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DreamFAB

Deconstruction and refabrication for the reuse of steel buildings

August 31, 2023, ECCS TC14/TC9
meeting at VTT

Zhongcheng Ma,
D.Sc. (Tech)

Häme University of
Applied Sciences (HAMK)

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Short introduction about HAMK

9000 bettermakers

8000
Students

700
Employees

100
Doctors/licentiates

120
Research and development projects

1 400
Degrees in 2022

429
Professional teachers graduated in 2022

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We offer multidisciplinary education and research

Educations

- Biotechnology and Natural Resources
- Design
- Teacher education
- Health and Social services
- **Technology and Transport**
- Information and communications technology
- Entrepreneurship and Business

Research ecosystem

General project info

Deconstruction and refabrication for the reuse of steel buildings (DreamFAB)

1.9.2023 - 31.8.2027

Funded by RFCS (Research fund for coal and steel)

Highlights

- Project duration **48** months, total budget **2.5** Meuros.
- **9** European partners – 3 universities, 1 research institute, 5 companies, from 4 countries.

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European Green Deal

The European Green Deal will improve the well-being and health of citizens and future generations by providing:

fresh air, clean water, healthy soil and biodiversity

renovated, energy efficient buildings

healthy and affordable food

more public transport

cleaner energy and cutting-edge clean technological innovation

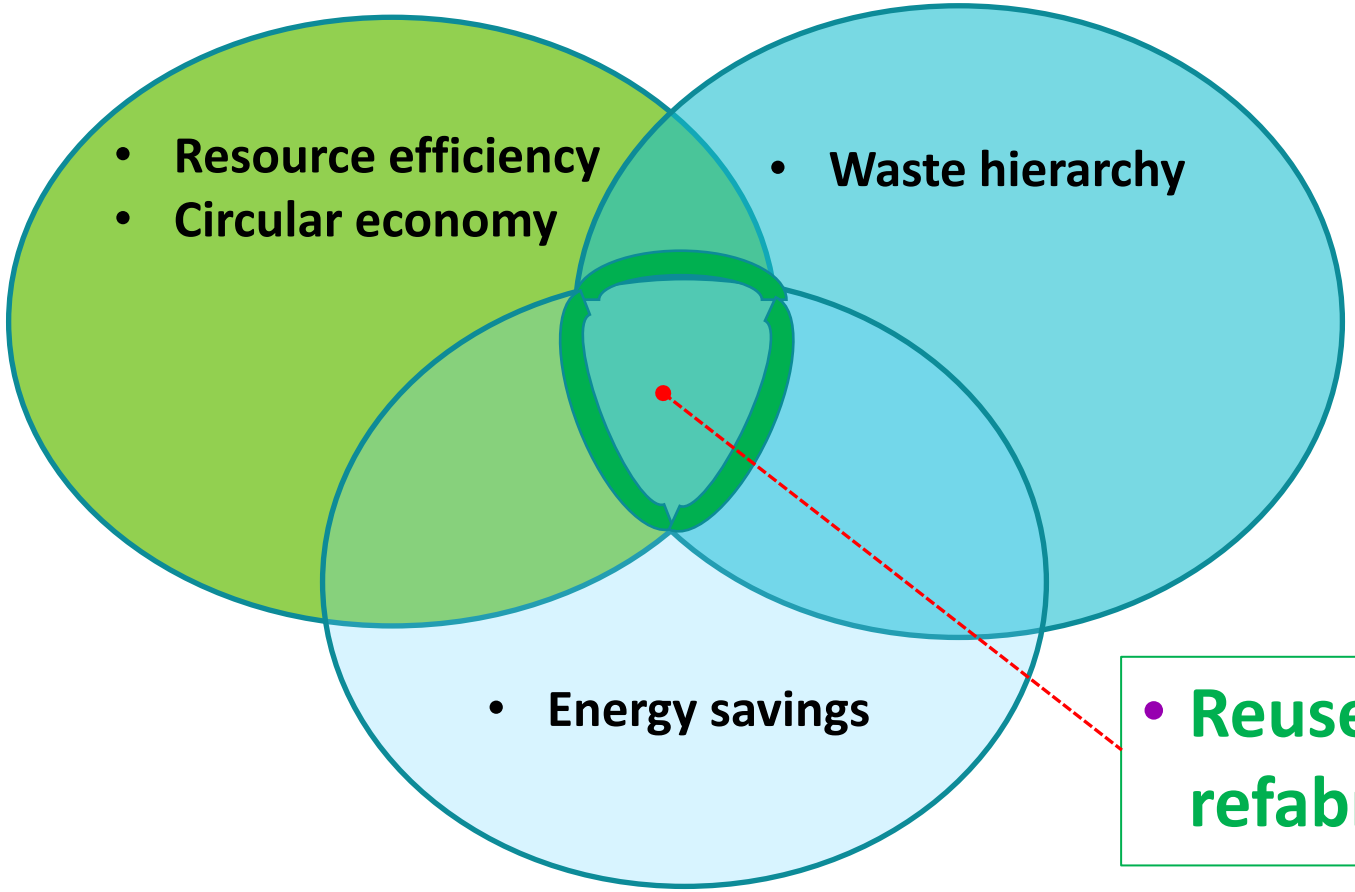
longer lasting products that can be repaired, recycled and re-used

