150.0	150.0
4	1	R_M1 120x150 1 - D50 Parametric - Massive I		4434.08	3375.00	2160.00	120.0	150.0
5	1	2R_M2 120x80x100 1 - D50 Parametric - Massive II		2426.18	2304.00	16576.01	280.0	120.0
6	1	R_M1 150x180 1 - D50 Parametric - Massive I		10046.00	7290.00	5062.50	150.0	180.0
7	1	R_M1 160x120 1 - D50 Parametric - Massive I		4976.26	2304.00	4096.00	160.0	120.0
8	1	R_M1 270x200 1 - D50 Parametric - Massive I		39242.99	19000.00	32805.00	270.0	200.0
9	1	R_M1 170x150 1 - D50 Parametric - Massive I		9030.75	4781.25	6141.25	170.0	150.0
10	1	R_M1 200x270 1 - D50 Parametric - Massive I		39242.99	32805.00	16000.00	200.0	270.0
11	1	R_M1 150x170 1 - D50 Parametric - Massive I		9030.75	6141.25	4781.25	150.0	170.0
12	1	R_M1 120x160 1 - D50 Parametric - Massive I		4976.26	4096.00	2304.00	120.0	160.0



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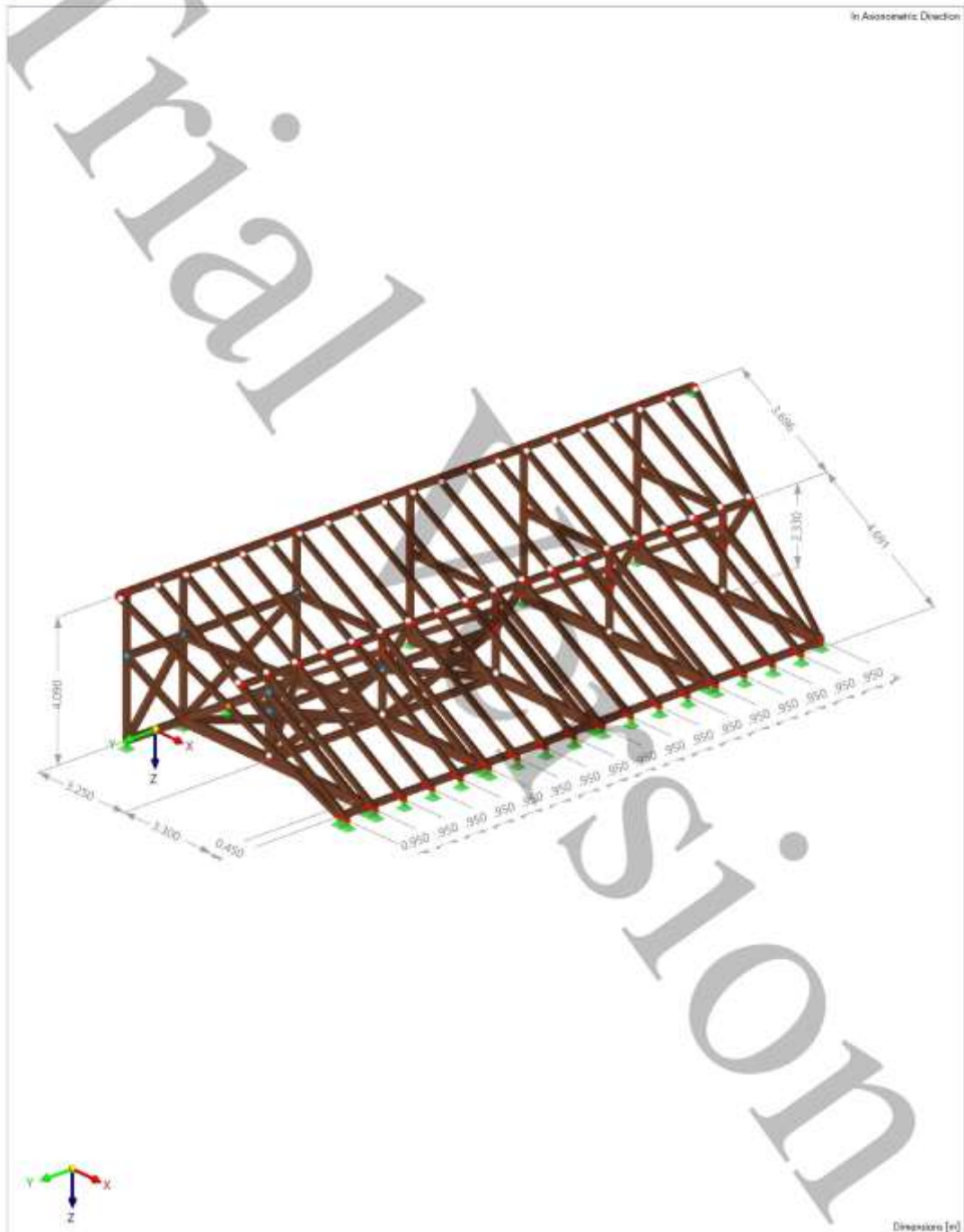
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Enia Klanec_1.zona krovitja - kopija (2)

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MODEL

1.4 DIMENZIJE

In Axonometric Direction



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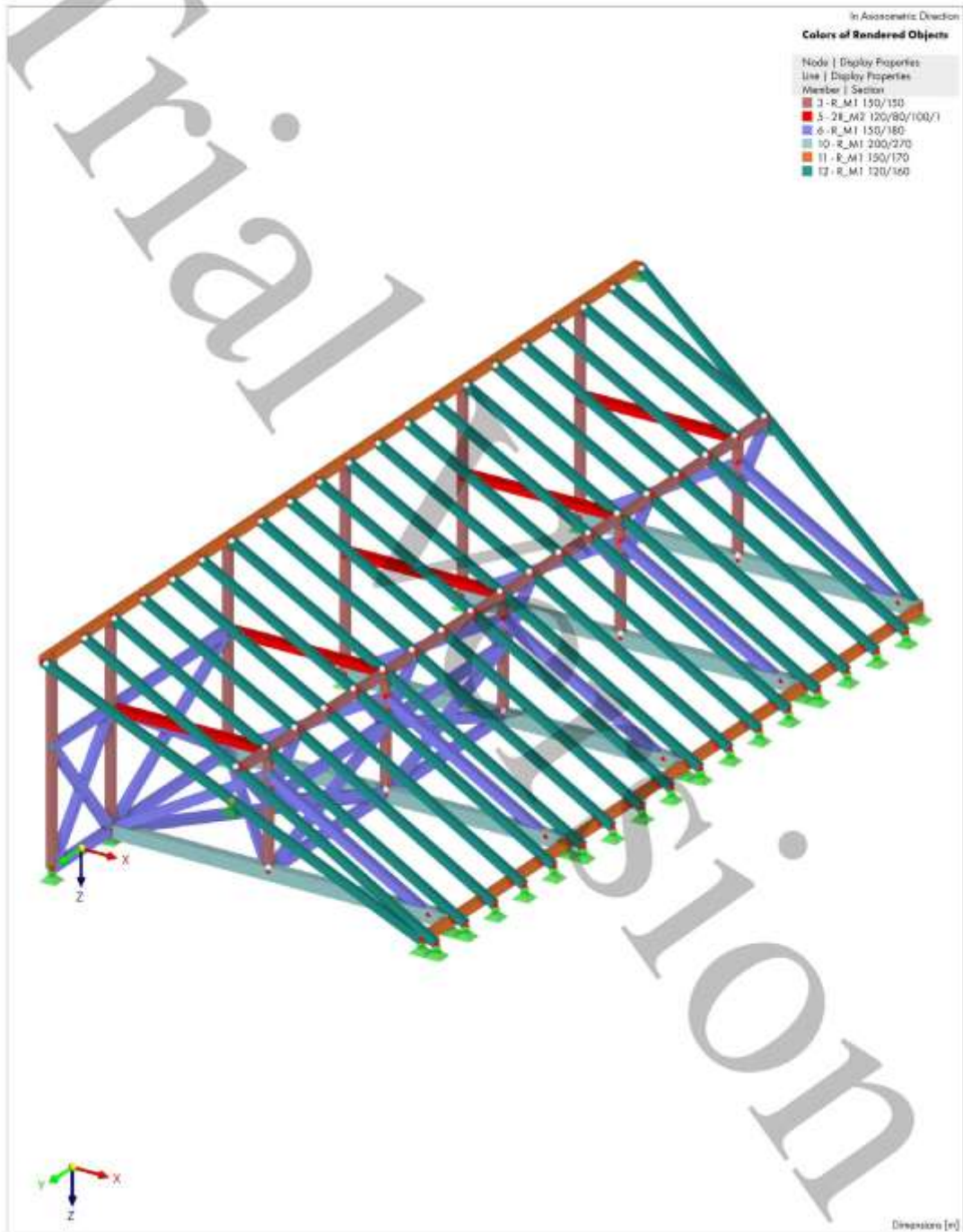


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MODEL

1.3 POPREČNI PRESJECI



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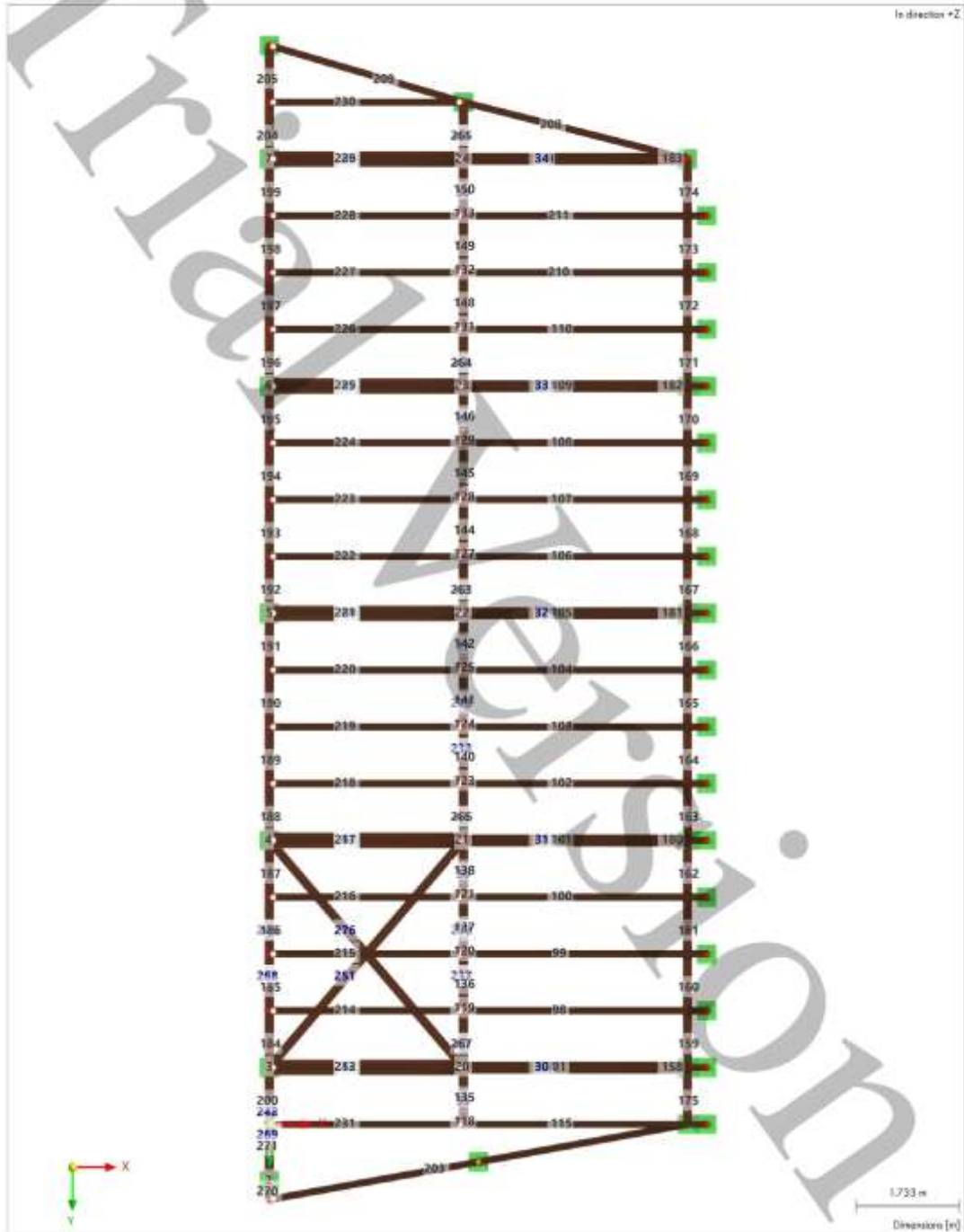


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MODEL

1.6 MEMBER SET - NUMBERING



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MODEL

2 Types for Nodes

2.1 NODAL SUPPORTS

Support No.	Nodes No.	Coordinate System	Translation Spring [kN/m]			Rotation Spring [kNm/rad]		
			C _{UX}	C _{UY}	C _{UZ}	C _{ϕX}	C _{ϕY}	C _{ϕZ}
1	71,141,145,149,153,155,172,183	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"/>
5	5,7,9,11,13,84,110-122,127,157,173,174	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 _{UX}	C _{UY}	C _{UZ}	C _{ϕX}	C _{ϕY}	C _{ϕZ}
1	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	Member Sets	Surfaces	Surface Sets	Service Class	Type	Comment
1	Service Class 1 (Members: 2-7,20-44,81,98-110,115,116-121,123-125,127-129,131-133,135-138,140-142,144-146,148-150,152-200,203-205,208-211,213-234,237,238,241-244,248,251,258-278)				1 - Dry		

5 Load Cases & Combinations

5.1 LOAD CASES

LC No.	Settings	Value	Unit	To Solve
1	Analysis type: <input checked="" type="checkbox"/> Static Static analysis settings: Static Analysis Action category: <input checked="" type="checkbox"/> 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	SA1 - Geometrically linear		<input checked="" type="checkbox"/>
2	Analysis type: <input checked="" type="checkbox"/> Snijeg Static analysis settings: Static Analysis Action category: <input checked="" type="checkbox"/> Permanent Load duration: Short-term	SA1 - Geometrically linear Snow/ice loads - H <= 1000 m		<input checked="" type="checkbox"/>
3	Analysis type: <input checked="" type="checkbox"/> Vjetar 1 Static analysis settings: Static Analysis Action category: <input checked="" type="checkbox"/> Wind Load duration: Short-term	SA1 - Geometrically linear		<input checked="" type="checkbox"/>





MODEL

5.2 ACTIONS

Action No.	Settings	Value	Active
1	PER Permanent Action Category Action Type	PER Permanent Simultaneously	<input checked="" type="checkbox"/>
2	SN Snow/ice loads - H <= 1000 m Action Category Action Type	SN Snow/ice loads - H <= 1000 m Alternatively	<input checked="" type="checkbox"/>
3	WIND Wind Action Category Action Type	WIND Wind Alternatively	<input checked="" type="checkbox"/>

5.3 DESIGN SITUATIONS

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

5.4 ACTION COMBINATIONS

AC No.	Settings	Value	Active
1	ULS 1.35 * A1 Design Situation Generated load combinations Generated by	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 1 Design Situation No. 1	<input checked="" type="checkbox"/>
2	ULS 1.35 * A1 + 1.50 * A2 Design Situation Generated load combinations Generated by	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 2 Design Situation No. 1	<input checked="" type="checkbox"/>
3	ULS 1.35 * A1 + 1.50 * A2 + 0.90 * A3 Design Situation Generated load combinations Generated by	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 3 Design Situation No. 1	<input checked="" type="checkbox"/>
4	ULS 1.35 * A1 + 1.50 * A3 Design Situation Generated load combinations Generated by	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 4 Design Situation No. 1	<input checked="" type="checkbox"/>
5	ULS 1.35 * A1 + 0.75 * A2 + 1.50 * A3 Design Situation Generated load combinations Generated by	ULS DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 5 Design Situation No. 1	<input checked="" type="checkbox"/>
6	SLS A1 Design Situation Generated load combinations Generated by	SLS DS2 - SLS - Characteristic 6 Design Situation No. 2	<input checked="" type="checkbox"/>
7	SLS A1 + A2 Design Situation Generated load combinations Generated by	SLS DS2 - SLS - Characteristic 7 Design Situation No. 2	<input checked="" type="checkbox"/>
8	SLS A1 + A2 + 0.60 * A3 Design Situation Generated load combinations Generated by	SLS DS2 - SLS - Characteristic 8 Design Situation No. 2	<input checked="" type="checkbox"/>





