Proposal overview submission form for Research, Pilot and Demonstration projects and Accompanying Measures for the promotion of knowledge gained

A0. Information on the Proposal[1]

Proposal Full Name	Robust Connections for Impact Loading				
Proposal Acronym[2]	RobCIL				
Research objectives[3]	**Coal**			**Steel**	X
Type of Proposal[4]	**Research**	X	**Pilot /Demonstration**		**Ac. Measure**
Starting Date (DD/MM/YYYY)	**01/07/2009**		**Project duration (in months)**[5]		**36**
Research objectives[6]	Steel 2	**Technical Group**[7]	TGS 8		

N°[8]	Beneficiary's Role[9]	Connec-tion[10]	Full official denomination[11]	Country name	Total costs (Euro)	Contribution requested[12] (Euro)
1	CO.	./.	Hämeen ammatillisen korkeakoulutuksen kuntayhtymä	Finland	302950	181770
2	CR.	./.	Rautaruukki Oyj	Finland	125000	75000
3	CR.	./.	Steel Construction Institute	UK	201850	121110
4	CR.	/.	Aarhus Universitet	Denmark	250610	150366
5	CR.	/.	Luleå University of Technology	Sweden	279287	167572,2
6	CR.	/.	Poznan University of Technology	Poland	150775	90465
7	CR.	./.	Faculdade de Ciencias e Tecnologia da Universidade de Coimbra	Portugal	238000	142800
Grand Total					1548472	929083,2

→ *Make sure that the information provided in this form is fully consistent with the information provided in forms 4.1, 4.2, 4.3 and 4.4.*

For Commission Use Only	
Proposal No	
Post stamp	**Date of receipt**

EUROPEAN COMMISSION
RESEARCH DIRECTORATE-GENERAL

Research Fund for Coal and Steel

FORM A

A1. PROPOSAL ADMINISTRATIVE OVERVIEW

Important notice: Please respect the document format given hereafter. Do not insert additional pages or any annexes as this section **must not exceed, under any circumstances, a maximum of 5 pages**.

Recommended format - Arial minimum font size 12.

Proposal summary (maximum 100 words)

In the design robust steel structures capable of withstanding impulsive loading due to explosions, earthquakes, snow avalanches and wind gusts, a gap exists in the knowledge of the behaviour of connections in steel structures under such loading. Experiments on connection and connection components under impulsive loading will lead to a new ‘component’ method for dynamic loading. By validating finite element based numerical simulation by these test results, more complex connections can then be designed. Finally, a methodology will be developed for combined risk assessment and probabilistic design of steel structures for accidental loading, including connection response.

Proposal resubmission: Yes/No (if yes, please also provide information requested under A3)

No.

Reference, title, date of actual or expected completion of all previous EC, ECSC or RFCS projects of major relevance to the objectives of the proposal (this list must be prioritised):

Explain in a concise manner to what extent your proposal brings added value to what has already been achieved to date at both European and worldwide level:

The proposed research in this project has been addressed in the strategic research agenda of the European Steel Technology Platforms [0.1], which cites the need for safety in the design, manufacture and performance of steel structures, especially against natural hazards and accidental loading.

While interest in robust design has accelerated in recent years, following events in the USA, a gap has been identified in the design of connections for such structures under impulsive loading. The proposal addresses the need to design robust steel structures capable of withstanding accidental impulsive loading which may arise out of a number of sources – earthquakes, explosions, vehicular impact, landslides due to soil erosion in adverse weather, and avalanches following heavy snow. The latter two causes are occurring increasingly in different parts of Europe owing to climate change. Eurocode 3 [0.2] has guidance on the design of steel connections for static loading, based on much research during 1990s. Much of the associated research was well coordinated under the programme European programme COST-C1 on semi-rigid connections [0.3].

A method of design based on the behaviour of simple components, whose behaviour is well understood, leads to realistic design of complex connections. This is the basis of guidance in Eurocode 3 [0.2]. The guidance in that code is limited to static design. Recently, under an RFCS project, this method has been extended to performance of connections subjected to fire.

Eurocode EN 1991-1-7 covers some accidental loading. Annex A includes some simple design methods to help design buildings so that they are strong enough in case of accidents. While this guidance helps in determining actions, the rules in Eurocode 3 do not give any specific guidance for the design of connections under such impulsive loading.

This proposal is aimed at studying the behaviour of connections subjected to impulsive loading, a topic not studied extensively before. However, where robust structures are to be designed, it is imperative to understand the behaviour of connections in steel structures.

The methods developed in this proposal will enable steel constructors and designers to provide their products and designs with the CE mark for accidental loading following changes in EU directive expected in 2011.

The project partners are all members of METNET and already have a history of cooperation and collaboration.

A2. PROPOSAL DESCRIPTION (TYPICALLY 3 TO 5 PAGES, MAXIMUM 10 PAGES)

Important notice: Please respect the document format given hereafter. Do not insert additional pages or any annexes as this section **must not exceed, under any circumstances, a maximum of 10 pages**.

Recommended format: Arial minimum, font size 12.

A2 - Page 1

Background

The proposal addresses the need to design robust steel structures capable of withstanding accidental impulsive loading which may arise out of a number of sources – earthquakes, explosions, vehicular impact, landslides due to soil erosion in adverse weather, and avalanches following heavy snow. While interest in robust design has accelerated in recent years, following events in the USA, a gap has been identified in the design of connections for such structures under impulsive loading. Eurocode 3 [0.2] has guidance on the design of steel connections for static loading, based on much research during 1990s. The method has come to be known as 'component method' for the design of connections. The principle used is that a connection is subdivided into components, the characteristics of which are well defined, resulting in a good design of complex connections. Much of the associated research was well coordinated under the programme COST-C1 on semi-rigid connections [0.3].

