Recommendations for reuse of constructional steel products

Teräs kiertotaloudessa webinaari 28.4.2021

Petr Hradil

STAD ANTWERPEN.

BLAUWE TOREN.

Verkoop voor afbraak.

Burgemeester & Schepenen

Brengen ter kennis der belanghebbenden dat er op Maandag 10 November aanstaande, ten één uur namiddag, in eene der zalen van het stadhuis, zal overgegaan worden tot het openen der inschrijvingen voor het afbreken van den Blauwen Toren.

Het lastkohier en het plan liggen ter inzage op het 4e bureel van het stadhuis.

TEN MINSTE ÉÉN DAG vóór de besteding, zullen de inschrijvingen moeten gestuurd worden, onder toegezegelden omslag, aan den Burgemeester der stad Antwerpen, bij aanbevolen brieven, op de post besteld. De omslag zal moeten voor opschrift dragen het adres van den Burgemeester met aanwijzing van het werk voor hetwelk men ingeschreven heeft.

Antwerpen, den 25e October 1879.

Voor den Burgemeester,
DE SCHEPEN,
Jac. CUYLITS.

BIJ VERORDENING : DE SECRETARIS,
J. DE CRAEN.

VILLE D'ANVERS

TOUR BLEUE.

Vente pour démolition.

Les Bourgmestre & Échevins

Portent à la connaissance des intéressés qu'il sera procédé le Lundi 10 Novembre prochain, à une heure de l'après-midi, dans une des salles de l'hôtel de ville, à l'ouverture des soumissions pour la démolition de la Tour bleue.

Le cahier des charges et le plan sont déposés au 4e bureau de l'hôtel de ville.

AU MOINS UN JOUR avant la date fixée pour l'adjudication, les soumissions devront être adressées, sous enveloppe cachetée, au Bourgmestre de la ville d'Anvers, par lettres recommandées, remises à la poste. L'enveloppe portera pour suscription l'adresse du Bourgmestre et indiquera l'entreprise pour laquelle on a soumissionné.

Anvers, le 25 Octobre 1879.

Pour le Bourgmestre,
L'ÉCHEVIN,
Jacq. CUYLITS.

PAR ORDONNANCE : LE SECRÉTAIRE,
J. DE CRAEN.

Antwerpen. — ED. DONNÉ, stadsdrukker, Begijnenpoortvest, 99 (nabij het Leopoldsplein).

VTT

Public sale of building for demolition,1879
Collection Felixarchief / stad Antwerpen

2017-2020

PROGRESS

PROVISIONS FOR GREATER REUSE OF STEEL STRUCTURES

VTT

Focus on single-storey steel buildings

Broad applicability (industrial, commercial, sports, exhibition, warehouses), suitable for reuse and viable for circular-economy business models. The results are easily extendable to other materials and buildings.

Existing and future buildings

Reuse of existing building stock is challenging and only marginally profitable.

ECCS CECM EKS

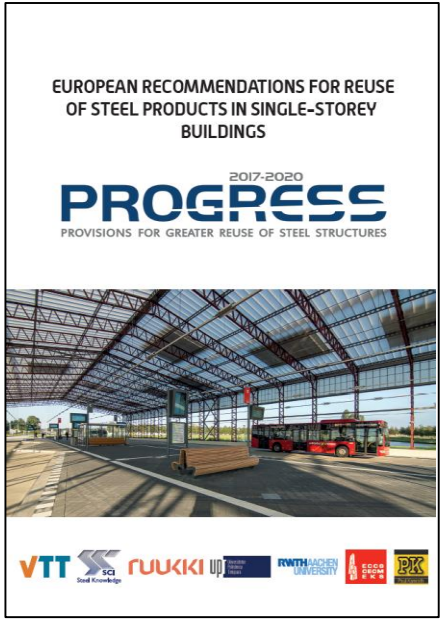
ruukki

SCI

up Universitatea Politehnica Timişoara

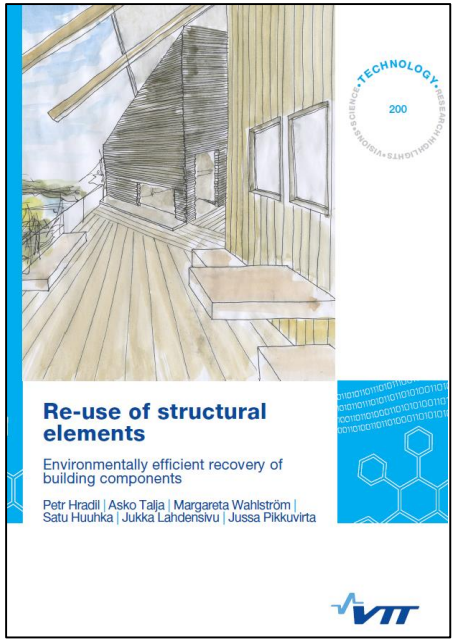
RWTH AACHEN UNIVERSITY

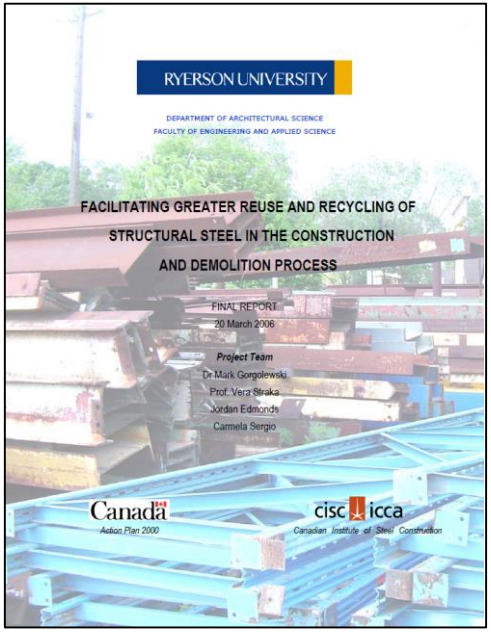
Paul Kamrath Ingenieurrückbau GmbH Abbruchtechnik und Entsorgung



https://www.steelconstruct.com/eu-projects/progress/

Other relevant projects and publications





https://www.vttresearch.com/sites/default/files/pdf/technology/2014/T200.pdf
https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/mineralsmetals/pdf/mms-smm/busi-indu/rad-rad/pdf/re-ste-fin-eng.pdf

