

Research Fund
for Coal & Steel



Teraskonstruktsioonide jätkusuutlikkuse analüüs

Näited



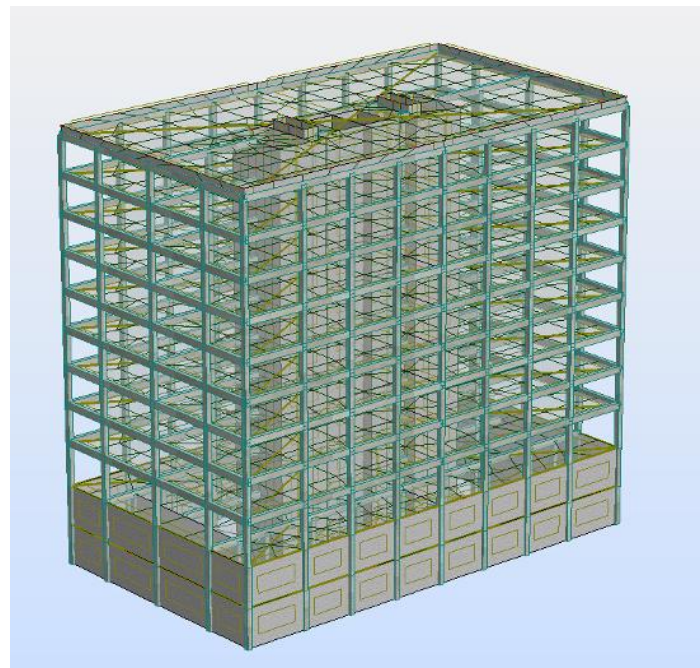
Juuni 2014



Sisu

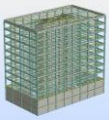
- 1) Büroohoone : tüüpiline büroohoone Pransusmaal
- 2) Elamu : CasaBuna tüüpi elamu Rumeenias
- 3) Tööstushoone : Terasest ja betoonist portaalraam Pariisis

Büroohoone : tüüpiline büroohoone Prantsusmaal





Eesmärk



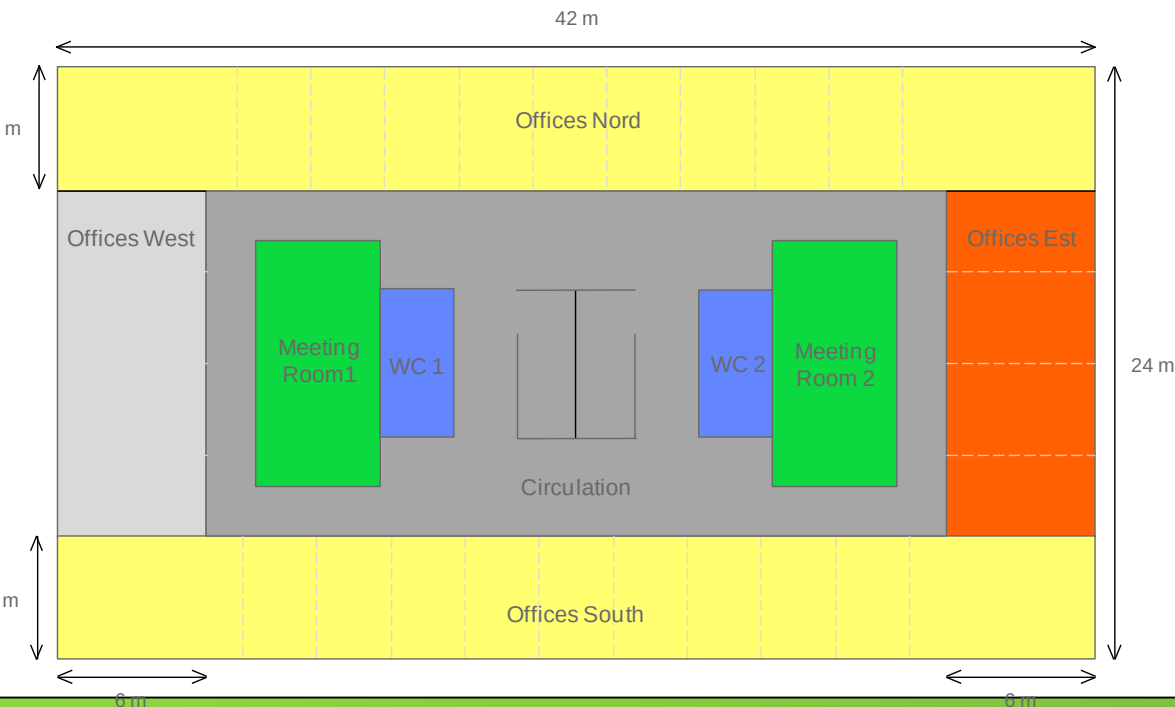
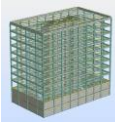
Võrrelda keskkonnamõjusid erinevate konstruktsioonivariantidega hoonetel

Kolm konstruktsioonitüüpi:

- Teras-betoon komposiitkonstruktsioon
- Betoonkonstruktsioon
- Optimeeritud teras-betoon komposiitkonstruktsioon

Hoone määratlus

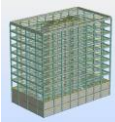
- Põhiplaan: 42x24 m
- Korruste arv (välja arvatud esimene korrus): 8 korrust
- Asukoht Pariis



Project	Building	Envelope	Base Floor	Roof
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North - South facade Length	42.4	m
East - West facade length	24.4	m
Floor height	3.4	m
Floor height under ceiling	2.7	m
Number of intermediate floors	8	
Area of intermediate floors	8276.48	m ²
Total area of building	9311	m ²
Structure only	No	▼
Building type	Office	▼

Piirdekonstruktsiooni komponendid

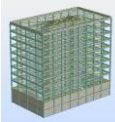


	North/South [m ²]	West/East [m ²]	Sum [m ²]
Walls	908	523	1431
Glazing	389	224	613
Total areas	1297	747	4088

Facade					
Direction	North	East	South	West	
Facade area	1297,44	746,64	1297,44	746,64	m²
Opening area	30	30	30	30	%

- Fassaad: kergpaneelid teraskarkassil, soojustus 50 mm polüstüreenvahtu (XPS)
- Aknad: topeltklaasidega, osaliselt päikese varjestusega
- Katus: soojustus 18 cm polüstüreenvahtu (EPS)

Kasutusrežiim & tehnosüsteemid



Project
Building
Envelope
Base Floor
Roof
Occupancy
Systems
Structure
Floors
Transport

Occupancy related data

Comfort requirements

Heating set-point temperature	20	°C
Cooling set-point temperature	26	°C
Air-flow-rate (heating mode)	0,6	ac/h
Air-flow-rate (cooling mode)	1	ac/h

Project
Building
Envelope
Base Floor
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Systems
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Floors
Transport

Systems

Vastavalt
nõuetele
büroohoonel



- Küte & jahutus
- Mehaaniline ventilatsioon soojustagastusega
- Soe tarbevesi: elektriboiler

Description of building systems

Heating system

Heating system type Split (heating)

Cooling system

Cooling type system Split (cooling)

Mechanical ventilation system

Heat recovery system Yes

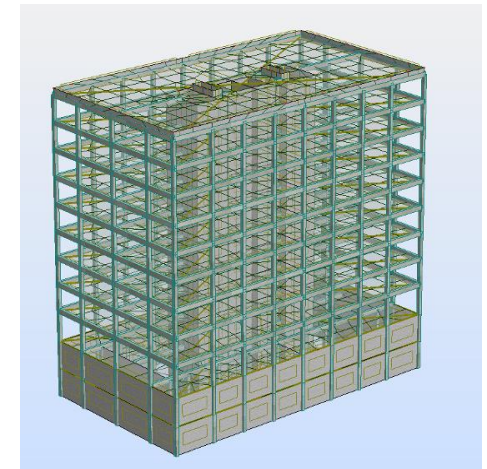
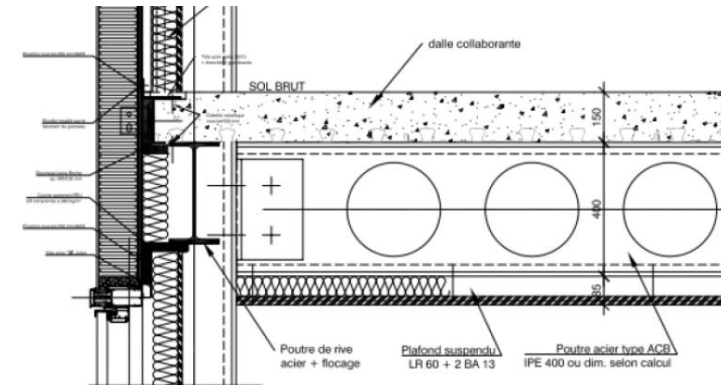
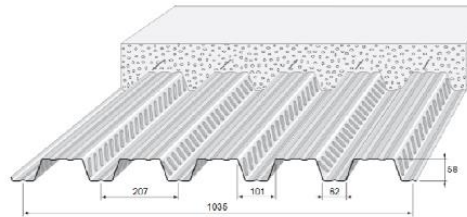
Heat recovery percentage 80

