

# Quality Enhancement by using Standardized Parts and Methods in Steel Structural Design

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## **Abstract**

The design process in steel structural design is a very complex process based on the knowledge of the engineers. By using the advantages of standardization, this paper outlines a solution for handling both standards and workflows. Hereby the quality in design process is enhanced; productivity is increased.

## **1 Introduction**

The design process in the maritime industry is a complex phenomenon where several partners like yards, subcontractors, and design offices work together in a heterogeneous network. Thus, a significant amount of time is needed for information exchange and the coordination of design activities. Often, the partners simultaneously perform similar design tasks by utilizing their own specific knowledge and design methods which therefore leads to different solutions to identical problems.

This paper outlines a flexible solution for handling standards. The application described is a result of the collaborative research project Context Sensual Structural Components (KonSenS) and relies on a service oriented architecture approach. Based on specific IT-based methods for the management and application of standards for steel structural design an improved standardization is developed that leads to quality enhancements of design tasks.

One major advantage of the application described is that all partners involved in the design process have access to an electronic catalog via network connection. By following a single-source approach there is only one catalog of standards needed for several design projects because a per-project configuration allows tailoring the standards to different problems. Furthermore, it is possible to select a subset of information for several design tasks or contexts which helps to avoid incorrect decisions. Additionally, for common design tasks there are already workflow selections defined. Based on standardized workflow management formats these workflows include both strength, manufacturing, and cost aspects.

## 2 Standardization at Steel Structural Design

Figure 1 shows the cost effect during the design process. As seen the design phase influences the total cost of delivery significantly. To reduce costs the shipyard, building the vessel, defines a set of regulations and best practice recommendations, so called standards. These standards are highly optimized to increase productivity during manufacturing.

### 2.1 The Role of Standardization

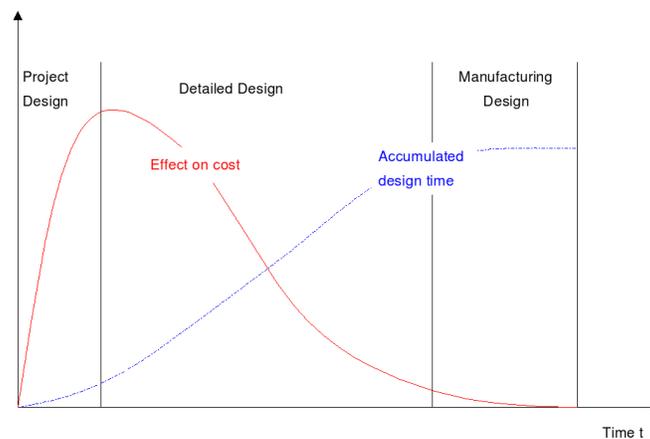


Figure 1: Effect of design time on cost

By using these standards the number of solutions used in a vessel or even in a series of vessels can be reduced, with these series effects the manufacturing costs can be reduced. Design agents are more familiar with the reduced solution, leading to a decrease in labor time needed and to an improvement in manufacturing quality.

To reduce design time similar tasks concerning independent aspects of the vessel design are deployed to different partners. For example the design of all steel structural parts of the bow section is done by one design office, the design of the aft section is done by another design office or directly on the shipyard. Independent design offices are often working on many projects at the same time. This requires that the employee of a design office

- must work in different design contexts at the same time,
- must be familiar with the recommendations and requirements of the contractor for each project.

These issues put a high load on the employees of the design office. For new projects the engineer must get familiar and productive within the standards and regulations by the contractor in a limited timeframe. Working on different projects also requires a change of used standards; the probability of using incorrect regulations or misinterpretation is increasing, leading to a decrease of the quality of the solutions.

So, standards offer a means to define solutions to common problems. These standards used by engineers on the shipyard and in design offices to design a vessel in a way that is best for manufacturing capabilities at the construction site. A result, manufacturing costs are reduced and the build quality is improved. If common standard parts are delivered or produced in large quantities, they don't need to be manufactured individually. The material flow is improved, storage requirements are reduced.