This proposal aims to develop robust steel structures, focussing primarily on research on connections subjected to impulsive loading. It is contended that the integrity of steel structures depends heavily on the response of connections between members. The proposal fits best to the action: KEY ELEMENT DESIGNED TO SUSTAIN NOTIONAL ACCIDENTAL ACTION A_d. The relevant figure from Eurocode 1 [0.4] is cited below.

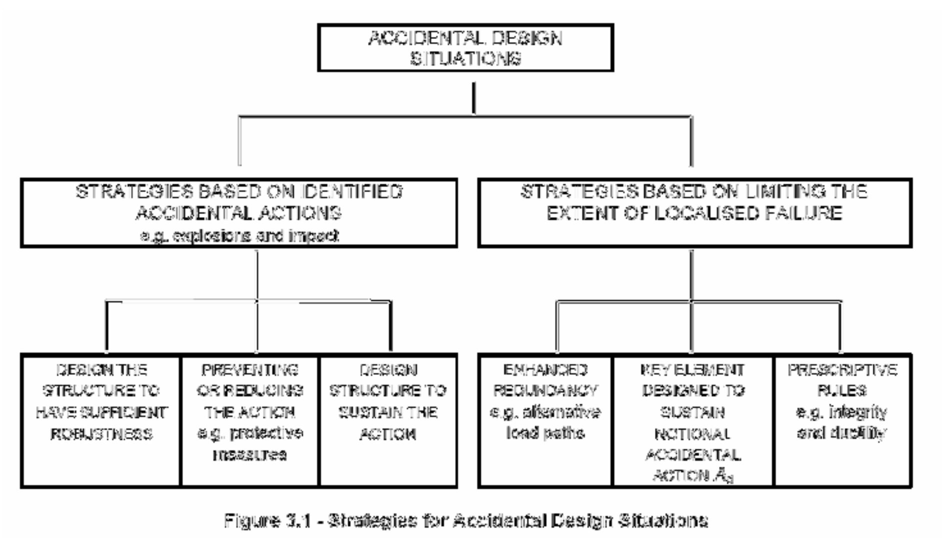

Fig.1 – Eurocode 1 schematic for dealing with accidental loading

A2 - Page 2

Methodology

Impact has been preferred to explosions since testing with explosives requires special safety precautions and in any case the source of explosion is usually rather remote from the connections. For the same reasons, testing by air-cannons has been excluded. The connections, in effect, receive an impulsive loading. The impact loading adopted in this proposal leads to more precise evaluation of the impulse, a priority for validating advanced numerical methods. Of course, the time histories of different actions covered in this project are different. A common feature is that they can all be represented by an impulsive loading.

The project extends the component based approach for the static design of steel connections to the case of impulsive loading. This implies the need to consider joints subjected to generalized and random loading conditions, with the consequent need to extend the framework of the component method [0.5], using a probabilistic characterization of the components [0.6].The methodology being proposed in the project will address the design of connections in steel structures from these varied causes. The types of experiments being proposed on structural steel connections subjected to dynamic loading have not been undertaken before. A strong feature of the proposal is that the proposed experiments will be used to validate numerical simulations based on the finite element method, so that further complex connections can be studied using these computer programs without the need for further expensive experiments.

In view of the random nature of the occurrence of exceptional loading being considered, it is a feature of the project that probabilistic methods of analysis combined with risk assessment will be implemented, aimed at reducing huge losses from unexpected hazardous loading. Note will be taken of guidance on risk assessment recently published by the Joint Committee of Structural Safety [0.7].

This project focuses on vertical loads. In accidental hazard situations (e.g. a truck crashing with a beam) the horizontal load may be huge on the connection and thus we should know the 3D-strenght of the structure. While the tests will focus on vertical loading, the numerical simulation will also take into account horizontal loading.

Strategic importance to steel industry

The ultimate aim of this proposal is to enable steel designers, fabricators and suppliers to offer competitive designs which address today's needs for robust structures exposed to accidental loading applied suddenly to the structure. Such impulsive loading can arise from both natural causes such as earthquakes, avalanches, wind gusts, etc and also from human interference such as from explosions and impact. The work described in this project should lead to an informative Annex in Eurocode 3, so all designers can benefit from the results.

Although much of the description in this proposal refers to steel structures, and by implication completed steel structures, it should be emphasised that the results of this project will also be applicable to structures under construction and assembly.

A2 – Page 3

Description of research work

The project will be accomplished through 5 Work Packages. These are described in detail in Forms 1-2. A summary is provided here to present the logic of the research programme.

Work Package 1 – Experiments with impact loading on 4 pairs of different connection types. Within each pair, one specimen will be tested for predominant moment (Fig 2), and the other in the form of a simply supported beam (Fig. 3). The specimens will be designed so that different failure modes of different components occur in tests.