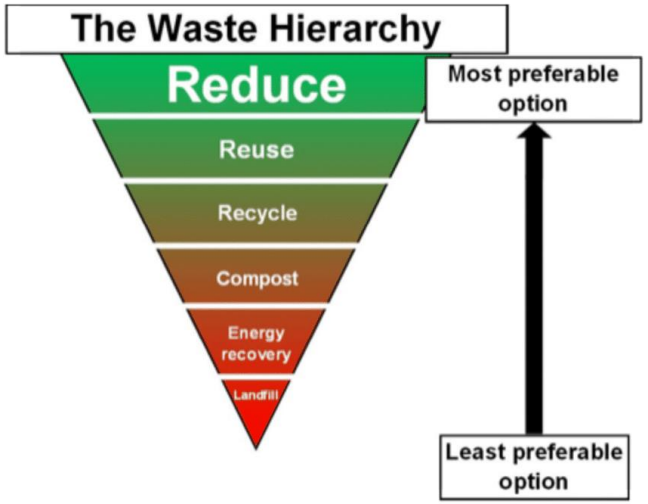
future-proof jobs and skills training for the transition

globally competitive and resilient industry

Reuse and remanufacturing

Sustainable construction





• **Reuse and refabrication**

Environmental and social impacts
by deconstruction and reuse

- 155 Mtones steel in 2019
- 42% in building sector
- Reuse in buildings save 16.3 Mtones
- Save $10.2x10^9$ kWh electricity

$10.2x10^9$ kWh

- Creation of specialist deconstruction constructors;
- Expansion of current fabricators' role into re-fabrication;
- Both above deconstruction contractors and re-fabricators can develop into stockholders and suppliers of reused steel;
- Deconstruction requires more labors so additional employment opportunities compared to demolition;

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Knowledge creation and technological impacts

- **Increased imperfections**
- **Multiple welding-cutting cycles**
- **Demountable solutions**
- **Framework for robot-assisted deconstruction**

Barriers to prevent reuse of steel buildings

- **Reuse scenarios**
- Relocated building elsewhere
- Hybrid reuse and refabrication
- Refabrication in workshops

- **Barriers**
- (1) The perceived risk in specifying reused materials;
- (2) Cost: reuse can be more expensive;
- (3) Composite construction (for structural steel: concrete and metal deck flooring with shear studs connected to steel floor beams)
- (4) Lack of reuse markets and supply chains;
- (5) Time constraints which favors demolition over deconstruction;
- (6) Inaccessible / irreversible joints.