MODEL

5.4 ACTION COMBINATIONS

AC No.	Settings	Value	Active
9	SICH A1 + A3 Design Situation Generated load combinations Generated by	SICH DS2 - SLS - Characteristic 9 Design Situation No. 2	<input checked="" type="checkbox"/>
10	SICH A1 + 0.50 * A2 + A3 Design Situation Generated load combinations Generated by	SICH DS2 - SLS - Characteristic 10 Design Situation No. 2	<input checked="" type="checkbox"/>
11	SLECI 1.00 * A1 Design Situation Generated load combinations Generated by	SLECI DS3 - SLS - Quasi-permanent 11 Design Situation No. 3	<input checked="" type="checkbox"/>
12	SLECI 1.00 * A1 + A2 Design Situation Generated load combinations Generated by	SLECI DS3 - SLS - Quasi-permanent 12 Design Situation No. 3	<input checked="" type="checkbox"/>
13	SLECI 1.00 * A1 + A2 + 0.50 * A3 Design Situation Generated load combinations Generated by	SLECI DS3 - SLS - Quasi-permanent 13 Design Situation No. 3	<input checked="" type="checkbox"/>
14	SLECI 1.00 * A1 + A3 Design Situation Generated load combinations Generated by	SLECI DS3 - SLS - Quasi-permanent 14 Design Situation No. 3	<input checked="" type="checkbox"/>
15	SLECI 1.00 * A1 + 0.50 * A2 + A3 Design Situation Generated load combinations Generated by	SLECI DS3 - SLS - Quasi-permanent 15 Design Situation No. 3	<input checked="" type="checkbox"/>

5.5 LOAD COMBINATIONS

CO No.	Settings	Value	Unit	To Solve
1	SLECI 1.35 * LC1 Analysis type Static analysis settings Design Situation Structure modification Load duration	Static Analysis SA2 - Second-order (P-Δ) Picard 100 1 DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 1 Permanent		<input checked="" type="checkbox"/>
2	SLECI 1.35 * LC1 + 1.50 * LC2 Analysis type Static analysis settings Design Situation Structure modification Load duration	Static Analysis SA2 - Second-order (P-Δ) Picard 100 1 DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 1 Short-term		<input checked="" type="checkbox"/>
3	SLECI 1.35 * LC1 + 1.50 * LC2 + 0.90 * LC3 Analysis type Static analysis settings Design Situation Structure modification Load duration	Static Analysis SA2 - Second-order (P-Δ) Picard 100 1 DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 1 Short-term		<input checked="" type="checkbox"/>
4	SLECI 1.35 * LC1 + 1.00 * LC3 Analysis type Static analysis settings Design Situation Structure modification Load duration	Static Analysis SA2 - Second-order (P-Δ) Picard 100 1 DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 1 Short-term		<input checked="" type="checkbox"/>
5	SLECI 1.35 * LC1 + 0.75 * LC2 + 1.50 * LC3 Analysis type Static analysis settings Design Situation Structure modification Load duration	Static Analysis SA2 - Second-order (P-Δ) Picard 100 1 DS1 - ULS (STR/GEO) - Permanent and transient - Eq. 6.10 1 Short-term		<input checked="" type="checkbox"/>
6	SICH LC1 Analysis type	Static Analysis		<input checked="" type="checkbox"/>





MODEL

5.5 LOAD COMBINATIONS

CO No.	Settings	Value	Unit	To Solve
7	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS2 - SLS - Characteristic		
	Load duration	Permanent		
	■ SICH LC1 + LC2			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
8	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS2 - SLS - Characteristic		
	Load duration	Short-term		
	■ SICH LC1 + LC2 + 0.60 * LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
9	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS2 - SLS - Characteristic		
	Load duration	Short-term		
	■ SICH LC1 + LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
10	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS2 - SLS - Characteristic		
	Load duration	Short-term		
	■ SICH LC1 + 0.50 * LC2 + LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
11	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS3 - SLS - Quasi-permanent		
	Load duration	Permanent		
	■ SIBET 1.60 * LC1			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
12	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS3 - SLS - Quasi-permanent		
	Load duration	Short-term		
	■ SIBET 1.60 * LC1 + LC2			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
13	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS3 - SLS - Quasi-permanent		
	Load duration	Short-term		
	■ SIBET 1.60 * LC1 + LC2 + 0.60 * LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
14	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS3 - SLS - Quasi-permanent		
	Load duration	Short-term		
	■ SIBET 1.60 * LC1 + LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>
15	Static analysis settings	SA2 - Second-order (P-Δ) Picard 100 1		
	Design Situation	DS3 - SLS - Quasi-permanent		
	Load duration	Short-term		
	■ SIBET 1.60 * LC1 + 0.50 * LC2 + LC3			
	Analysis type	Static Analysis		<input checked="" type="checkbox"/>

5.6 STATIC ANALYSIS SETTINGS5

Settings No.	Description	Symbol	Value	Unit
1	Geometrically linear		Geometrically linear	
	Analysis type		<input checked="" type="checkbox"/>	
	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 type="checkbox"/>	
	Equilibrium for undeformed structure		<input type="checkbox"/>	
2	Second-order (P-Δ) Picard 100 1		Second-order (P-Δ)	
	Analysis type		<input checked="" type="checkbox"/>	





MODEL

5.6 STATIC ANALYSIS SETTINGS

Settings No.	Description	Symbol	Value	Unit
	Iterative method for nonlinear analysis		<input checked="" type="checkbox"/> Picard	
	Maximum number of iterations		100	
	Number of load increments		1	
	Modify standard precision and tolerance settings		<input type="checkbox"/>	
	Ignore all nonlinearities		<input type="checkbox"/>	
	Modify loading by multiplier factor		<input type="checkbox"/>	
	Consider favorable effect due to tension in members		<input checked="" type="checkbox"/>	
	Displacements due to member load of type 'Pipe internal pressure' (Boussin effect)		<input type="checkbox"/>	
	Refer internal forces to deformed structure		<input checked="" type="checkbox"/>	
	Refer internal forces to deformed structure for normal forces		<input checked="" type="checkbox"/>	
	Refer internal forces to deformed structure for shear forces		<input checked="" type="checkbox"/>	
	Refer internal forces to deformed structure for moments		<input checked="" 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"/>	
	Stability check based on deformation rate		<input type="checkbox"/>	
3	<input checked="" type="checkbox"/> Large deformations Newton-Raphson 100 1		<input checked="" type="checkbox"/> Large deformations	
	Iterative method for nonlinear analysis		Newton-Raphson	
	Maximum number of iterations		100	
	Number of load increments		1	
	Modify standard precision and tolerance settings		<input type="checkbox"/>	
	Ignore all nonlinearities		<input type="checkbox"/>	
	Modify loading by multiplier factor		<input type="checkbox"/>	
	Consider favorable effect due to tension in members		<input checked="" type="checkbox"/>	
	Try to calculate unstable structure		<input type="checkbox"/>	
	Displacements due to member load of type 'Pipe internal pressure' (Boussin 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"/>	
	Stability check based on deformation rate		<input type="checkbox"/>	

5.7 COMBINATION WIZARDS

Wizard No.	Settings	Value
1	Load combinations SA2 - Second-order (P-Δ) Picard 100 1	
	Assigned to	DS 1-3
	Generate combinations	Load combinations (non-linear analysis)
	Static analysis settings	<input checked="" type="checkbox"/> SA2 - Second-order (P-Δ) Picard 100 1
	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"/>
	User-defined action combinations	<input type="checkbox"/>
	Favorable permanent actions	<input type="checkbox"/>
	Reduce number of generated combinations	<input type="checkbox"/>
2	<input checked="" type="checkbox"/> Load combinations SA1 - Geometrically linear	
	Assigned to	Load combinations (non-linear analysis)
	Generate combinations	SA1 - Geometrically linear
	Static analysis settings	<input type="checkbox"/>
	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



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Obala kraja P. Kraljevič W, 23450 Obrovac

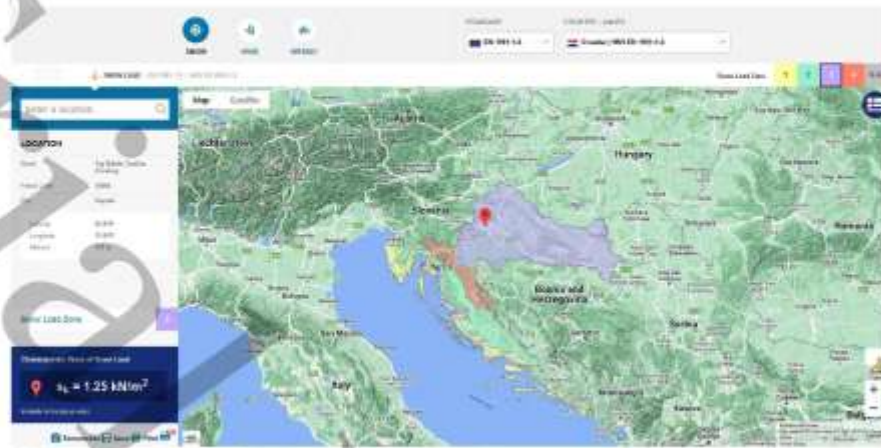


Model:
Enia Klanec_1.zona krovitka - kopija (2)

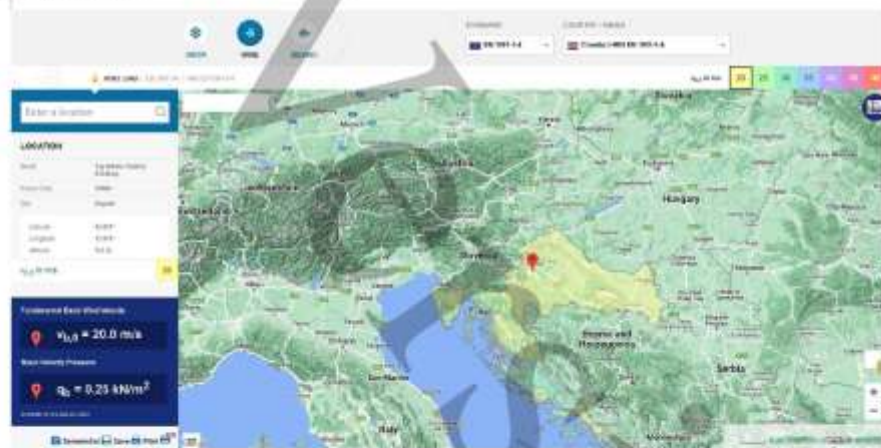
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MODEL

6.1.1 SNIJEG.JPG



6.1.1 VJETAR.JPG





MODEL

6.3.1 OPTEREĆENJE.JPG

ANALIZA OPTEREĆENJA - Ministarstvo vanjskih poslova

Pozicija		K1		
Opis pozicije		Krov		
Stablo posređivača opterećenja (k)	Stij	Zapremniska optina (kg/m ³)	Debljina stije (cm)	Imas površinskog opterećenja (kN/m ²)
	1. Izbaci snijeg			0,50
	2. Dodatno stalno			0,10
Ukupno:				0,60
Površina posređivača opterećenja (l)	Položaj		Imas opterećenja (kN/m ²)	
	s	Tronj	L,RP	
	w	Vjatar	Software	

Snijeg (s)	Područje: 3	Kontinentalna Hrvatska	
	Nudrinska visina: 122	(m.s.m.)	
	$s_r = 32$		
	$s_{r0} = 1,25$	(kN/m ²)	Učinkovitost opterećenja snijegom na 0,4
	$\mu(s) = 0,8$		Koeficijent stabilnosti opterećenja snijegom
	$C_e = 1$		Koeficijent stabilnosti
	$C_s = 1$		Koeficijent
	$s_{k0} = s_{r0} \cdot \mu(s) \cdot C_e \cdot C_s = 32$		
	$s_k = 3,00$	(kN/m ²)	

Vjatar (w)	$s_{k0} = 1$		Učinkovitost opterećenja vjatom na 0,4
	$s_{kmax} = 1$		Koeficijent stabilnosti opterećenja vjatom
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4
	$s_{k0} = 20$	(kN/m ²)	Koeficijent stabilnosti opterećenja vjatom na 0,4

OSVJEDENE VRIJEDNOSTI ZA SVI PLOHE (POKROVNOSTAVLJENO)

Enia Klanec
Obala kraja P. Kraljevića IV, 23450 Obrovac



Model:
Enia Klanec_1.zona krovitva - kopija (2)

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MODEL

6.4.1 LC1: LOADING, IN AXONOMETRIC DIRECTION



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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

4.5.1 LC2: LOADING, IN AXONOMETRIC DIRECTION



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Obala kraja P. Križevca IV., 23450 Obrovac



Model:
Enia Klanec, izjava krovitva - kopija (2)

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MODEL

6.6.1 LC3: LOADING, IN AXONOMETRIC DIRECTION



Enia Klanec
Obala kraja P. Kraljevića W., 23450 Obrovac



Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

7 Guide Objects

X1 COORDINATE SYSTEMS

System No.	Type	Symbol	Coordinates			Rotation			Comment
			Value	Unit	Sequence	Symbol	Value	Unit	
1	Global XYZ								
2	3 Points Load Wizard Wind Load No. 1		0.000	-18.050	-4.090 m	0.744	-17.543	-3.655 m	(-0.504, -18.050, -3.227 m)
	3 Points	X ₀	0.000	m					
		Y ₀	-18.050	m					
		Z ₀	-4.090	m					
		X ₁	0.744	m					
		Y ₁	-17.543	m					
		Z ₁	-3.655	m					
		X ₂	-0.504	m					
		Y ₂	-18.050	m					
		Z ₂	-3.227	m					

8 Static Analysis Results



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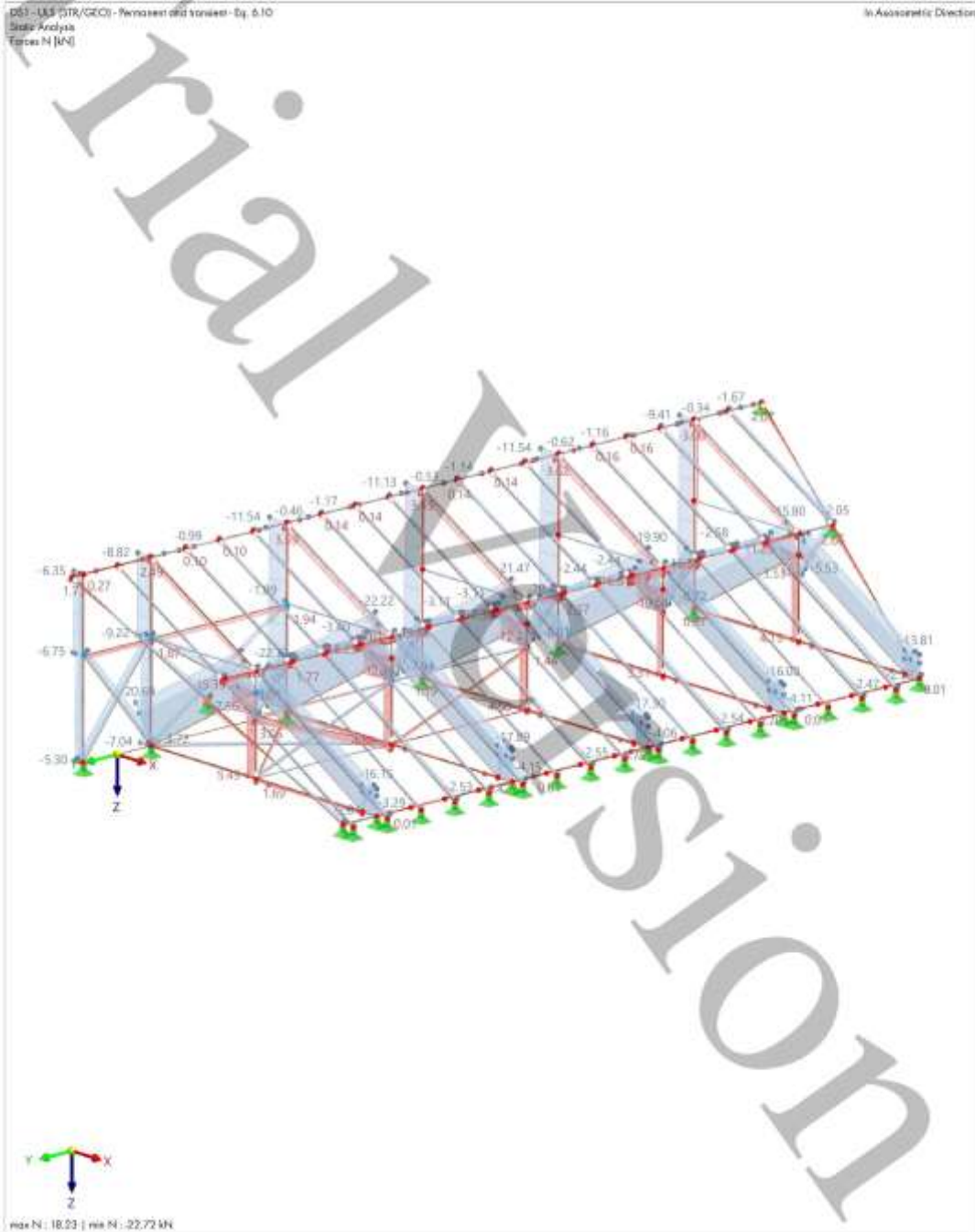
Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