DHW system

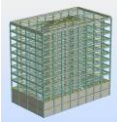
DHW system type Electric boiler

Kandekonstruktsioon

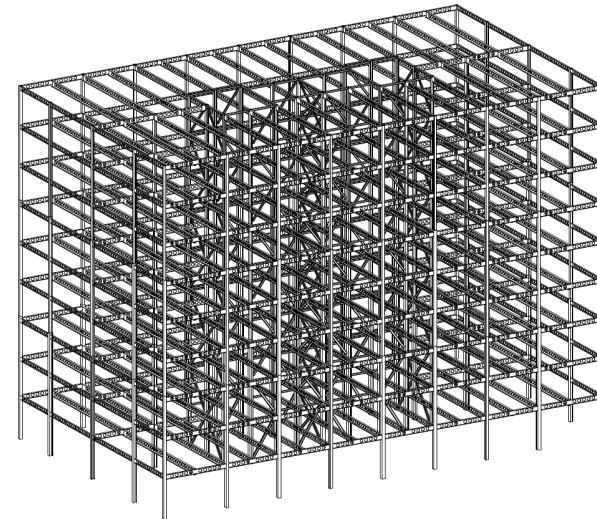
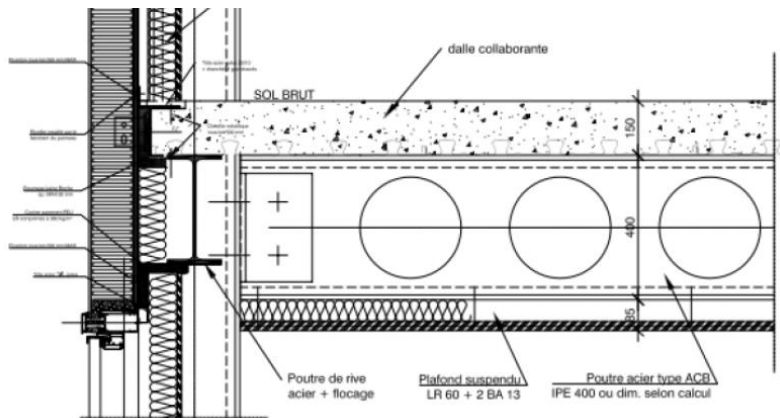
- Teras & betoon komposiit
 - Komposiit talad avadega S355
 - Profiilplekk COFRA+60 ja 15 cm betooni (C30/37)
 - Stabiliseeritud betoonsüdamikuga (C30/37)
- Betoonkonstruktsioon
 - Terasarmatuur (C30/37)
 - Monteeritavad õõnespaneelid (C30/37)
 - Stabiliseeritud betoonsüdamikuga (C30/37)



Kandekonstruktsioon



- Optimiseeritud teras ja betoon komposiit
 - Komposiittalad avadega S460
 - Profiilplekk COFRA+60 ja 15 cm betooni (C30/37)
 - Stabiliseeritud terrassidemetega (teras S460)





Büroohoone konstruktsioonid



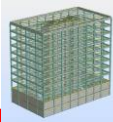
Konstruktsiooni osa	Variant 1 Komposiit	Variant 2 Beton	Variant 3 Optimiseeritud komposiit
Põhielemendid	239.9 terast	1199 t betooni	197.1 t terast
Teraslehed sõlmedes	14.994 t	/	11.827 t
Armatuur	/	59.1 t	/
Betoonsüdamik	Betoon C30/37 1941 t armatuur 44.16 t	Betoon C30/37 1941 t armatuur 44.16 t	/
Terassüdamik	/	/	Terasprofiilid 75.46 t terastlehed 6.037 t

Bearing structure of the building

Steel elements

Beams (Hot rolled profiles)	239.9	t
Columns (Hot rolled profiles)	0.0	t
Studs	0.0	t
Bolts	0.0	t
Plate Connections	14.99	t

Büroohoone vahelaeplaat

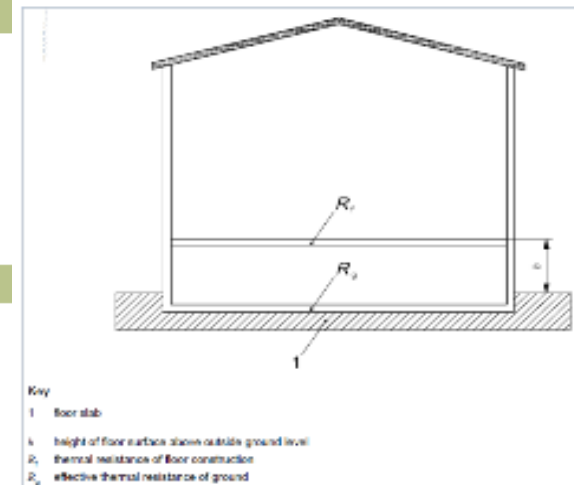


Konstruksiooniosa	Variant 1 Komposiit	Variant 2 Beton	Variant 3 Optimiseeritud komposiit
Profiilplekk	Cofraplus 60 : 70.6 t	/	Cofraplus 60 : 70.6 t
Kogupaksus	150 mm	240 mm + 70mm of screed	150 mm
Betoonplaat	2246 t	4688 t	2246 t
Armatuur	16.56 t	16.56 t	16.56 t

Steel elements	
Type of slab	Composite slab
Steel deck	Cofraplus 60
Thickness of the deck	0.750 mm
Mass of sheeting per m2 of floor	8.53 kg/m ²
Mass of sheeting for the building	70.6 t
Minimum depth of the floor	100 mm

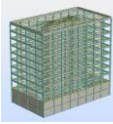
Concrete elements	
Total depth of the floor	150.0 mm
Concrete Type	In-situ/Poured
Concrete Grade	C30/37
Total mass of the floor concrete (incl. base floor)	2735 t
Steel reinforcement	0.0 t

Total mass of the floor slabs	2805 t
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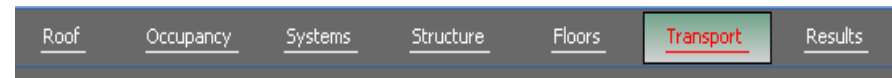




Transport



- Teras transport :
 - Kogukaal : 369.6 t
 - Transport : 500 km tavaveok
- Betooni transport:
 - Kogukaal : 4676 t
 - Transport : 50 km segistiveokiga



Transport parameters

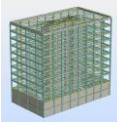
Steel elements

Total steel transported	369.6	t
Values for the transport impacts	User values	
Mass transported by electric train	0.0	t
Distance	0.0	km
Mass transported by regular trucks	369.6	t
Distance	500	km

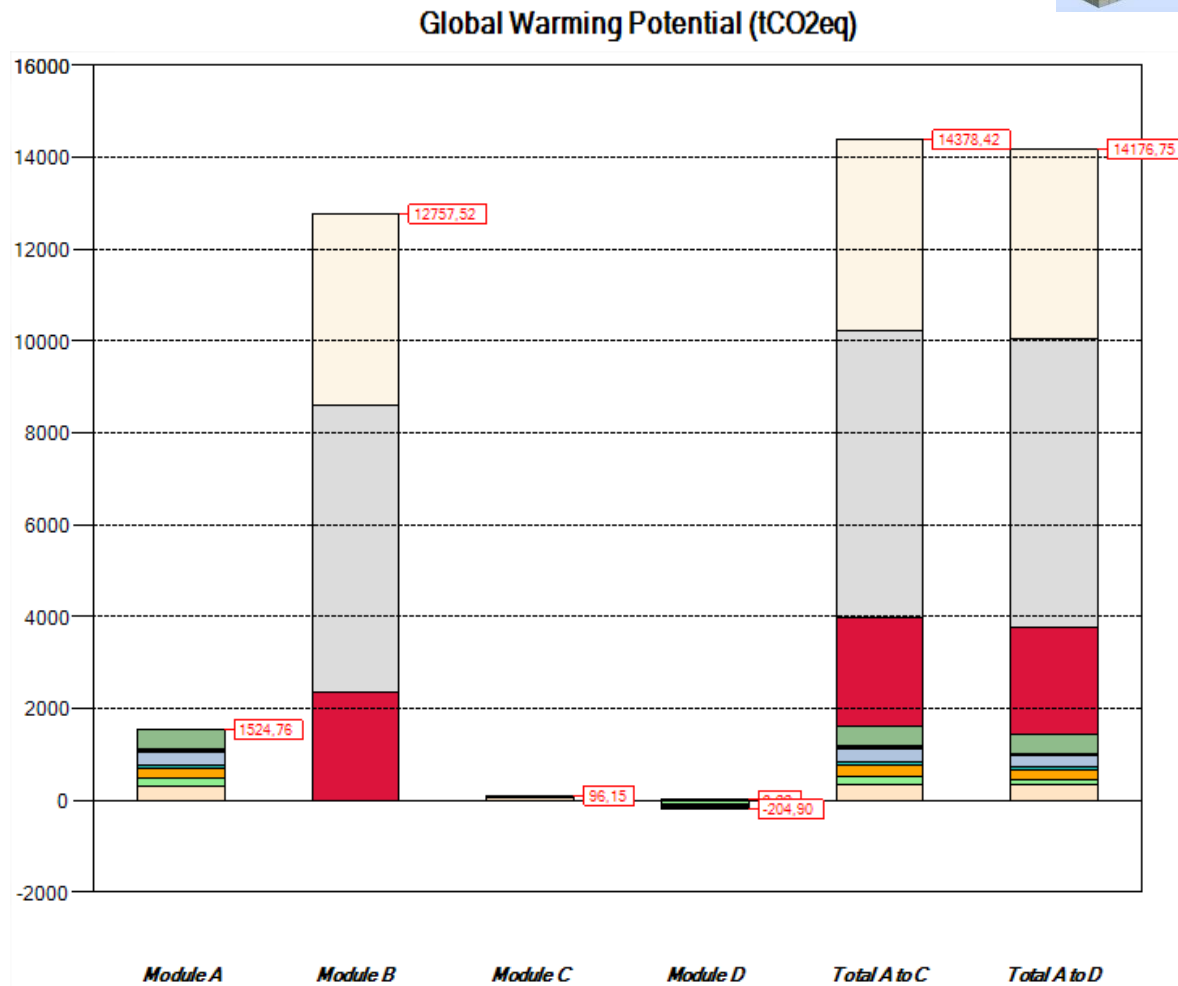
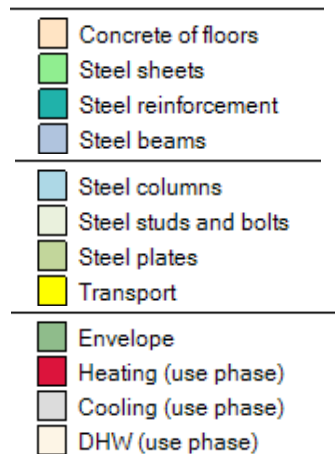
Concrete elements