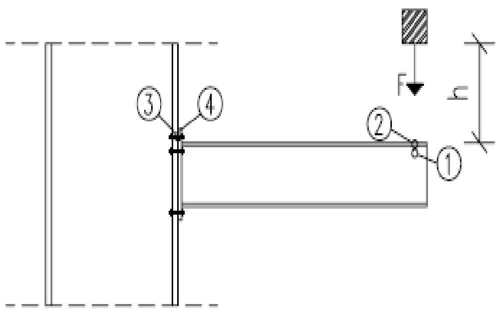

Fig 2 - Arrangement for moment test

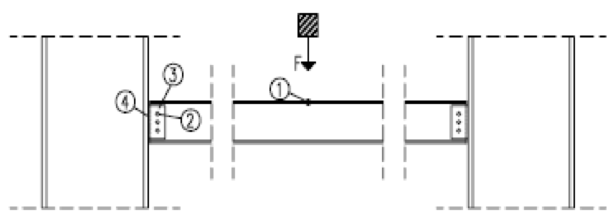

Fig 3 -Test for different critical components of simple joints

Work Package 2 – Experiments with impact loading on components identified as making up the connections tested in Work Package 1. Twelve experiments are planned for this phase of the work. The test arrangements for the shear, simple and T-stub connection are shown in Figs. 4-6 below. The specimen geometry will be varied to obtain different failure modes of different components.

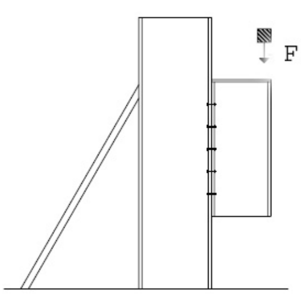

Fig 4 - Shear Panel Test

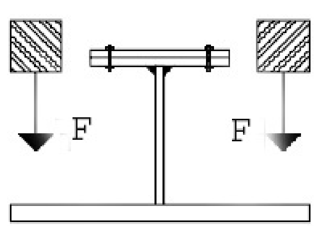

Fig 5 - T-stub connection

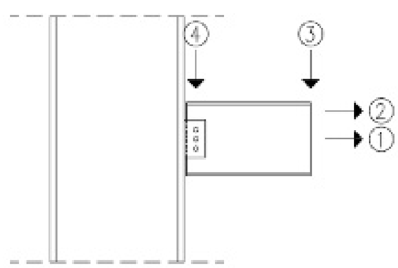

Fig 6 – Simple connection

Work Package 3 – Numerical Simulation of connections tested in Work Packages 1 and 2 and development of the component method of design of steel connections subjected to impulsive loading. Work Package 4 – Robustness studies on steel structures subjected to accidental loading, including stages during erection.

Work Package 5 – Probabilistic analysis of steel structures subjected to impact loading, including risk assessment.

The tests in Work Package 1 will serve two purposes. On the one hand they will provide a means of testing the accuracy of the new component method of design of connections for impulsive loading developed in Work Package 3. On the other hand, the results will be used to validate numerical simulations using the Finite Element method carried out under Work Package 3. Robustness of steel structures will form the theme of Work Package 4. Initially, assumed characteristics of connections will be used for preliminary work.

As information on connection characteristics become available from Work Package 1, these will then be used. Towards the end, connection characteristics based on those given by the new component method will be used for this purpose. It is accepted that not every aspect of the connection behaviour can be included. For example, the role of friction in the bolt behaviour in the contact zones may be a factor, but it is extremely difficult to quantify. The approach is that the experimental results will be assumed to have included these aspects in the overall response.

While the project aims to extend the component method to the case of impulsive loading, it is not aimed to use dampers in structural connections other than in column bases. Dampers are outside the scope of this project.

Work Package 5 will look at risk assessment combined with probabilistic analysis to examine different scenarios of accidental loading on the same structure, aimed at developing a methodology. Here, the recommendations of the Joint Committee of Structural Safety [0.4] will be adopted.

Justification of key budget requests

The project requests support for one research staff member in each of the participating organisation. Staff input will also be forthcoming from Senior contact persons from each of the partner organisations. Where computer intensive work will be carried out, requests for software licences (for ABAQUS, LS-DYNA, etc) and enhancements to computer hardware are requested. Costs of conducting full scale connections and certain connection components under impact loading are also included.

Project Coordination

Coordination meeting involving all the partners will be arranged, rotating the venue every six months. All the project partners, as Members of METNET already have a close working relationship.

Expected results

The results of this research project should result in construction of steel structures which add a feature of robustness towards safety against accidental loading both from natural and man-made hazards. The fact that steel is a sustainable material is now well documented [0.5].

It is perceived that, if through the use of results of research from this project, even if one disastrous failure of an occupied structure is prevented, the research would be worthwhile, especially if lives are saved. Of course, the potential benefits of this research are of potentially far greater scale. In view of the probabilistic nature of these studies, it would be impossible to put a definite monetary value on the potential savings.

Description of organisations and key personnel involved in the project

HAMK (coordinating organisation)

HAMK is a multidisciplinary university of applied sciences with 25 first-cycle degree programmes, 5 second-cycle degree programmes and around 7000 students. It offers broad-based, high-quality education, research and development, and strong internationalisation

HAMK has developed an international Degree Programme in Construction Engineering. This Degree Programme, as well as the Degree Programme in Product Development and Design, includes a lot of steel construction modules. HAMK library is one of the biggest steel construction libraries in northern Europe. The professional staff of HAMK includes many experts in steel construction. The Finnish local cooperation on the area of steel construction is situated in the training and development centre InnoSteel, where HAMK is the responsible body

HAMK R&D projects involve about 250 people with a volume of appr. 100 person-years.

Rautaruukki

Ruukki means comprehensive metal based, value-added solutions and pure cooperation. Ruukki supplies metal based components, systems and integrated systems to the construction and mechanical engineering industry. Ruukki has a wide selection of metal products and services. The solutions Ruukki offers are based on continuous interaction with its customers, knowledge of its customers businesses and in-depth expertise of metal materials

Ruukki delivers metal-based solutions and components for building construction and infrastructure construction. In building construction Ruukki's focus is on retail, industrial and logistics buildings as well as on offices, sports facilities and shopping centres.