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

Static Analysis



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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MODEL

6.2 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES VY, IN AXONOMETRIC DIRECTION

Static Analysis

DS1 - ULS (STR/CECI) - Pomoćni ojačani - Dg. 6.10
Static Analysis
Forces V_y [kN]

In Axonometric Direction



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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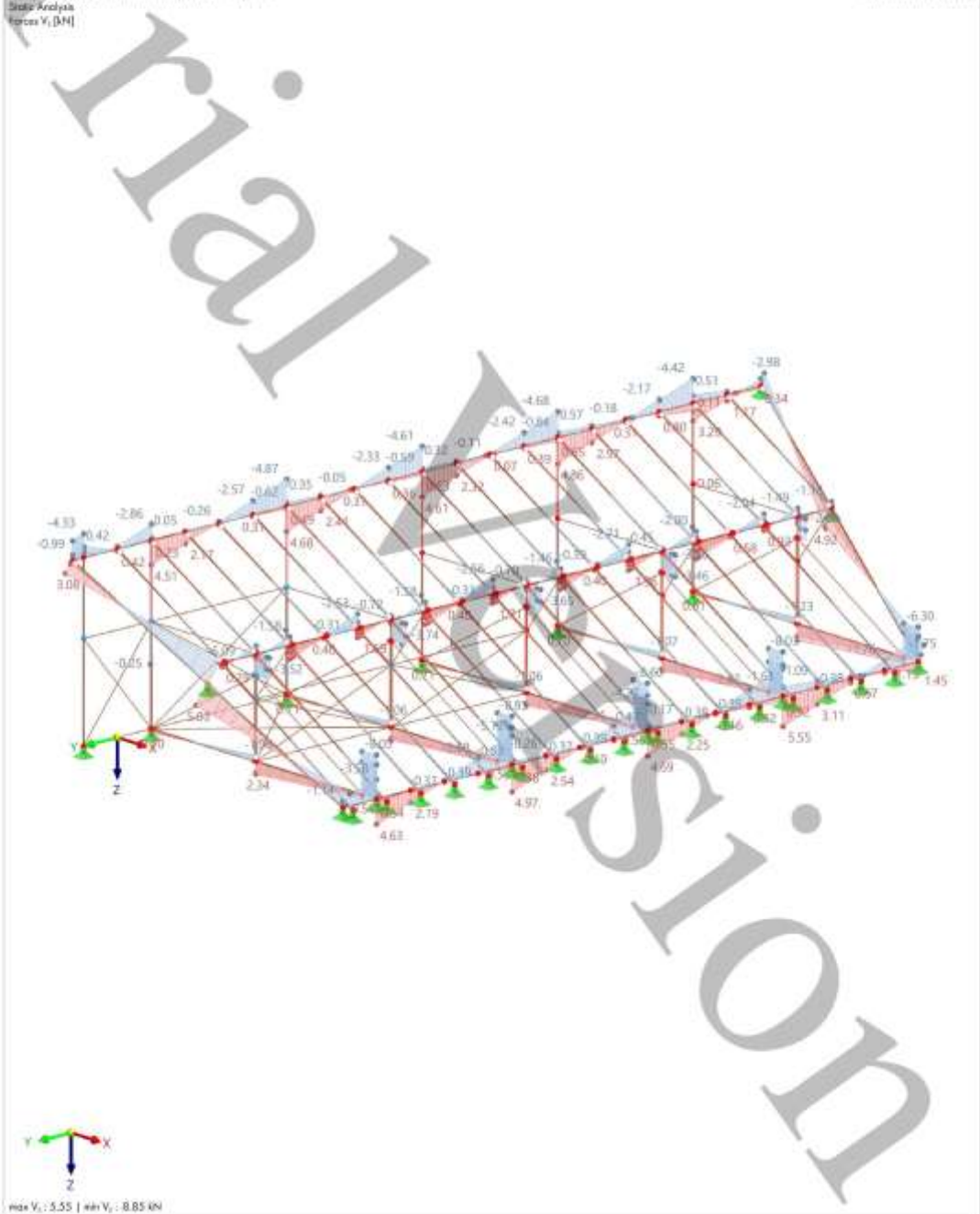
MODEL

6.3 DS1: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES VZ, IN AXONOMETRIC DIRECTION

Static Analysis

DS1 - ULS (STR/CECI) - Pomoćni otkloni - Dg. 6.10
Static Analysis
Forces V_i [kN]

In Axonometric Direction



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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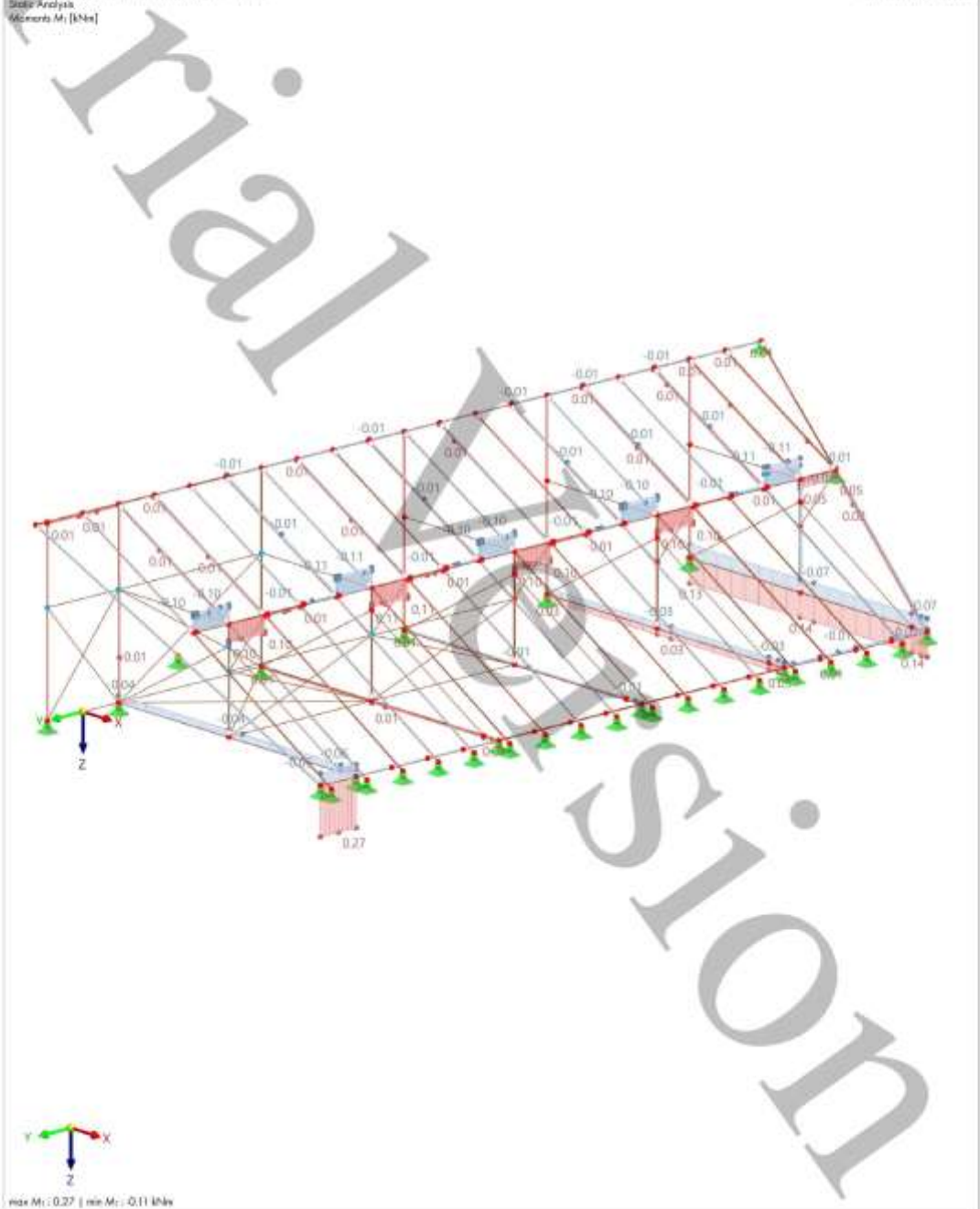
MODEL

6.4 D51: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES MT, IN AXONOMETRIC DIRECTION

Static Analysis

D51 - ULS (STR/CECI) - Pomoćni ojačani - Dg. 6.10
Static Analysis
Moments M_t [kNm]

In Axonometric Direction



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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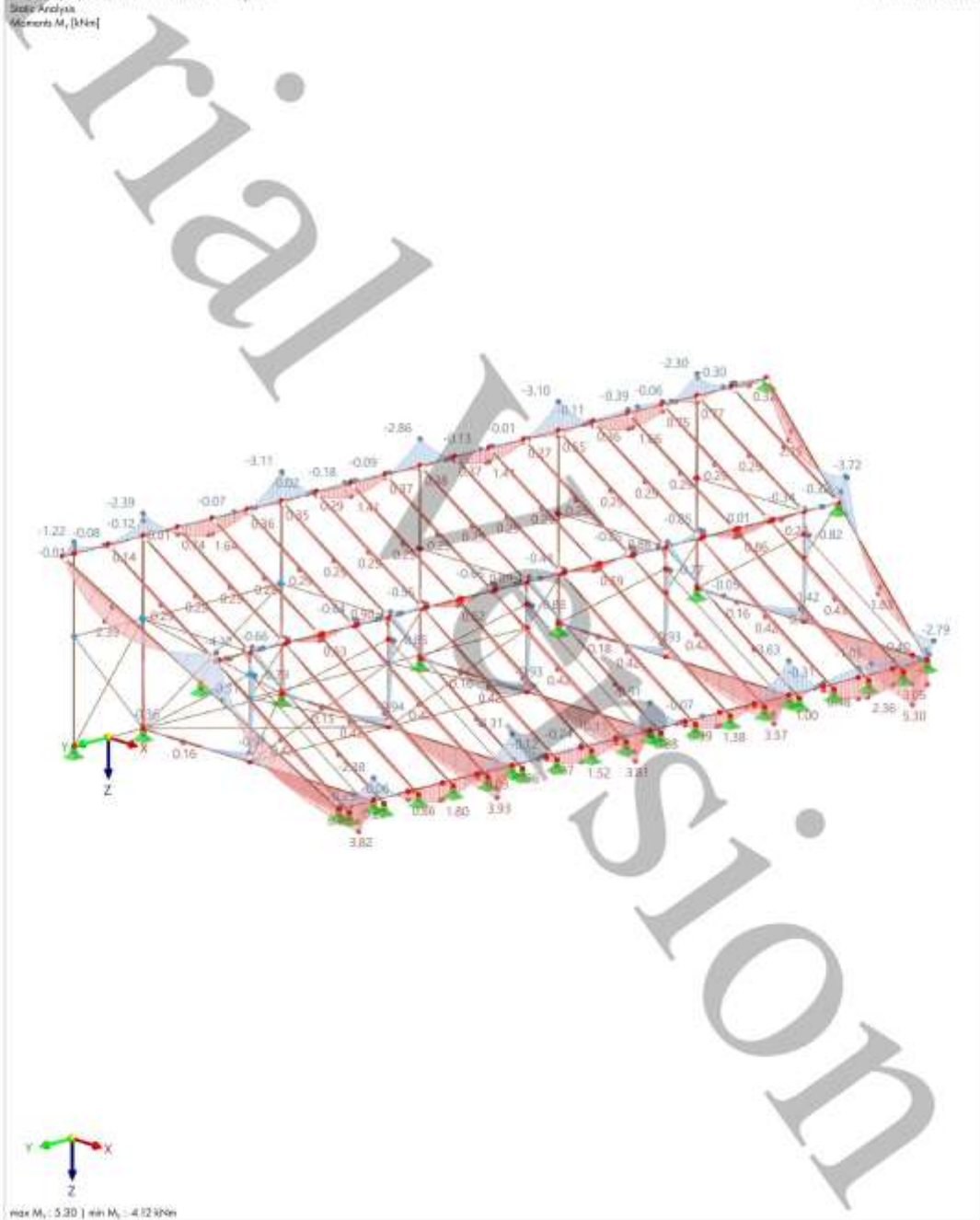
MODEL

6.5 D51: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES MY, IN AXONOMETRIC DIRECTION

Static Analysis

D51 - ULS (STR/CECI) - Pomoćni ojačani - Dg. 6.10
Static Analysis
Moments M_y [kNm]

In Axonometric Direction



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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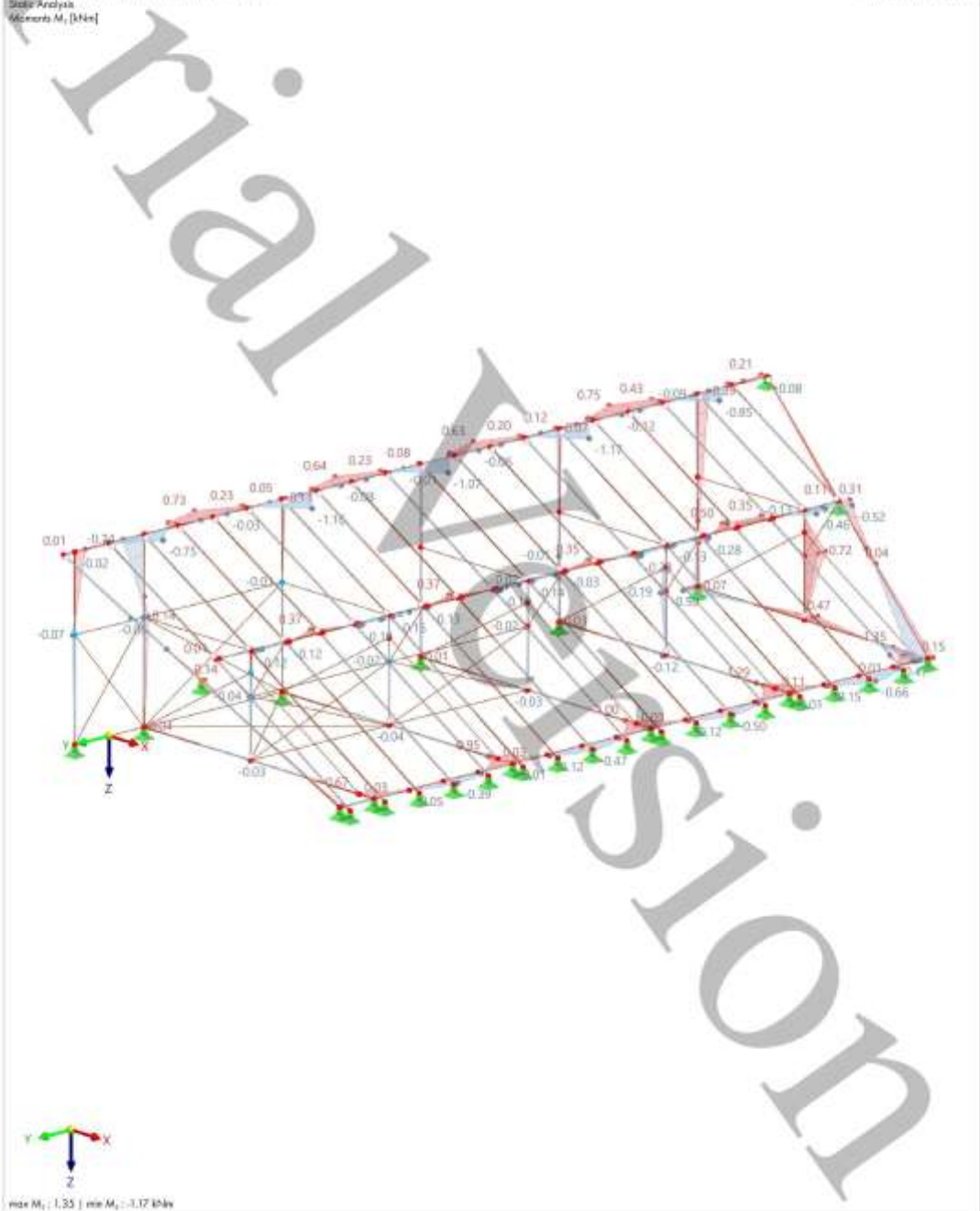
MODEL

6.6 D51: ENVELOPE VALUES - MAX AND MIN VALUES, INTERNAL FORCES MZ, IN AXONOMETRIC DIRECTION

Static Analysis

D51 - ULS (STR/CECI) - Pomoćni otkloni - Dg. 6.10
Static Analysis
Moments Mz [kNm]

In Axonometric Direction



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Model:
Enia Klanec_1.zona krovitja - kopija (2)