Total concrete transported	4676	t
Concrete produced on site	4676	t
Distance by mixer trucks	50.0	km
Prefabricated concrete	0.0	t
Distance by regular trucks	0.0	km

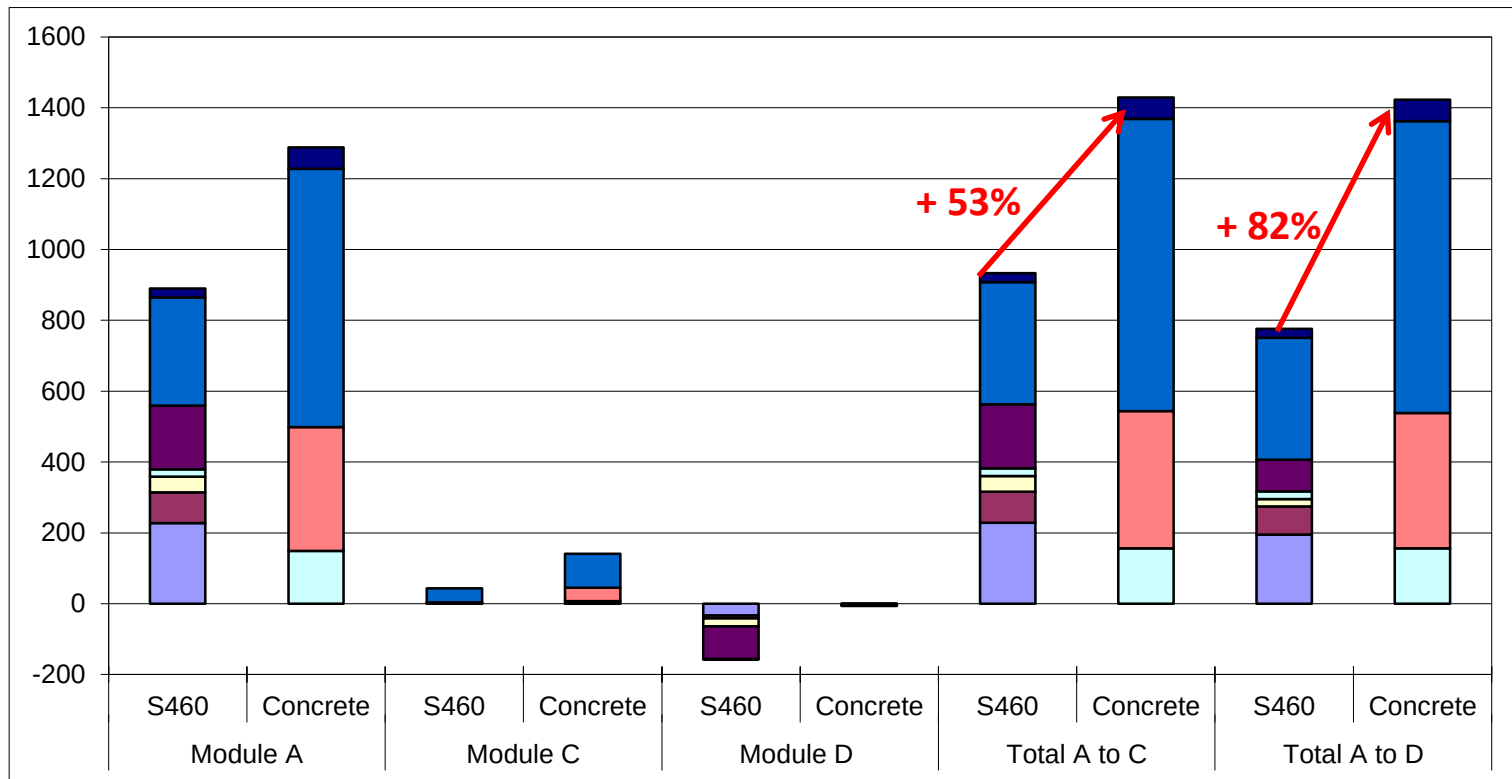
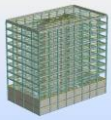
Tulemused: üldkokkuvõte (teras S355)



- Kasutusfaas (moodul B) annab 90% GWP mõjust iga konstruktsioonitüübi puhul



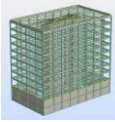
Tulemused: teras S460 vs betoon GWP mõju



■ Beams
■ Columns
■ Plates connections
■ Reinforcement
■ Floor sheets
■ Concrete of structure
■ Concrete slabs
■ Envelope
■ Transport



Tulemused: kokkuvõte

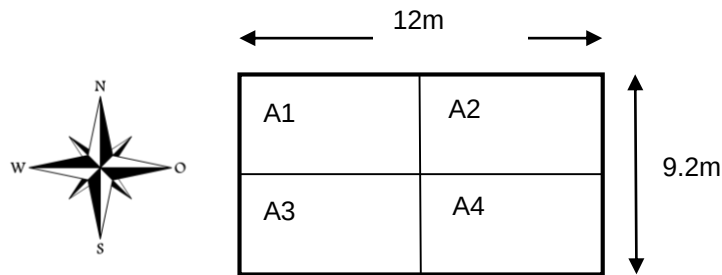


- Kasutusfaas annab suurema osa keskkonna jalajäljest. Efektiivsete fassaadisüsteemide kasutamine võimaldab LCA optimeerida sõltumata kandekonstruktsioonitüübist.
- *Komposiitkonstruktsioon on jätkusuutlikum kui betoonkonstruktsioon* isegi terase ümbertöötlemist arvestamata. Teras ümbertöötlemise korral betoon- ja komposiitkonstruktsiooni erinevus suureneb (umbes 82%)
- Keskkonnamõjude seisukohalt on kasulikum kasutada kõrgtugevat terast.

Elamu : CasaBuna tüüpi elamu Rumeenias



Hoone määratlus



- 4 korterit 55m², kahel korrusel.
- Asukoht - Timisoara

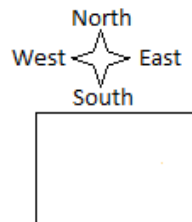


Project **Building** Envelope Base Floor Roof

Definition of the building

General parameters

North - South facade Length	12	m
East - West facade length	9.2	m
Floor height	2.9	m
Floor height under ceiling	2.7	m
Number of intermediate floors	1	
Area of intermediate floors	110,4	m ²
Total area of building	220,8	m ²
Structure only	No	
Building type	Residential	



Location

Country Romania

Location Timisoara

Display

Piirdekonstruktsioonid



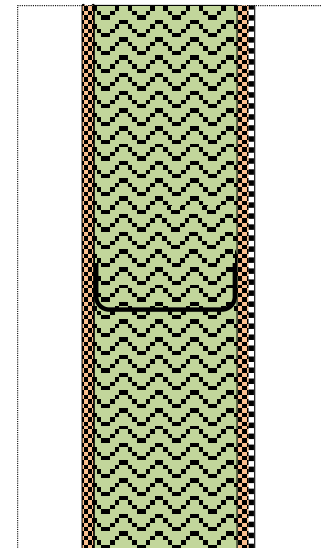
	North/South [m ²]	West/East [m ²]	Sum [m ²]
Seinad	47	41	87
Klaasid	22	12	34
Kogupindala	69	53	122

Definition of the building envelope

Facade

Direction	North	East	South	West	
Facade area	69.6	53.36	69.6	53.36	m ²
Opening area	22	12	22	12	%

- Fassad : teraskarkassil kergpaneelid, soojustus 120 mm kivivilla
- Aknad : topeltklaasiga, alumiiniumraamiga
- Katus : soojustatud 18 cm polüstüreenvahuga



Kasutusrežiim ja tehnosüsteemid



Project Building Envelope Base Floor Roof **Occupancy** Systems Structure Floors Transport

