



TAMPERE UNIVERSITY OF TECHNOLOGY

Faculty of business and built environment, Department of structural engineering

Research Centre of Metal Structures, Seinäjoki, Hämeenlinna, Tampere, Finland

Vipuvoimaa
EU:lta
2007-2013



Euroopan unioni
Euroopan aluekehitysrahasto



Metallin ilosanomia Metkusta

Markku Heinisuo
Metallirakenteiden professori
Tampereen teknillinen yliopisto



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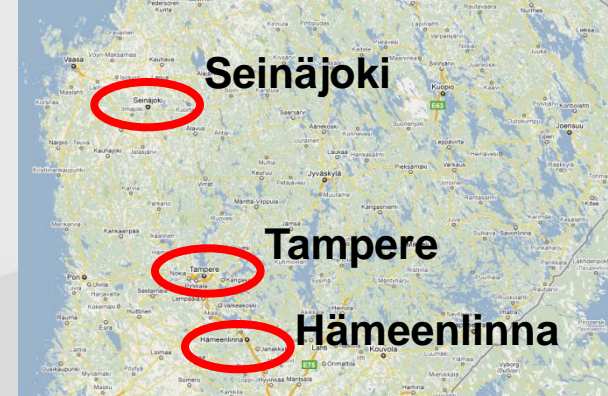
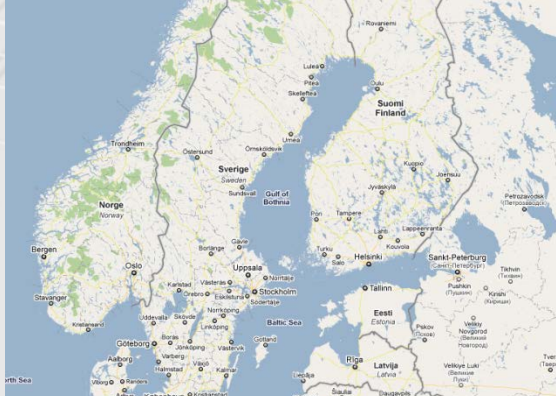
Mikä Metku on? Metallirakentamisen tutkimuskeskus

Research Centre of Metal Structures. Founded in 2004 Seinäjoki.

Actions in Seinäjoki, Hämeenlinna, Tampere.

Professor + 8-9 researchers, some part-time.

Turnover , mean 400000 Euro/a. Financing mean 50 % from "budget", 50 % from projects.





Task

- Perform research and development so that metal intensive companies manage better in national and international markets.

Scope

- Metal structures from cradle to re-use: design, quality, fabrication, transport, erection, re-use, cycling.

Visions

- All potential from computing and related actions (product modeling, optimization) have not been utilized in building business => these are in the core of all research.
- Industry and Academy funding have not been in active role during last years => Networking abroad has been active recently.

Representing Finland

- Cost TU0904 IFER: Integrated Fire Resistance and Response.
- ECCS, Technical Committee 8, Stability.
- ECCS, Technical Committee 10, Joints.
- Evolution Group EN 1993-1-3 . Eurocode 3 : Design of steel structures. Part 1-3: General rules. Supplementary rules for cold-formed members and sheeting.
- European Group of Intelligent Computing in Engineering (EG-ICE).
- The International Society for Computing in Civil and Building Engineering (ISCCBE).



Research Centre of Metal Structures, 2004-...

Doctoral thesis

- Mikko Salminen. Shear Resistance of Thin Metal Plate at Non-Uniform Elevated Temperatures. 2012
- Karol Bzdawka. Optimization of Office Building Frame with Semi-Rigid Joints in Normal and Fire Conditions. 2012
- Jaakko Haapio. Feature-Based Costing Method for Skeletal Steel Structures based on the Process Approach. 2012

Licentiate thesis

- Salminen M., Shear Buckling Resistance of Thin Metal Plate at Non-Uniform Elevated Temperatures. 2010
- Pada D., Steel Skeleton Behaviour in Decaying Fire. 2010

Master thesis: During 2004-2012: 22 pieces.

EU projects

- Partner in Research Fund of Coal and Steel (RFCS) project: Rules on high strength steel, RUOSTE, 10 European partners, 1.7.2012-30.7.2015.
- Partner in EU-FP7-SME project: Development of modular construction for sustainable design, stability and seismic applications, MODCONS, 7 European partners, 1.1.2013-31.12.2014.