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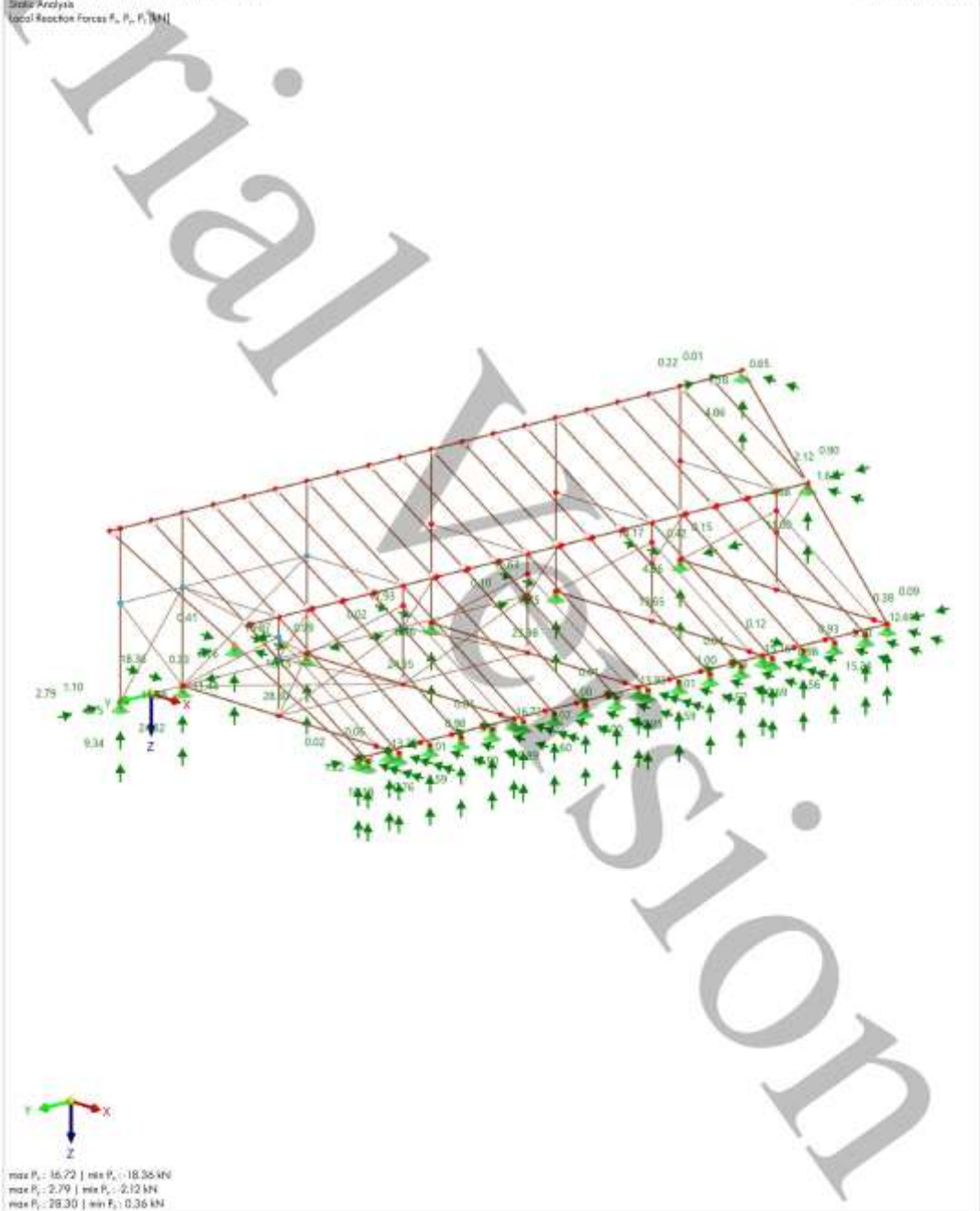
MODEL

6.7 D51: ENVELOPE VALUES - MAX AND MIN VALUES, NODAL SUPPORTS PX, NODAL SUPPORTS PY, NODAL SUPPORTS PZ, IN AXONOMETRIC DIRECTION

Static Analysis

D51 - ULS (STR/CECI) - Pomoćni ojačani sistem - Dg, 6.10
Static Analysis
Local Reaction Forces F_x , F_y , F_z [kN]

In Axonometric Direction



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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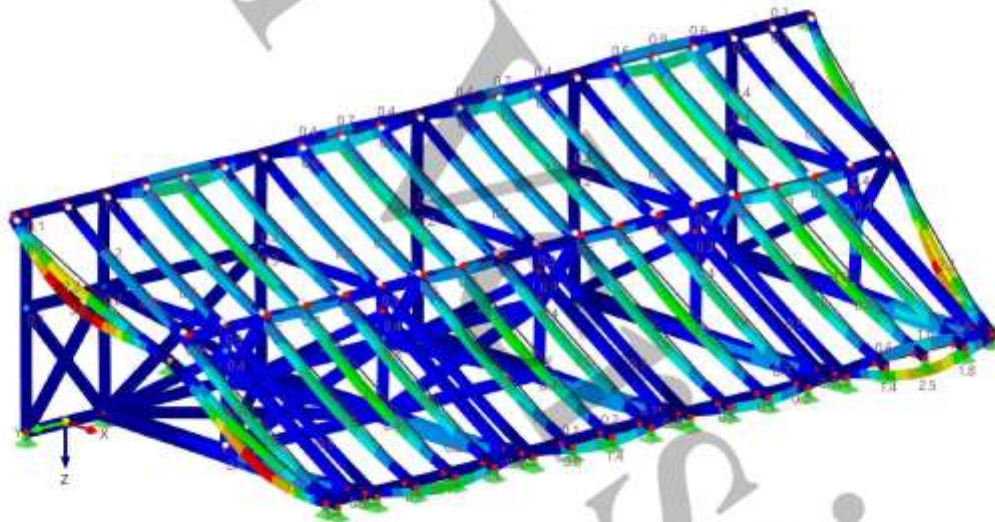
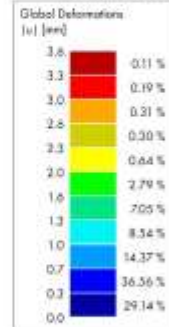
MODEL

6.8. D52: ENVELOPE VALUES - MAX AND MIN VALUES, GLOBAL DEFORMATIONS UI, IN AXONOMETRIC DIRECTION

Static Analysis

D02 - S05 - Characteristic
Static Analysis
Displacements [u] [mm]

In Axonometric Direction



max [u] : 3.6 | min [u] : 0.0 mm



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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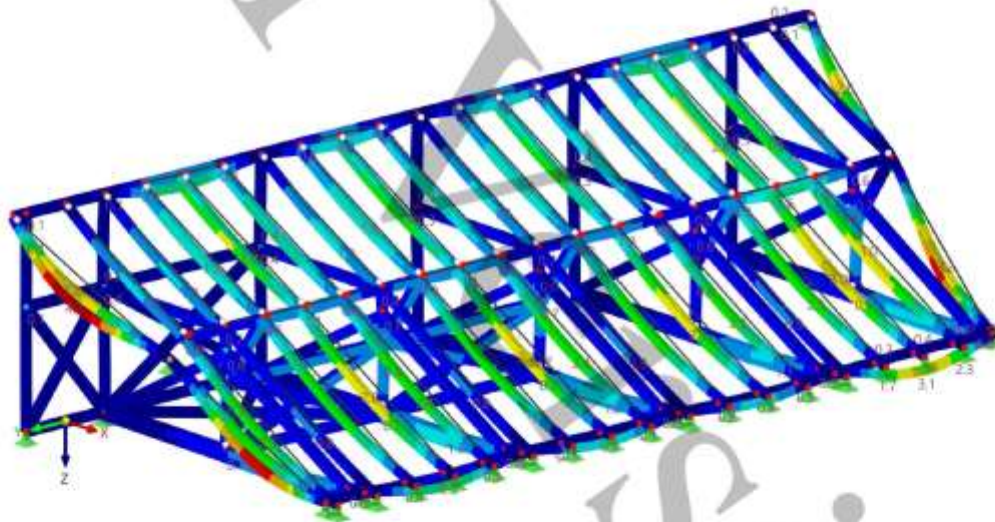
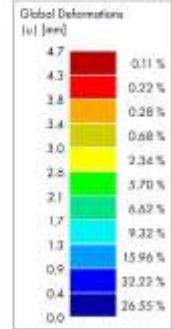
MODEL

6.9 D53: ENVELOPE VALUES - MAX AND MIN VALUES, GLOBAL DEFORMATIONS UI, IN AXONOMETRIC DIRECTION

Static Analysis

D53 - S65 - Quasi-permanent
Static Analysis
Displacements [u] [mm]

In Axonometric Direction



max [u] : 4.7 | min [u] : 0.0 mm





TIMBER

9 Timber Design

9.1 OBJECTS TO DESIGN

Object Type	Design All	Objects to Design		Not Valid / Deact.	Comment	
		Selected	To Calculate			
Members	<input checked="" type="checkbox"/>	2-7,20-44,81,98-11 0,115,118-121,123- 125,127-129,131-1 33,135-138,140-14 2,144-146,148-150, 152-200,203-205,2 08-211,213-234,23 7,236,241-244,248, 251,258-278	2-7,20-44,81,98-11 0,115,118-121,123- 125,127-129,131-1 33,135-138,140-14 2,144-146,148-150, 152-200,203-205,2 08-211,213-234,23 7,236,241-244,248, 251,263-278		258-262	

9.2 DESIGN SITUATIONS

DS No.	EN 1995 Timber CEN 2019-04 Design Situation Type	To Design	Active	EN 1995 CEN 2014-05 Design Situation Type	Combinations to Design for Enumeration Method
1	ULS (STR/GEO) - Permanent and transient - Eq. 6.10	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	ULS (STR/GEO) - Permanent and transient	All
2	SLS - Characteristic	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	SLS - Characteristic	All
3	SLS - Quasi-permanent	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	SLS - Quasi-permanent 1	All

9.3 MATERIALS

Legend
 Stiffness modification

Material No.	Name	To Design	Material Type	Options	Comment
1	D50	<input checked="" type="checkbox"/>	Timber	<input checked="" type="checkbox"/>	

9.4 SECTIONS

Legend
 Warping stiffness deactivated

Section No.	Name	Material	To Design	Section Type	Use Other Section for Design	Options
1	R_M1 160/220	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
2	R_M1 160/160	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
3	R_M1 150/150	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
4	R_M1 120/150	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
5	2R_M2 120/80/100/1	1	<input checked="" type="checkbox"/>	Parametric - Massive II	<input type="checkbox"/>	<input type="checkbox"/>
6	R_M1 150/180	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
7	R_M1 160/120	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
8	R_M1 270/200	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
9	R_M1 170/150	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
10	R_M1 200/270	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
11	R_M1 150/170	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>
12	R_M1 120/160	1	<input checked="" type="checkbox"/>	Parametric - Massive I	<input type="checkbox"/>	<input type="checkbox"/>

9.5 ULTIMATE CONFIGURATIONS

Config. No.	Name	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 ($\sigma_{t,Ed} / f_{t,k}$)	$\sigma_{t,Ed}$	0.001	-
	Compression ($\sigma_{c,Ed} / f_{c,k}$)	$\sigma_{c,Ed}$	0.001	-
	Shear ($\tau_{v,Ed} / f_{v,k}$)	$\tau_{v,Ed}$	0.001	-
	Shear ($\tau_{t,Ed} / f_{t,k}$)	$\tau_{t,Ed}$	0.001	-
	Torsion ($\tau_{t,Ed} / f_{t,k}$)	$\tau_{t,Ed}$	0.010	-
	Bending ($\sigma_{b,Ed} / f_{b,k}$)	$\sigma_{b,Ed}$	0.001	-
	Bending ($\sigma_{b,Ed} / f_{b,k}$)	$\sigma_{b,Ed}$	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			





TIMBER

9.5.1 **ULTIMATE CONFIGURATIONS - SETTINGS - MEMBERS**

Config. No.	Description	Symbol	Value	Unit
	Cut-to-Grain Angle Limit Allow further design if angle does not exceed limit	α [°]	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 $1/(1+k_{st})$ 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)			

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	-
	Can'tilever limits			
	Characteristic	$L_x/$	150	-
	Quasi-permanent 1	$L_x/$	125	-
	Quasi-permanent 2	$L_x/$	75	-
	Vibration Design Vibration design	W _{max}	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)			



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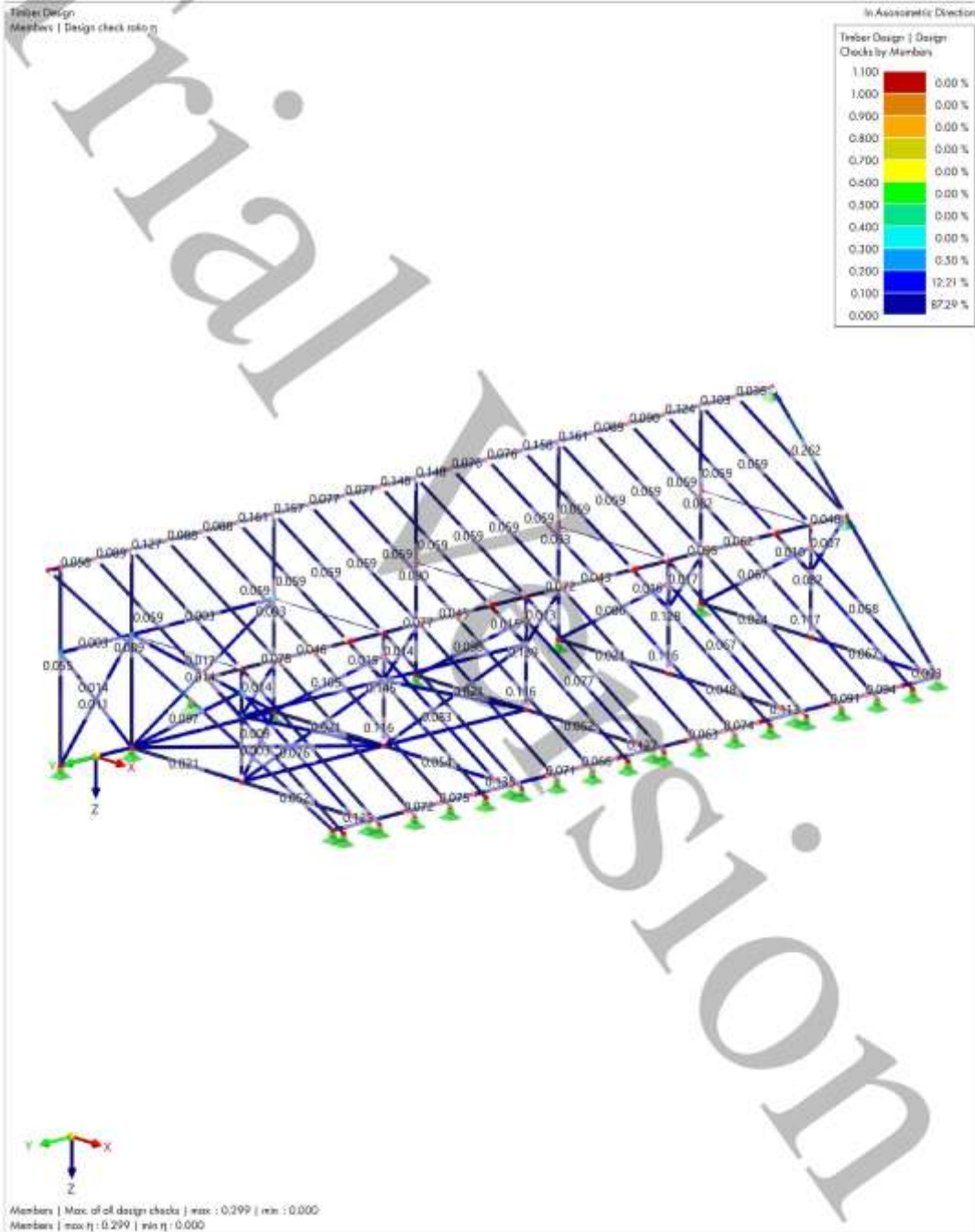
Model:
Enia Klanec_1.zona krovitva - kopija (2)