Benefits of constructional steel reuse

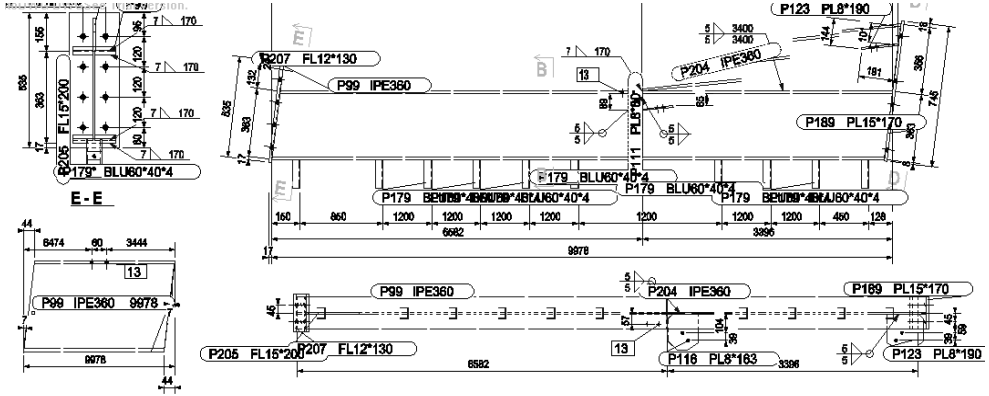
Environmental benefits of reuse

Three existing methods to calculate environmental impacts:

- Worldsteel's LCA methodology — *under revision at the moment*
- CEN/TC-350 (EN 15978, EN 15804) — *new mandate and EN 15804 (2018)*
- Product Environmental Footprint (PEF) — *in pilot phase*

The most problematic is accounting for the future savings (e.g. design for reuse) in Module D of EPDs. PROGRESS project has developed a solution for this.

Example of calculated impacts of one reused structural beam (Hradil et al., EUROSTEEL 2017)



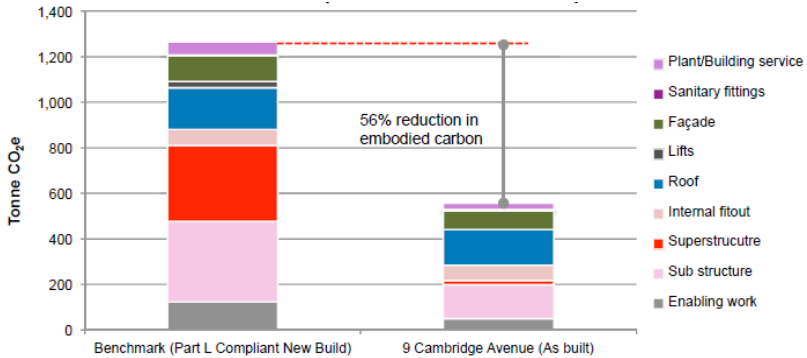
LCIA category	units	no re-use	1x re-use	2x re-use	3x re-use
Global warming potential (GWP100)	kg CO_2 eq.	1075	901	642	454
Stratospheric ozone depletion (ODP10)	kg CFC11 eq. x 10^{-8}	4.27	4.44	3.52	2.78
Acidification potential (AP generic)	kg SO_2 eq.	3.33	2.90	2.11	1.53
Eutrophication potential (EP generic)	kg $(PO_4)^{3-}$ eq.	0.293	0.278	0.212	0.160
Photochemical oxidation (POCP high NOx)	kg ethylene eq.	0.089	0.046	0.032	0.025

174 - 621 kg CO_2 saved

Environmental benefits (industrial warehouse)

Original location (Leigh Road)

New location (Cambridge Avenue)

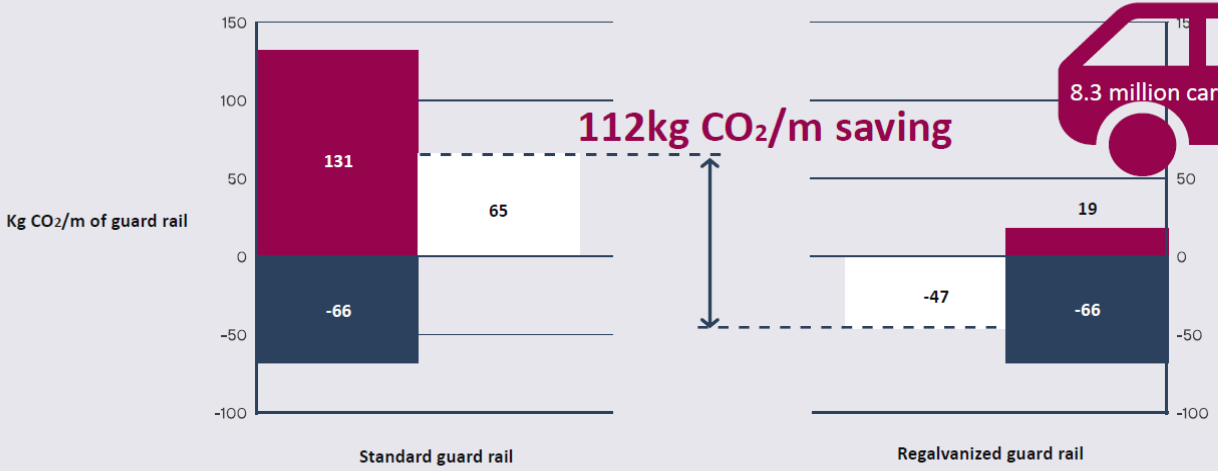


700 t CO_2 saved

Source: Steel Construction Institute

Environmental benefits (highway guard rails)