## 2.2 A Definition for Standards

For a given problem, even if limited to feasible solutions only, the number of solutions is large. Based on these solutions, standards impose certain constraints with the objective to limit the solution domain. Constraints can

- either be placed on certain aspects,
- can exclude some solutions completely
- or can allow certain solutions only.

Generally, aspects can be anything that concerns the problem at hand and that influences the result. Constraints limit the parameter space for aspects. This limitation is based on mathematical operations. For example the class rules define certain requirements regarding stiffener dimensions in relation to plate thickness. Description logic allows the definition of relationships between different aspects hence forming a network of rules for a given standard.

Here, a distinction between constraints that only affect aspects of the standardized object and relations that also encompass information from the surroundings of the object need to be distinguished.

Figure 2 shows as example a bracket used for a stiffener–stiffener connection. This bracket has two parameters:  $l$  – the length of the flange and its thickness  $t$ . For the selection of the bracket another parameter is used:  $H$  – the height of one of the connected stiffeners, i. e. information from another object used for the dimensioning of the bracket.

In practice, the number of aspects applied for a given standard is limited by issues like maintenance and complexity. From an economic point of view, standardization is only used if the effect of the standardization gives benefits regarding cost or quality compared to the effort needed to define, distribute and apply these standards.

In ship design standardization is mostly applied in the area of steel structural design. Here, high numbers of identical solutions like parts or features are used.

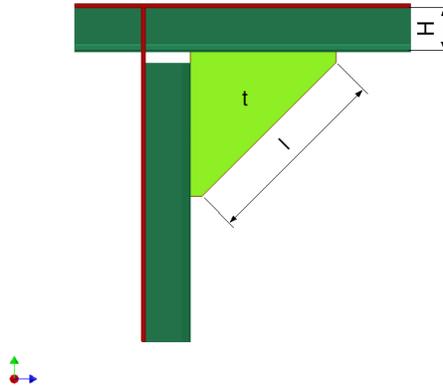


Figure 2: Relevant aspects for a standardized object

### 2.3 A system for Managing Standards

Today, the definition and management of standards is mostly performed using standard office applications. In most cases distribution and deployment are done on paper. For each project the shipyard needs to create a new document describing all relevant standards. Changes in the standard require that all related documents need to be updated and distributed to all partners involved. Due to the delay in the distribution process design decisions might occur based on deprecated standards.

An electronic system for the management of standards eases the handling of standards. With a centralized database for the storage and distribution of parts and methods, the deployment of up-to-date informations is improved. Using knowledge-based engineering methods tools are provided to support the application of a set of standards by the engineer. Intelligent functions allow to search for solutions for a given problem.

As part of the collaborative research project “KonSenS” *Bronsart et al. (2006)* an electronic database for

- the creation of a set of standards,
- the management of standards,
- the distribution of standards to all partners involved for a project,
- the application of these standards by the engineers,

is developed.

These system is based on an information server to provide information about design procedures, standards and documentation. Using a platform- and systemindependent design, a Client/Server solution offers both flexibility and a centralized infrastructure. With the help of adapter interfaces to CAE-systems

or other applications present in shipyards it is possible to consolidate and centralize the management and configuration of different applications in the system. A stand-alone client can be used to access the data stored in the information server directly. Communication to the clients and adapters is done via SOAP and XML-RPC calls, interfaces for search and retrieval of applicable solutions or informations are offered.

Such a system offers the following advantages:

- Standards can be accessed by all partners
- Information retrieval is eased
- All partners work with up-to-date informations
- Deployment of updated standards is no longer required
- Consolidation, i. e. central management of information used within a shipyard and by the partners
- If needed partner only sees the standards they have to see

### 3 Quality enhancement in design process

First of all the meaning of quality enhancement in the design process must be defined. Therefor some criteria for a later measurement of the quality will be declared. As the main goal, reducing costs in the design process, the following criteria are able to show the quality enhancement.