TEKES projects

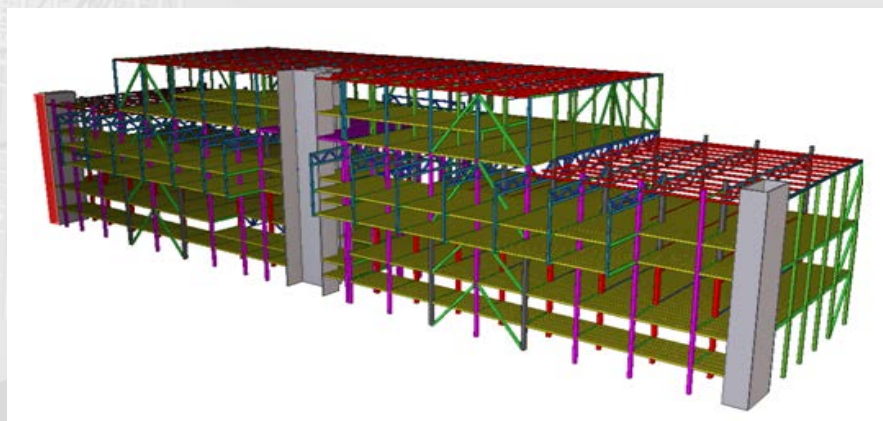
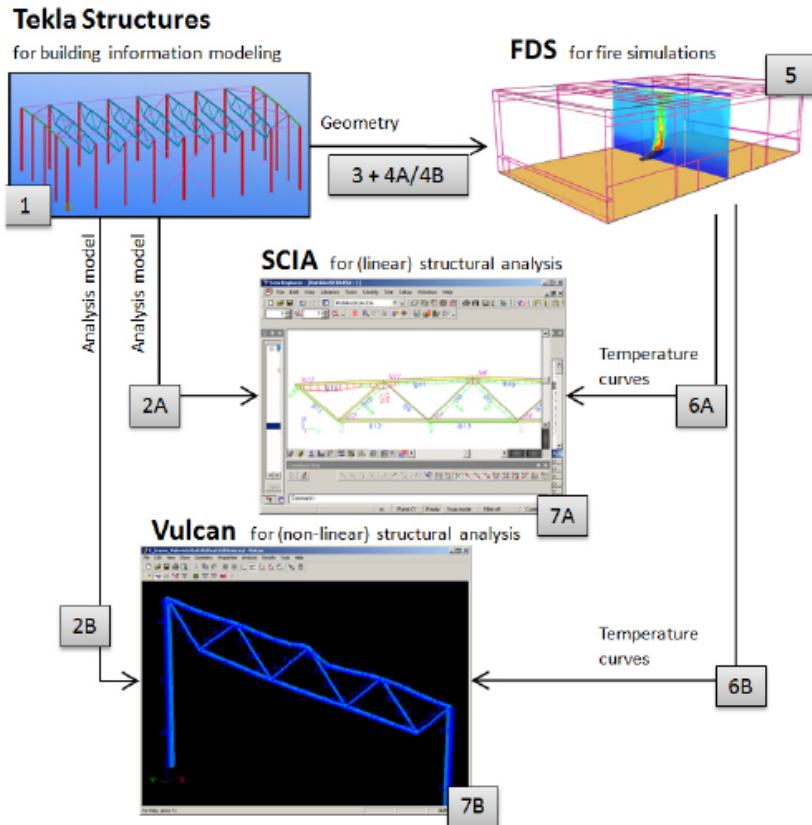
- Multi-criteria optimization and related decision making in building projects MORA, 2010-2012. Chair.
- Innovative Modular Cell Design for Residential and Renovation Applications CONCELLS, 2011-2013. Partner.
- Minimization of wet concrete works in site. SARA Technology Program. Industrial project of Rautaruukki Oyj, 2006-2008. Partner.

Industrial projects: Many (Rautaruukki Oyj, Weckman Steel Oy, Ympäristöministeriö, Finnmap Consulting Oy)



Industrial project: Integrated fire design = NFD (Natural Fire Design of Ruukki)

- Idea:**
- Integrate** following tasks: building information modeling, fire simulations, structural analysis.
 - ** More safe design: bulding and fire entities **just for the project** under consideration.
 - ** Enhance design: no manual data transfer between tasks, **time&errors!**





Research Centre of Metal Structures, 2004-...