26 000 t CO_2 saved

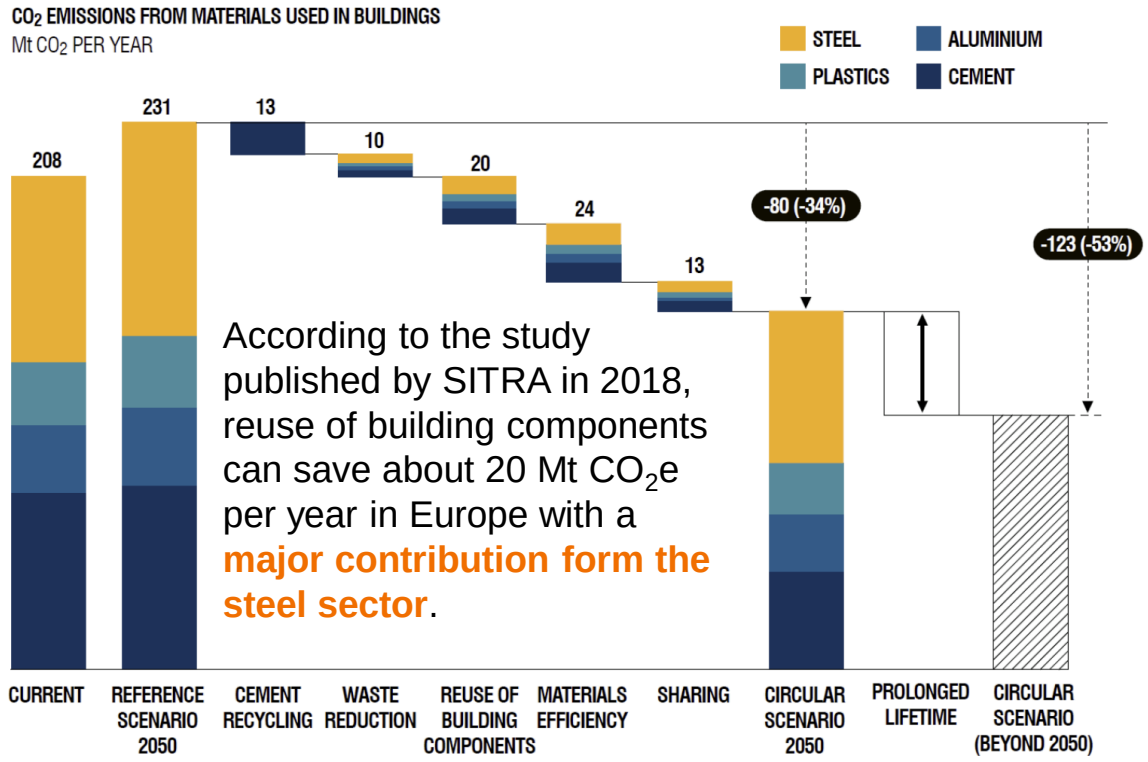


CE Delft study (2017), Netherlands

Production & use Recycling* Total

Source: European General Galvanizers Association

Environmental benefits (all buildings)



Source: SITRA 2018

Economic impact of steelwork reuse

Example of the LCC model outcome

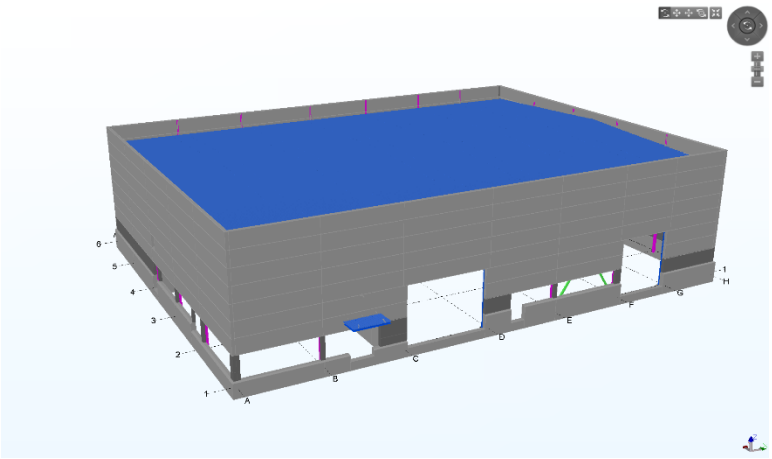
	New steel and recycling[1)]	New or reused steel and reuse (reconditioning)	New or reused steel and reuse (re-erection)	New or reused steel and reuse (in-situ)
LCC (A-C)	2329 €/t	2444 €/t	2444 €/t	2076 €/t
LCC (D)	-200 €/t	-409 €/t	- 869 €/t	- 1501 €/t
Total LCC (A-D)	2129 €/t	2036 €/t	1576 €/t	575 €/t
Price of the steel	673 €/t (new) and 409 €/t (reclaimed)			
Price of the components	1329 €/t (new) and 869 €/t (reclaimed)			
Price of the structure	2019 €/t (new) and 1501 €/t (used)			
Residual value	-111 €/t	-17 €/t	443 €/t	1444 €/t
Depreciation rate (27 y)	3.91%	3.73%	2.89%	0.94%

The worst case scenario was nearly equivalent to the new material production, however, there are possible savings:

Fabrication	up to 27%
Additional modifications	up to 14%
Testing	up to 7%
Additional transport	up to 1%

PROGRESS project was investigating quality checking and component tracing (reduces testing costs), product design (reduces re-fabrication costs), building design (reduces additional modifications) and online marketing (reduces transport/handling).