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Project objectives

Structural safety

- Increased imperfections
- Multiple welding-cutting cycles

Demoutable solutions

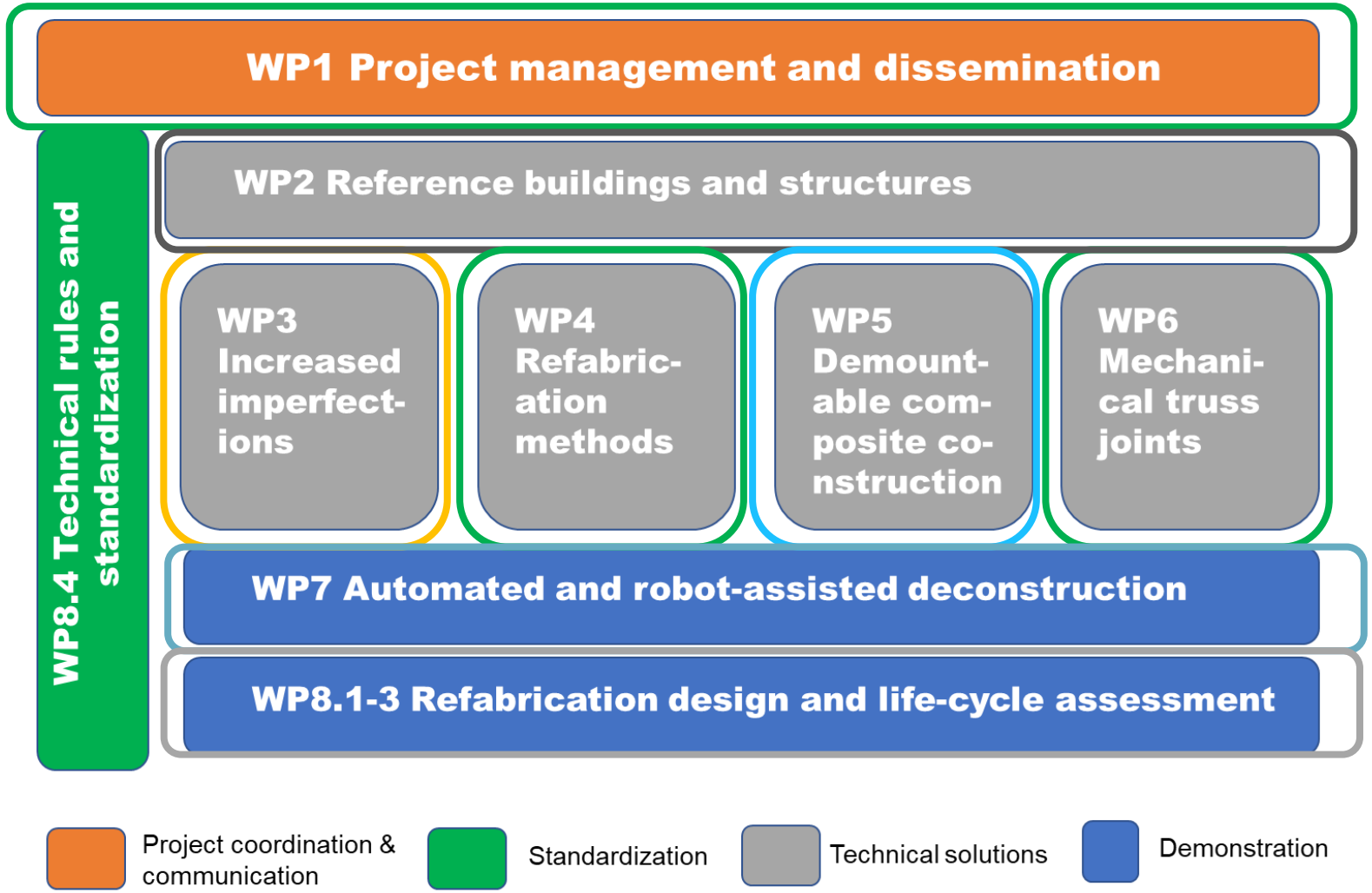
- Composite construction
- Mechnical truss joints