On going doctoral studies

- Enlargement of component method for analysis of steel joints in ambient conditions. Henry Perttola
- Enlargement of component method for analysis of steel joints in fire. Hilikka Ronni
- Enlargement of component method for analysis of aluminum joints. Keijo Fränti
- Shape optimization of closed cold formed sections. Teemu Tiainen
- Structural analysis of thin walled all-metal sandwich panels. Juuso Lahdenmaa
- Organizational creativity. Matti Mikkola

Peer-reviewed papers 2012

- Mela K., Tiainen T., Heinisuo M., Comparative Study of Multiple Criteria Decision Making Methods for Building Design, Advanced Engineering Informatics, Vol 26. Num 4. 2012. pp 716-726.
- Heinisuo M., Ronni H., Perttola H., Aalto A., Tiainen T., End and base plate joints with corner bolts for rectangular tubular members, Journal of Constructional Steel research 75 (2012) 85-92.
- Heinisuo M., Perttola H., Ronni H., Component method for end plate joints, modeling of 3D frames, literature review, Steel Construction, Volume 5, Issue 2, June 2012. pp. 101-107.
- Tiainen T., Heinisuo M., Jokinen T., Salminen M., Steel building optimization applying meta-model techniques. Rakenteiden Mekaniikka, Vol 45, Num 3, 2012. pp. 152-161.



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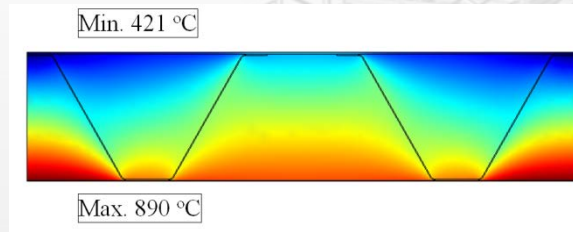


Three 2012 completed doctoral theses in RCMS



Doctoral thesis completed 2012: Mikko Salminen. Shear resistance of carbon steel, stainless steel and aluminum plates in non-uniform elevated temperature

Examples: All metal sandwich panel in fire

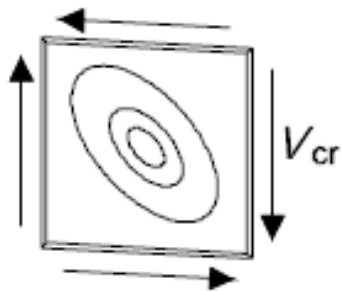


Slim floor beam web (WQ-beam)

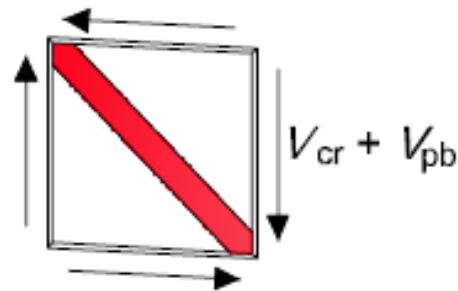


Development of theory in three steps: 1. Shear buckling (M. Salminen Lic thesis, 2011). 2. Post buckling (M. Salminen PhD thesis, 2012). 3. Flange effect (Oslo 2012).

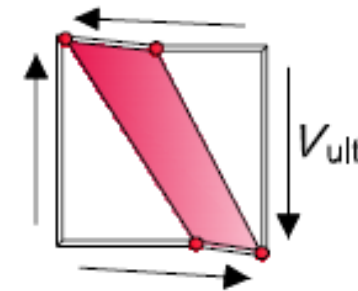
1. Shear buckling



2. Post-buckling (Tension field)



3. Flange effect





Main results:

New temperature reduction for Eurocode design, verification with comprehensive non-lin FEM.

Isolated plate: Eurocode mean temperature => unsafe design => use Salminen's reduction

Non-isolated plate: Eurocode design safe, flange effect considerable, see Oslo paper 2012.

Idea:

Non-uniform temperature distribution (no design methods)

Uniform temperature distribution (design methods available)