Ruukki Metals supplies first-class steel products either prefabricated or as parts from works or stock. Ruukki's operations near the customer enable Ruukki to give an outstanding delivery promise. Ruukki's high-quality special products give its customers the possibility to make more cost-efficient end-products of higher quality. Main customers are the transportation, construction, automotive, engineering and electronics industries.

Steel Construction Institute

The Steel Construction Institute, based near Ascot, UK, employs 50 staff with expertise in all aspects of building design and construction. For over 20 years, SCI has undertaken research and developed guidance on the design of steel structures to resist fires and explosions. Notably, SCI has led the research projects which followed the Piper Alpha disaster and the Buncefield explosion and has been a key player in the R&D and the development of design guidance for explosion and fire hazards. SCI has published over 40 design documents on explosion and fire engineering of steel structures; these are widely used by practicing engineers. SCI has also organised over 60 seminars and workshops aimed at training practicing engineers in the design and protection of structures against explosion and fire hazards. SCI manages and runs the Fire and Blast Information Group (FABIG), the largest special interest group in the world that is devoted solely to developing and promoting best practice in the design of petrochemical facilities against hydrocarbon explosions and fires.

Aarhus University

Aarhus University celebrated its 75th anniversary in 2003. It is recognised for cutting edge research in Science. It has recently established the Aarhus Graduate School of Engineering. Professor Kuldeep Virdi holds the chair of structural engineering. He has extensive research experience in the field steel and composite columns, semi-rigid connection behaviour, progressive collapse of structures subjected to explosive loading, and ultimate strength of steel and reinforced concrete structures under fire conditions. A recent industry-funded project was on low-rise structures subjected to earthquake loading. For several years, he was a member of the Steering Committee of the Model Studies Group of the Institution of Structural Engineers, dealing with experimental techniques. His research on semi-rigid connections led, in 1999, to his election to the Royal Society for the Arts and Sciences in Göteborg, Sweden, as a Foreign Member.

He has developed a new model for material properties under high strain rates was developed [4.1], an important factor in correctly modelling the behaviour of structures subjected to impact loading. He has studied material and geometric nonlinearity under dynamic loading using both implicit and explicit formulations, showing that considerable advantages could be gained by adopting explicit solution techniques without sacrificing accuracy [4.2]. Following on from this, an algorithm was developed to predict the progressive collapse behaviour of plane rigid jointed frames subjected to an impulsive loading, combining a local failure analysis of the member or members affected by the impulse, together with a quasi-static analysis of the remaining frame. The procedure recursively seeks further damage and further analysis, until no further local collapse is indicated [4.3]. Recent work on low-rise structures under earthquake loading has sought to identify details in non-engineered buildings, which result in structural failure. Noting that the vast majority of deaths in earthquake-affected regions occur in such buildings, it is the aim of the project to recommend simple strengthening measures, which will prevent total collapse of the structure, thereby helping to save lives. The principal output of findings is through a web-site [4.4].

Luleå University of Technology

Luleå University of Technology (LTU), Division of Structural Engineering - Steel Structures is a research and education organisation located in northern Sweden. The Division of Structural Engineering was established at the beginning of 2004 as a merger between the former divisions of Steel Structures, Timber Structures and Structural Engineering. The division includes a staff of about 40, of which seven are professors covering the subjects of steel structures, composite structures, timber structures and concrete structures. The division is organised in six different sub-groups; one for teaching and five different research groups. The Steel Structures research group is focused on steel and composite structures. Plated structures have been a research area for the last ten years. Steel Structures is actively involved in the development of common European design rules in Eurocode 3-1-5 and Eurocode 3-1-12. The senior staff consists of Prof. Milan Veljkovic, the head of the group, and four part-time professors that totally supervise six PhD students employed by LTU and 5 PhD students employed by industry. The research group share a laboratory with five technicians and modern equipment for mechanical testing and measuring. Steel Structures research group also has modern high-performance computers and state of the art software for FE simulation, including substantial experience of simulating the mechanical behaviour of steel structures. Two part-time professors, Prof. Ulf Wickström and Prof. Björn Sundström work in SP Technical Research Institute of Sweden, Borås, where the Swedish best equipped commercial laboratory is located.

University of Coimbra

The partner University of Coimbra, Faculty of Science and Technology (FCTUC), Department of Civil Engineering is a research and education organization located in central Portugal which was created in 1290. The Department of Civil Engineering is responsible for undergraduate teaching in Civil and Environmental Engineering and a large spectrum of postgraduate courses. It was established in 1972 and includes a staff of about 80 teaching academics covering structural engineering, hydraulics, geotechnics, construction materials and technology, urban planning, roads and transportation.

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Structural Engineering is organized in three different research groups. The research Group on Steel and Composite Construction comprises 45 people, including post-graduate students, plus a shared laboratory and modern equipment for mechanical testing and instrumentation. This research group is also responsible for running a specialized postgraduate course on Steel and Composite Structures. The behaviour of steel and composite joints has been a strong research area for the past 10 years, including the specific issue of the development of the component method. Various members of the research group have been actively involved in the development of common European design rules in Eurocode 3, parts 1-8 and 1-2. Professor Luís Simões da Silva is heavily involved in the development of advanced methodologies for the design of steel and composite joints and is currently Chairman of the Technical Management Board of ECCS and President of the Portuguese Association of Steel and Composite Construction.