Economic impact of steelwork reuse



LCC study	10 years	20 years	30 years
Original design (recycling)			
Residual value	-231 k€	-282 k€	-343 k€
PV of Residual value	-98 k€	-50 k€	-26 k€
Design for reuse (reusing)			
Residual value	-112 k€	-176 k€	-263 k€
PV of Residual value	-47 k€	-31 k€	-20 k€
Extra investment for DfD	-61 k€	-61 k€	-61 k€
PV including extra investment	-108 k€	-92 k€	-81 k€

Warehouse with office space in Tampere

Span: 31.5 m

Length: 42 m

Height: 10 m

► Currently, the clear economic benefit is for temporary (< 10 years) buildings such as Pikkulaiva in Espoo or Hakaniemi market hall in Helsinki.

► However, virgin steel cost will likely increase and additional investments for reuse will decrease in the future.

Source: Olli-Pekka Pajala

Reusing existing steel

Sources of reusable material

Not used

- **Surplus steel**

Cleveland Steel & Tubes, Ltd.

London Olympic Stadium
(> 2000 t of gas pipe)

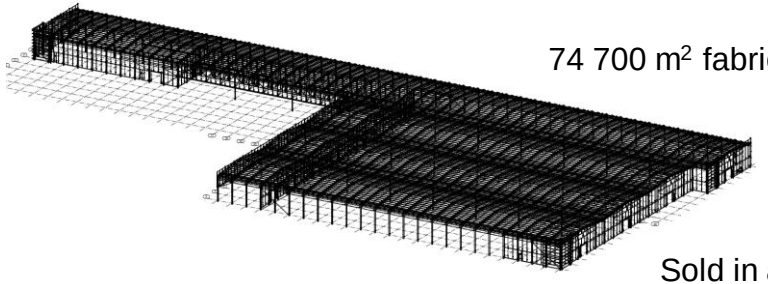
Source: Roy Fishwick, ASBP 2020 Reuse Summit

Sources of reusable material

Not used

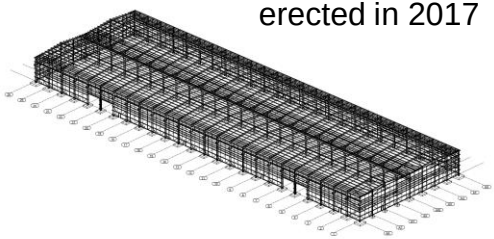
- Surplus steel
- **Fabricated steelwork**

National Tube Stockholders, Thirsk, UK



74 700 m^2 fabricated in 2008

Sold in auction divided in 4 lots in 2013



11 700 m^2 erected in 2017

Sources of reusable material

Not used

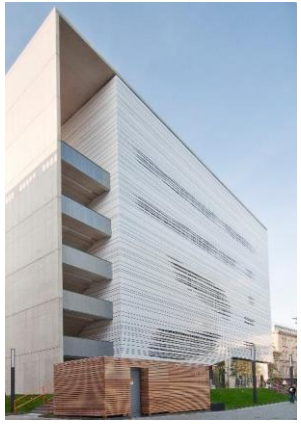
- Surplus steel
- Fabricated steelwork

Used, but still assembled

- **Conversion of existing building**

Hidrotim office, Timisoara, Romania

RWTH seminar building, Aachen, Germany



Sources of reusable material

Not used

- Surplus steel
- Fabricated steelwork

Used, but still assembled

- Conversion of existing building
- **Relocation without dismantling**

Best-Hall, Länsisatama terminal, Helsinki

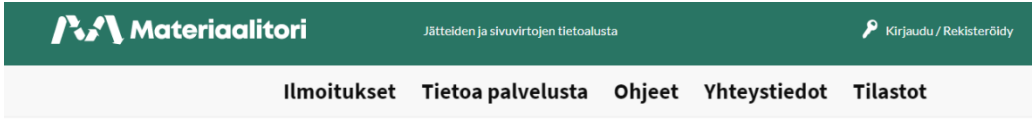
Source: Best-Hall Oy

Sources of reusable material

Not used
- Surplus steel
- Fabricated steelwork

Used, but still assembled
- Conversion of existing building
- Relocation without dismantling

Used and disassembled
- **Reduction to constituents**



uudelleenkäyttöön erilaisia rakennusosia, metallisia kaiteita, portaita, teräsprofiileja

Sources of reusable material

Not used
- Surplus steel
- Fabricated steelwork

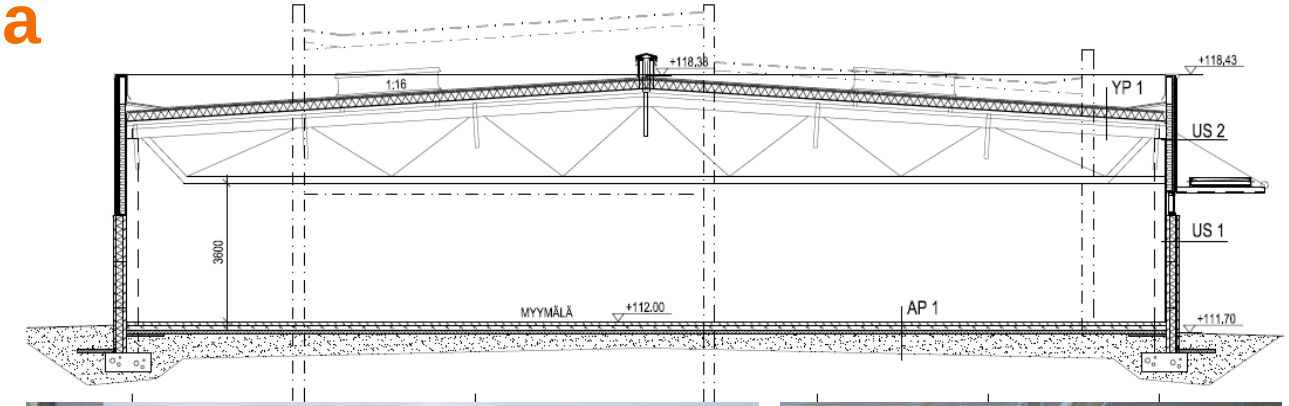
Used, but still assembled
- Conversion of existing building
- Relocation without dismantling