**Simplicity** Decisions and calculations should be done by an electronic system as much as possible. Engineers have access to the electronic standard catalog and can use both standardized parts and methods for the design process. So these process will be simplified, the quality of the results is increased.

**Reproducibility** Based on workflow definitions and standardized parts as base, every step through the design process is reproduceable. Engineers can execute the workflows step-by-step guided by a “wizard”, backtracking and undo functionality are supported. All solutions for a given problem are identical, so the quality increased.

**Usability** Tools for supporting the design process should have an easy understandable user interface.

For the tests of quality enhancement a suitable testbed is needed. Based on the system architecture of the application KonSenS the Tribon-integrated client solution used, see figure 3. So, there are two machines, the KonSenS Server with a standard installation and the CAD Workstation with Tribon M3 and the KonSenS client software installed. Both machines are connected via network (intranet).

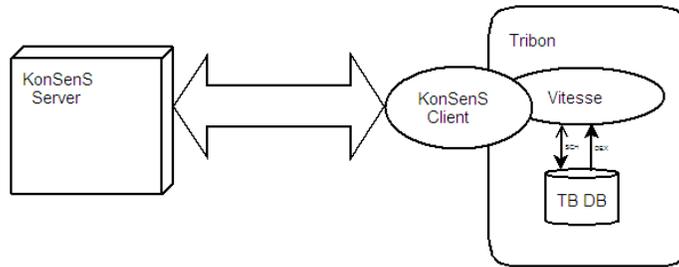


Figure 3: Infrastructure for testing quality enhancement

The placement of brackets as one step of the detail design will be exemplary used for further analysis of the quality enhancement. Going this way, a standardized description of all brackets available is needed.

### 3.1 Standardization of brackets

Brackets are parts, that means they are solid objects used as main structures in steel structural design. For standardization purposes all brackets used by the shipyard must be describeable in a unique manner. A parametric description is used to achieve this requirement *Hoffmann (2005)*. Figure 4 shows some of the used parameters. The denotation of these parameters is derived from the

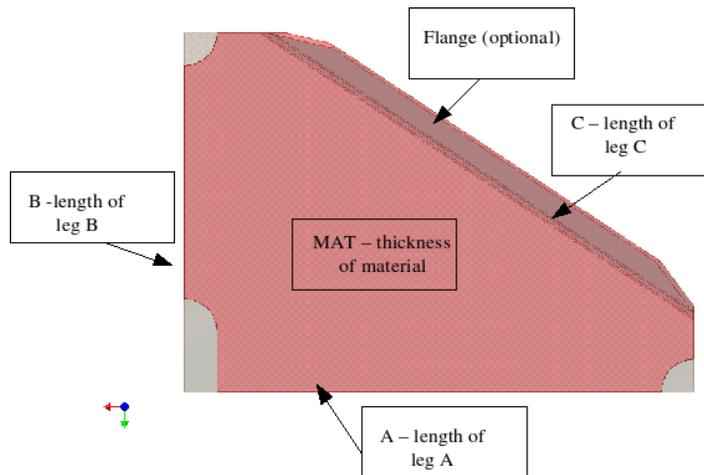


Figure 4: Some parameters for bracket description

syntax used by the Tribon system. Table 1 shows all parameters needed for the

description of a bracket. More parameters, acting as constraints for example to

Table 1: Parameters for bracket description

name	description	needed for	remarks
A	length of leg A	description	mandatory
B	length of leg B	description	mandatory
C	length of leg C	description	mandatory
MAT	the thickness	description	mandatory
FL	is bracket flanged?	description	calculated by rule
NOA	notch on leg A	description	association to feature
NOB	notch on leg B	description	association to feature
NOT	notch on leg C	description	association to feature
FP	connectable to flatbar	placement	
HP	connectable to bulb profiles	placement	

assign the bracket to a single project, are associated to the bracket in the same manner.

By this way, all parts and features used on a shipyard can be added to the standard catalog used for all projects on this yard.