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MODEL

9.8.1 **TIMBER DESIGN: MAX. OF ALL DESIGN CHECKS, MAX. OF ALL DESIGN CHECKS, IN AXONOMETRIC DIRECTION**

Timber Design



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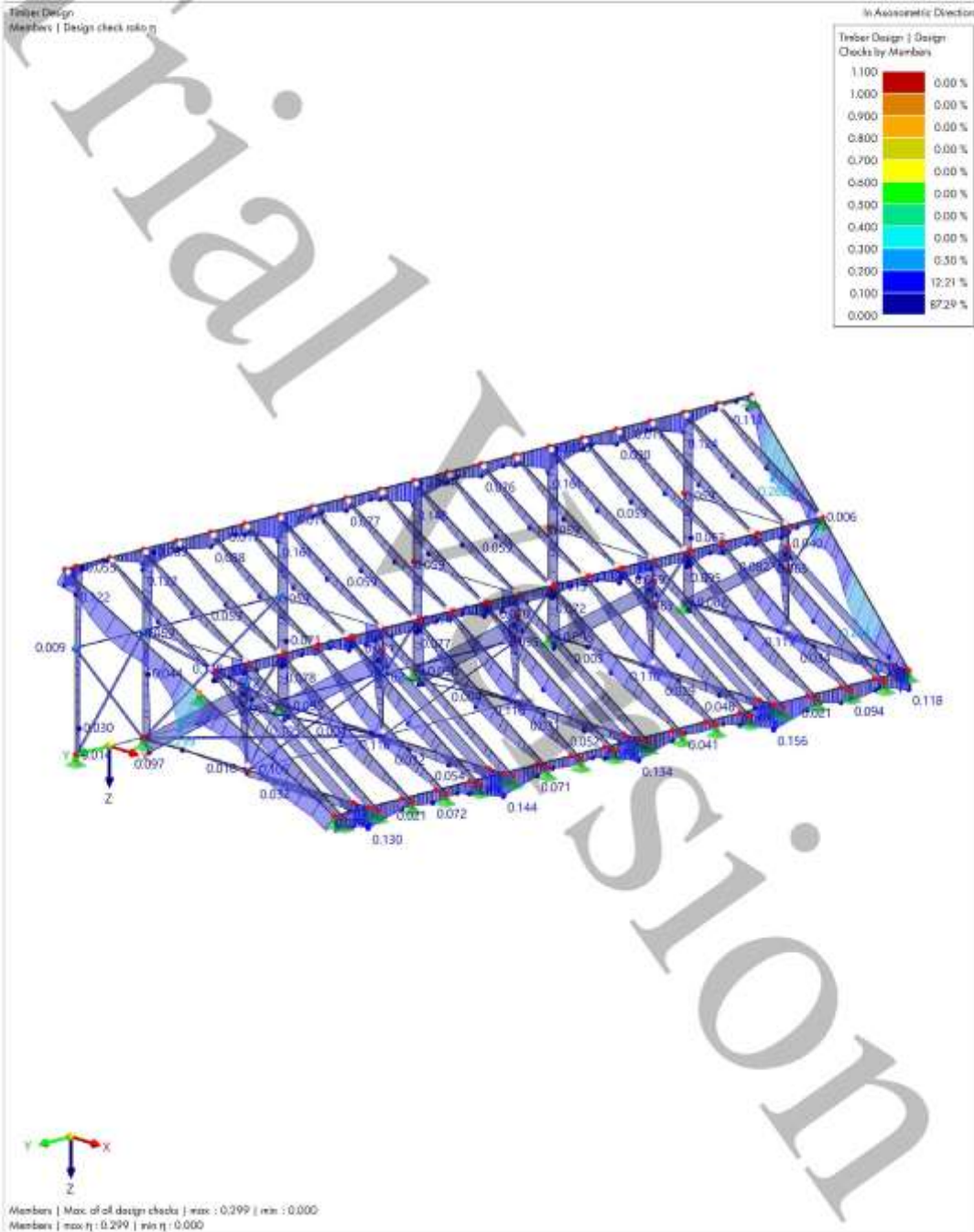
Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.8.2 **TIMBER DESIGN: MAX. OF ALL DESIGN CHECKS, MAX. OF ALL DESIGN CHECKS, IN AXONOMETRIC DIRECTION**

Timber Design



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Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.8.3 TIMBER DESIGN: MAX. OF ALL DESIGN CHECKS, MAX. OF ALL DESIGN CHECKS, IN AXONOMETRIC DIRECTION

Timber Design



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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.9 MEMBER NO. 203 | D53 | CO12 | 5.926 M | SE1200.02

Timber Design

Design Check SE1200.02 | EN 1995 | CEN | 2014-05

Serviceability
Combination of actions 'Quasi-permanent 1' | z-direction acc. to 7.2

Segment type in z-dir: Beam

$$w_{\text{net},z} = w_{1,z} - w_{1,z} \\ = 4.1 \text{ mm} - 0.0 \text{ mm} \\ = 4.1 \text{ mm}$$

$$w_{\text{net},z,lim,z} = \frac{l}{175 w_{\text{net},z,lim,z}} \\ = \frac{5.926 \text{ m}}{175} \\ = 32.8 \text{ mm}$$

$$\eta = \frac{|w_{\text{net},z}|}{w_{\text{net},z,lim,z}} \\ = \frac{4.1 \text{ mm}}{32.8 \text{ mm}} \\ = 0.126$$

$$\eta = 0.126 \leq 1 \checkmark$$

- $w_{\text{net},z}$ Net final deflection
- $w_{1,z}$ Deflection
- $w_{1,z}$ Presamber at z-location
- $w_{\text{net},z,lim,z}$ Limit value of deflection
- l Reference length
- $1/175 w_{\text{net},z,lim,z}$ Limit value criterion

7.2



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Model:
Enia Klanec, 1.zona krovitva - koplja (2)

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MODEL

9.10 MEMBER NO. 7 | D53 | CO12 | 2.337 M | SE1100.02

Timber Design

Design Check SE1100.02 | EN 1995 | CEN | 2014-05

Serviceability
Combination of actions: Quasi-permanent 1 | y-direction acc. to 7.2

Segment type in y-axis: Beam

$$w_{\text{net},y} = w_{1,y} - w_{c,y}$$

$$= -0.5 \text{ mm} - 0.0 \text{ mm}$$

$$= -0.5 \text{ mm}$$

$$w_{\text{net},y} / l = \frac{-0.5 \text{ mm}}{4.000 \text{ m}}$$

$$= \frac{-0.5}{4000}$$

$$= -0.125 \text{ mm/m}$$

$$\eta = \frac{|w_{\text{net},y}|}{w_{\text{lim},y}}$$

$$= \frac{0.5 \text{ mm}}{16.4 \text{ mm}}$$

$$= 0.028$$

$$\eta = 0.028 < 1 \quad \checkmark$$

- $w_{\text{net},y}$ Net final deflection
- $w_{1,y}$ Deflection
- $w_{c,y}$ Precamber at x-location
- $w_{\text{lim},y}$ Limit value of deflection
- l Reference length
- $l/w_{\text{lim},y}$ Limit value criterion

7.2



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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

6.11 **MEMBER NO. 203 | D52 | CO7 | 5.926 M | SE1200.01**

Timber Design

Design Check SE1200.01 | EN 1995 | CEN | 2014-05

Serviceability
Combination of actions 'Characteristic' | z-direction acc. to 7.2

Segment type in z-axis: Beam

$$w_{\text{rel},z} = \frac{l}{W_{\text{rel},z}} = \frac{8,205 \text{ m}}{300,00} = 27,3 \text{ mm}$$

$$\eta = \frac{|w_{\text{rel},z}|}{W_{\text{rel},z}} = \frac{27,3 \text{ mm}}{27,3 \text{ mm}} = 0,118$$

$$\eta = 0,118 \leq 1,0^*$$

$w_{\text{rel},z}$: Limit value of deflection
l: Reference length
 $l/W_{\text{rel},z}$: Limit value criterion
 $w_{\text{rel},z}$: Deflection

7.2



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Model:
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MODEL

9.12 MEMBER NO. 7 | D52 | CO7 | 2.337 M | SE1100.01

Timber Design

Design Check SE1100.01 | EN 1995 | CEN | 2014-05

Serviceability
Combination of actions 'Characteristic' | y-direction acc. to 7.2

Segment type in y-axis: Beam

$$w_{\text{inst,y}} = \frac{l}{4000} \cdot \frac{1}{1000} \cdot 300 \cdot 0.05 = 13.6 \text{ mm}$$

$$\eta = \frac{|w_{\text{inst,y}}|}{w_{\text{lim,y}}} = \frac{13.6 \text{ mm}}{0.3 \text{ mm}} = 0.025$$

$$\eta = 0.025 \leq 1 \quad \checkmark$$

$w_{\text{lim,y}}$: Limit value of deflection
l: Reference length
 $1/w_{\text{lim,y}}$: Limit value criterion
 $w_{\text{inst,y}}$: Deflection

7.2



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Model:
Enia Klanec, I.zona krovitva - kopija (2)

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MODEL

9.13 MEMBER NO. 203 | D51 | CO2 | 4.102 M | STRESS POINT NO. 1 | ST3100

Timber Design

Design Check ST3100 | EN 1995 | CEN | 2014-05

Security
Bending about y-axis and compression acc. to 6.3.3

$$f_{c,0,d} = k_{mod} \cdot \frac{f_{c,0,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 20.769 \text{ N/mm}^2$$

24.1, Eq. 2.14

$$f_{m,y,d} = k_{mod} \cdot \frac{f_{m,y,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

24.1, Eq. 2.14

$$i_x = \frac{I_{y,z}}{I_y}$$

$$= \frac{8.205 \text{ m}}{34.6 \text{ mm}}$$

$$= 236.85$$

$$\lambda_{rel,x} = \frac{i_x}{e} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05,x}}}$$

$$= \frac{236.85}{e} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11800 \text{ N/mm}^2}}$$

$$= 3.80$$

6.3.2, Eq. 6.22

$$k_y = 0.5 \cdot (1 + \beta_c \cdot (\lambda_{rel,x} - 0.3) + (\lambda_{rel,x})^2)$$

$$= 0.5 \cdot (1 + 0.20 \cdot (3.80 - 0.3) + (3.80)^2)$$

$$= 8.08$$

6.3.2, Eq. 6.28

$$k_{c,y} = \frac{1}{k_y + \sqrt{(\beta_c)^2 - (\lambda_{rel,x})^2}}$$

$$= \frac{1}{8.08 + \sqrt{(0.20)^2 - (3.80)^2}}$$

$$= 0.07$$

6.3.2, Eq. 6.28

$$\sigma_{m,eff} = \frac{\pi \cdot \sqrt{E_{0,05,x}} \cdot I_z \cdot G_{05} \cdot k}{L_{cr} \cdot W_y}$$

$$= \frac{\pi \cdot \sqrt{11800.0 \text{ N/mm}^2} \cdot 2304.00 \text{ cm}^4 \cdot 741.8 \text{ N/mm}^2 \cdot 4976.26 \text{ cm}^3}{8.925 \text{ m} \cdot 512.00 \text{ cm}^3}$$

$$= 72.108 \text{ N/mm}^2$$

6.3.3, Eq. 6.31

$$\lambda_{rel,y} = \sqrt{\frac{f_{m,y,k}}{\sigma_{m,eff}}}$$

$$= \sqrt{\frac{50.000 \text{ N/mm}^2}{72.108 \text{ N/mm}^2}}$$

$$= 0.83$$

6.3.3, Eq. 6.36

0.75 < $\lambda_{rel,y}$ <= 1.4

$$k_{c,y} = 1.50 - 0.75 \cdot \lambda_{rel,y}$$

$$= 1.50 - 0.75 \cdot 0.83$$

$$= 0.94$$

6.3.3, Eq. 6.34

$$\eta = \sqrt{\left| \frac{(\sigma_{m,y,d})^2}{k_{c,y} \cdot f_{m,y,d}} + \frac{\sigma_{c,0,d}}{k_{c,y} \cdot f_{c,0,d}} \right|}$$

$$= \sqrt{\left| \frac{(-20.309 \text{ N/mm}^2)^2}{0.94 \cdot 34.615 \text{ N/mm}^2} + \frac{-0.029 \text{ N/mm}^2}{0.07 \cdot 20.769 \text{ N/mm}^2} \right|}$$

$$= 0.785$$

6.3.3, Eq. 6.30



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Enia Klanec, I.zona krovitva - kopija (2)

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MODEL

9.13 **MEMBER NO. 203 | D51 | CO2 | 4.102 M | STRESS POINT NO. 1 | ST3100**

Timber Design

$\eta = 0.985 \leq 1$

- $f_{c,0d}$ Design compressive strength
- k_{mod} Modification factor
- $f_{t,0k}$ Characteristic compressive strength
- γ_M Partial factor
- $f_{m,0d}$ Design bending strength
- $f_{m,0k}$ Characteristic bending strength
- λ_y Slenderness ratio
- $l_{cr,z}$ Equivalent member length
- i_y Radius of gyration
- $\lambda_{rel,z}$ Relative slenderness ratio
- $E_{0,05,z}$ Modulus of elasticity
- k_z Instability factor
- β_z Straightness factor
- $k_{z,z}$ Instability factor
- $\sigma_{m,cr,z}$ Critical bending stress
- I_y Moment of inertia
- G_{05} Shear modulus
- I_t Torsional constant
- $l_{cr,y}$ Equivalent member length
- W_y Elastic section modulus to more compressed edge
- $\lambda_{rel,y}$ Relative slenderness ratio
- $k_{y,z}$ Lateral buckling coefficient
- $\sigma_{m,0d}$ Design bending stress
- $\sigma_{c,0d}$ Design compressive stress





MODEL

9.14 MEMBER NO. 203 | D51 | CO2 | 3.861 M | LEFT SIDE | STRESS POINT NO. 1 | ST2100

Timber Design

Design Check ST2100 | EN 1995 | CEN | 2014-05

Security

Besural member without compression force | Bending about y-axis acc. to 6.3.3

$$f_{m,y,d} = k_{mod} \cdot \frac{f_{m,y,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$\sigma_{m,crit} = \pi \cdot \sqrt{\frac{E_{0,05,k} \cdot I_y \cdot G_{05} \cdot I_t}{L_{eq} \cdot W_y}}$$

$$= \pi \cdot \sqrt{\frac{11800.0 \text{ N/mm}^2 \cdot 2304.30 \text{ cm}^4 \cdot 743.8 \text{ N/mm}^2 \cdot 4976.26 \text{ cm}^4}{8.525 \text{ m} \cdot 512.00 \text{ cm}^3}}$$

$$= 72.308 \text{ N/mm}^2$$

6.3.3, Eq. 6.33

$$\lambda_{rel,y} = \sqrt{\frac{f_{m,y,k}}{\sigma_{m,crit}}}$$

$$= \sqrt{\frac{50.000 \text{ N/mm}^2}{72.308 \text{ N/mm}^2}}$$

$$= 0.83$$

6.3.3, Eq. 6.36

$$0.75 < \lambda_{rel,y} \leq 1.4$$

$$k_{lat} = 1.56 - 0.75 \cdot \lambda_{rel,y}$$

$$= 1.56 - 0.75 \cdot 0.83$$

$$= 0.94$$

6.3.3, Eq. 6.34

$$\eta = \frac{\sigma_{m,y,d}}{k_{lat} \cdot f_{m,y,d}}$$

$$= \frac{-20.308 \text{ N/mm}^2}{0.94 \cdot 34.615 \text{ N/mm}^2}$$

$$= 0.877$$

6.3.3, Eq. 6.33

$$\eta = 0.877 \leq 1.0^*$$

- $f_{m,y,d}$ Design bending strength
- k_{mod} Modification factor
- $f_{m,y,k}$ Characteristic bending strength
- γ_M Partial factor
- $\sigma_{m,crit}$ Critical bending stress
- $E_{0,05,k}$ Modulus of elasticity
- I_y Moment of inertia
- G_{05} Shear modulus
- I_t Torsional constant
- L_{eq} Equivalent member length
- W_y Elastic section modulus to more compressed edge
- $\lambda_{rel,y}$ Relative slenderness ratio
- k_{lat} Lateral buckling coefficient
- $\sigma_{m,y,d}$ Design bending stress