Used and disassembled
- Reduction to constituents
- **Relocated reuse**

S-market Urjala

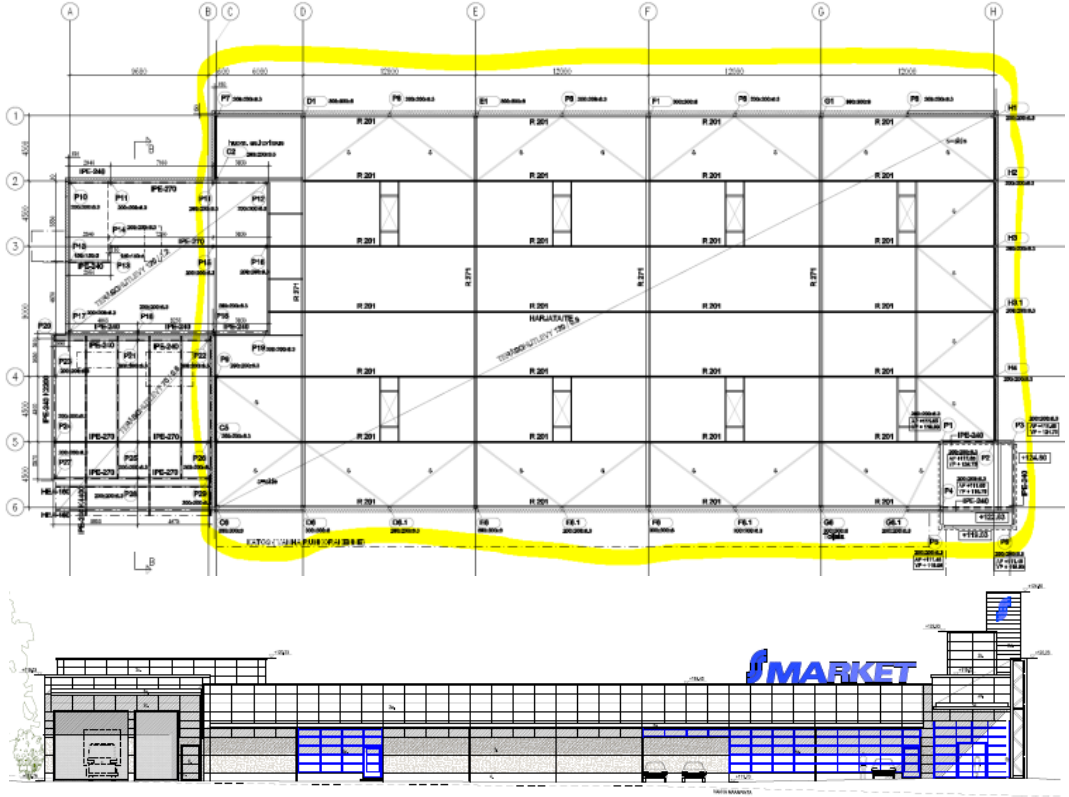
Span:	27 m
Length:	54 m
Height:	6.3 m

Columns:	RHS composite
Trusses:	RHS
Roofing:	Trapezoidal sheet
	Mineral wool
	Bitumen membrane
Walls:	Prefabricated concrete



Source: Ruukki Construction

S-market Urjala



Original building: 1980s

Reuse: 2008 – 2009

The same design code (B7)

The same snow load (1.7 kN/m^2)

The same contractor for deconstruction and construction (Ari Hiltunen)

New fire regulations ►New intumescent paint

New U-value ► Walls were not reused

Saving in total construction cost: 10%

Quality verification protocol

	Class A	Class B	Class C
Classification	Original material test certificates are available and constitute evidence of conformity with the relevant product standard	Original material test certificates are not available. Comprehensive testing protocol is applied.	Original material test certificates are not available. Most conservative steel grade in accordance with structure age and location is adopted.
Adequacy assessment	**Optional minimal testing** Original material documentation used for the adequacy assessment. If required, minimum NDT can be carried out to confirm material provenance.	**Comprehensive testing** Reclaimed steel is tested for the adequacy assessment. All required material characteristics are justified according to EN1090-2 section 5.1 shall be justified and declared.	***No adequacy assessment***
Reliability assessment	**Original certification** Original inspection documents are available and it is possible to trace back the material and ensure that it meets the relevant product standards	**Material re-certified** Reclaimed steel is tested and it is demonstrated that it meets all reliability requirements (frequency of testing to be specified in the protocol)	***No reliability assessment***

Design recommendations

Although steel members have to meet the **geometric tolerances from EN 1090-2, cross-sectional imperfections and member imperfections (mainly due to imprecisions during the geometric assessment) may still affect the member buckling resistance**; increase reliability to account for such uncertainty; see SCI P427 for more detail; Values for UK practice are:

$$\gamma_{M0} = 1.0 \qquad \gamma_{M1,mod} = \mathbf{1.15} \qquad \gamma_{M2} = 1.1$$