Vastavalt elamu nõuetele



Occupancy related data

Comfort requirements

Heating set-point temperature	20	°C
Cooling set-point temperature	26	°C
Air-flow-rate (heating mode)	0,6	ac/h
Air-flow-rate (cooling mode)	1	ac/h

Project Building Envelope Base Floor Roof Occupancy **Systems** Structure Floors Transport

Description of building systems

Heating system

Heating system type

Cooling system

Cooling type system

Mechanical ventilation system

Heat recovery system

DHW system

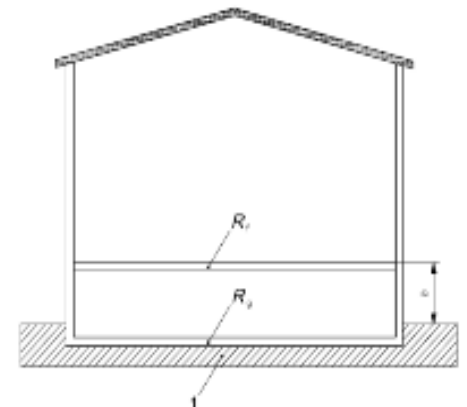
DHW system type

- Gaasiküte
- Jahutus puudub
- Mehaaniline ventilatsioon puudub
- Soe tarbevesi elektriboileriga

Alumine põrand & hoone konstruktsioonid



- Tuulutatav põrand, 0.2m raudbetoonist (0.7t armatuuri)



Project	Building	Envelope	Base Floor	Roof	Occupancy	Systems	Structure	Floors	Transport
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- Kergprofiilidest teraskarkassiga sein- ja katusekomponendid = muud teraselemendid puuduvad



Steel elements		
Beams (Hot rolled profiles)	0	t
Columns (Hot rolled profiles)	0	t
Studs	0,0	t
Bolts	0	t
Plate Connections	0,0	t
Total mass of structure	0,0	t

Transport



- Teras transport :
 - kogukaal : 1.6 tonni (armatuur)
 - Transport : keskmine Euroopa terasetransport, 1 t keskmine Euroopa vahemaa
- Betooni transport :
 - Kogukaal: 52 tonni (Alumine põrand)
 - Transport : 30km segistiveokitega

Roof
Occupancy
Systems
Structure
Floors
Transport
Results

Transport parameters

Steel elements

Total steel transported
 t

Values for the transport impacts

Concrete elements

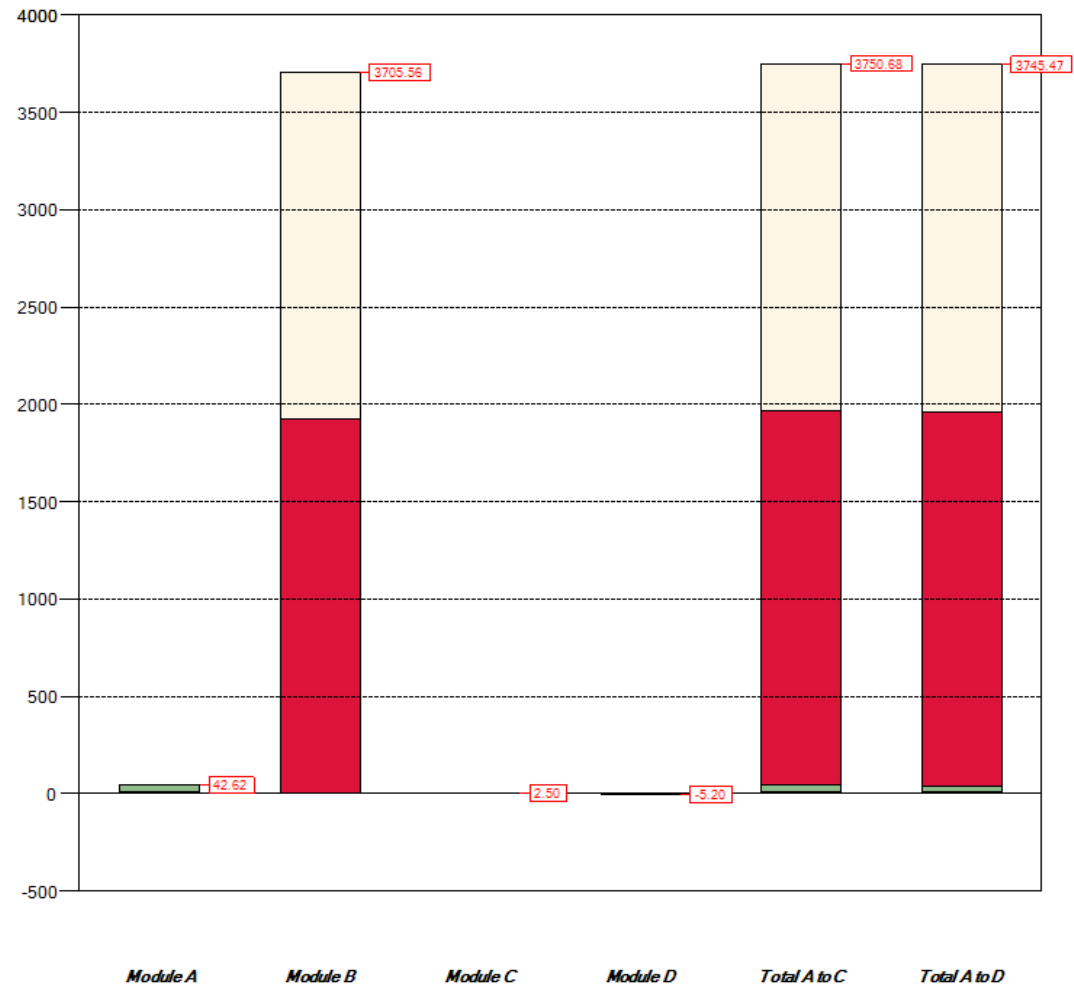
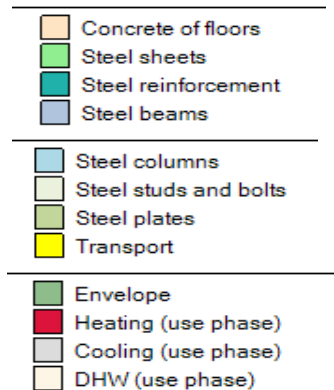
Total concrete transported	52,11	t
Concrete produced on site	52,11	t
Distance by mixer trucks	30,0	km
Prefabricated concrete	0,0	t
Distance by regular trucks	0,0	km

Tulemused: üldtulemused elamule

Global Warming Potential (tCO₂eq)



- Kasutusfaas (moodul B) annab umbes 99% GWP mõjust





Küttekulud



Use phase heating

Energy for space heating					
Heat transfer by transmission					
Walls	Glazing	Ext Floor	Roof	Ground	Total
kWh/year	kWh/year	kWh/year	kWh/year	kWh/year	kWh/year
4845.1	5968.3	0.0	3328.8	3008.7	16882.1
Heat Transfer by ventilation			Heat gains		
Ventilation			Glazed	Opaque	Internal
kWh/year			kWh/year	kWh/year	kWh/year
8963.6			14064.4	783.0	10757.0

Energy need for heating												
Qh,nd	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
kWh	911.2	606.4	435.1	129.2	0.0	0.0	0.0	0.0	0.0	100.9	454.8	816.6
kWh/m²	4.1	2.7	2.0	0.6	0.0	0.0	0.0	0.0	0.0	0.5	2.1	3.7