MODEL

9.15 MEMBER NO. 203 | D51 | CO2 | 4.102 M | STRESS POINT NO. 3 | ST1600.03

Timber Design

Design Check ST1600.03 | EN 1995 | CEN | 2014-05

Stability

Biaxial bending and compression with buckling about both axes acc. to 6.3.2

$$f_{c,0,d} = k_{red} \cdot \frac{f_{c,0,k}}{\gamma_M} \quad 24.1, \text{ Eq. 2.14}$$

$$= 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 20.769 \text{ N/mm}^2$$

$$f_{m,y,d} = k_{red} \cdot \frac{f_{m,k}}{\gamma_M} \quad 24.1, \text{ Eq. 2.14}$$

$$= 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

$$f_{m,z,d} = k_{red} \cdot \frac{f_{m,k}}{\gamma_M} \quad 24.1, \text{ Eq. 2.14}$$

$$= 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

$$\lambda_y = \frac{l_{cr,y}}{i_y}$$

$$= \frac{8.205 \text{ m}}{46.2 \text{ mm}}$$

$$= 177.64$$

$$\lambda_z = \frac{l_{cr,z}}{i_z}$$

$$= \frac{8.205 \text{ m}}{34.6 \text{ mm}}$$

$$= 236.85$$

$$\lambda_{rel,y} = \frac{\lambda_y}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05,y}}} \quad 6.3.2, \text{ Eq. 6.21}$$

$$= \frac{177.64}{\pi} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11800.0 \text{ N/mm}^2}}$$

$$= 2.85$$

$$\lambda_{rel,z} = \frac{\lambda_z}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05,z}}} \quad 6.3.2, \text{ Eq. 6.22}$$

$$= \frac{236.85}{\pi} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11800.0 \text{ N/mm}^2}}$$

$$= 3.80$$

$\lambda_{rel,y} > 0.3$ or $\lambda_{rel,z} > 0.3$

$$k_y = 0.5 \cdot \left(1 + \beta_c \cdot (\lambda_{rel,y} - 0.3) + (\lambda_{rel,y})^2 \right) \quad 6.3.2, \text{ Eq. 6.27}$$

$$= 0.5 \cdot \left(1 + 0.20 \cdot (2.85 - 0.3) + (2.85)^2 \right)$$

$$= 4.82$$

$$k_z = 0.5 \cdot \left(1 + \beta_c \cdot (\lambda_{rel,z} - 0.3) + (\lambda_{rel,z})^2 \right) \quad 6.3.2, \text{ Eq. 6.28}$$

$$= 0.5 \cdot \left(1 + 0.20 \cdot (3.80 - 0.3) + (3.80)^2 \right)$$

$$= 5.68$$

$$k_{ty} = \frac{1}{k_y + \sqrt{(k_y)^2 - (\lambda_{rel,y})^2}} \quad 6.3.2, \text{ Eq. 6.26}$$

$$= \frac{1}{4.82 + \sqrt{(4.82)^2 - (2.85)^2}}$$

$$= 0.11$$



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MODEL

9.15 MEMBER NO. 203 | D51 | CO2 | 4.102 M | STRESS POINT NO. 3 | ST1600.03

Timber Design

$$k_{c,0.4} = \frac{1}{k_{c,0.4} + \sqrt{(k_{c,0.4})^2 - (l_{m,z})^2}}$$

$$= \frac{1}{8.08 + \sqrt{(8.08)^2 - (3.80)^2}}$$

$$= 0.07$$

$$\eta_1 = \frac{\sigma_{c,0.4} + \sigma_{m,y,d} + k_{c,0.4} \cdot \sigma_{m,z,d}}{k_{c,0.4} \cdot f_{c,0.4} + f_{m,y,d} + k_{c,0.4} \cdot f_{m,z,d}}$$

$$= \frac{-0.026 \text{ N/mm}^2 + \frac{-28.309 \text{ N/mm}^2}{34.615 \text{ N/mm}^2} + 0.70 \cdot \frac{-0.912 \text{ N/mm}^2}{34.615 \text{ N/mm}^2}}{0.11 \cdot 20.759 \text{ N/mm}^2 + 34.615 \text{ N/mm}^2 + 0.70 \cdot 34.615 \text{ N/mm}^2}$$

$$= 0.848$$

$$\eta_2 = \frac{\sigma_{c,0.4} + k_{c,0.4} \cdot \sigma_{m,y,d} + \sigma_{m,z,d}}{k_{c,0.4} \cdot f_{c,0.4} + f_{m,y,d} + f_{m,z,d}}$$

$$= \frac{-0.026 \text{ N/mm}^2 + 0.70 \cdot \frac{-28.309 \text{ N/mm}^2}{34.615 \text{ N/mm}^2} + \frac{-0.912 \text{ N/mm}^2}{34.615 \text{ N/mm}^2}}{0.07 \cdot 20.759 \text{ N/mm}^2 + 0.70 \cdot 34.615 \text{ N/mm}^2 + 34.615 \text{ N/mm}^2}$$

$$= 0.620$$

$$\eta = \max(\eta_1, \eta_2)$$

$$= \max(0.848, 0.620)$$

$$= 0.848$$

$\eta = 0.848 \leq 1.0$

8.3.2, Eq. 6.28
Eq. 6.23
Eq. 6.24
6.32

- $f_{c,0.4}$ Design compressive strength
- $k_{c,0.4}$ Modification factor
- $f_{c,0.4}$ Characteristic compressive strength
- $k_{c,0.4}$ Partial factor
- $f_{m,y,d}$ Design bending strength
- $f_{m,y,k}$ Characteristic bending strength
- $f_{m,z,d}$ Design bending strength
- $f_{m,z,k}$ Characteristic bending strength
- λ_y Slenderness ratio
- $l_{m,y}$ Equivalent member length
- i_y Radius of gyration
- λ_z Slenderness ratio
- $l_{m,z}$ Equivalent member length
- i_z Radius of gyration
- $\lambda_{rel,y}$ Relative slenderness ratio
- $E_{0.05,y}$ Modulus of elasticity
- $\lambda_{rel,z}$ Relative slenderness ratio
- $E_{0.05,z}$ Modulus of elasticity
- k_y Instability factor
- β_z Straightness factor
- k_z Instability factor
- $k_{c,y}$ Instability factor
- $k_{c,z}$ Instability factor
- η_1 Design ratio 1
- $\sigma_{c,0.4}$ Design compressive stress
- $\sigma_{m,y,d}$ Design bending stress
- $k_{c,0.4}$ Redistribution factor
- $\sigma_{m,z,d}$ Design bending stress
- η_2 Design ratio 2



Enio Klanac
Obala kroja P. Kraljevića W, 23450 Obrovac



Model:
Enio Klanac_1.zona krovitka - kopija (2)

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MODEL

9.16 MEMBER NO. 7 | D51 | CO2 | 1.398 M | STRESS POINT NO. 1 | ST1600.02

Timber Design

Design Check ST1600.02 | EN 1995 | CEN | 2014-05

Security

Bending about z-axis and compression with buckling about both axes acc. to 6.3.2.

$$f_{c,0,d} = k_{red} \cdot \frac{f_{c,0,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 20.769 \text{ N/mm}^2$$

24.1, Eq. 2.14

$$f_{m,z,d} = k_{red} \cdot \frac{f_{m,z,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 20.769 \text{ N/mm}^2$$

24.1, Eq. 2.14

$$i_y = \frac{I_{0,y}}{A}$$

$$= \frac{4.090 \text{ m}}{43.3 \text{ mm}}$$

$$= 94.45$$

$$i_x = \frac{I_{0,x}}{A}$$

$$= \frac{4.090 \text{ m}}{43.3 \text{ mm}}$$

$$= 94.45$$

$$i_{rel,y} = \frac{i_y}{r} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05,z}}}$$

$$= \frac{94.45}{r} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11800.0 \text{ N/mm}^2}}$$

$$= 1.52$$

6.3.2, Eq. 6.21

$$i_{rel,x} = \frac{i_x}{r} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05,z}}}$$

$$= \frac{94.45}{r} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11800.0 \text{ N/mm}^2}}$$

$$= 1.52$$

6.3.2, Eq. 6.21

$i_{rel,y} > 0.3$ or $i_{rel,x} > 0.3$

$$k_y = 0.5 \cdot \left(1 + \beta_c \cdot (i_{rel,y} - 0.3) + (i_{rel,y})^2 \right)$$

$$= 0.5 \cdot \left(1 + 0.20 \cdot (1.52 - 0.3) + (1.52)^2 \right)$$

$$= 1.77$$

6.3.2, Eq. 6.27

$$k_x = 0.5 \cdot \left(1 + \beta_c \cdot (i_{rel,x} - 0.3) + (i_{rel,x})^2 \right)$$

$$= 0.5 \cdot \left(1 + 0.20 \cdot (1.52 - 0.3) + (1.52)^2 \right)$$

$$= 1.77$$

6.3.2, Eq. 6.28

$$k_{cy} = \frac{1}{k_y + \sqrt{(k_y)^2 - (i_{rel,y})^2}}$$

$$= \frac{1}{1.77 + \sqrt{(1.77)^2 - (1.52)^2}}$$

$$= 0.37$$

6.3.2, Eq. 6.25

$$k_{cx} = \frac{1}{k_x + \sqrt{(k_x)^2 - (i_{rel,x})^2}}$$

$$= \frac{1}{1.77 + \sqrt{(1.77)^2 - (1.52)^2}}$$

$$= 0.37$$

6.3.2, Eq. 6.26



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Model:
Enia Klanec_1.zona krovitka - kopija (3)

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MODEL

9.16 MEMBER NO. 7 | D51 | CO2 | 1.398 M | STRESS POINT NO. 1 | ST1600.02

Timber Design

$$\eta_1 = \frac{\frac{\sigma_{c,d}}{k_{c,p} \cdot f_{c,d}} + k_{c,m} \frac{\sigma_{m,d}}{f_{m,d}}}{0.37 - 20.799 \text{ N/mm}^2} + 0.70 \cdot \frac{0.085 \text{ N/mm}^2}{34.615 \text{ N/mm}^2}$$

$$= 0.058$$

$$\eta_2 = \frac{\frac{\sigma_{c,d}}{k_{c,p} \cdot f_{c,d}} + \frac{\sigma_{m,d}}{f_{m,d}}}{0.37 - 20.799 \text{ N/mm}^2} + \frac{0.085 \text{ N/mm}^2}{34.615 \text{ N/mm}^2}$$

$$= 0.057$$

$$\eta = \max(\eta_1, \eta_2)$$

$$= \max(0.058, 0.057)$$

$$= 0.058$$

$$\eta = 0.058 \leq 1 \checkmark$$

E₀ 4.23

E₀ 4.24

4.3.2

- f_{c,d} Design compressive strength
- k_{mod} Modification factor
- f_{c,0,k} Characteristic compressive strength
- ψ₁ Partial factor
- f_{m,d} Design bending strength
- f_{m,k} Characteristic bending strength
- λ_y Slenderness ratio
- l_{eq,y} Equivalent member length
- i_y Radius of gyration
- λ_y Slenderness ratio
- l_{eq,z} Equivalent member length
- i_z Radius of gyration
- λ_{rel,y} Relative slenderness ratio
- E_{00,y} Modulus of elasticity
- λ_{rel,z} Relative slenderness ratio
- E_{00,z} Modulus of elasticity
- k_y Instability factor
- k_z Instability factor
- k_{0,y} Instability factor
- k_{0,z} Instability factor
- η₁ Design ratio 1
- σ_{c,d} Design compressive stress
- k_m Redistribution factor
- σ_{m,d} Design bending stress
- η₂ Design ratio 2





MODEL

9.17 MEMBER NO. 203 | D51 | CO3 | 4.102 M | STRESS POINT NO. 1 | ST1600.01

Timber Design

Design Check ST1600.01 | EN 1995 | CEN | 2014-05

Security

Bending about y-axis and compression with buckling about both axes acc. to 6.3.2.

$$f_{c,0,d}$$

$$= k_{red} \cdot \frac{f_{c,0,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 20.769 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$f_{m,y,d}$$

$$= k_{red} \cdot \frac{f_{m,y,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$i_y$$

$$= \frac{I_{cr,y}}{I_y}$$

$$= \frac{8.285 \text{ m}}{46.2 \text{ mm}}$$

$$= 177.64$$

$$i_x$$

$$= \frac{I_{cr,x}}{I_x}$$

$$= \frac{8.285 \text{ m}}{34.6 \text{ mm}}$$

$$= 236.85$$

$$i_{rel,y}$$

$$= \frac{i_y}{\sigma} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05,y}}}$$

$$= \frac{177.64}{\sigma} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11000.0 \text{ N/mm}^2}}$$

$$= 2.85$$

6.3.2, Eq. 6.20

$$i_{rel,x}$$

$$= \frac{i_x}{\sigma} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05,x}}}$$

$$= \frac{236.85}{\sigma} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11800.0 \text{ N/mm}^2}}$$

$$= 3.80$$

6.3.2, Eq. 6.20

$i_{rel,y} > 0.3$ or $i_{rel,x} > 0.3$

$$k_y = 0.5 \cdot \left(1 + \beta_y \cdot (i_{rel,y} - 0.3) + (i_{rel,y})^2 \right)$$

$$= 0.5 \cdot \left(1 + 0.20 \cdot (2.85 - 0.3) + (2.85)^2 \right)$$

$$= 4.82$$

6.3.2, Eq. 6.07

$$k_x = 0.5 \cdot \left(1 + \beta_x \cdot (i_{rel,x} - 0.3) + (i_{rel,x})^2 \right)$$

$$= 0.5 \cdot \left(1 + 0.20 \cdot (3.80 - 0.3) + (3.80)^2 \right)$$

$$= 8.08$$

6.3.2, Eq. 6.08

$$k_{c,y}$$

$$= \frac{1}{k_y + \sqrt{(k_y)^2 - (i_{rel,y})^2}}$$

$$= \frac{1}{4.82 + \sqrt{(4.82)^2 - (2.85)^2}}$$

$$= 0.11$$

6.3.2, Eq. 6.25

$$k_{c,x}$$

$$= \frac{1}{k_x + \sqrt{(k_x)^2 - (i_{rel,x})^2}}$$

$$= \frac{1}{8.08 + \sqrt{(8.08)^2 - (3.80)^2}}$$

$$= 0.07$$

6.3.2, Eq. 6.26



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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.17 MEMBER NO. 203 | D51 | CO3 | 4.102 M | STRESS POINT NO. 1 | ST1600.01

Timber Design

$$\eta_1 = \frac{\sigma_{z,0,d} + \sigma_{m,y,d}}{k_{c,y} \cdot f_{c,0,d} + f_{m,y,d}}$$

$$= \frac{-0.075 \text{ N/mm}^2 + -19.736 \text{ N/mm}^2}{0.11 \cdot 20.769 \text{ N/mm}^2 + 34.615 \text{ N/mm}^2}$$

$$= 0.601$$

$$\eta_2 = \frac{\sigma_{z,0,d} + k_{m1} \cdot \sigma_{m,y,d}}{k_{c,z} \cdot f_{c,0,d} + k_{m1} \cdot f_{m,y,d}}$$

$$= \frac{-0.075 \text{ N/mm}^2 + 0.70 \cdot -19.736 \text{ N/mm}^2}{0.07 \cdot 20.769 \text{ N/mm}^2 + 0.70 \cdot 34.615 \text{ N/mm}^2}$$

$$= 0.454$$

$$\eta = \max(\eta_1, \eta_2)$$

$$= \max(0.601, 0.454)$$

$$= 0.601$$

$$\eta = 0.601 \leq 1 \text{ "OK"}$$

E₀ 4.23

E₀ 4.24

8.3.2

- f_{c,0,d} Design compressive strength
- k_{mod} Modification factor
- f_{c,0,k} Characteristic compressive strength
- γ_M Partial factor
- f_{m,y,d} Design bending strength
- f_{m,y,k} Characteristic bending strength
- λ_y Slenderness ratio
- l_{eq,y} Equivalent member length
- i_y Radius of gyration
- λ₀ Slenderness ratio
- l_{eq,z} Equivalent member length
- i_z Radius of gyration
- λ_{0,z} Relative slenderness ratio
- E_{0,0,y} Modulus of elasticity
- λ_{rel,z} Relative slenderness ratio
- E_{0,0,z} Modulus of elasticity
- k_y Instability factor
- B_c Straightness factor
- k_z Instability factor
- k_{0,y} Instability factor
- k_{0,z} Instability factor
- η₁ Design ratio 1
- σ_{z,0,d} Design compressive stress
- σ_{m,y,d} Design bending stress
- η₂ Design ratio 2
- k_{m1} Redistribution factor



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Model:
Enia Klanec, I.zona krovitva - kopija (3)

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MODEL

9.18 MEMBER NO. 29 | D51 | CO2 | 0.000 M | STRESS POINT NO. 1 | ST1300

Timber Design

Design Check ST1300 | EN 1995 | CEN | 2014-05

Security
Axial compression with buckling about both axes acc. to 6.3.2

$$f_{c,0,d} = \frac{f_{c,0,k}}{\gamma_M}$$

$$= \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 23.077 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$\lambda_y = \frac{l_{cr,y}}{i_y}$$

$$= \frac{3.745 \text{ m}}{52.0 \text{ mm}}$$

$$= 72.07$$

$$\lambda_x = \frac{l_{cr,x}}{i_x}$$

$$= \frac{3.745 \text{ m}}{43.3 \text{ mm}}$$

$$= 86.48$$

$$\lambda_{rel,y} = \frac{\lambda_y}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,0,y}}}$$

$$= \frac{72.07}{\pi} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11800.0 \text{ N/mm}^2}}$$

$$= 1.16$$

6.3.2, Eq. 6.21

$$\lambda_{rel,x} = \frac{\lambda_x}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,0,x}}}$$

$$= \frac{86.48}{\pi} \cdot \sqrt{\frac{30.000 \text{ N/mm}^2}{11800.0 \text{ N/mm}^2}}$$

$$= 1.39$$

6.3.2, Eq. 6.22

$$\lambda_{rel,y} > 0.3 \text{ or } \lambda_{rel,x} > 0.3$$

$$k_y = 0.5 \cdot \left(1 + \beta_c \cdot (\lambda_{rel,y} - 0.3) + (\lambda_{rel,y})^2 \right)$$

$$= 0.5 \cdot \left(1 + 0.25 \cdot (1.16 - 0.3) + (1.16)^2 \right)$$

$$= 1.25$$

6.3.2, Eq. 6.27

$$k_x = 0.5 \cdot \left(1 + \beta_c \cdot (\lambda_{rel,x} - 0.3) + (\lambda_{rel,x})^2 \right)$$

$$= 0.5 \cdot \left(1 + 0.25 \cdot (1.39 - 0.3) + (1.39)^2 \right)$$

$$= 1.57$$

6.3.2, Eq. 6.28

$$k_{cr,y} = \frac{1}{k_y + \sqrt{(k_y)^2 - (\lambda_{rel,y})^2}}$$

$$= \frac{1}{1.25 + \sqrt{(1.25)^2 - (1.16)^2}}$$

$$= 0.57$$

6.3.2, Eq. 6.25

$$k_{cr,x} = \frac{1}{k_x + \sqrt{(k_x)^2 - (\lambda_{rel,x})^2}}$$

$$= \frac{1}{1.57 + \sqrt{(1.57)^2 - (1.39)^2}}$$

$$= 0.43$$

6.3.2, Eq. 6.26

$$\eta_1 = \frac{|\sigma_{c,0,d}|}{k_{cr} \cdot f_{c,0,d}}$$

$$= \frac{|-0.604 \text{ N/mm}^2|}{0.57 \cdot 23.077 \text{ N/mm}^2}$$

$$= 0.051$$

Eq. 6.21



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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MODEL