### 3.2 Standardization of bracket placement

Based on the electronic standard catalog, all suitable brackets are well defined. The placement procedure is based on several workflows, executed by the workflow engine of the KonSenS Server.

Such workflows can be described as activity diagrams. Figure 5 shows the activities needed for the placement of brackets. Activities can be either actions like user input or computing processes like the calculation of the bracket dimensions. The whole process is divided into five single steps:

1. **Selection of bracket buildform** First of all the user must select the place of installation for bracket to place for. This can be:
  - Profile/Profile:** The bracket is connected to two profiles.
  - Profile/Panel:** The bracket is connected to a panel and a profile.
  - Panel/Panel:** The bracket is connected to two panels.
2. **Selection of the objects** Based on the installation location the user selects the objects, which will be connected with the bracket, usually in the CAD-System.
3. **Dimensioning** Based on the dimension of the panels/profiles the system KonSenS calculates the correct dimensions for the bracket. Furthermore, the decision, if the bracket will be flanged, is done in this step. All matching results from the standard catalog are presented to the user.

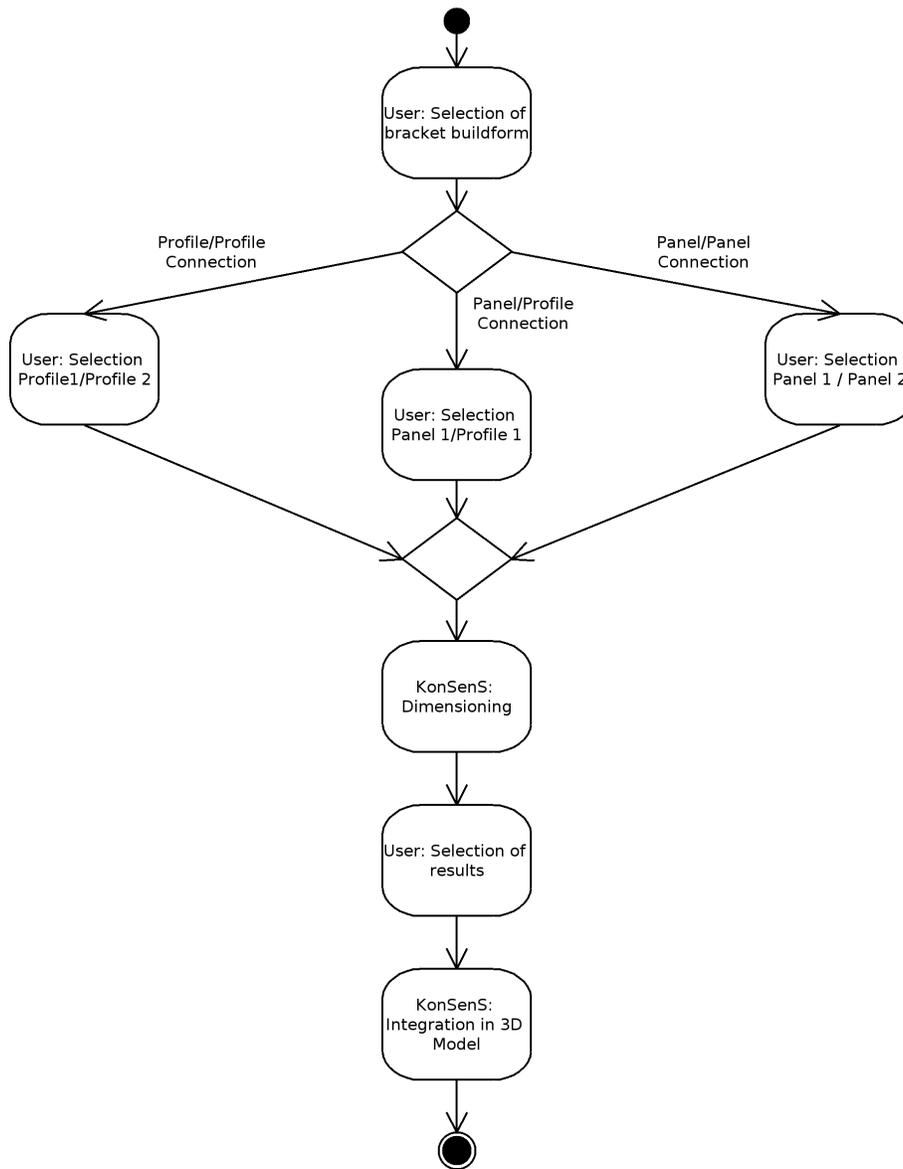


Figure 5: Activity diagram for bracket placement

4. **Selection of results and integration of founded bracket into the 3D-model** If more than one bracket will match all requirements, the user can select the adequate bracket from a list with all founded brackets. Based on this selection a statement for the creation of the bracket is generated and executed in the CAD-System.