Eurocode reduction factor $kp0.2, \theta$

Salminen factor: $kp0.2, \theta_{ref}$

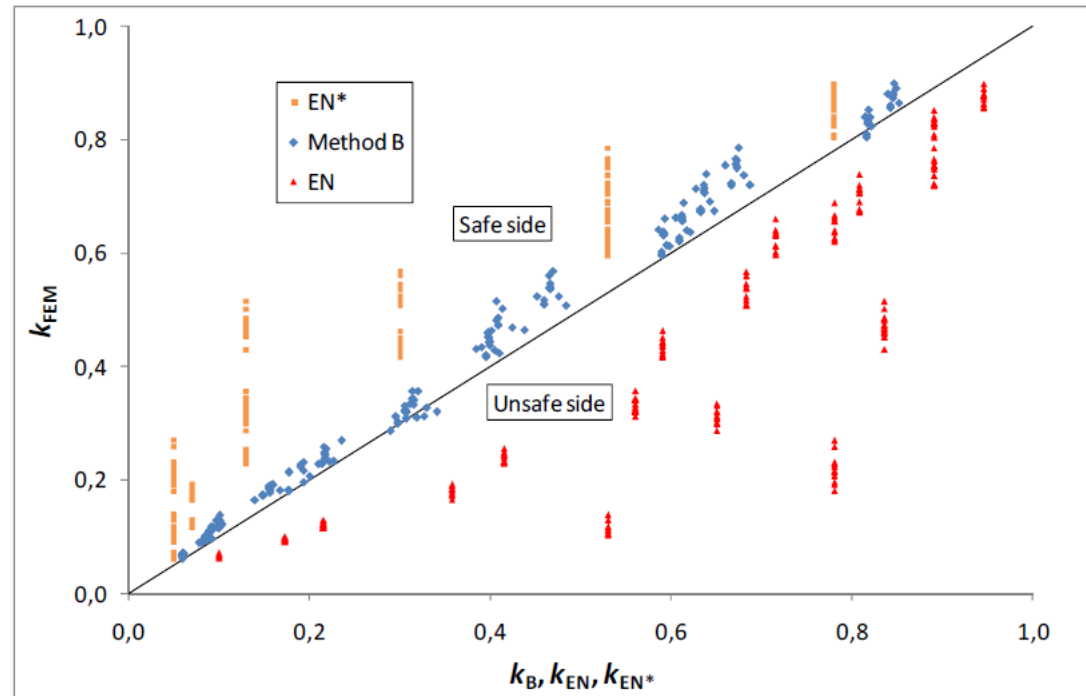
$\theta_{ref} = \theta_{hot} - d (\theta_{hot} - \theta_{web})$

$$d = k_y k_a k_d \left[0.33 + 0.025 \left(\frac{\theta_{hot} - \theta_{web}}{\theta_{web} - \theta_{cold}} - 1 \right) \right]$$

$$k_y = 1 + 0.00035(f_y - 235), \quad 1 \leq k_y \leq 1.06$$

$$k_a = 0.9 + 0.1 \left(\frac{a}{h} \right), \quad 0.95 \leq k_a \leq 1.15$$

$$k_d = 1 + \left(\frac{\theta_{hot} - \theta_{web}}{\theta_{web} - \theta_{cold}} - 1 \right) \left(\frac{\theta_{cold} - 200}{2000} \right), \quad 1 \leq k_d \leq 1.40$$





Doctoral thesis completed 2012: Karol Bzdawka. Optimization of Office Building Frame with Semi-Rigid Joints in Normal and Fire Conditions.

Buildings considered: Typical office buildings in Scandinavia.

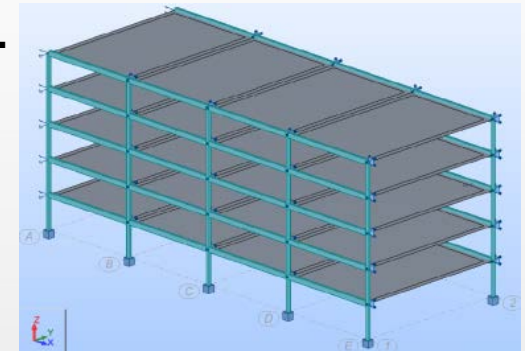
- Columns: Reinforced concrete filled square steel tubes;
- Beams: WQ-steel beams;
- Slabs: Hollow core pre-tensioned concrete slabs.

Optimization criteria: Costs: material, fabrication, erection.

Variables: Frame types, sizes of members, materials of members, **rotational stiffness of beam-to-column joints.**