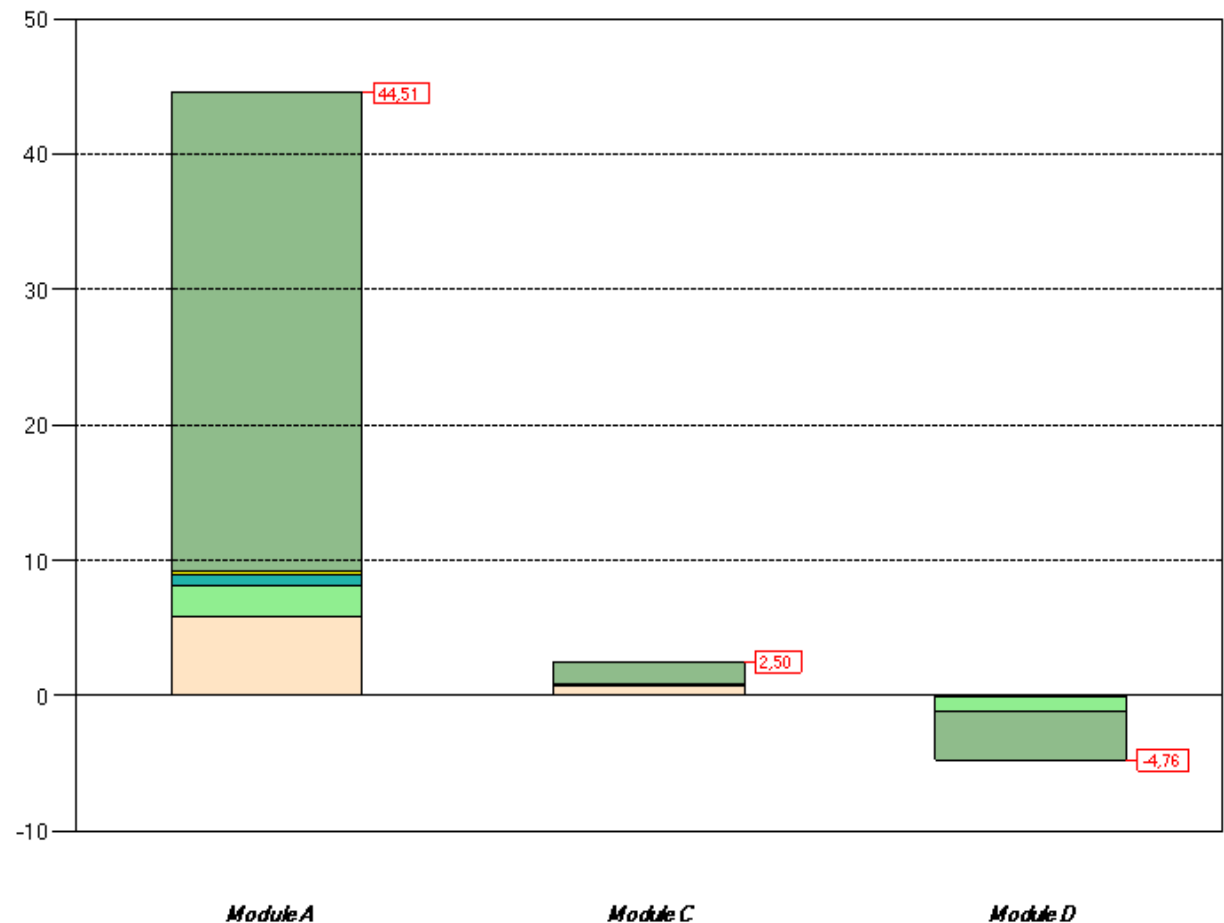
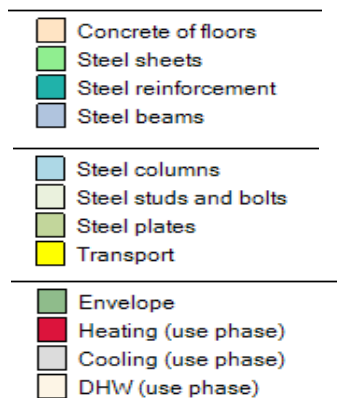
Energy Breakdowns		
Building totals for heating		
Energy need	3454.2	kWh/year
	15.6	kWh/m²/year
Delivered energy	3970.4	kWh/year
COP : 0.87	18.0	kWh/m²/year
Primary	341.5	kgoe/year
fconv : 0.086	1.5	kgoe/m²/year

Tulemused: materjalide mõju

Global Warming Potential (tCO₂eq)



- Piirete materjalid annavad 79% GWP mõjust (moodul A)





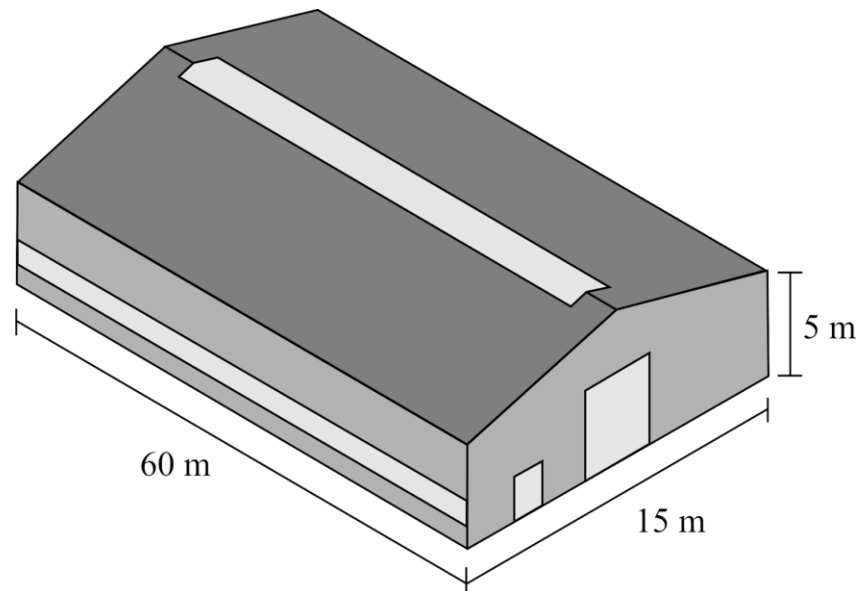
Tulemused: kokkuvõte



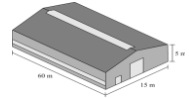
- ***Kasutusfaas*** (Moodul B) annab praktiliselt kogu keskkonna jalajälje.

Konstruktsiooni osa on tühine. Efektiivne fassaadisüsteem võimaldab vähendada LCA alusel määratud keskkonnamõju

Tööstushoone: Terasest ja betoonist portaakraamiga hoone Pariisis



Eesmärk

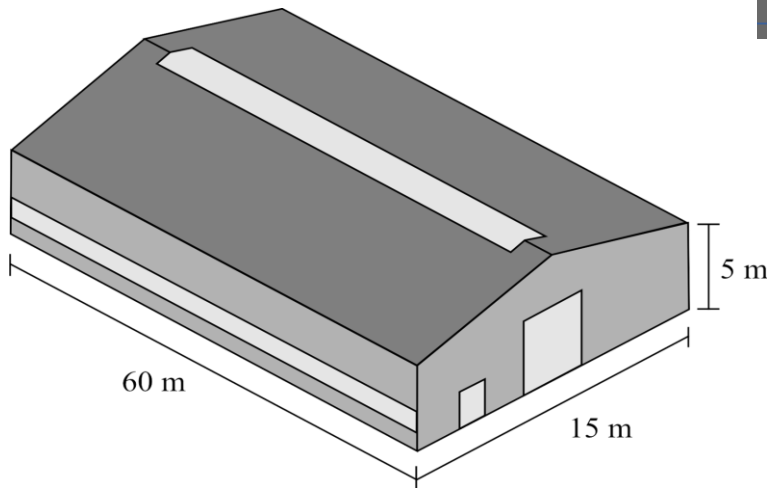


Võrrelda LCA kahe erineva konstruktsiooniga hoone puhul

- Liigendtugedega portaalraam kuumvaltsitud terasprofiilidest
- Jäikade tugedega postid, liigendtoetusega tala, postid ja talad raudbetoonist



Hoone määratlus

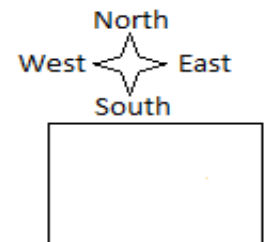


Project	Building	Envelope	Base Floor	Roof	Occupancy	Systems	Structure
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Definition of the building

General parameters

North - South facade Length	60	m
East - West facade length	15	m
Floor height	5	m
Floor height under ceiling	5	m
Number of intermediate floors	0	
Area of intermediate floors	0	m²
Total area of building	900,0	m²
Structure only	No	▼
Building type	Industrial	▼



- 900m² tööstushoone
- Asukoht - Pariis

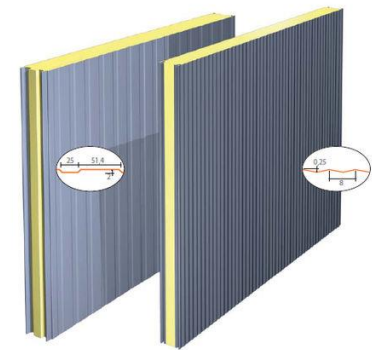
Location

Country	France ▼
Location	Paris ▼
Display	

Piirdekonstruktsiooni komponendid

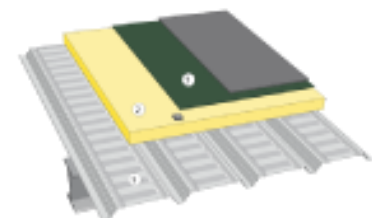
- Fassaad : 80mm PUR sandwich paneelid
- Energiatõhus variant : 200mm PUR sandwich paneelid*
- Aknad: topeltklaasiga & Alumiiniumraamiga

Project	Building	Envelope	Base Floor	Roof	Occupancy	Systems	Structure
Facade properties							
Wall type	Sandwich panel (PUR 80 mm)						
U-value for walls	0,3						W/(m².K)
Opening type	Double glazing						
U-value for openings	2,9						W/(m².K)
Shading device type	No shading device						
Shutter type	No shutter						

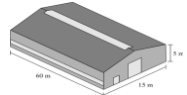


- Katus : Hüdroisolatsiooni all 140mm mineraalvilla

Roof	
Roof type	Waterproof membrane
U-value for the roof (flat part)	0,31



Tööstushoone põrand



Konstruktiooni osa	Variant 1 terasraam S235	Variant 2 terasraam S460	Variant 3 betoonraam
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Alumise korruse
põrand

betoon : 425.7 kg
armatuur : 14.4 t

Project
Building
Envelope
Base Floor
Roof
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Results

Base floor

U-value for the base floor	0.44	W/(m ² .K)
Base floor type	Slab on Ground Floor	
Thickness of concret base floor	0.2	m
Mass of reinforcing steel	14.4	t
Internal heat capacity of ground	74612	J/(m ² .K)
Internal heat capacity of intermediate floor	0	J/(m ² .K)
Internal heat capacity of internal wall	0	J/(m ² .K)