Robot-assisted deconstruction

- Framework & architecture
- AI, digital twin & mixed reality
- Demonstrators

Design rules and standardization

Work packages



WP1: project coordination and dissemination

- **Task 1.1 Coordination of the project**
- **Task 1.2 Organize workshops in 3 participating countries**
- **Task 1.3 Present results in conferences and journals**
- **Task 1.4 Design guides**

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WP2 Reference buildings and structures

- **Task 2.1 Design of a multi-storey composite building**
  - **2.1-A – Design with standard design practice and standard shear connectors**
  - **2.1-B – Design for deconstruction and innovative shear connectors**
- **Task 2.2 Design of a single-story industrial hall with tubular roof truss**
  - **2.2-A – Design with standard design practice**
  - **2.2-B – Optimised Design for deconstruction**
- **Task 2.3 Deconstruction options for composite buildings**
- **Task 2.4 Deconstruction options for tubular truss structures**

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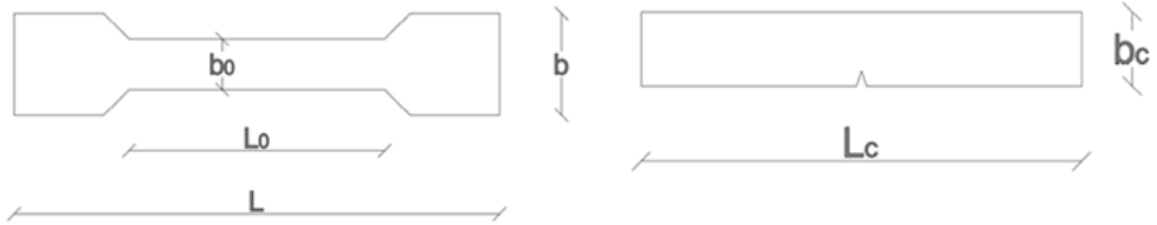
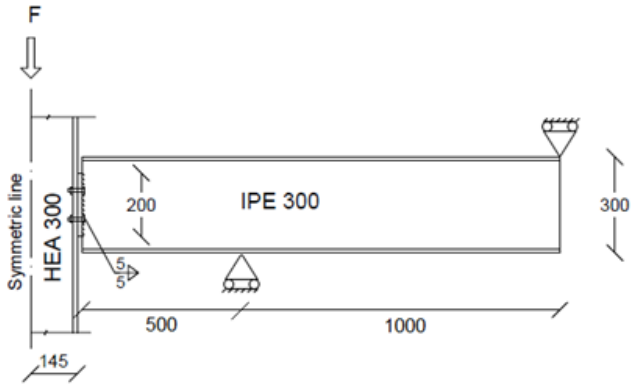
WP3 Increased imperfections

- **Task 3.1 Design and execution of a robotized scanner for imperfections**
- **Task 3.2 Deriving geometric imperfections on existing structural elements**
  - **3.2-A – Measurements on steel elements loaded in bending**
  - **3.2-B – Measurements on compressed RHS sections**
  - **3.2-C – Measurements on deconstructed elements**
- **Task 3.3 Deriving geometric imperfections on re-fabricated structural elements**
  - **3.3-A – adaptation of members loaded in bending**
  - **3.3-B – adaptation of refabricated members from deconstructions**
- **Task 3.4 Influence of geometric imperfections on element response**

WP4 Refabrication methods

- **Task 4.1 Effect of welding execution parameters on microstructure and mechanical properties**
- **Task 4.2 Effect of multiple welding – thermal cutting – welding thermal cycles**
- **Task 4.3 Effect of rewelding on mechanical properties of HAZ**
- **Task 4.4 FE simulations of welding temperatures, residual stresses and tensile test of weld joint under repeated welding-cutting cycles**