For other parts or features like stiffeners placement workflows can be defined in the same manner.

### 3.3 Bracket placement in Tribon M3

To place a bracket the engineer must select the objects which should be connected with the bracket. Now the user selects the buildform (syntax) of the bracket. In Tribon there are seven buildforms available, the right choice is based on the users knowledge. After this selection, a dialog is shown, asking for the parameters of the bracket. As shown in figure 6 this dialog is very complex.

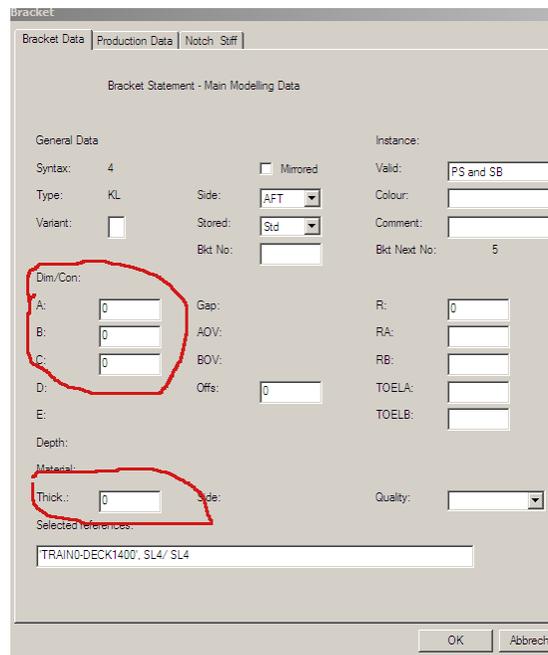


Figure 6: Property dialog for brackets in Tribon

The engineer must calculate the right dimensions for the parameters A, B and C. Other parameters like notches are found at the tab “Notch Stiff”. So switching between tabs is necessary; usability is poor. After setting all needed data, the bracket is created in the 3D-model. There is no support for engineers, they only have their knowledge and documents describing the yard standard.

### 3.4 Bracket placement using the system KonSenS

As seen in figure 3 the KonSenS-client is partially integrated in the system Tribon. All user input is done via the Tribon user interface.

For bracket placement the user select the accordant workflow from the menu (figure 7). Now the workflow shown in figure 5 is executed. The engineer will

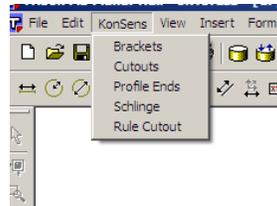


Figure 7: Selection of workflow for bracket placement

ask for the bracket buildform by a dialog which shows all possible buildforms as pictures, as seen in figure 8. Next, the user selects the two objects for bracket