Key

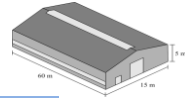
1 floor slab

2 ground

w thickness of external walls

Figure 1 — Schematic diagram of slab-on-ground floor

Kasutusrežiim ja tehnoseadmed



Project Building Envelope Base Floor Roof **Occupancy** Systems Structure Floors Transport

Tööstushoone
– hoone tüüp



Comfort requirements		
Heating set-point temperature	18	°C
Cooling set-point temperature	26	°C
Air-flow-rate (heating mode)	0,6	ac/h
Air-flow-rate (cooling mode)	1	ac/h

Project Building Envelope Base Floor Roof Occupancy **Systems** Structure Floors Transport

Description of building systems

Heating system

Heating system type

Cooling system

Cooling type system

Mechanical ventilation system

Heat recovery system

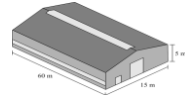
DHW system

DHW system type

- Küttesüsteem : gaasiküte
- Jahutussüsteem puudub
- Mehaaniline vent.-süsteem puudub
- Soe tarbevesi puudub



Hoone konstruktsioon



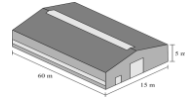
Konstruktsiooni osa	Variant 1 terasraam S235	Variant 2 terasraam S460	Variant 3 Betonraam
tala	IPE 450 (6.88t)	IPE 330 (4.33 t)	Monteeritav betoontala T80 (34.19 t) armatuur BSt500 202.5 kg/m ³ (2.93 t)
postid	Primaarpost: IPE400 Sekundaarpost : HEA480 (4.17 t)	Primaarpost : IPE400 Sekundaarpost : HEA480 (4.17 t)	Betoonristlõige 0.4x0.4m C30/37 (30.12 t) armatuur BSt500 108.1 kg/m ³ (1.38 t)
polidid	43 kg		/
lehed sõlmedes	336 kg		/

Occupancy Systems **Structure** Floors Transport

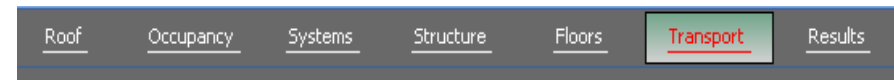
Steel elements		
Beams (Hot rolled profiles)	4,330	t
Columns (Hot rolled profiles)	4,170	t
Studs	0,0	t
Bolts	0,043	t
Plate Connections	0,336	t

Total mass of structure	8,879	t
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Transport



- Teras transport :
 - Kogukaal: 26 tonni
Talad + Postid + Sõlmed
 - Transport : keskmine distants Euroopas
- Betooni transport :
 - Kogukaal : 425 tonni
Talad + Postid
 - Transport : 30 km segistiveokiga

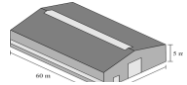


Transport parameters

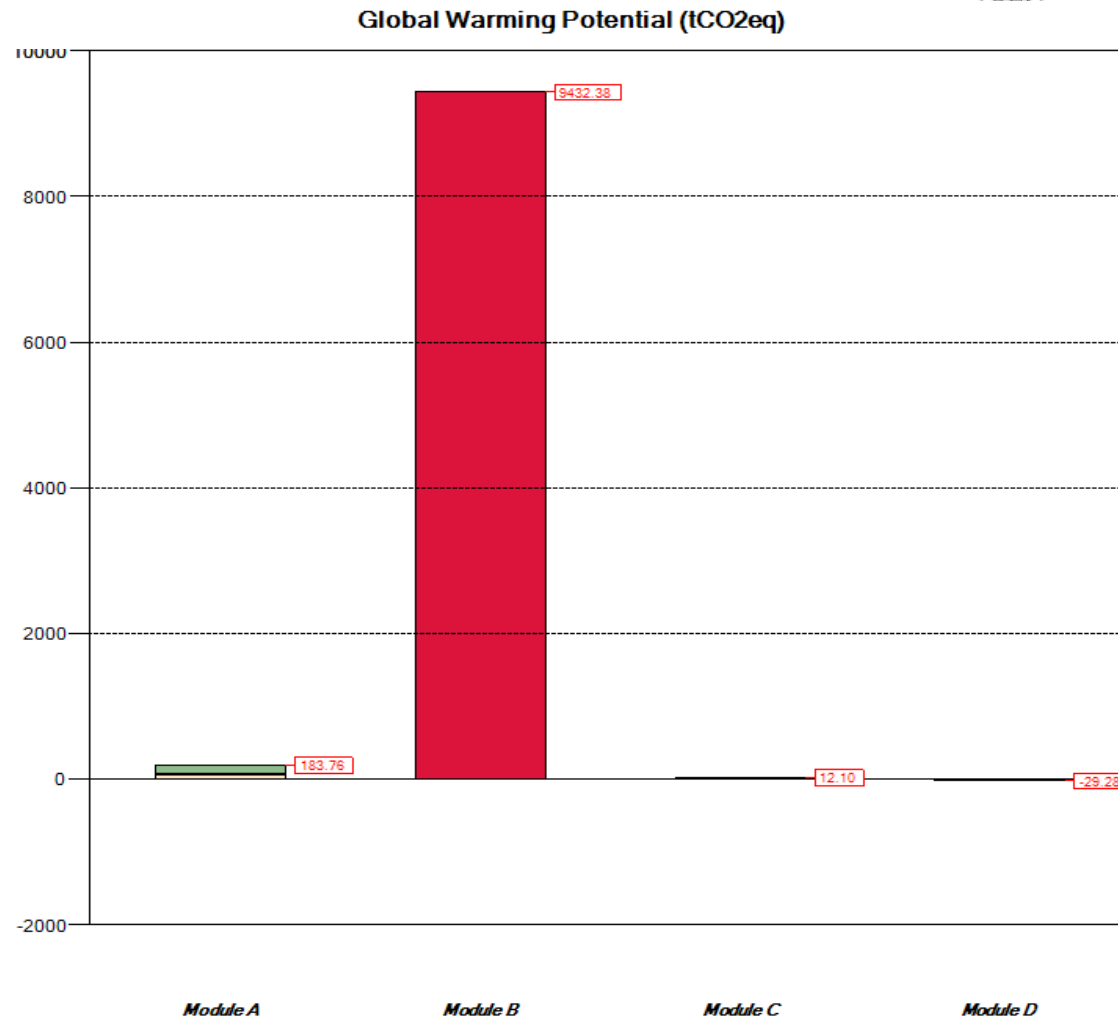
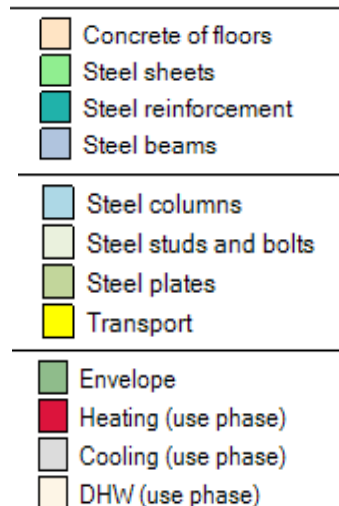
Steel elements		
Total steel transported	25.83	t
Values for the transport impacts	Average values ▼	

Concrete elements		
Total concrete transported	424.8	t
Concrete produced on site	424.8	t
Distance by mixer trucks	30.0	km
Prefabricated concrete	0.0	t
Distance by regular trucks	0.0	km