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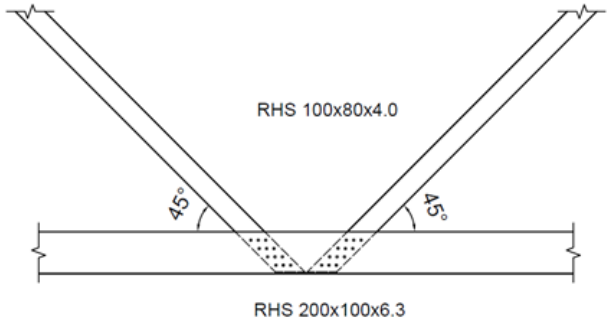
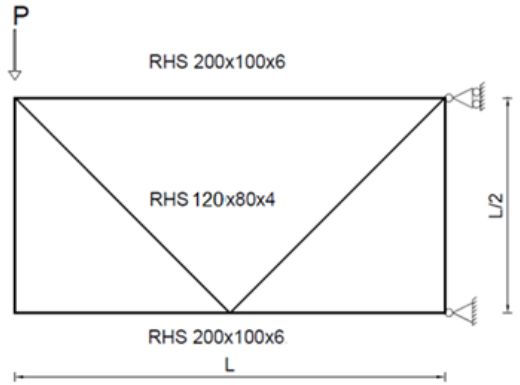
WP5 Demountable composite construction

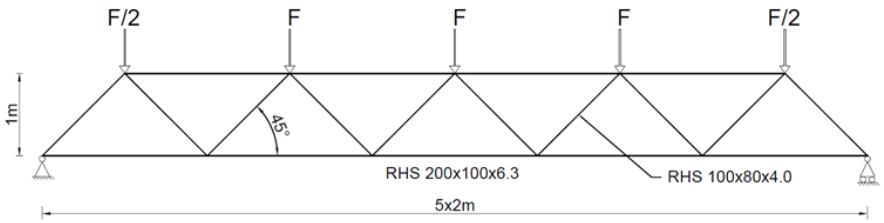
- **Task 5.1 Conceptual development of innovative demountable shear connectors**
- **Task 5.2 Experimental characterization of the behaviour of the demountable shear connectors**
- **Task 5.3 Full scale testing of composite beams**
  - **5.3-A Composite beam experimental tests**
  - ***5.3-B*** **FEM modelling**
- **Task 5.4 Design guidelines**

WP6 Mechanical truss joints

- **Task 6.1 Solution development for demountable mechanical truss joint**
- **Task 6.2 Structural behavior of T-joints and K-joints with mechanical solution**
- **Task 6.3 Full truss structures with demountable non-welding joint solution**
- **Task 6.4 Design rules and manufacturing guidelines, design and assembly process automation**







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WP7 Robot-assisted deconstruction

- **Task 7.1 Framework for robot assisted construction and deconstruction (FRACD)**
- **Task 7.2 Simulation of scenarios, system specification and requirements**
- **Task 7.3 General system architecture and Digital Twin**
- **Task 7.4 Data management, Artificial Intelligence (AI) & Mixed Reality (MR) integration**
- **Task 7.5 Steel-concrete composite construction: robot assisted construction and deconstruction process**
- **Task 7.6 Non-welded tubular roof truss: the deconstruction of roof truss**
- **Task 7.7 Transporting FRACD to standard rules of robot-assisted construction and deconstruction**

WP8 Re-fabrication design and LCA, technical rules and standardization

- **Task 8.1 Improved strategies for deconstruction**
- **Task 8.2 Information management and BIM tool**
- **Task 8.3 Life-cycle assessment**
- **Task 8.4 Pre-normative guidance for reuse of steel and steel-concrete composite structures**
  - Structural instability due to increased imperfections (EN1993-1-1, EN1991-1-8). CEN/TC250/SC3
  - Execution rules for re-fabrications for reuse (EN1090-2)
  - Structural design of demountable solutions of composite beam construction (EN1994-1-1)
  - Structural design of demountable roof truss connections. (EN1993-1-8)
  - LCA with economic and social dimensions, for refabrication and deconstruction. CEN TC 350 (EN15978 and EN15804)
  - Design guide: European recommendations for deconstruction and refabrication of steel and steel-concrete composite buildings (ECCS TC14)
  - Guide on robot-oriented design of steel building for construction and deconstruction

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Thank you!

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