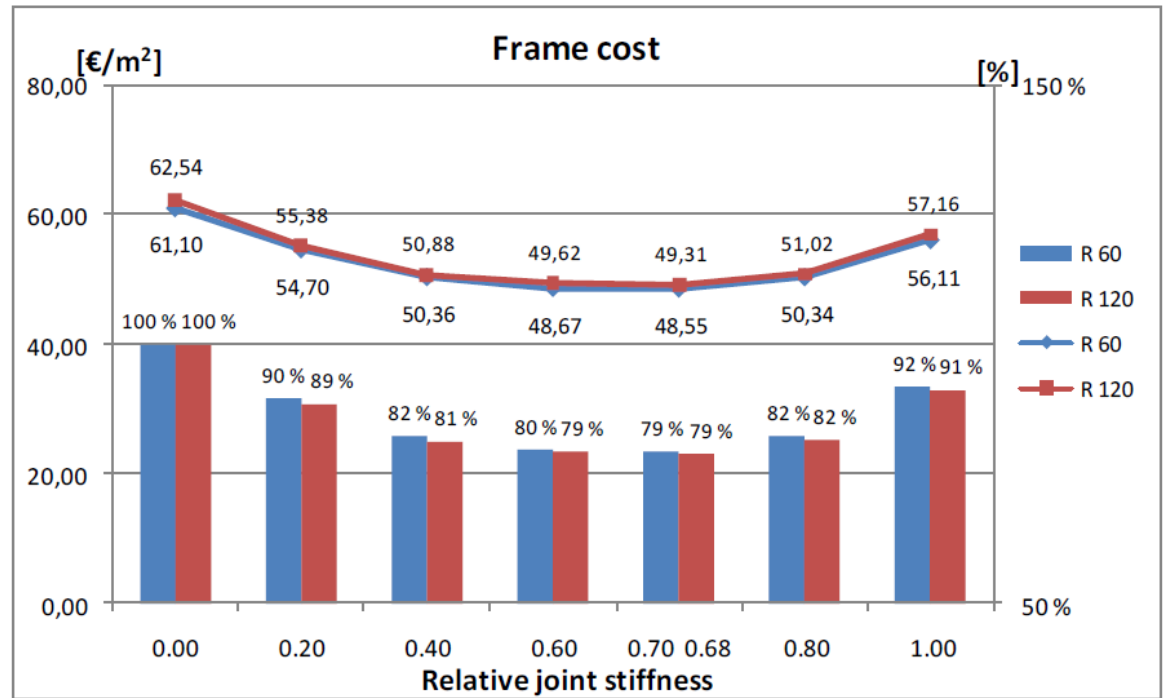
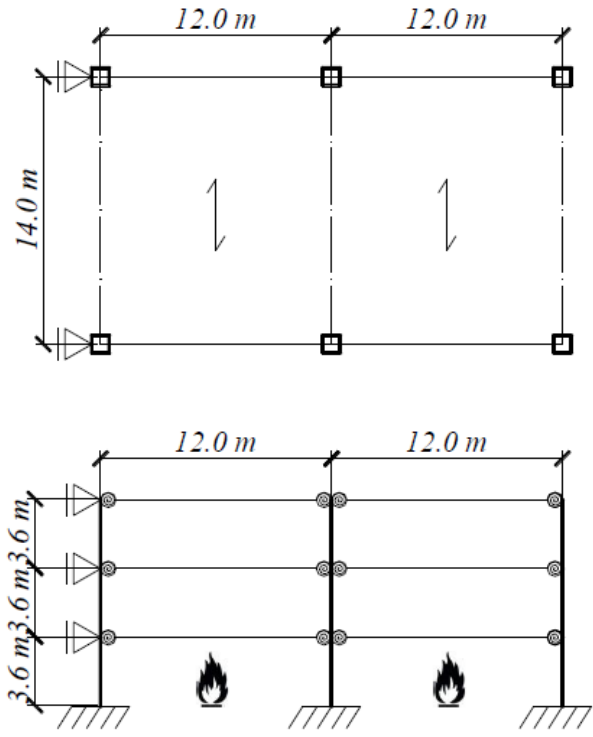
Constraints: Resistance following Eurocodes, ambient and fire.

Optimization techniques: Particle swarm (PSO).