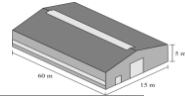
Tulemised: üldtulemused tööstushoonele



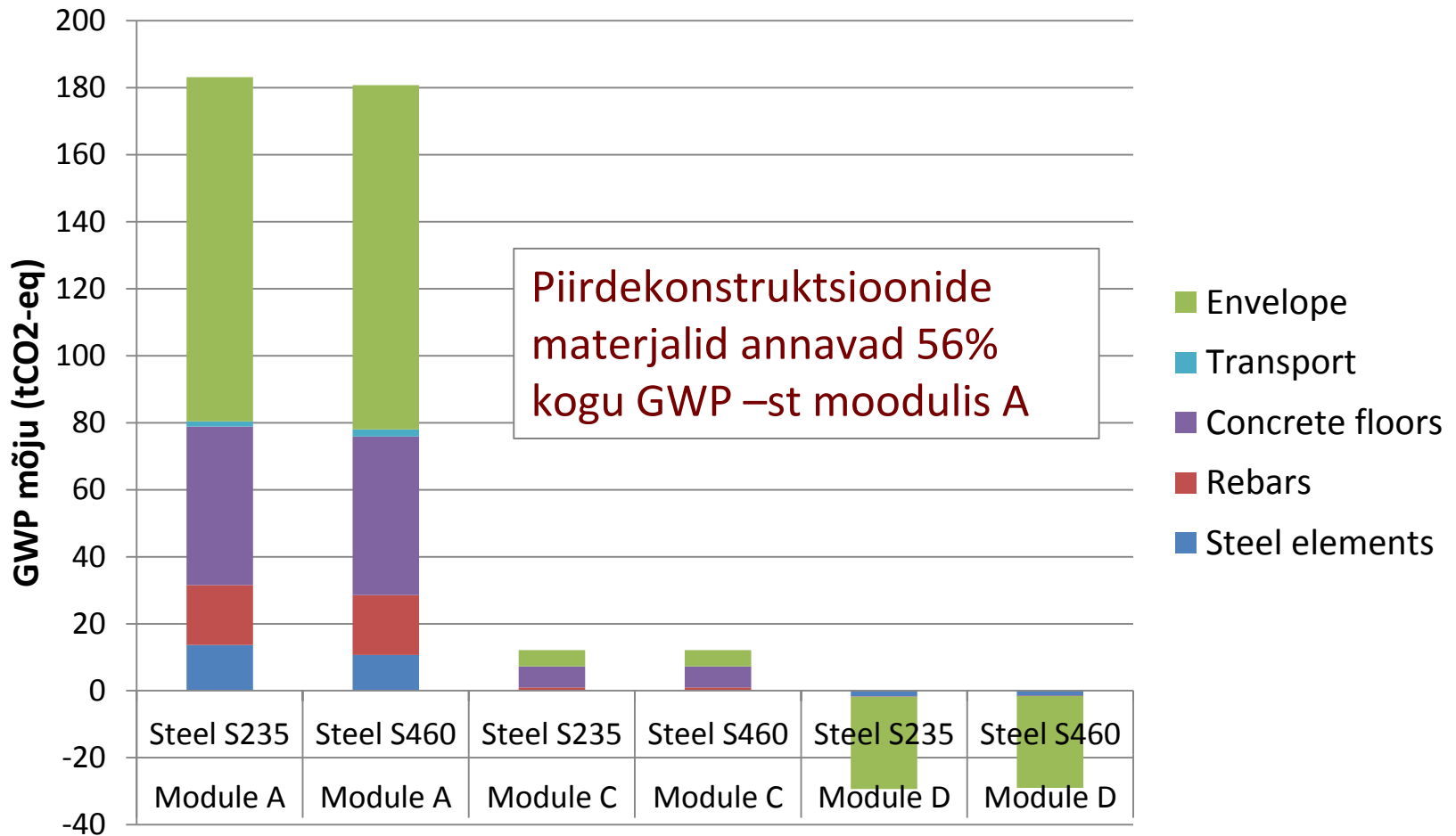
- **Kasutusfaas** (Moodul B) annab 99% GWP-st mõlemal konstruktsioonitüübil



Tulemused: teraskonstruktsioon

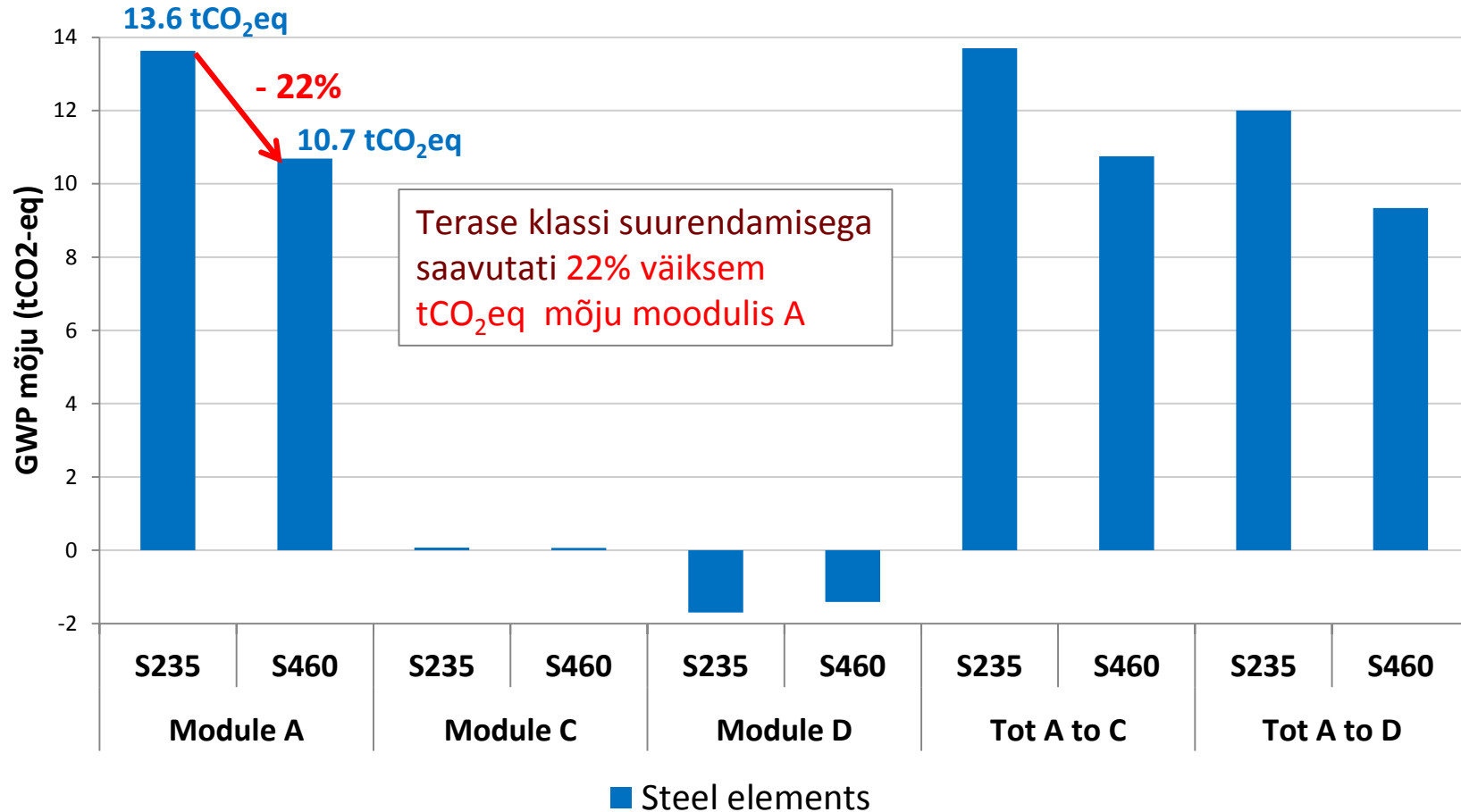
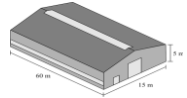


GWP mõju võrdlus terase klassidele S235 vs S460

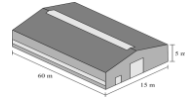


Tulemused: teraskonstruktsioonid

GWP mõju võrdlus terase klassidele S235 vs S460



Tulemused : Moodul D , terasraam S460

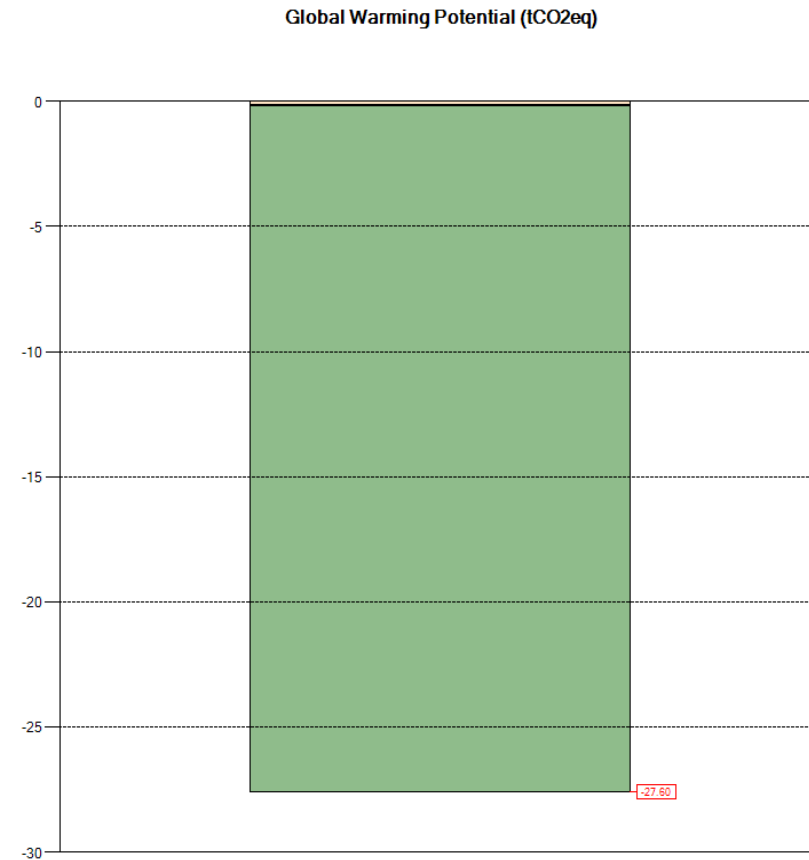


- **Moodul D** (kasu väljaspool süsteemi piire)
teras S460 puhul kogumõju GWP :
-27.6 t CO₂eq

- Näha on kasu
piirdekonstruktsioonimaterjalide
ümbertöötlemisest:

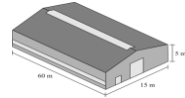
- *Kergel teraskarkassil
fassaadielemendid*
- *Profiilplekk katusel*

Concrete of floors	Steel columns	Envelope
Steel sheets	Steel studs and bolts	Heating (use phase)
Steel reinforcement	Steel plates	Cooling (use phase)
Steel beams	Transport	DHW (use phase)