Partial factors for actions

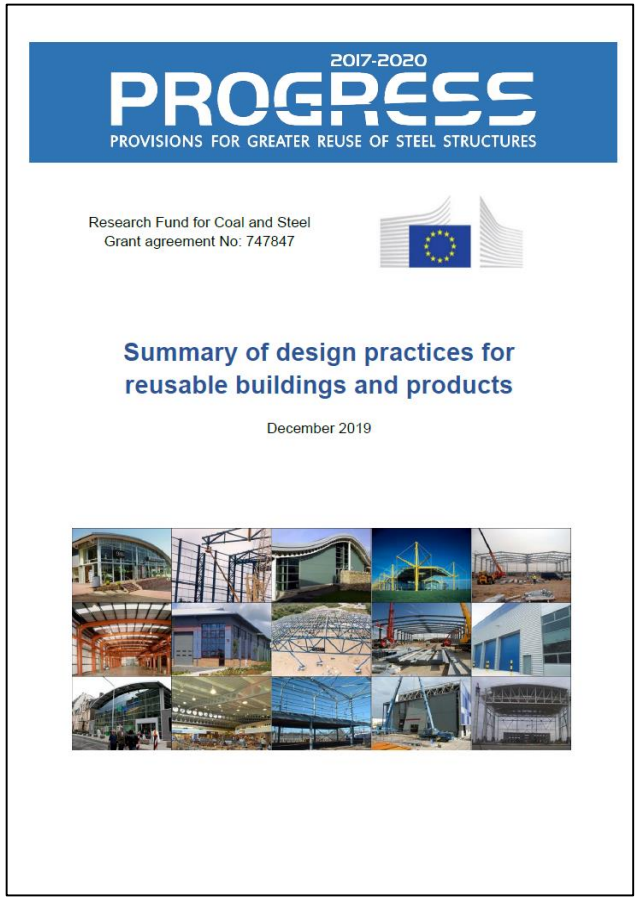
Reuse	Persistent and transient design situations	Permanent actions		Leading variable action	Accompanying variable actions (i > 1)
		Unfavourable	Favourable		
15-30 notional design working life (K_{FI} = 0.9)	Eq. 6.10 (not 6.10a and 6.10b)	1.215 $G_{k,j,sup}$	1.0 $G_{k,j,inf}$	1.35 $Q_{k,1}$	1.35 $\Psi_{0,i}$ $Q_{k,I}$

Source: Steel Construction Institute

Design for future reuse

Design recommendations

- Allow **structural extension and reduction**
  - Horizontal modularity (and if possible vertical)
- Use **standardized** sizes, spans, detailing
- Easily accessible and reversible **connections**
  - Use bolts or screws
- Reduce **interfaces**
  - Avoid secondary structure ► Long span cladding
- Reduce number of different **components and materials**
  - Fewer robust members
  - Fewer cross-sections
  - Fewer material grades and sub-grades
- Consider environmental (snow, wind) loads



Design recommendations

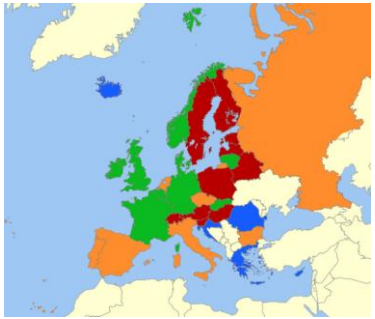
Country	s_k (kN/m²)			Class
	Min.[a]	Country average[b]	Min. European value	
Finland	2.00	2.75	2.00	S1
France	0.45	**0.65**	**0.70**	S3
Germany	0.45	0.85	1.00	S2
Ireland	0.40	**0.55**	**0.70**	S3
Italy	0.60	1.00	1.00	S2
The Netherlands	0.70	**0.70**	**0.70**	S3
Norway	1.50	3.50	2.00	S1
Portugal	0.10	0.30	0.40	S4
Romania	1.50	2.00	2.00	S1
Spain	0.30	0.40	0.40	S4
Sweden	1.50	2.50	2.00	S1
United Kingdom	0.45	**0.65**	**0.70**	S3

[a] Assuming the average altitude for the less critical zone of the country

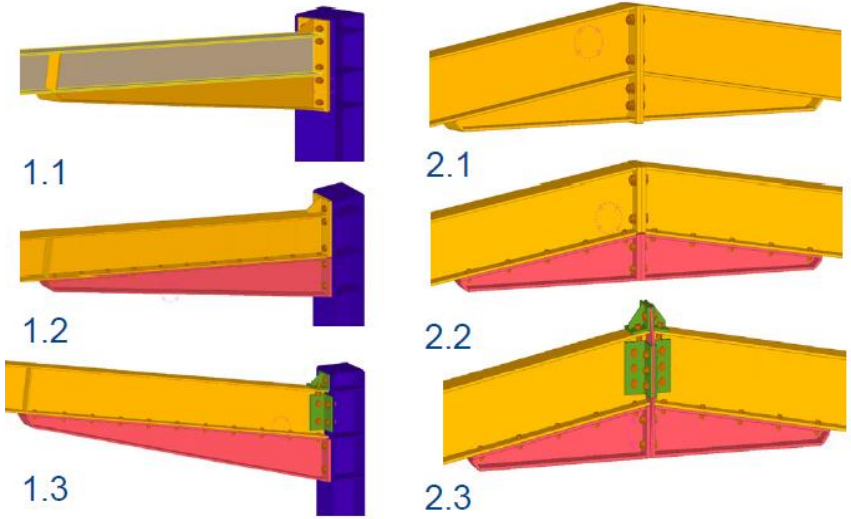
[b] Assuming the average altitude for the zone representing most area of the country