Poznan University

In 1999 Poznan University of Technology (PUT) celebrated 80 anniversary of higher educational technical system in Poznan. It continues traditions of the State Higher School of Mechanical Engineering, which was opened in August 1919. The school remained open at the outbreak of the Second World War, during which time 716 graduates had completed their studies there. It was allocated in a building nowadays situated at M. Skłodowska-Curie Square, today the Rector's Office. In 1929, the school changed its name to the State Higher School of Mechanical and Electrical Engineering. As a result of further development, the Higher School was to be given the status of a University in 1940. Unfortunately, this did not occur during the war period. In September 1945, the School received the title High School of Engineering and after ten years became Poznan University of Technology.

PUT is at present autonomous state institution consisting of nine faculties in which institutes and chairs over one thousand academic staff members do research and run educational tasks for over fourteen thousand students of full -time and part-time studies. PUT has been granted the right to confer doctorates in technical science. Moreover, it runs postgraduate studies within different faculties.

In 1995 PUT, as the first Polish University of Technology, became a member of the Conference of European Schools for Advanced Engineering Education and Research – CESAER-bringing together the best European Engineering Colleges and Universities of Technology. In 1999 PUT was the host organization of the IX CESAER Conference.

In the academic year 1999 / 2000 European Credit Transfer System –ECTS-was introduced at the PUT.

A2 - Page 9

REFERENCES

[0.1] The European Steel Technology Platform. Strategic Research Agenda. Information and Communications Unit. DG Research. European Commission. Brussels. April 2005.

[0.2] Eurocode 3 Part 8 (BS EN 1993-1-8) Design of Steel Structures : Design of joints. British Standards Institution, 2005

[0.3] COST C1 - International Conference on Control of the Semi-Rigid Connection Behaviour of Civil Engineering Connections. University of Liège, Belgium, September 17-19, 1998. *(Published in book form by the European Union)*

[0.4] Eurocode 1 Part 7 (BS EN 1991-1-7) Actions on Structures. British Standards Institution, 2005

[0.5] Simões da Silva, L. Towards a consistent design approach for steel joints under generalized loading, Journal of Constructional Steel Research, 64(9), pp. 1059-1075, 2008, doi: 10.1016/j.jcsr.2008.02.017.

[0.6] Gervásio, H., Simões da Silva, L., and Borges, L. Reliability assessment of the post-limit stiffness and ductility of steel joints, Journal of Constructional Steel Research 60(4), 635-648 (2004)

[0.7] Faber, M H (editor) Risk Assessment in Engineering. JCSS – Joint Committee of Structural Safety. June 2008. ISBN 978-3-909386-78-9.

[4.1] Beshara, F B A, and Virdi, K S. Nonlinear Finite Element Dynamic Analysis of Two-Dimensional Concrete Structures. *Computers & Structures*. Volume 41, No 6, pp1281-1294, 1991.

[4.2] Beshara, F B A, and Virdi, K S. Prediction of Dynamic Response of Blast Loaded Reinforced Concrete Structures. *Computers & Structures*. Volume 44, Nos 1-2 , pp297-313, 1992.

[4.3] Virdi, K S, and Beshara, F B A. Numerical Simulation of Buildings Demolition as a progressive Collapse Process. *Decommissioning and Demolition*. Conference organised by The Institution of Civil Engineers. Manchester, March, 1992. *(Published by Thomas Telford, London).*

[4.4] www.staff.city.ac.uk/earthquakes

A3. **FOR RESUBMITTED PROPOSALS ONLY: ADDITIONAL INFORMATION**

Please fill in this section only if your proposal has already been submitted and evaluated under a prior call for proposals.

Important notice: Please respect the document format given hereafter. Do not insert additional pages or any annexes as this section **must not exceed, under any circumstances, a maximum of 2 pages**.

Recommended format: Arial, minimum font size 12.

This section should provide the following additional information for resubmitted proposals only:

- Title, reference number and year of the previous submission(s)
- Evaluation report received from the Commission following the last submission
- A short description of main changes made, making reference to the comments of the evaluators in the last evaluation report (maximum 2 pages)

A3

(Copy of the evaluation report of the last submission)

A3 - Page 1

- Title, reference number and year of the previous submission

- Short description of main changes made

A3 - Page 2

Project acronym: **RobCIL**

Proposal No[2]:

Grant Agreement No:

(will be attributed by the Commission)

TITLE: **Robust Design of Connections under Impact Loading**

PROJECT OBJECTIVES

Objectives clearly stated in a concise manner **(½ to 1 page maximum).**

To study the behaviour of connections in steel structures under impulsive loading such as that encountered in earthquakes, explosions, vehicular impact, landslides due to soil erosion in adverse weather, and avalanches following heavy snow.

To conduct experiments with impact loading on selected connection types to understand the failure mechanisms and to provide data for validating numerical simulation.

To conduct experiments with impact loading on components identified as making up the connections tested above.

To carry out numerical simulation of connections tested above and to extend the existing component method of design of steel connections subjected to the case of impulsive loading.

To carry out robustness studies on steel structures subjected to accidental loading, including stages during erection, with emphasis on contribution of the connection to the overall behaviour.

To carry out probabilistic analysis of steel structures subjected to impact loading, including risk assessment. At least one of the structures studied will be an existing structure.

Form 1-2

WORK PACKAGE DESCRIPTION	**WP No**	**1**

Work package Title	Experiments on connections under impact			**Number of man hours**[29]
WP Leader (full name & acronym)	HAMK University of Applied Sciences	HAMK	(1)	1000
Beneficiary (s) (full name & acronym)	Rautaruukki Oyj	Ruukki	(2)	460
	Luleå University of Technology	LTU	(5)	1600
Total				

1 – Objectives

(Objectives clearly stated in a concise manner using bullet points (½ page)).