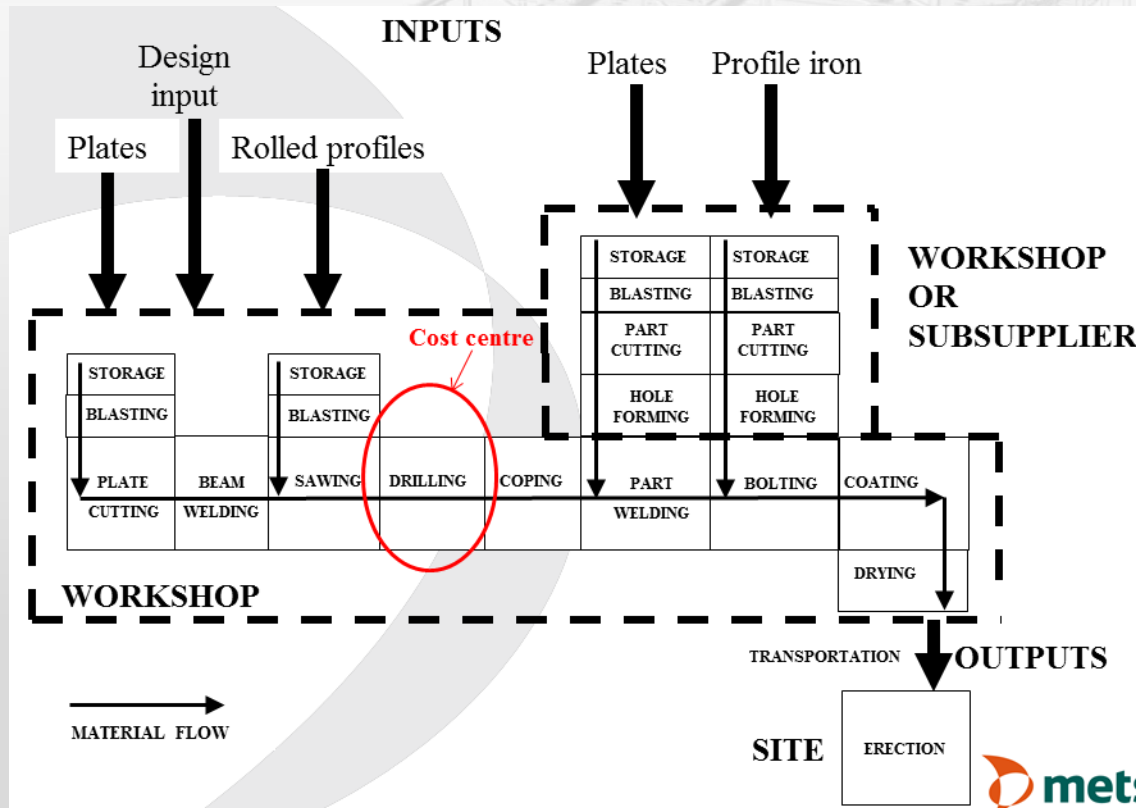
Results





Doctoral thesis completed 2012: Jaakko Haapio. Feature-based costing method for skeletal structures based on the process approach

Basic idea: Virtual factory and site with all cost centres needed to produce steel skeletons.



For all cost centres developed cost functions.
Sum of those = Total costs.

Fixed costs [€/minute]:

- Equipment (default: 20 years)
- Equipment service
- Real Estate (default: 50 years)
- Real Estate service (ventilation, heating, lighting)
- Labour (default: Finland)

Variable costs:

- Equipment electricity
- Process tools (e.g. drill bits)
- Consumables (e.g. welding wire)

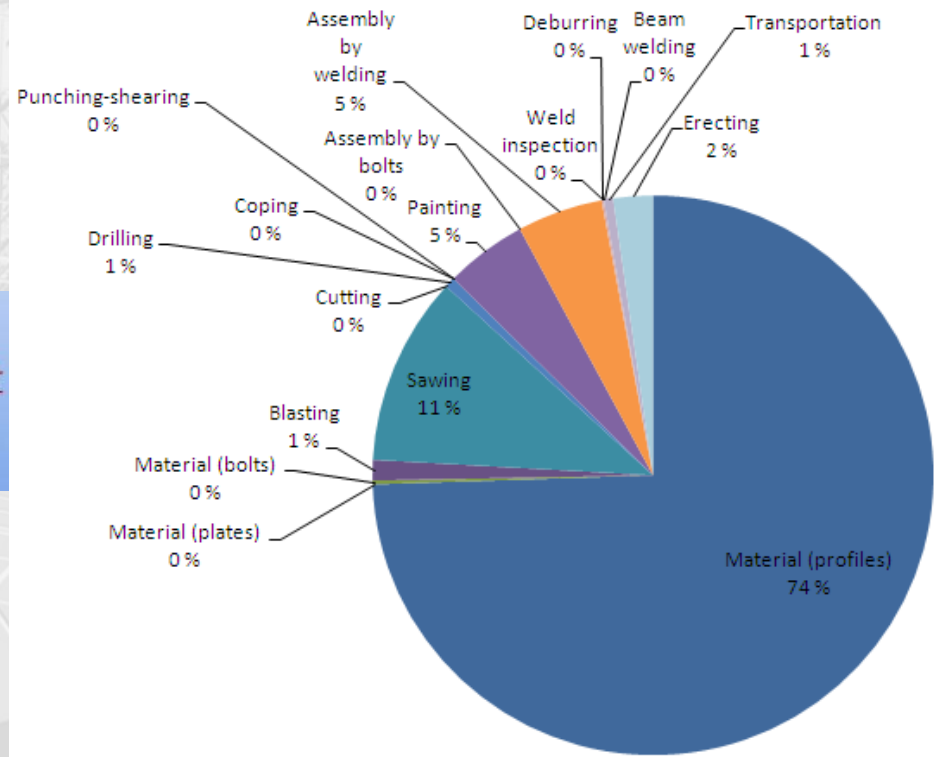


Quantity data: from BIM

- ⇒ Requirements for BIM, e.g. welds should be modeled.
- ⇒ Can be used in pre-design, e.g. using joint macros of BIM to see effects of different joint layouts to costs. No extra work for designers!

Enlarged to CO2 calculations in Miskolc conference paper, 2013.