9.18 MEMBER NO. 29 | D51 | CO2 | 0.000 M | STRESS POINT NO. 1 | ST1300

Timber Design

$$\eta_2 = \frac{\sigma_{c,2,d}}{k_{c,2} \cdot f_{c,d,1}}$$

$$= \frac{-0.004 \text{ M/mm}^2}{0.43 \cdot 20.789 \text{ N/mm}^2}$$

$$= 0.067$$

$$\eta = \max(\eta_1, \eta_2)$$

$$= \max(0.051, 0.067)$$

$$= 0.067$$

$$\eta = 0.067 \leq 1 \text{ "OK"}$$

E_0 134

8.3.2

- $f_{c,d,1}$ Design compressive strength
- $k_{c,2}$ Modification factor
- $f_{c,d,1}$ Characteristic compressive strength
- η_1 Partial factor
- λ_y Slenderness ratio
- $l_{eq,y}$ Equivalent member length
- i_y Radius of gyration
- λ_y Slenderness ratio
- $l_{eq,z}$ Equivalent member length
- i_z Radius of gyration
- $\lambda_{rel,y}$ Relative slenderness ratio
- $E_{0,0,y}$ Modulus of elasticity
- $\lambda_{rel,z}$ Relative slenderness ratio
- $E_{0,0,z}$ Modulus of elasticity
- η_y Instability factor
- β_c Straightness factor
- k_z Instability factor
- $k_{z,1}$ Instability factor
- $k_{z,2}$ Instability factor
- η_1 Design ratio 1
- $\sigma_{c,2,d}$ Design compressive stress
- η_2 Design ratio 2



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Model:
Enio Klanac_1.zona krovitva - kopija (2)

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MODEL

9.19 MEMBER NO. 203 | D51 | CO2 | 4.102 M | STRESS POINT NO. 3 | SP6300

Timber Design

Design Check SP6300 | EN 1995 | CEN | 2014-05

Service Proof
Biaxial bending and compressive axial force acc. to 6.2.4

$$f_{c,0,d} = k_{mod} \cdot \frac{f_{c,0,k}}{\gamma_M} \quad 2.4.1, Eq. 2.14$$

$$= 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 20.769 \text{ N/mm}^2$$

$$f_{m,y,d} = k_{mod} \cdot \frac{f_{m,y,k}}{\gamma_M} \quad 2.4.1, Eq. 2.14$$

$$= 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

$$f_{m,z,d} = k_{mod} \cdot \frac{f_{m,z,k}}{\gamma_M} \quad 2.4.1, Eq. 2.14$$

$$= 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

$$\eta_1 = \sqrt{\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_{re} \cdot \frac{\sigma_{m,z,d}}{f_{m,z,d}}} \quad 6.2.4, Eq. 6.18$$

$$= \sqrt{\left(\frac{-0.029 \text{ N/mm}^2}{20.769 \text{ N/mm}^2}\right)^2 + \frac{-28.309 \text{ N/mm}^2}{34.615 \text{ N/mm}^2} + 0.70 \cdot \frac{-0.912 \text{ N/mm}^2}{34.615 \text{ N/mm}^2}}$$

$$= 0.636$$

$$\eta_2 = \sqrt{\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + k_{re} \cdot \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}}} \quad 6.2.4, Eq. 6.20$$

$$= \sqrt{\left(\frac{-0.029 \text{ N/mm}^2}{20.769 \text{ N/mm}^2}\right)^2 + 0.70 \cdot \frac{-28.309 \text{ N/mm}^2}{34.615 \text{ N/mm}^2} + \frac{-0.912 \text{ N/mm}^2}{34.615 \text{ N/mm}^2}}$$

$$= 0.599$$

$$\eta = \max(\eta_1, \eta_2) \quad 6.2.4$$

$$= \max(0.636, 0.599)$$

$$= 0.636$$

$$\eta = 0.636 \leq 1 \quad \text{OK}$$

- $f_{c,0,d}$ Design compressive strength
- k_{mod} Modification factor
- $f_{c,0,k}$ Characteristic compressive strength
- γ_M Partial factor
- $f_{m,y,d}$ Design bending strength
- $f_{m,y,k}$ Characteristic bending strength
- $f_{m,z,d}$ Design bending strength
- $f_{m,z,k}$ Characteristic bending strength
- η_1 Design ratio 1
- $\sigma_{c,0,d}$ Design compressive stress
- $\sigma_{m,y,d}$ Design bending stress
- k_{re} Redistribution factor
- $\sigma_{m,z,d}$ Design bending stress
- η_2 Design ratio 2



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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MODEL

9.20 MEMBER NO. 2 | DS1 | CO2 | 4.090 M | STRESS POINT NO. 3 | SP6200

Timber Design

Design Check SP6200 | EN 1995 | CEN | 2014-05

Service Proof
Bending about z-axis and compressive axial force acc. to 6.2.4

$$f_{c,d} = k_{mod} \cdot \frac{f_{c,0,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 20.769 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$f_{m,d} = k_{mod} \cdot \frac{f_{m,0,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{39.000 \text{ N/mm}^2}{1.30}$$

$$= 26.615 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$\eta = \sqrt{\left| -\left(\frac{\sigma_{c,d}}{f_{c,d}}\right)^2 + \frac{\sigma_{m,d}}{f_{m,d}} \right|}$$

$$= \sqrt{\left| -\left(\frac{-0.282 \text{ N/mm}^2}{20.769 \text{ N/mm}^2}\right)^2 + \frac{-0.458 \text{ N/mm}^2}{26.615 \text{ N/mm}^2} \right|}$$

$$= 0.019$$

6.2.4, Eq. 6.36

$$\eta = 0.019 \leq 1 \quad \checkmark$$

- $f_{c,d}$ Design compressive strength
- k_{mod} Modification factor
- $f_{c,0,k}$ Characteristic compressive strength
- γ_M Partial factor
- $f_{m,d}$ Design bending strength
- $f_{m,0,k}$ Characteristic bending strength
- $\sigma_{c,d}$ Design compressive stress
- $\sigma_{m,d}$ Design bending stress



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Model:
Enia Klanec_1.zona krovitva - kopija (2)

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MODEL

9.21 MEMBER NO. 203 | D51 | CO3 | 4.102 M | STRESS POINT NO. 1 | SP6100

Timber Design

Design Check SP6100 | EN 1995 | CEN | 2014-05

Service Proof
Bending about y-axis and compressive axial force acc. to 6.2.4

$$f_{c,0,d} = k_{mod} \cdot \frac{f_{c,0,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30}$$

$$= 20.769 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$f_{m,y,d} = k_{mod} \cdot \frac{f_{m,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$\eta = \sqrt{\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \left(\frac{\sigma_{m,y,d}}{f_{m,y,d}}\right)^2}$$

$$= \sqrt{\left(\frac{-0.075 \text{ N/mm}^2}{20.769 \text{ N/mm}^2}\right)^2 + \left(\frac{-19.790 \text{ N/mm}^2}{34.615 \text{ N/mm}^2}\right)^2}$$

$$= 0.570$$

6.2.4, Eq. 6.16

$$\eta = 0.570 \leq 1 \checkmark$$

- $f_{c,0,d}$ Design compressive strength
- k_{mod} Modification factor
- $f_{c,0,k}$ Characteristic compressive strength
- γ_M Partial factor
- $f_{m,y,d}$ Design bending strength
- $f_{m,k}$ Characteristic bending strength
- $\sigma_{c,0,d}$ Design compressive stress
- $\sigma_{m,y,d}$ Design bending stress





MODEL

9.22 MEMBER NO. 203 | D51 | CO2 | 3.861 M | LEFT SIDE | STRESS POINT NO. 3 | SP4300

Timber Design

Design Check SP4300 | EN 1995 | CEN | 2014-05

Service Proof
Biaxial bending acc. to 6.1.6

$$f_{m,y,d} = k_{mod} \cdot \frac{f_{m,y,k}}{\gamma_M} = 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30} = 34.615 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$f_{m,z,d} = k_{mod} \cdot \frac{f_{m,z,k}}{\gamma_M} = 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30} = 34.615 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$\eta_1 = \frac{\sigma_{m,y,d} + k_{rel} \cdot \sigma_{m,z,d}}{f_{m,y,d} + k_{rel} \cdot f_{m,z,d}} = \frac{-26.398 \text{ N/mm}^2 + 0.70 \cdot -0.853 \text{ N/mm}^2}{34.615 \text{ N/mm}^2 + 0.70 \cdot 34.615 \text{ N/mm}^2} = 0.838$$

8.1.6, Eq. 6.11

$$\eta_2 = \frac{k_{rel} \cdot \sigma_{m,y,d} + \sigma_{m,z,d}}{k_{rel} \cdot f_{m,y,d} + f_{m,z,d}} = \frac{0.70 \cdot -26.398 \text{ N/mm}^2 + -0.853 \text{ N/mm}^2}{0.70 \cdot 34.615 \text{ N/mm}^2 + 34.615 \text{ N/mm}^2} = 0.599$$

8.1.6, Eq. 6.12

$$\eta = \max(\eta_1, \eta_2) = \max(0.838, 0.599) = 0.838$$

8.1.6

$$\eta = 0.838 \leq 1.00$$

- $f_{m,y,d}$ Design bending strength
- k_{mod} Modification factor
- $f_{m,y,k}$ Characteristic bending strength
- γ_M Partial factor
- $f_{m,z,d}$ Design bending strength
- $f_{m,z,k}$ Characteristic bending strength
- η_1 Design ratio 1
- $\sigma_{m,y,d}$ Design bending stress
- k_{rel} Redistribution factor
- $\sigma_{m,z,d}$ Design bending stress
- η_2 Design ratio 2



Enia Klanec
Obala kraja P. Kraljevića IV, 23450 Obrovac



Model:
Enia Klanec, I.zona krovitka - kopija (2)

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MODEL

9.23 MEMBER NO. 170 | D51 | C05 | 0.777 M | STRESS POINT NO. 1 | SP4200

Timber Design

Design Check SP4200 | EN 1995 | CEN | 2014-05

Service Proof
Bending about z-axis acc. to 6.1.6

$$f_{m,z,d} = k_{mod} \cdot \frac{f_{m,k}}{\gamma_M} = 0.90 \cdot \frac{50.000 \text{ N/mm}^2}{1.30} = 34.615 \text{ N/mm}^2$$

$$\eta = \frac{|f_{m,z,d}|}{f_{m,k}} = \frac{34.615 \text{ N/mm}^2}{50.000 \text{ N/mm}^2} = 0.692$$

$$\lambda = 0.034 \leq 1 \checkmark$$

2.4.1, Eq. 2.14

6.1.6, Eq. 6.12

- $f_{m,z,d}$ Design bending strength
- k_{mod} Modification factor
- $f_{m,k}$ Characteristic bending strength
- γ_M Partial factor
- $\sigma_{m,z,d}$ Design bending stress



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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.24 MEMBER NO. 171 | DS1 | CO2 | 0.000 M | STRESS POINT NO. 1 | SP4100

Timber Design

Design Check SP4100 | EN 1995 | CEN | 2014-05

Service Proof
Bending about y-axis acc. to 6.1.6

$$f_{m,y,d} = k_{mod} \cdot \frac{f_{m,y,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{38.000 \text{ N/mm}^2}{1.30}$$

$$= 34.615 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$\eta = \frac{\sigma_{m,y,d}}{f_{m,y,d}}$$

$$= \frac{5.029 \text{ N/mm}^2}{34.615 \text{ N/mm}^2}$$

$$= 0.145$$

6.1.6, Eq. 6.11

$$\eta = 0.145 \leq 1 \quad \checkmark$$

- $f_{m,y,d}$ Design bending strength
- k_{mod} Modification factor
- $f_{m,y,k}$ Characteristic bending strength
- γ_M Partial factor
- $\sigma_{m,y,d}$ Design bending stress



Enia Klanec
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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.25 MEMBER NO. 24 | D51 | CO2 | 0.000 M | STRESS POINT NO. 2 | SP3200

Timber Design

Design Check SP3200 | EN 1995 | CEN | 2014-05

Shear in y-axis acc. to 6.1.7 | Rectangular section

$$f_{v,y,d} = k_{mod} \cdot \frac{f_{v,y,k}}{\gamma_M}$$

$$= 0,90 \cdot \frac{4,500 \text{ N/mm}^2}{1,30}$$

$$= 3,115 \text{ N/mm}^2$$

$$\tau_{v,y,d} = \frac{T_{v,y}}{k_{cr}}$$

$$= \frac{-0,088 \text{ N/mm}^2}{0,67}$$

$$= -0,086 \text{ N/mm}^2$$

$$\eta = \frac{|\tau_{v,y,d}|}{f_{v,y,d}}$$

$$= \frac{|-0,086 \text{ N/mm}^2|}{3,115 \text{ N/mm}^2}$$

$$= 0,028$$

$$\eta = 0,028 \leq 1 \quad \checkmark$$

- $f_{v,y,d}$ Design shear strength
- k_{mod} Modification factor
- $f_{v,y,k}$ Characteristic shear strength
- γ_M Partial factor
- $T_{v,y,d}$ Design shear stress
- $T_{v,y}$ Shear stress
- k_{cr} Crack influence factor

2.4.1, Eq. 2.14

6.1.7, Eq. 6.13



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Model:
Enia Klanec, I.zona krovitka - kopija (2)

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MODEL

9.26 MEMBER NO. 203 | D51 | CO2 | 8.205 M | STRESS POINT NO. 4 | SP3100

Timber Design

Design Check SP3100 | EN 1995 | CEN | 2014-05

Shear in z-axis acc. to 6.1.7 | Rectangular section

$$f_{v,z,d} = k_{mod} \frac{f_{v,z,k}}{\gamma_M}$$

$$= 0,90 \cdot \frac{4,500 \text{ N/mm}^2}{1,30}$$

$$= 3,115 \text{ N/mm}^2$$

2.4.1, Eq. 2.14

$$\tau_{v,z,d} = \frac{V_{z,d}}{k_{cr}}$$

$$= \frac{-0,703 \text{ N/mm}^2}{0,67}$$

$$= -1,048 \text{ N/mm}^2$$

6.1.7, Eq. 6.13

$$\eta = \frac{|\tau_{v,z,d}|}{f_{v,z,d}}$$

$$= \frac{|-1,048 \text{ N/mm}^2|}{3,115 \text{ N/mm}^2}$$

$$= 0,336$$

$$\eta = 0,336 \leq 1 \quad \checkmark$$

- $f_{v,z,d}$ Design shear strength
- k_{mod} Modification factor
- $f_{v,z,k}$ Characteristic shear strength
- γ_M Partial factor
- $V_{z,d}$ Design shear stress
- $\tau_{v,z}$ Shear stress
- k_{cr} Crack influence factor



Enia Klanec
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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.27 MEMBER NO. 175 | D51 | CO2 | 0.475 M | STRESS POINT NO. 4 | SP2100