To conduct experiments on selected types of connections, such as a beam-column end plate connection. The choice of connection will be based on ease and safe of assembly.

In all 8 tests will be carried out:

Task 1.1 - 4 moment connection at HAMK and
Task 1.2 - 4 simply supported (cleat) connection at LTU

The total mass estimated (specimens and set-up) is about 2.3t for moment connection-cantilever and about 4.7 t for simply supported beams including supporting frames.

The impact load will be applied by dropping a specified weight through a specified height in an upside down orientation, to simulate the impacting force coming from an explosion underneath. The precise values of these parameters of weight and height will be decided after some numerical experiments under Work Package 3.

Each test will be performed on two nominally identical specimens. In the first test, the known load will be applied by increasing the height of the drop from 0.5m in increments of 0.5m, until the connection progressively fails. In the second test, the load will be applied associated directly with the failure height obtained from the first test.

The test results will be used to validate the strength calculated by the new component method (developed in Work Package 3) for connections subjected to impact.

The test results will also be used to calibrate the Finite Element simulations in Work Package 3.

2 - Work programme and distribution of tasks with indication of participating beneficiaries

(Specify the beneficiary's responsibility within each task).

The test programme will consist of 12 experiments. Six experiments on beam-column connections will be carried out HAMK, and another six experiments will be conducted at Luleå.

The measurements will include not only the strength of the connection, but the deformation response of the bolts in the connections. Pictures with high speed cameras will be recorded to enable processing of the deflections, identification of failure modes and establishing the critical component for failure.

The results will be presented in a form which will make it easy for other researchers to use the data electronically.

3 - Interrelation with other work packages (please give WP No)

(Briefly describe the interrelation with the other WPs).

The values of parameters of weight and height in these tests will be decided after some numerical experiments under Work Package 3.

The choice of components to be tested under Work Package 2 is clearly related to the connections being tested under this Work Package.

The test results will be used to validate the strength calculated by the new component method (developed in Work Package 3) for connections subjected to impact.

The test results will also be used to calibrate the Finite Element simulations in Work Package 3.

4 - Deliverables and milestones

(Specify the beneficiary's responsibility for the different deliverables).

(1) Test results on selected connections subjected to impact. This will be the shared responsibility of HAMK and LUT.

Form 1-2

WORK PACKAGE DESCRIPTION	WP No	2

Work package Title	Experiments on components of connections under impact	Number of man hours[29]
WP Leader (full name & acronym)	Luleå University of Technology LTU (5)	1600
Beneficiary (s) (full name & acronym)	University of Coimbra FCTUC (7)	1900
	HAMK University of Applied Sciences HAMK (1)	1000
	Rautaruukki Oyj Ruukki (2)	460
Total		

1 – Objectives

(Objectives clearly stated in a concise manner using bullet points (½ page)).

To conduct experiments on components of selected types of connections, such as T-stubs and shear panels. These components would be appropriate for a variety of connections.

The impact load will again be applied by dropping a specified weight through a specified height. Again, the values of these parameters of weight and height will be decided after some numerical experiments under Work Package 3.

As for the experiments on full connections, each test will be performed on two nominally identical specimens. In the first test, the known load will be applied by increasing the height of the drop from a small value in increments until the component progressively fails. In the second test, the load will be applied associated directly with the failure height.

The test results will be used to build up data for the application of the new component method (to be developed in Work Package 3).

2 - Work programme and distribution of tasks with indication of participating beneficiaries

(Specify the beneficiary's responsibility within each task).

The test programme will consist of 12 pairs of experiments:

Task 2.1	-	4 T-stub connections,	FCTUC
Task 2.2	-	4 simple connection components,	HAMK
Task 2.3	-	4 web shear tests	LTU

The specimen geometry will be varied to obtain different failure modes of components.

The measurements will include not only the strength of the connection, but the deformation response of the bolts in the connections. Pictures with high speed cameras will be recorded to enable processing of the deflections, identification of failure modes and establishing the critical component for failure.

The results will be presented in a form which will make it easy for other researchers to use the data electronically.

3 - Interrelation with other work packages (please give WP No)

(Briefly describe the interrelation with the other WPs).

The values of parameters of weight and height in these tests will be decided after some numerical experiments under Work Package 3.

The choice of components to be tested under this will be influenced by the choice of connections being tested under Work Package 1. Of course, the T-stub component has applicability to many different types of connections. It is for this reason, the number of tests on T-stub components has been set at twice that of other components.

The test results will be used to validate the strength calculated by the new component method (developed in Work Package 3) for connections subjected to impact.

The test results will also be used to calibrate the Finite Element simulations in Work Package 3.

4 - Deliverables and milestones

(Specify the beneficiary's responsibility for the different deliverables).

(2) Test results on selected components subjected to impact. This will be the shared responsibility among LUT, FCTUC, Ruukki and HAMK.

Form 1-2

WORK PACKAGE DESCRIPTION	WP No	3

Work package Title	Numerical simulations using finite elements			Number of man hours[29]
WP Leader (full name & acronym)	Aarhus University	Aarhus	(4)	3450
Beneficiary (s) (full name & acronym)	Luleå University of Technology	LTU	(5)	2400
	Poznan University of Technology	PUT	(6)	850
Total				

1 – Objectives

(Objectives clearly stated in a concise manner using bullet points (½ page)).

