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COMET 21.1.3.1
Software development experience in designing of steel structural joints

Viktor KARPILOVSKYI
Director, Candidate of Sciences, SCAD Group

Eduard KRYKSUNOV
Director, Candidate of Sciences, SCAD Soft

Anatoly PERELMUTER
Professor, Doctor of Sciences, SCAD Soft

Vitalina YURCHENKO
Associate Professor, Candidate of Sciences, SCAD Soft
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Introduction

The current version of COMET enables to design steel structural joints widely used in civil and industrial engineering. The application is also used to perform a structural appraisal of steel joints according to the requirements of Ukrainian design codes (DBN B 2.6-163: 2010 or DBN B 2.6-198: 2014), Russian design codes (SNiP II-23-81*, SP 53-103-2004 or SP 16.13330.2011) and European codes (EN 1993-1-8, EN 1993-1-1).
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Parametric prototypes orientation

Algorithm for designing each joint prototype has been presented as a set of operations implementing the rules for determining the interrelated values of the joint parameters. Each prototype is developed as an independent program that performs a full cycle of designing the joint and verification of the joint parameters according to the specified design codes.

Set of joint prototypes includes only the joints that are reflected in the text of the corresponded design codes.
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Rigid Column Bases & Nominally Pinned Column Bases PROTOTYPES
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Beam Splices PROTOTYPES
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Beam-To-Column Joints PROTOTYPES
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Truss Panel Points PROTOTYPES
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Initial data

INITIAL DATA include:

- joint type (prototype);
- information about the structural members connected in the considered joint (their sections and steel grades);
- data allowing to select the properties of the used bolted and welded connections;
- set of internal forces combinations acting in adjacent sections of the connected members.
SOFTWARE DEVELOPMENT EXPERIENCE IN DESIGNING OF STEEL STRUCTURAL JOINTS

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Software implementation: CONCEPTUAL PROVISIONS

The CONCEPTUAL BASIS of the project was the idea of creating a program with the following functions:

- automatic determination of all joint parameters which formally satisfies the requirements of design codes for the given internal forces combinations;
- automatic determination of some joint parameters, taking into account the fact that other parameters are specified by the user and can not be changed;
- implementation of all verifications of whether the load-carrying capacity constraints as well as structural constraints are satisfied in the cases when all joint parameters are specified and can not be changed.
Software implementation: GENERALIZED FLOWCHART

The role of the program can change from the “generator of all joint parameters” of the design specified by the user, to the “simple verification” of the joint load-carrying capacity in accordance with the design codes (taking into account parameters specified by the user).
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Software implementation: Searching of Unknown Joint Parameters

Searching of unknown joint parameters has been transformed to a DECISION MAKING PROBLEM based on analysis of the joint mathematical model.

Set of input parameters:
(i) GOVERNING parameters for steel structural joint (bolt diameter, number of bolt rows, end-plate thickness, etc.) and (ii) DEPENDENT parameters (distance between bolts, end-plate width, etc.)

System of constraints:
- Load-carrying capacity constraints of connected members and auxiliary elements;
- Assortment-based constraints for shaped and sheet steel;
- Structural constraints (geometrical constraints caused by mutual arrangement of the welded and/or bolted connections; weldability for elements with different thicknesses etc.) have been described using functional dependencies between governing and dependent parameters;

Set of output parameters:
STATE PARAMETERS: load-carrying capacity factors (utilization ratios)
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Software implementation: MODES

Mode «Design»

1. Automatic searching of unknown joint parameters
(all parameters of the structural joint are not specified by user):

Multiple improvement of current joint design is performed on the basis of sensitivity analysis relative to variation of governing joint parameters.

Multiple improvement of a certain initial joint design in order to satisfy load-carrying capacity constraints taking into account the structural and assortment-based constraints.
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Software implementation: MODES

Mode «Calculate»

2. Verification of the joint load-carrying capacity
(all parameters of the structural joint are specified by user):

(i) Verification of structural constraints and assortment-based constraints;
(ii) Calculation of load-carrying capacity factors (utilization ratios)

\[ k_i = \frac{E_{d,i}}{R_{d,i}} \leq 1,0 \]
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Software development experience in designing of steel structural joints
Software implementation: MODES

In cases when the values of some joint parameters have to be taken as fixed (or user-defined), the program considers these parameters as the same kind of initial data.

All other (unknown) parameters will be considered as design variables of the searching problem.

Thus, the technology implemented in COMET supports the mode of **ACTIVE USER DECISION MAKING**. Such a mode can both satisfy an experienced designer allowing him to achieve the necessary solution, and allow the beginner to solve a design problem with minimal interference in the decision-making process.
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Presentation of result: Factors Diagrams

- Results of the load-carrying capacity verifications for compliance with the requirements of design codes are presented in the form of a factors diagram
- The values of the factors are given in the form of the utilization factors of load-carrying capacity constraints

\[ k_i = \frac{E_{d,i}}{R_{d,i}} \leq 1,0 \]
A graphical representation of the designed joint is given in the form of a **drawing**, which describes the joint structural decision **completely and in detail**, including the specification.

The drawing can be presented in **DXF format**, a file that can be used by various graphic editors.
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Presentation of result: Load-Carrying Capacity Regions

- Load-carrying capacity region for the structural joint is a family of graphs in the coordinate system of the selected internal forces bounding the region where all utilization factors are less or equal to one.

- Such family of graphs gives us a representation of the load-carrying capacity of the designed joint in terms of the selected design code.

$$k_i = \frac{E_{d,i}}{R_{d,i}} \leq 1,0$$
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Load-Carrying Capacity Regions & Convex Shell of Internal Forces

THE PROGRAM ENABLES:
- to show the position of points corresponding to the specified internal forces
- to plot a convex shell on the basis of these points thus bounding the part of the load-carrying capacity region, which corresponds to any linear combination of design internal forces in the considered joint
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Presentation of result: Load-Carrying Capacity Regions

The poster shows variants of the load-carrying capacity regions for the different type of beam splices designed for the same set of internal forces.

It can be seen that the selection of the joint prototype has affected on the shape of the load-carrying capacity region.
An important feature of the load-carrying capacity region is its **CONVEXITY**. Due to this feature it is enough to verify only the ultimate combinations of internal forces, and the positive result of such verifications automatically means that all other possible combinations will be allowable.

This approach is **valid** only for a **CONVEX REGION!** If the region is **non-convex**, an intermediate value of the internal forces factor can be **unfavorable!!!**
Thank you for your kind attention

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