Available in www.metallirakentaminen.fi (JouCO2&COST)





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Three on-going international projects



COST TU0904: Integrated fire engineering and response. 2010-2013. Finland: Jyri Outinen, Markku Heinisuo

Worked packages

- WP1 State of the art report
- WP2 Case study
- WP3 Fire brigade reports and investigations
- WP4 Benchmarks studies
- WP5 Dissemination
- WP6 Thought for Eurocodes upgrade
- WP7 Educational dimension

Working groups

- WG1 Fire behaviour and life safety
- WG2 Structural safety
- WG3 Integrated design

TUD Action TU0904

Management Committee

- MC Chair ▶ Prof Frantisek WALD (CZ)
- MC Vice Chair ▶ Prof. Ian BURGESS (UK)

Parties (total 22 countries)

Country	Date	Country	Date	Country	Date	Country	Date
Austria	03/02/2010	Belgium	03/02/2010	Croatia	08/10/2012	Czech Republic	12/07/2010
Finland	20/01/2010	France	10/02/2010	Germany	20/01/2010	Greece	10/03/2010
Hungary	12/07/2010	Iceland	05/07/2010	Italy	03/02/2010	Malta	23/02/2011
Poland	20/01/2010	Portugal	26/01/2010	Romania	03/02/2010	Slovakia	10/05/2010
Slovenia	08/10/2012	Spain	20/01/2010	Sweden	10/05/2011	Switzerland	12/07/2010
The Former Yugoslav Republic of Macedonia	03/02/2010	United Kingdom	20/01/2010				



Realized STSMs

1

COST STSM Reference Number: COST-STSM-TU0904-8270

Period: 2011-06-19 00:00:00 to 2011-06-25 00:00:00

STSM type: Regular (from United Kingdom to Portugal)

STSM Applicant: [Mr Gang Dong](#), University of Sheffield, s10 2tn(UK)

STSM Topic: REVERSE CHANNEL COMPONENT

2

COST STSM Reference Number: COST-STSM-TU0904-7608

Period: 2011-02-21 00:00:00 to 2011-03-07 00:00:00

STSM type: Regular (from Czech Republic to Finland)

STSM Applicant: [Ms Kamila Horova](#), Czech Technical University in Prague, Prague (CZ)

STSM Topic: Design Fires

3

COST STSM Reference Number: COST-STSM-TU0904-10575

Period: 2012-05-08 00:00:00 to 2012-05-17 00:00:00

STSM type: Regular (from Italy to United Kingdom)

STSM Applicant: [Dr Antonio Bilotta](#), University of Naples Federico II, Napoli (IT)

STSM Topic: Fire behaviour of FRP-RC members: experimental results and numerical simulations.

4

COST STSM Reference Number: COST-STSM-TU0904-10857

Period: 2012-06-18 00:00:00 to 2012-06-25 00:00:00

STSM type: Regular (from Greece to United Kingdom)

STSM Applicant: [Ms Daphne Pantousa](#), University of Thessaly, Volos (EL)

STSM Topic: Numerical analysis of steel structures under fire conditions

5

COST STSM Reference Number: COST-STSM-TU0904-9626

Period: 2011-12-05 00:00:00 to 2011-12-18 00:00:00

STSM type: Regular (from Finland to United Kingdom)

STSM Applicant: [Mr Eki Lehtimäki](#), Tampere University of Technology, Tampere (FI)

STSM Topic: Integration of structural analysis in fire with building information model



Example of output: Proceedings, 374 pages. Available in:
<http://fire.fsv.cvut.cz/ifer/WP2/index.htm>

WP2 - Case study

Case Studies presenting current practice and accumulated knowledge. These will be prepared and disseminated during the second year of the Action. They will cover fire engineering applications including clear explanations of the decision processes, the scientific assumptions and the practical constraints, as well as how different aspects of fire engineering are integrated.

[Text in pdf](#) for download

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- [Refurbishments](#)
- [Bridges](#)
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RFCS project RUOSTE: Rules on high strength steel, 2012-2015

Scope: Remove technical restrictions in Eurocodes for high strength steel

Partners:

RWTH Rheinisch Westfälische Technische Hochschule Aachen, Germany

AU Aarhus Universitet, Danmark

LUT Lappeenranta University of Technology, Finland

LTU Luleå University of Technology, Sweden

TUT Tampere University of Technology, Finland

Ruukki Rautaruukki Oyj, Finland

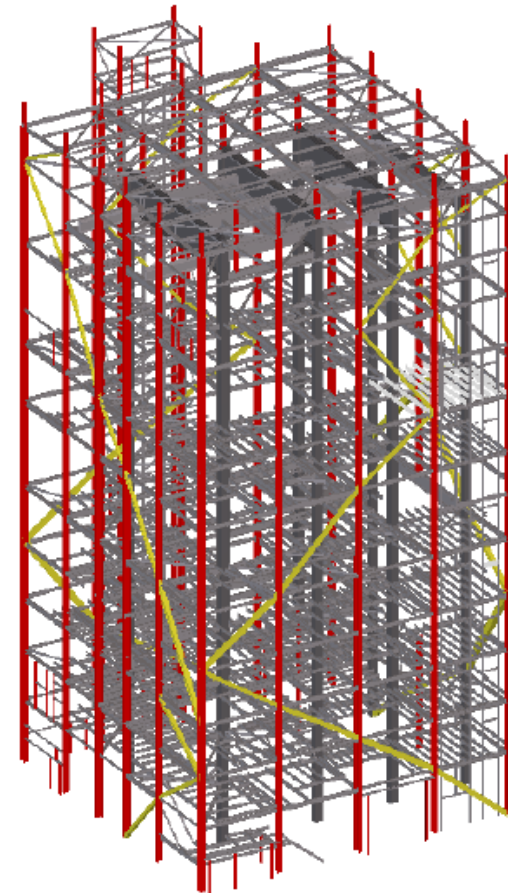
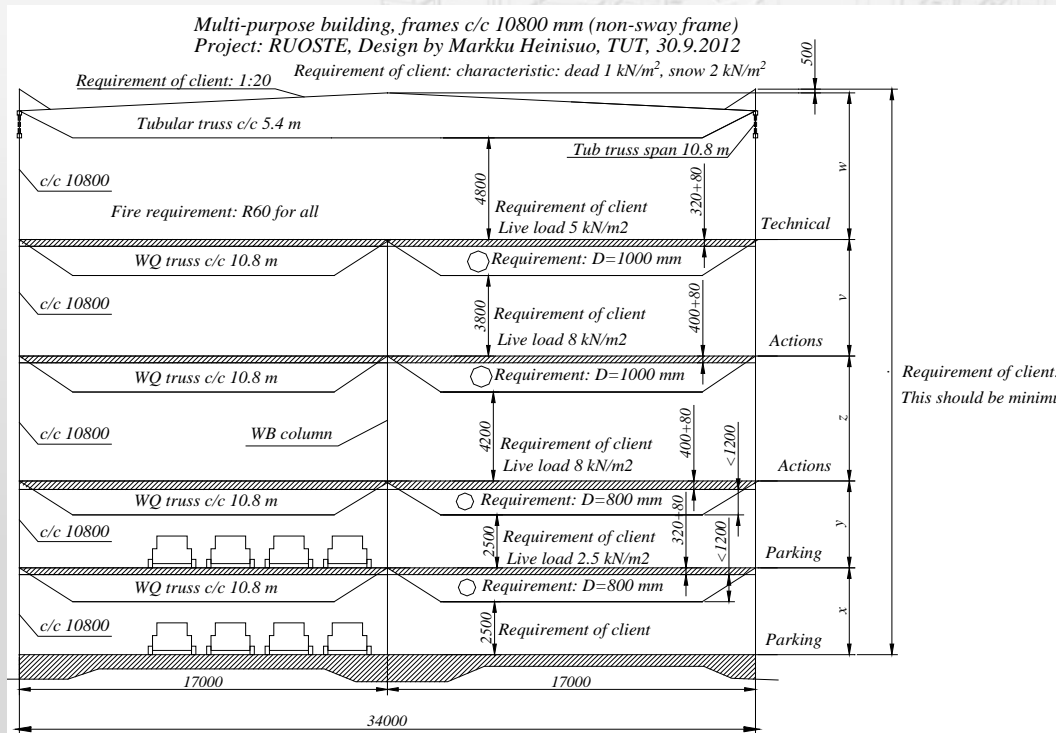
SSAB SSAB EMEA, Sweden

Voest Voestalpine Krems GmbH, Austria

BME Budapesti Műszaki és Gazdaságtudományi Egyetem, Hungary



RCMS response in the project: Cost optimization of structures from S355 to S960.





FP7-SME: MODCONS: Development of Modular Construction for Sustainable Design Stability and Seismic Applications, 2013-2014

Participant no. */ Type of participant	Participant organisation name	Participant short name	Country
1 / RTD	The Steel Construction Institute	SCI	UK
2 / RTD	Tecnalia	Tecnalia	Spain
3 / RTD	Tampere University of Technology	TUT	Fin
4/ SMEP	NEAPO	NEAPO	Fin
5/ SMEP	Futureform	FF	UK
6/ SMEP	AST	AST	Spain
7/ OTHER	HTA Architects	HTA	UK



TUT: RCMS & School of Architecture.

RCMS responses: Testing and analysing of modular steel structures in ambient and fire conditions.



28-29.5.2013, T&K päivät, Märkku Heinisuo





Kiitos

Ja merkitkää kalentereihin:

13:th Nordic Steel Construction Conference in Tampere on September 23-25, 2015.