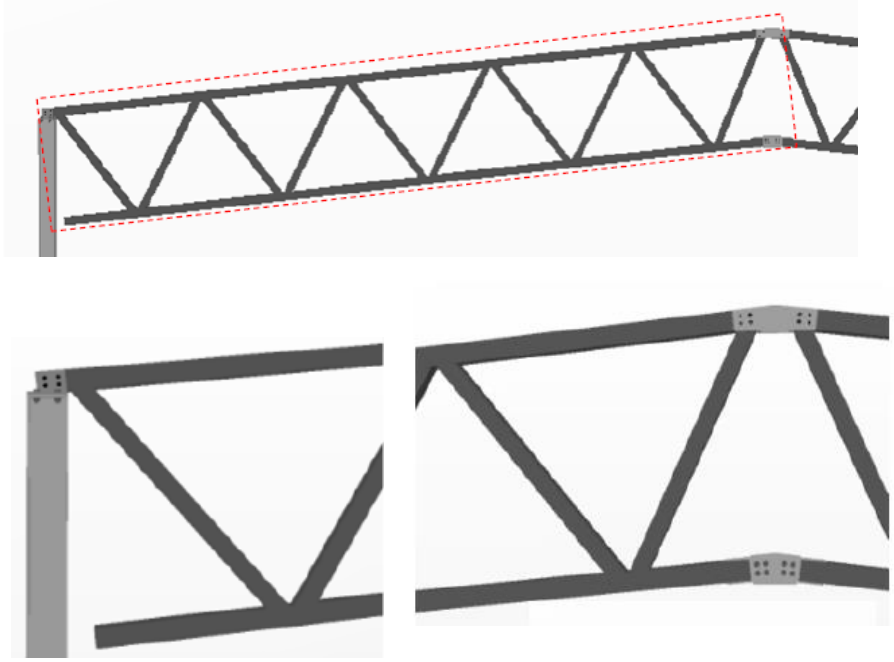
Snow loads

Wind loads

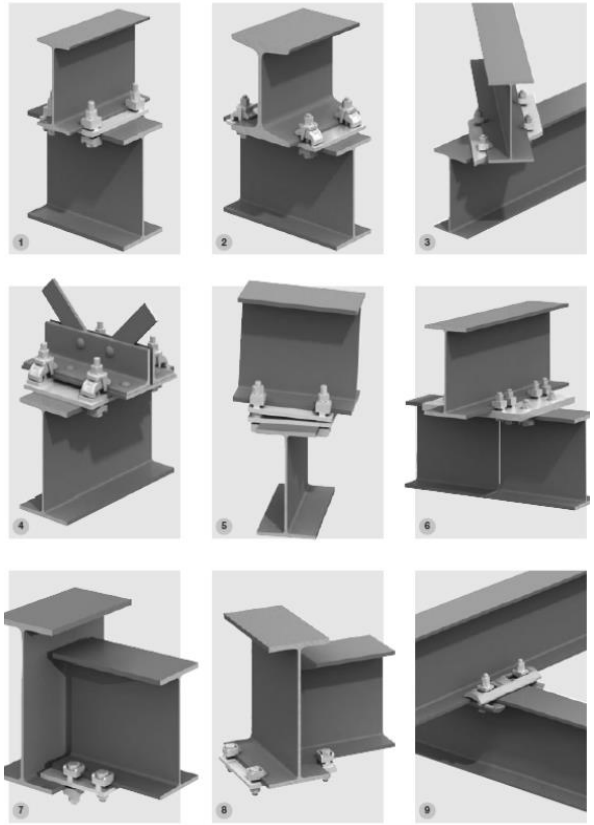


Improved design of frames and trusses

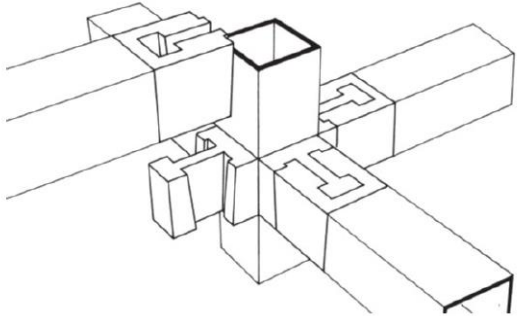


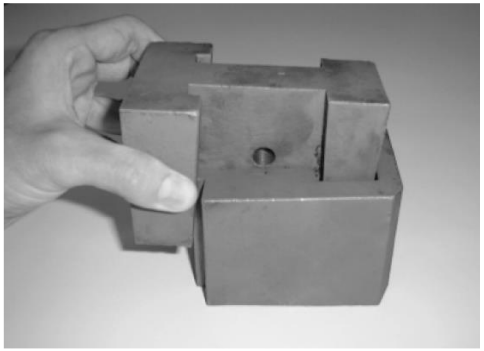


Improved connection detailing

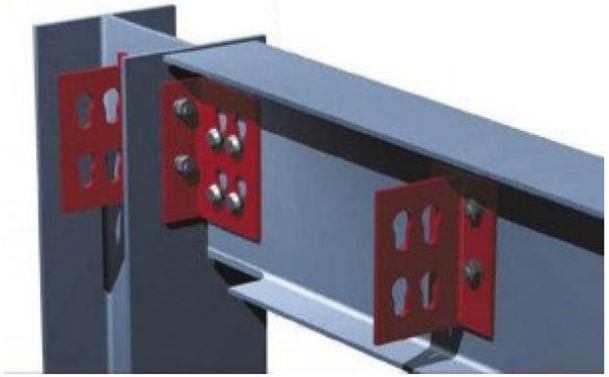


SIGMA joint

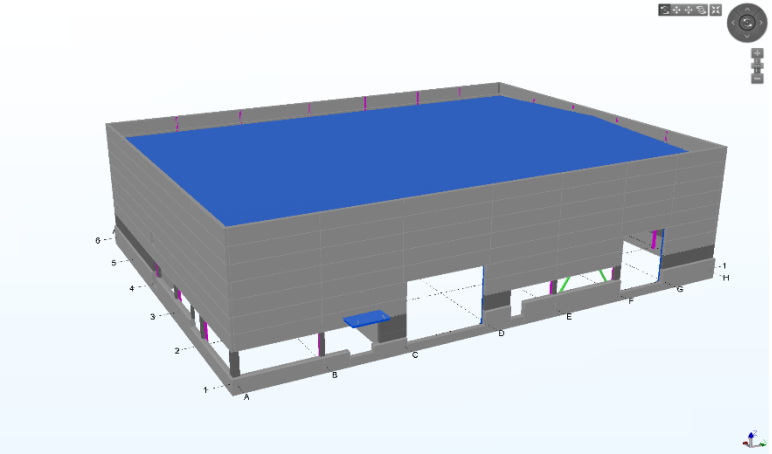


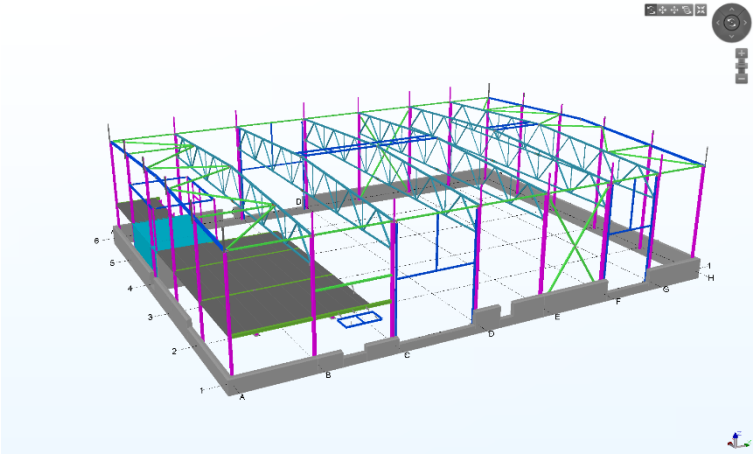


QUICON joint



Warehouse with office space, Tampere

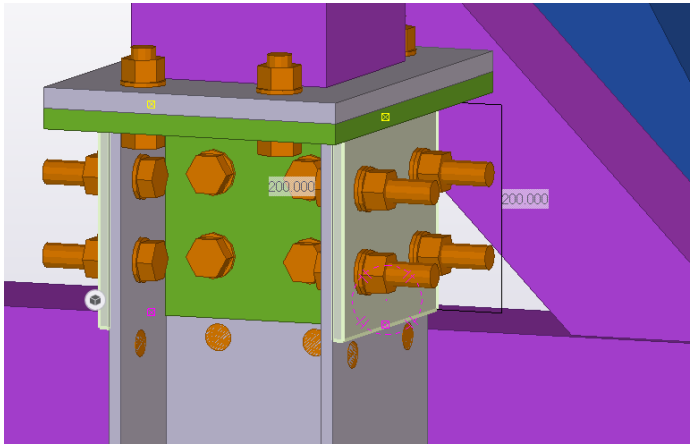


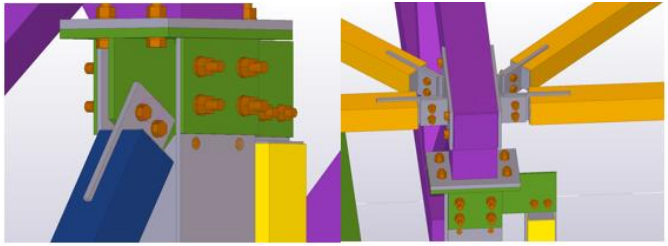


Span:	31.5 m	Columns, Tusses:	RHS
Length:	42 m	Beams:	HEA
Height:	10 m	Walls:	Sandwich panels
		Roofing:	Corrugated sheet

Source: Juha Savolainen

Warehouse with office space, Tampere



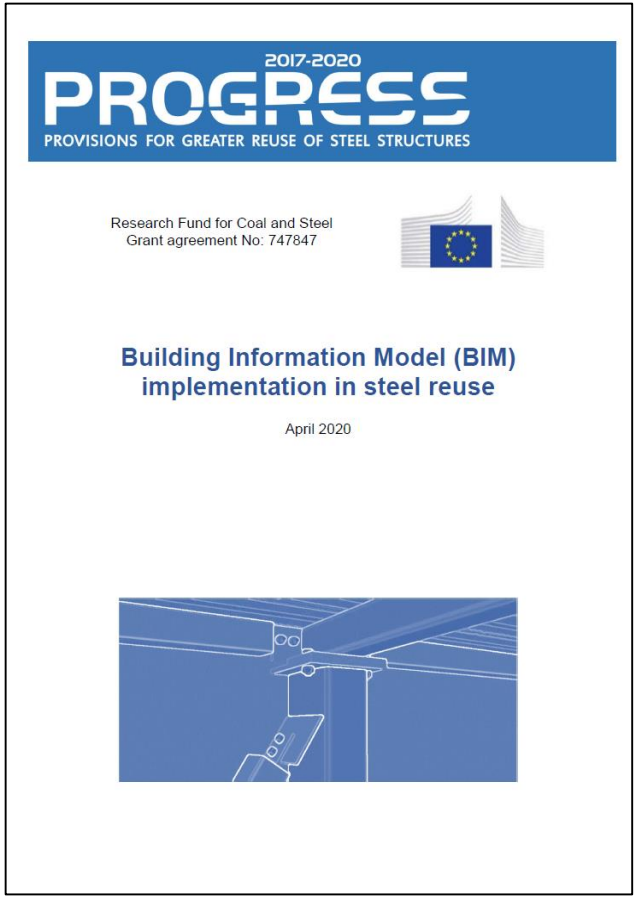


	Total mass	Fasteners
Original design	61.0 t	387
Regular and standardized distances Increased load Stiffening with braces Regular cross sections (except for truss diagonals) Uniform material grades Friction clamps in sandwich connections Bolted end plates in columns Expendable parts	66.8 t	1315

Source: Juha Savolainen

BIM for reuse

- Overview of implementation, standardization and deployment
- Analysis of software and data format gaps
- Smart CE marking for steelwork
- Proposal for Smart EPD



Discussion

Acknowledgements

Project PROGRESS has received funding from the Research Fund for Coal and Steel under grant agreement No 747847, Ruukki Construction, Ramboll Finland, Peikko Group and Jernkontoret. Project ReUSE was supported by the Finnish Ministry of Environment, Finnish Wood Research and Ekokem. Both projects were co-financed by VTT.