To simulate the behaviour, using finite element method, of structural connections subjected to impact loading tested under Work Package 1. The simulation will also cover the components tested under Work Package 2.

The software to be used for this purpose will be different at each of the universities participating in this Work Package. This is being done so that the capabilities of different packages can be evaluated when compared with the same set of experimental results. The preferred packages are ABAQUS, LS-DYNA, and ADINA.

A key objective is to develop the component method for the design of connections for the case of impact loading. It is anticipated that the methodology for determining the components will be the same as include in Eurocode 3. However, work in this package will lead to the definition of the characteristics of the connection components.

Checks will also be made against the benefits of using explicit solutions (for faster analysis) against implicit solutions (for possibly more accurate results).

2 - Work programme and distribution of tasks with indication of participating beneficiaries

(Specify the beneficiary's responsibility within each task).

Task 3.1 - The numerical simulations will be carried out on all the tests under Work Packages 1 and 2. The distribution of work is based on the software licence selected for each of the participating universities.

Task 3.2 - LUT will focus on the development of component method for the design of connections for impact loading. Aarhus and Poznan will calibrate the new method against rigorous calculations using the finite element method.

3 - Interrelation with other work packages (please give WP No)

(Briefly describe the interrelation with the other WPs).

The values of parameters of weight and height in these tests will be decided after some numerical experiments under Work Package 3.

The choice of components to be tested under Work Package 2 is clearly related to the connections being tested under this Work Package.

The test results will be used to validate the strength calculated by the new component method (developed in Work Package 3) for connections subjected to impact.

The test results will also be used to calibrate the Finite Element simulations in Work Package 3.

4 - Deliverables and milestones

(Specify the beneficiary's responsibility for the different deliverables).

(1) Validation of numerical simulation of test results on selected connections and their components subjected to impact. The computer programmes can then be used for further numerical experiments that may be required for developing the new component method for the design of connections subjected to impact. The responsibility for this work will be shared between Aarhus, LUT and Poznan.

(2) The development of the component method of design of connections for impact loading.

Form 1-2

WORK PACKAGE DESCRIPTION	**WP No**	**4**

Work package Title	Robustness of steel structures including erection and completed state			**Number of man hours**[29]
WP Leader (full name & acronym)	Steel Construction Institute	SCI	(3)	1000
Beneficiary (s) (full name & acronym)	Aarhus University	Aarhus	(4)	900
	University of Coimbra	FCTUC	(7)	1925
	HAMK University of Applied Sciences	HAMK	(1)	650
	Poznan University of Technology	PUT	(6)	850
Total				

1 – Objectives

(Objectives clearly stated in a concise manner using bullet points (½ page)).

To simulate the behaviour of complete steel structures subjected to impact loading, taking into account the dynamic behaviour of connections using finite element method of analysis. The simulation will also cover the structure during assembly and erection. The simulation will identify the possibility of sudden failure and the performance of the structure will be monitored to ensure that progressive collapse does not occur so as to obtain robust structures.

The software to be used for this purpose will be the same as for Work Package 3. Hazards covered will include explosions (gas etc), earthquakes, avalanche from unexpected localised snow loading, and wind gusts.

2 - Work programme and distribution of tasks with indication of participating beneficiaries

(Specify the beneficiary's responsibility within each task).

Task 4.1 - As in Work Package 3, parallel analyses will be carried out using identical input data by at least three different computer programs. All five participating institutions will be involved in these parametric studies. In view of the rather large time required for setting up the numerical models and the processing times, the number of cases analysed will inevitably be limited.

Once the data for a specific structure has been prepared, a number of scenarios will be examined. One key variation will be the location of the impact for the trigger. The aim of the study is to ensure that alternative load paths are always available to ensure the robustness of the structure.

Structures will also be analysed for similar loading scenarios but under different stages of erection and assembly.

Task 4.2 - The numerical simulations will be carried out on existing structures, where permission will be sought from the designers for this type of speculative analysis on existing structures.

It is visualised that pairs of institutions will have the same software, although it is possible to investigate computer programs beyond those listed above, such as the program 'Inventor' available at HAMK.

3 - Interrelation with other work packages (please give WP No)

(Briefly describe the interrelation with the other WPs).

The numerical simulation will use connection characteristics based on test results where available from Work Package 1, or use will be made of connection characteristics derived from the new design method for connections under Work Package 3.

There will be further interrelation with Work Package 3, in view of the common software used.

4 - Deliverables and milestones

(Specify the beneficiary's responsibility for the different deliverables).

(1) A methodology for testing the robustness of structures using connections characteristics as influenced by impact.

(2) A methodology for assessing the performance of structures under erection and assembly subjected to impact loading.

Form 1-2

WORK PACKAGE DESCRIPTION	**WP No**	**5**

Work package Title	Probabilistic analysis of steel structures subjected to impact loading, including risk assessment.			**Number of man hours**[29]
WP Leader (full name & acronym)	University of Coimbra	FCTUC	(7)	1925
Beneficiary (s) (full name & acronym)	Poznan University of Technology	PUT	(6)	850
	Steel Construction Institute	SCI	(3)	1075
	Aarhus University	Aarhus	(4)	900
	HAMK University of Applied Sciences	HAMK	(1)	900
Total				

1 – Objectives

(Objectives clearly stated in a concise manner using bullet points (½ page)).

To develop the probabilistic analysis of steel structures subjected to impact loading, but incorporating risk assessment.