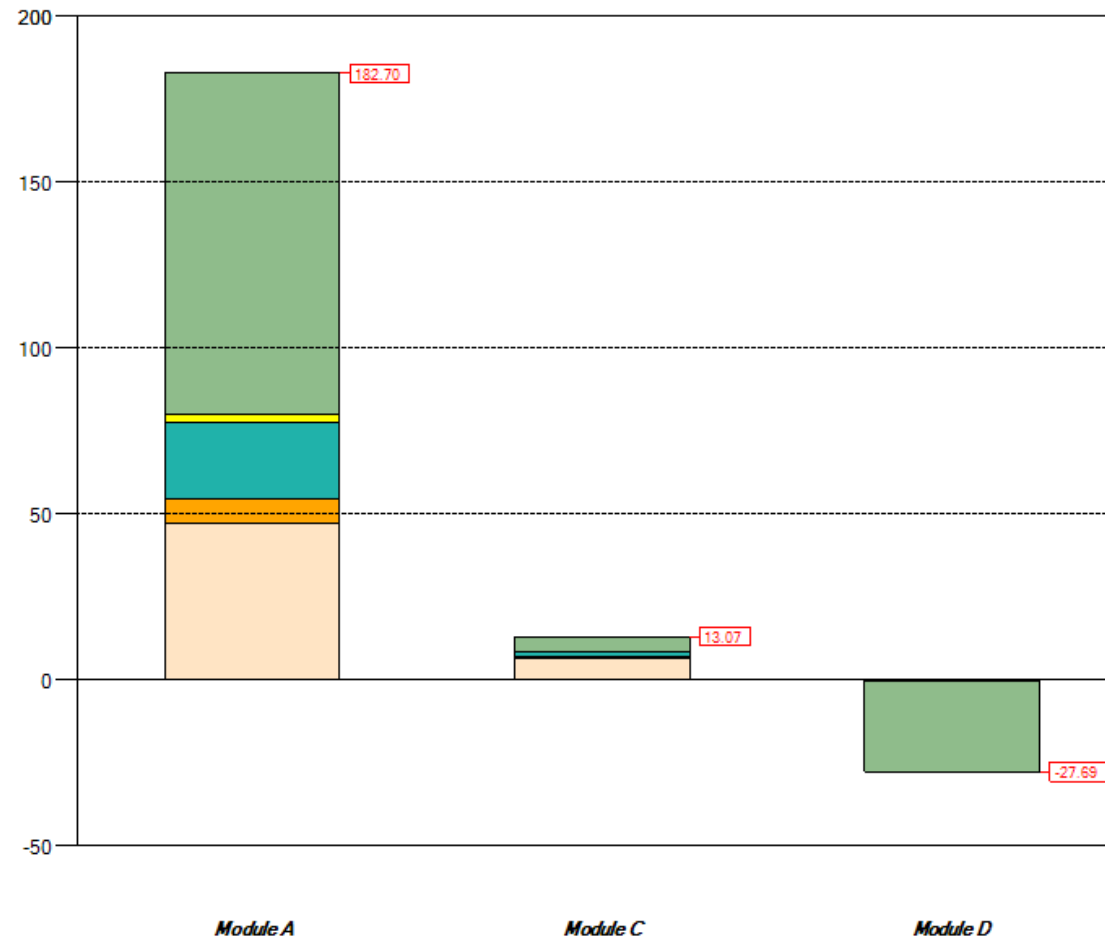


Tulemused : betoonkonstruktsioon

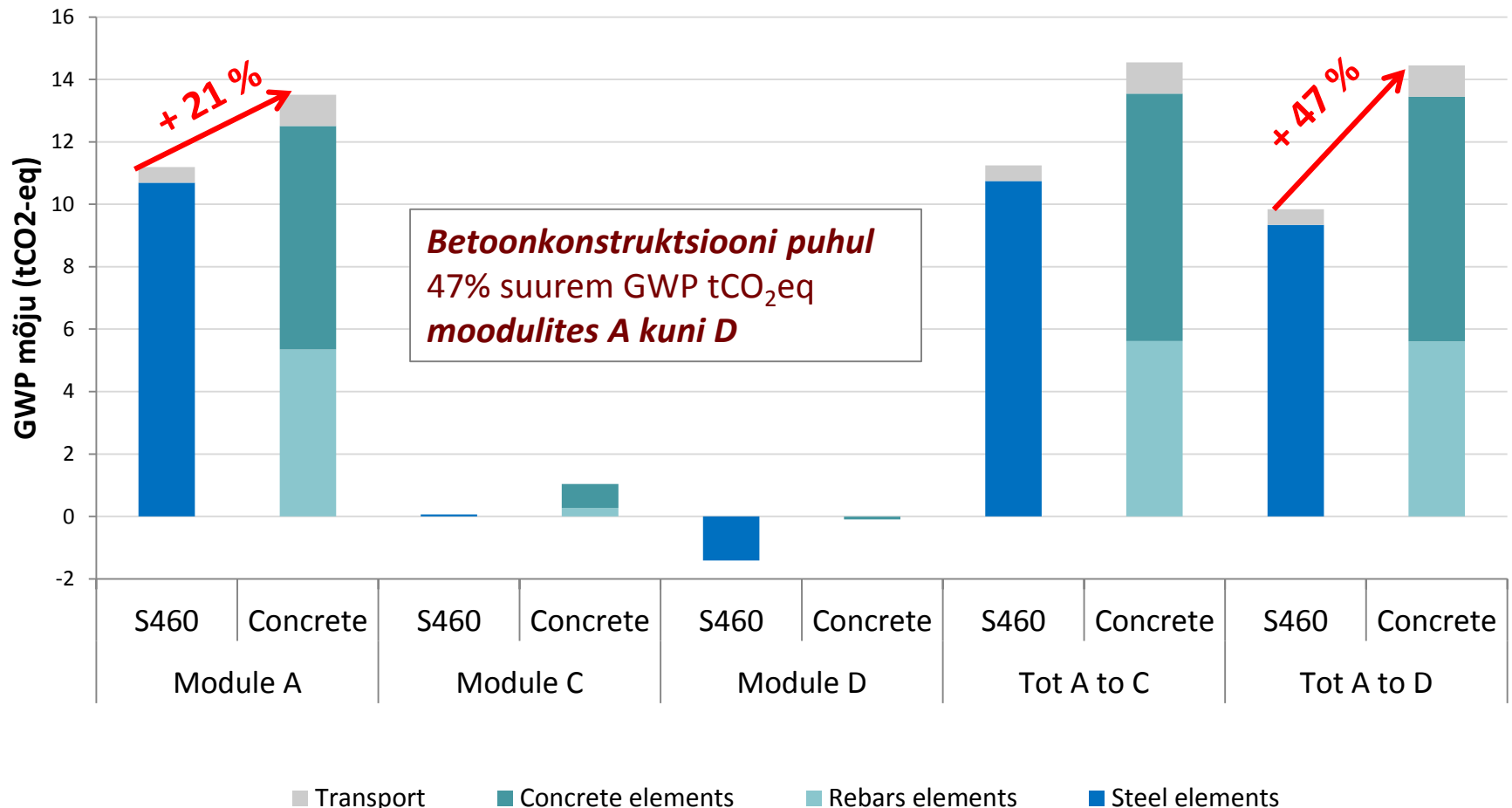
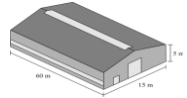
Global Warming Potential (tCO₂eq)



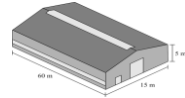
- **Moodul A: kogu GWP mõju = 183 tCO₂eq**
- Kogu GWP mõju **konstruktsioonisüsteemist** = 80 tCO₂eq, millest 40% on põrandabetoon.



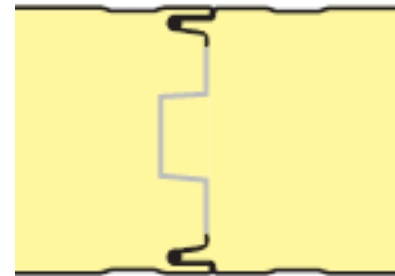
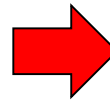
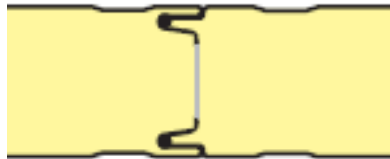
Tulemused: GWP mõju võrdlus teras vs betoon



Keskkonnasäästlikkuse kasv isolatsiooni paksuse suurendamisega



80 mm

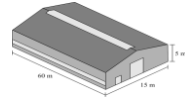


200 mm

- Lihtne hinnata AMECO3-ga : kasutajasõbralik tarkvara
- **Kasutusfaas** (moodul B): netosääst 888 tCO₂-eq
- **Tootmisfaasis** (moodul A) : suureneb 13 tCO₂eq, lisasoojustuse arvel
- Võrreldes energiatarbe vähenemisega on see suurenemine tühine, põhjendatud on hoone kasutusaegse energiatõhususe suurendamine.



Tulemused: kokkuvõte



- ***Kasutusfaasist tuleneb kõige suurem osa hoone jalajäljest. Efektiivsed fassaadilahendused võimaldavad LCA optimaalsemaid tulemusi***
- ***Kuumvaltsitud profiilidest teraskonstruktsioonid on väiksema mõjuga keskkonnale kui raudbetoon, isegi siis kui ei arvestata ümbertöötlemist***
- Kõrgtugeva terase kasutamine ehitistes on keskkonna seisukorrale soodne..