Timber Design

Design Check SP2100 | EN 1995 | CEN | 2014-05

Shear Proof
Shear due to torsion acc. to 6.3.8

$$f_{v,t,d} = k_{mod} \cdot \frac{f_{v,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{4.500 \text{ N/mm}^2}{1.30}$$

$$= 3.115 \text{ N/mm}^2$$

24.1, Eq. 2.14

$$f_{v,y,d} = k_{mod} \cdot \frac{f_{v,y,k}}{\gamma_M}$$

$$= 0.90 \cdot \frac{4.500 \text{ N/mm}^2}{1.30}$$

$$= 3.115 \text{ N/mm}^2$$

24.1, Eq. 2.14

$$\eta = \frac{\tau_{tors,d}}{k_{tors} \cdot f_{v,d}}$$

$$= \frac{0.532 \text{ N/mm}^2}{1.06 \cdot 3.115 \text{ N/mm}^2}$$

$$= 0.161$$

6.3.8, Eq. 6.14

$$\eta = 0.161 \leq 1 \quad \checkmark$$

- $f_{v,d}$ Design shear strength
- k_{mod} Modification factor
- $f_{v,k}$ Characteristic shear strength
- γ_M Partial factor
- $f_{v,y,d}$ Design shear strength
- $f_{v,y,k}$ Characteristic shear strength
- $\tau_{tors,d}$ Design torsional stress
- k_{tors} Torsion factor
- $f_{v,t}$ Design shear strength



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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.24 MEMBER NO. 29 | D51 | CO2 | 0.000 M | STRESS POINT NO. 1 | SP1200

Timber Design

Design Check SP1200 | EN 1995 | CEN | 2014-05

Service Proof
Compression along grain acc. to 6.1.4

$$f_{c,0,d} = k_{mod} \cdot \frac{f_{c,0,k}}{\gamma_M} = 0.90 \cdot \frac{30.000 \text{ N/mm}^2}{1.30} = 20.769 \text{ N/mm}^2$$

$$\eta = \frac{|f_{c,0,d}|}{f_{c,0,d}} = \frac{|-0.004 \text{ N/mm}^2|}{20.769 \text{ N/mm}^2} = 0.029$$

$$\eta = -0.029 \leq 1 \checkmark$$

2.4.1, Eq. 2.14

6.1.4, Eq. 6.2

- $f_{c,0,d}$ Design compressive strength
- k_{mod} Modification factor
- $f_{c,0,k}$ Characteristic compressive strength
- γ_M Partial factor
- $\sigma_{c,0,d}$ Design compressive stress



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Model:
Enia Klanec_1.zona krovitka - kopija (2)

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MODEL

9.29 MEMBER NO. 24 | D51 | CO2 | 0.470 M | RIGHT SIDE | STRESS POINT NO. 1 | SP1100

Timber Design

Design Check SP1100 | EN 1995 | CEN | 2014-05

Scrutin Proof
Tension along grain acc. to 5.1.2.

$$\begin{aligned} \sigma_{t,d} &= k_{mod} \cdot \frac{f_{t,k}}{\gamma_M} \\ &= 0,90 \cdot \frac{30,000 \text{ N/mm}^2}{1,30} \\ &= 20,769 \text{ N/mm}^2 \end{aligned}$$

$$\begin{aligned} \eta &= \frac{\sigma_{t,d}}{f_{t,d}} \\ &= \frac{20,769 \text{ N/mm}^2}{0,500 \text{ N/mm}^2} \\ &= 0,024 \end{aligned}$$

$$\eta = 0,024 \leq 1 \quad \checkmark$$

- $f_{t,d}$ Design tensile strength
- k_{mod} Modification factor
- $f_{t,k}$ Characteristic tensile strength
- γ_M Partial factor
- $\sigma_{t,d}$ Design tensile stress

2.4.1, Eq. 2.34

6.1.2(1), Eq. 6.1



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Model:
Enia Klanec, I.zona krovitva - kopija (2)

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MODEL

9.30 MEMBER NO. 152 | D51 | C05 | 1.219 M | SP0100

Timber Design

Design Check SP0100 | EN 1995 | CEN | 2014-05

Sanction Proof
Negligible internal forces

$$\begin{aligned} \sigma_{x,d} &= k_{mod} \cdot \frac{f_{t,k}}{7 M} \\ &= 0,90 \cdot \frac{30.000 \text{ N/mm}^2}{1,30} \\ &= 20.769 \text{ N/mm}^2 \end{aligned}$$

24.1, Eq. 2.14

$$\begin{aligned} \sigma_{y,d} &= k_{mod} \cdot \frac{f_{y,k}}{7 M} \\ &= 0,90 \cdot \frac{4.300 \text{ N/mm}^2}{1,30} \\ &= 3.115 \text{ N/mm}^2 \end{aligned}$$

24.1, Eq. 2.14

$$\begin{aligned} \sigma_{y,d} &= k_{mod} \cdot \frac{f_{y,k}}{7 M} \\ &= 0,90 \cdot \frac{4.300 \text{ N/mm}^2}{1,30} \\ &= 3.115 \text{ N/mm}^2 \end{aligned}$$

24.1, Eq. 2.14

$$\begin{aligned} \sigma_{x,d} &= k_{mod} \cdot \frac{f_{t,k}}{7 M} \\ &= 0,90 \cdot \frac{50.000 \text{ N/mm}^2}{1,30} \\ &= 34.615 \text{ N/mm}^2 \end{aligned}$$

24.1, Eq. 2.14

$$\begin{aligned} \sigma_{x,d} &= k_{mod} \cdot \frac{f_{t,k}}{7 M} \\ &= 0,90 \cdot \frac{50.000 \text{ N/mm}^2}{1,30} \\ &= 34.615 \text{ N/mm}^2 \end{aligned}$$

24.1, Eq. 2.14

Tension:

$$\begin{aligned} \eta_{t,d} &= \frac{\sigma_{t,d}}{f_{t,d}} \\ &= \frac{20.769 \text{ N/mm}^2}{20.769 \text{ N/mm}^2} \\ &= 0,001 \end{aligned}$$

$$\eta_{t,d} \leq \eta_{t,lim}$$

$\eta_{t,d}$ is negligible.

Shear in y-axis:

$$\begin{aligned} \eta_{t,y} &= \frac{|\tau_{xy}|}{\sigma_{y,d}} \\ &= \frac{0,000 \text{ N/mm}^2}{3.115 \text{ N/mm}^2} \\ &= 0,000 \end{aligned}$$

$$\eta_{t,y} \leq \eta_{t,y,lim}$$

$\eta_{t,y}$ is negligible.

Shear in z-axis:

$$\begin{aligned} \eta_{t,z} &= \frac{|\tau_{xz}|}{\sigma_{z,d}} \\ &= \frac{0,000 \text{ N/mm}^2}{3.115 \text{ N/mm}^2} \\ &= 0,000 \end{aligned}$$

$$\eta_{t,z} \leq \eta_{t,z,lim}$$



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Model:
Enia Klanec, izjava krovitva - kopija (2)

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MODEL

9.30 MEMBER NO. 152 | DS1 | CO5 | 1.219 M | SP0100

Timber Design

τ_{xy} is negligible

Torsion:

$$\eta_{\text{tor}} = \frac{|\tau_{xy}|}{f_{v,d}} = \frac{|-0.007 \text{ N/mm}^2|}{3.315 \text{ N/mm}^2} = 0.002$$

$\eta_{\text{tor}} \leq \eta_{\text{tor,lim}}$

M_x is negligible

Bending about y-axis:

$$\eta_{xy} = \frac{|\sigma_{x,y}|}{f_{m,y,d}} = \frac{|-0.027 \text{ N/mm}^2|}{34.623 \text{ N/mm}^2} = 0.001$$

$\eta_{xy} \leq \eta_{xy,lim}$

$M_{x,y}$ is negligible

Bending about z-axis:

$$\eta_{xz} = \frac{|\sigma_{x,z}|}{f_{m,z,d}} = \frac{|-0.003 \text{ N/mm}^2|}{34.615 \text{ N/mm}^2} = 0.000$$

$\eta_{xz} \leq \eta_{xz,lim}$

$M_{x,z}$ is negligible

All internal forces are negligible

$$\eta = 0.000 \leq 1.0^*$$

- $f_{t,d}$ Design tensile strength
- k_{mod} Modification factor
- $f_{t,0,k}$ Characteristic tensile strength
- $\gamma_{M,t}$ Partial factor
- $f_{v,d}$ Design shear strength
- $f_{v,k}$ Characteristic shear strength
- $f_{v,0,k}$ Design shear strength
- $f_{v,0,k}$ Characteristic shear strength
- $f_{m,y,d}$ Design bending strength
- $f_{m,y,k}$ Characteristic bending strength
- $f_{m,z,d}$ Design bending strength
- $f_{m,z,k}$ Characteristic bending strength
- η_{xy} Design component for tension
- $\sigma_{x,y}$ Design tensile stress
- η_{tor} Limit value of design ratio for tension
- η_{xy} Design component for shear
- τ_{xy} Shear stress
- $\eta_{v,lim}$ Limit value of design ratio for shear
- η_{v} Design component for shear
- τ_{xy} Shear stress
- $\eta_{v,lim}$ Limit value of design ratio for shear
- η_{tor} Design component for torsional moment



Enia Klanec
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Model:
Enia Klanec_1.zona krovitla - kopija (2)

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MODEL

9.30 MEMBER NO. 152 | D51 | C05 | 1.219 M | SP0100

Timber Design

- $\tau_{t,d}$ Design torsional stress
- $f_{v,d}$ Design shear strength
- $\eta_{t,lim}$ Limit value of design ratio for torsional moment
- $\eta_{b,c}$ Design component for bending moment
- $\sigma_{w,d}$ Design bending stress
- $\eta_{b,lim}$ Limit value of design ratio for bending moment
- $\eta_{b,c}$ Design component for bending moment
- $\sigma_{w,d}$ Design bending stress
- $\eta_{b,lim}$ Limit value of design ratio for bending moment



Enio Klanac
Obala kralja P. Krešimira IV., 23450 Obrovac



Model:
Enio Klanac_1.zona krovitka - kopija (3)

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MODEL

10 Design Overview

10.1 DESIGN OVERVIEW

Design Overview

	Addon	Type	Objects No.	Location [m]	Design Situation	Loading No.	Ratio η [-]	Design Check Type	Description
	Timber Design	Member	203	x: 4.102	DS1	CO2	0.299 ✓	ST1600.03	Stability Biaxial bending and compression with buckling about both axes acc. to 6.3.2
	Timber Design	Member	209	x: 2.181	DS9	CO12	0.262 ✓	SE1200.02	Serviceability Combination of actions 'Quasi-permanent 1' z-direction acc. to 7.2
	Timber Design	Member	209	x: 2.181	DS2	CO7	0.248 ✓	SE1200.01	Serviceability Combination of actions 'Characteristic' z-direction acc. to 7.2
	Timber Design	Member	209	x: 4.102	DS1	CO2	0.248 ✓	ST2100.00	Stability Flexural member without compression force Bending about y-axis acc. to 6.3.3
	Timber Design	Member	203	x: 4.102	DS1	CO2	0.239 ✓	SP5300.00	Section Proof Biaxial bending and tensile axial force acc. to 6.2.3
	Timber Design	Member	203	x: 4.102	DS1	CO2	0.233 ✓	SP6300.00	Section Proof Biaxial bending and compressive axial force acc. to 6.2.4
	Timber Design	Member	203	x: 4.102	DS1	CO1	0.194 ✓	ST1600.01	Stability Bending about y-axis and compression with buckling about both axes acc. to 6.3.2
	Timber Design	Member	203	x: 4.102	DS1	CO2	0.190 ✓	SP3100.00	Section Proof Shear in z-axis acc. to 6.1.7 Rectangular section
	Timber Design	Member	209	x: 4.102	DS1	CO2	0.176 ✓	ST3100.00	Stability Bending about y-axis and compression acc. to 6.3.3
	Timber Design	Member	196	x: 0.000	DS1	CO2	0.161 ✓	SP4300.00	Section Proof Biaxial bending acc. to 6.1.6
	Timber Design	Member	203	x: 4.102	DS1	CO1	0.152 ✓	SP6100.00	Section Proof Bending about y-axis and compressive axial force acc. to 6.2.4
	Timber Design	Member	171	x: 0.000	DS1	CO2	0.145 ✓	SP4100.00	Section Proof Bending about y-axis acc. to 6.1.6
	Timber Design	Member	203	x: 1.025	DS1	CO2	0.121 ✓	SP6100.00	Section Proof Bending about y-axis and tensile axial force acc. to 6.2.3
	Timber Design	Member	26	x: 0.000	DS1	CO1	0.105 ✓	ST1300.00	Stability Axial compression with buckling about both axes acc. to 6.3.2
	Timber Design	Member	175	x: 0.475	DS1	CO2	0.101 ✓	SP2100.00	Section Proof Shear due to torsion acc. to 6.1.8
	Timber Design	Member	3	x: 4.090	DS1	CO2	0.089 ✓	ST1600.02	Stability Bending about z-axis and compression with buckling about both axes acc. to 6.3.2
	Timber Design	Member	174	x: 0.950	DS1	CO4	0.062 ✓	SP3200.00	Section Proof Shear in y-axis acc. to 6.1.7 Rectangular section
	Timber Design	Member	24	x: 1.036	DS3	CO13	0.061 ✓	SE1100.02	Serviceability Combination of actions 'Quasi-permanent 1' y-direction acc. to 7.2
	Timber Design	Member	24	x: 1.036	DS2	CO8	0.053 ✓	SE1100.01	Serviceability Combination of actions 'Characteristic' y-direction acc. to 7.2
	Timber Design	Member	26	x: 0.000	DS1	CO1	0.046 ✓	SP1200.00	Section Proof Compression along grain acc. to 6.1.4
	Timber Design	Member	21	x: 0.470	DS1	CO3	0.043 ✓	SP1100.00	Section Proof Tension along grain acc. to 6.1.2
	Timber Design	Member	3	x: 4.090	DS1	CO2	0.038 ✓	SP6200.00	Section Proof Bending about z-axis and compressive axial force acc. to 6.2.4
	Timber Design	Member	170	x: 0.831	DS1	CO6	0.038 ✓	SP4200.00	Section Proof Bending about z-axis acc. to 6.1.6
	Timber Design	Member	150	x: 0.704	DS1	CO6	0.018 ✓	SP3200.00	Section Proof Bending about z-axis and tensile axial force acc. to 6.2.3
	Timber Design	Member	152,232-234,237, 241,243,244,248,2 51,268,273,274	x: 1.218	DS1	CO2	0.000 ✓	SP0100.00	Section Proof Negligible internal forces
	Timber Design	Member	2-7,20-44,81,89-1 10,115,118-121,12 3-125,127-129,13 1-133,135-138,14 0-142,144-146,14 8-150,152-200,20 3-205,208-211,21 3-234,237,238,24 1-244,248,251,26	x: 0.000	DS2	CO6	0.000 ✓	SE0100.01	Serviceability Negligible deflection Combination of actions 'Characteristic'
	Timber Design	Member	2-7,20-44,81,89-1 10,115,118-121,12 3-125,127-129,13 1-133,135-138,14 0-142,144-146,14	x: 0.000	DS3	CO11	0.000 ✓	SE0100.02	Serviceability Negligible deflection Combination of actions 'Quasi-permanent 1'



Enia Klanec
Obala kraja P. Kraljevičeve W, 23450 Obrovac



Model:
Enia Klanec, I.zona krovitka - kopija (2)

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RESULTS

10.1 **DESIGN OVERVIEW**

Design Overview

Addon	Type	Objects No.	Location [m]	Design Situation	Loading No.	Design Check Ratio η [-]	Design Check Type	Description
		8-150, 152-200, 20						
		3-205, 208-211, 21						
		3-234, 237, 238, 24						
		1-244, 248, 251, 26						



Iz prethodno prikazanog proračuna, vidimo kako su rezultati pokazali da svi dijelovi nosivog sustava zadovoljavaju provjeru graničnih stanja nosivosti i uporabljivosti prema Eurokodu 5. Konstrukcijski elementi zadovoljavaju uvjet stabilnosti te nije potrebno vršiti ojačanje dodavanjem drvenih elemenata.

4. ZAKLJUČAK

U ovom radu prikazali smo postupak evaluacije stanja stare krovne konstrukcije na primjeru Stare gradske vijećnice u Zagrebu, Ćirilometodska ul. 5, 10000 Zagreb, s fokusom na prvu zonu krovišta. Prvi korak obuhvaća vizualni pregled krovišta i nedestruktivna ispitivanja pomoću vlagomjera i rezistografa. Ove metode omogućile su analizu stanja drvene konstrukcije, s posebnim naglaskom na vlažnost drva i ocjenu mehaničkih svojstava elemenata krovišta. Na temelju dobivenih rezultata provedeni su daljnji proračuni. Koristeći mehaničke i geometrijske karakteristike, izrađen je statički model krovišta uz pomoć softverskog alata Dlubal RFEM 6. Analizom prethodnih ispitivanja provjerena je usklađenost trenutnog stanja krovišta s sigurnosnim zahtjevima za nosive konstrukcije prema Eurokodu 5. Rezultati analize i proračuna pokazali su da konstrukcijski elementi udovoljavaju uvjetima graničnog stanja nosivosti i uporabljivosti te da nije potrebno dodatno ojačanje jer je stabilnost krovišta već osigurana.

POPIS LITERATURE

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