The risk assessment is influenced by some imprecise values judgments, whereas the probabilistic analysis is calculation intensive. The aim will be to examine the risks associated with different design solutions with different probability of failure in

The different failure scenarios will be influenced by the degree of robustness desired by the designer. This may include selection of probable failure away from critical locations.

2 - Work programme and distribution of tasks with indication of participating beneficiaries

(Specify the beneficiary's responsibility within each task).

In this package the consequences of different failure scenario will be assessed. The use of the method based on Risk Premium Numbers will be examined. Use will be made of published data on costs associated with different types of failure. Approach will be made to obtain more up-to-date figures from Insurance Companies.

FCTUC will lead on the probabilistic methods. HAMK will liaise with Insurance Companies and will examine the Cost-Benefit aspects of different scenarios. Poznan and Aarhus will develop the combined Probabilistic Analysis and Risk Assessment tools. SCI will provide guidance on selection of known hazards.

3 - Interrelation with other work packages (please give WP No)

(Briefly describe the interrelation with the other WPs).

The principal linkage will be with Work Package 4 where the focus is on analysis of complete structures under impact.

4 - Deliverables and milestones

(Specify the beneficiary's responsibility for the different deliverables).

(1) The development of a methodology for combined risk assessment and probabilistic analysis of robust steel structures subjected to impact.

PROGRAMME BAR CHART (TASK, PARTNER, DELIVERABLES, MILESTONES)

Work packages	*Work packages' title*	*Deliverables*	Hours on project/ Contractor(s)							1st year				2nd year				3rd year			
			1	2	3	4	5	6	7	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP 1	**Connection tests**																				
Task **1.1**	Moment connections	Test report	1000	460	0	0	0	0	0	160	260	260	260	260	260						
Task **1.2**	Simple connections	Test report	0	0	0	0	1600	0	0	150	290	290	290	290	290						
WP 2	**Component tests**																				
Task **2.1**	T-stub tests	Test report	0	0	0	0	0	0	1900	200	340	340	340	340	340						
Task **2.2**	Simple tests	Test report	1000	460	0	0	0	0	0	160	260	260	260	260	260						
Task **2.3**	Web shear tests	Test report	0	0	0	0	1600	0	0	0	200	300	300	400	400						
WP 3	**Numerical Simulation**																				
Task **3.1**	Validation	Test report	0	0	0	2800	1800	600	0	250	470	470	470	470	470	470	470	470	470	470	250
Task **3.2**	Component method	Design Method	0	0	0	650	600	250	0									300	300	300	600
WP 4	**Robust Design**																				
Task **4.1**	Parametric Study	Test Report	300	0	500	500	0	450	1000							550	550	550	550	550	
Task **4.2**	Real Structure Analysis	Design Guide	350	0	500	400	0	400	925							640	640	640	655		
WP 5	**Probabilistic Analysis and Risk**																				
Task **5.1**	Risk Based Design	Design Guide	900	0	1075	900	0	850	1925				620	620	620	620	620	620	620	620	690
Total Hours on project			**3550**	**920**	**2075**	**5250**	**5600**	**2650**	**5750**												

Form 1-3

HOW TO COMPLETE THE PROPOSAL SUBMISSION FORM A (SECTIONS A0 TO A3)

[1] This overview information has to be completed by the coordinator.

[2] Provide a short title or acronym of no more than 20 characters, to be used to identify the proposal.

[3] Please cross under which area (Coal or Steel) you submit the proposal.

[4] Please cross the correct answer.

[5] Project duration in months. Project shall normally run between 36 and 42 months. Please be aware that the Commission operates a general policy of non-prolongation of research grant agreements.

[6] Please indicate the research objectives under which the proposal falls:
Coal 1 Improving the Competitive position of Community Coal.
Coal 2 Health and Safety in Mines.
Coal 3 Efficient Protection of Environment & improvement of the use of coal as a clean energy source.
Coal 4 Management of External Dependence on Energy Supply.
Steel 1 New and improved Steel making and finishing techniques.
Steel 2 RTD and the utilisation of steel.
Steel 3 Conservation of resources and improvement of working conditions.

[7] Please indicate the Technical Group under which the proposal falls:
TGC 1 Coal mining operations, mine infrastructure and management, unconventional use of coal deposits
TGC 2 Coal preparation, conversion and upgrading
TGC 3 Coal combustion, clean and efficient coal technologies, CO_2 capture
TGS 1 Ore agglomeration and Iron making
TGS 2 Steelmaking processes
TGS 3 Casting, reheating and direct rolling
TGS 4 Hot and cold rolling processes
TGS 5 Finishing and coating
TGS 6 Physical metallurgy and design of new generic steel grades
TGS 7 Steel products and applications for automobiles, packaging and home appliances
TGS 8 Steel products and applications for building, construction and industry
TGS 9 Factory-wide control, social and environmental issues

[8] The number allocated by the consortium to the participant for this proposal. The co-ordinator of a proposal is always number one.

[9] The role for the participant as defined by the consortium for this proposal. The following codes should be used:
CO: Co-ordinator
CR: Contractor (different from the co-ordinator)
SC: Subcontractor

[10] Only for subcontractors. They should indicate the number (e.g. 1, 2, 3 etc.) of the beneficiary(ies) to which they are connected to.

[11] Please indicate the full official denomination which is the name under which the entity is registered in the Official Trade registers, if applicable.

[12] The maximum contribution requested from the Community for each participant in Euro, expressed as a percentage of the allowable costs are:
a) for research projects: up to 60%
b) for pilot and demonstration projects: up to 50%
c) accompanying measure - promotion of knowledge gained and conferences: in principle up to 60%