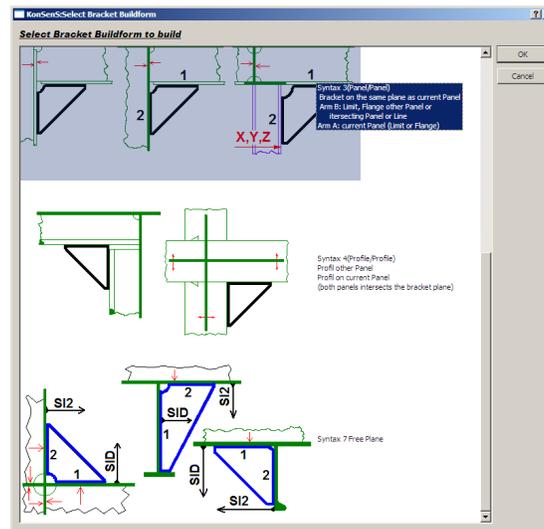


Figure 8: Selection of bracket buildform

placement in the 3D-model. The system KonSenS calculates the dimensions for the brackets by rules. The result is shown in a dialog (figure 9). Advanced users can edit the resulting statement here. Also variable data, which need user interaction and system specifics (for example Tribon) can be edited in this dialog. Last, the generated statement is executed, the bracket is generated.

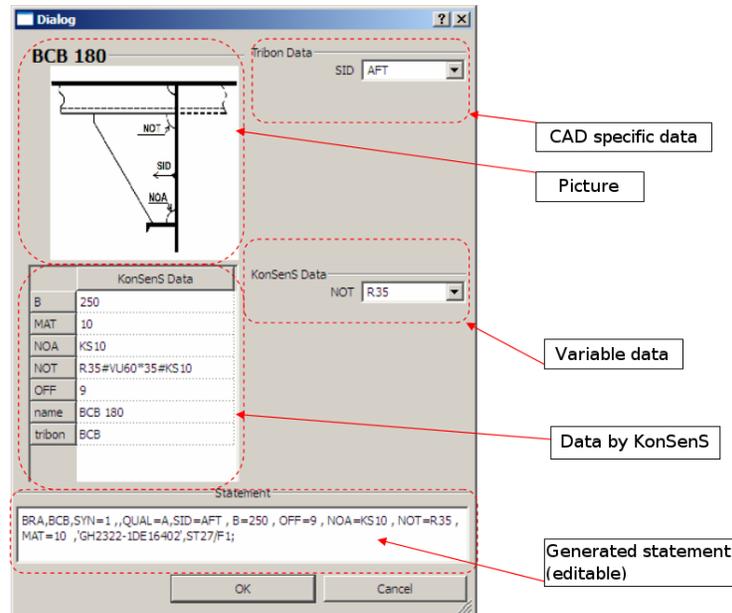


Figure 9: Presentation of matching brackets

### 3.5 Comparison of variants for bracket placement

Table 2 shows a comparison of interaction for both variants of bracket generation. As seen, the generation of a bracket is done in eleven steps. By using Tribon only, all these steps are triggered by user interaction. With KonSenS only five user interactions are needed, the other, mostly complex steps are done by system. The process of bracket placement is drastically simplified. Using the automatically dimensioning of brackets the amount of possible errors can be minimized, engineers will be comfortably guided through the design process. Usability is improved by minimizing decisions per dialog; the dialogs are clearly arranged. Looking at the further defined quality criteria quality in design process is enhanced.

## 4 Summary

The design process in steel structural design is very complex, standardized parts and methods can be used to simplify it. Giving all engineers access to up-to-date informations about both standards and workflows design time can be reduced. User interaction are minimized, selection and dimensioning of used parts are mostly done by the system.

Accumulating all these advantages quality in design process can be enhanced.

Table 2: Comparison of interaction

#	interaction name	by	Tribon	KonSenS	
			possible errors	by	possible errors
1	activate panel	user	-	user	-
2	menu selection	user	-	user	-
3	selection - build-form	user	-	user	-
4	selection - profiles	user	-	user	-
5	selection - bracket type	user	-	system	-
6	selection - bracket	user	-		
7	selection - bracket parameters	user	parameters not allowed for	system	-
8	selection - parameter values from catalog	user	wrong dimensions selected	system	-
9	input parameter A, B, MAT	user	input errors parameters not set	system	-
10	change to tab "Notch Stiff"	user	input error	system	-
11	input parameter NOTCH, H	user	input error parameters not set	system	-

## 5 Acknowledgment

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