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# PRESENT STATE ANALYSIS OF TEKLA STRUCTURES COMPONENTS - HOW TO IMPROVE THE USER EXPERIENCE

Master of Science thesis

Examiner: prof. Mikko Malaska
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# ABSTRACT

**IIDA KUMMALA**: Present state analysis of Tekla Structures components - How to improve the user experience
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Tekla Structures (TS) is building information modeling (BIM) software that provides a program to model complex structures for structural engineers. The new user interface of TS was launched in March 2016, which initiated the study of TS components.

Currently, Tekla Structures contains system components and custom components. Additionally, there is AutoConnection feature to automate the modeling of the steel connections. In the new system, there are new components that have been created along the way, on top of the old ones. Therefore, there are over 700 components in TS version 2016 environment, which includes the old components from previous versions.

For this study the information was collected by doing interview, and analyzing user data, component help data, real-life cases and from web survey. In the beginning of the study, the current system and custom components and their importance were defined and their problems were examined. Based on the data collected, improvement proposals were made, which were reviewed by the end users.

In general, TS components were considered functional, and most of the problems mainly concerned a novice user. The two main findings were that the single small problems within specific components should be fixed, and the component needs to be exploded to finish the design. The biggest problem with the component dialog was that the default values were not shown and component dialogs of the complex components were considered as confusing. Other issues that was found were that the new components were difficult to find from Tekla Warehouse, the component catalog search does not always find the right component, and the differences of the similar components cannot be known without trying.

In the end, proposals on the component catalog, and dialog as well as the modeling of the components, were presented, and reviewed in a web survey. The 3D guidance of the component dialog was rated as the most useful proposal in the survey. The users found most of the proposals useful, but they were concerned that these improvements should not decrease the speed of the task or the process of the program.

# TIIVISTELMÄ

**IIDA KUMMALA**: Tekla Structures komponenttien nykytila-analyysi - Kuinka käyttäjäkokemusta voidaan parantaa
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Avainsanat: Tekla Structures, TS, tietomallintaminen, BIM, komponentit

Tekla Structures (TS) on tietomallinnusohjelma, jolla rakennesuunnittelijat voivat mallintaa monimutkaisia rakenteita. TS ohjelmaan julkaistiin uusi käyttöliittymä maaliskuussa 2016, joka herätti mielenkiinnon TS komponenttien tutkimukseen.

Nykyisin TS sisältää järjestelmän omia komponentteja sekä ulkopuolisten luomia komponentteja. Lisäksi ohjelmaan kuuluu Autonnection-ominaisuus, jolla voidaan automatisoida teräsliitoskomponenttien luomista. Uusia komponentteja on tehty matkan varrella lisää, mutta vanhoja komponentteja ei ole poistettu. Siksi nykyään TS 2016 version ympäristöissä on yli 700 järjestelmän omaa komponenttia.

Tietoa kerättiin haastattelusta, datan analyysistä, komponenttien aputiedostoista, toteutuneista asiakkaiden tietomalleista sekä verkkokyselystä. Alussa määriteltiin komponenttien käyttö ja tärkeys sekä kerättiin tietoa ongelmista. Lopuksi ongelmiin kehiteltiin ratkaisuvaihtoehtoja, joita arvioitiin käyttäjille tehdyn verkkokyselyn avulla.

Pääosin TS komponenteista pidettiin ja suurin osa ongelmista kohdistui aloitteleviin käyttäjiin. Komponenttien ydinongelmiksi nousivat komponentin pakollinen räjäyttäminen, sekä yksittäisten komponenttien virheet. Komponentti-valintaikkunan suurin ongelma on, että oletusarvot eivät ole näkyvissä ja monimutkaisten komponenttien komponentti-valintaikkunat koettiin sekaviksi. Muita ongelmia olivat: uusien komponenttien hakeminen Tekla Warehouse-palvelusta oli hankalaa, komponenttien haku katalogista ei aina löytänyt oikeaa komponenttia ja katalogissa oli paljon samankaltaisia komponentteja.

Lopuksi parannusehdotukset liittyen komponenttikatalogiin, komponentti-valintaikkunaan ja komponentin mallintamiseen arvioitiin verkkokyselyssä. Komponentti-valintaikkunaan lisätty visuaalinen ohjaus arvosteltiin kaikkein hyödyllisimmäksi parannusehdotukseksi. Pääasiassa kaikista parannusehdotuksista pidettiin, mutta tärkeämpänä käyttäjät pitivät, että parannusehdotukset eivät haittaa prosessien ja tehtävien nopeutta.

# PREFACE

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I would like to express my gratitude to my supervisor, Professor Mikko Malaska.

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Espoo, 8.2.2017

Iida Kummala

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# LIST OF ABBREVIATIONS AND TERMINOLOGY

| | |
|---|---|
| API | Application programming interface |
| AUF | Automatic user feedback |
| BEC | Finnish Precast Industry's Modeling Instructions |
| BIM | Building information modelling |
| CAD | Computer-aided drafting |
| CIP | Cast-in-place |
| IFC | Industry Foundation Classes |
| IT | Information technology |
| TS | Tekla Structures |
| UI | User interface |

| | |
|---|---|
| AutoConnection | TS tool that creates connections with predefined properties in certain framing conditions |
| AutoDefaults | Predefined properties that AutoConnection uses when creating connection |
| Component | Functionality that is used for creating a group of model objects that are easy to model and modify as a single unit |
| Custom component | Component that the user created and uses for creating model objects |
| Custom part | Component for creating a part that cannot be created by using any existing part command or profile |
| Direct modification | Allows user to modify the model objects by using handles |
| Extension | Functionality that is not included in the Tekla Structures installation. |
| Feature | Functionality that is maintained and owned by Trimble Solutions and that is included in the Tekla Structures installation |
| Nested component | Component that consist of several components |
| Plug-in | Component that is developed using Tekla Open API |
| Rebar | Reinforcing bar in the TS |
| System component | Component that is included in a TS configuration. |
| Tekla Structures | BIM software for organizations that operate in design, detailing, manufacturing, and construction |
| TS Environment | Region- or company-specific settings and information that are predefined in Tekla Structures or that are defined by the user |

# 1. INTRODUCTION

## 1.1 Background

Building information modeling (BIM) is a new trend in construction that is already being used. One descriptive definition of BIM by National BIM Standard-United States is:

*"Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from the earliest conception to demolition."* [1]

BIM (4D) is conquering area from computer-aided drafting (CAD) (2D/3D) in architecture, engineering and construction industries. The advantage of BIM compared to a CAD is the ability to combine data and information throughout the building process. [2] Additionally, a survey was released in 2016 of BIM use in the UK, and it supports the value of BIM in project delivery, and it considers the poor predictability as the main problem with 2D methods [3].

Tekla Structures (TS) is BIM software for structural engineers, detailers, and fabricators. TS supports communication between project participants, and provides accurate information of materials, and the geometry of structures among other functionalities, which are highly appreciated, especially in complex construction projects. [4]

TS can be used with all materials, to model complex structures, and to detail the structures with components. Earlier, several masters' thesis projects have been conducted in order to improve TS. The most recent studies were about a cast-in-place concept and filtering. [5; 6]

## 1.2 Statement of the problem

TS version 2016 renewed its user interface initiated the study on TS components' usability and improvement proposals. TS 2016 version environments contain over 700 system components. These components contain modeling components for steel and concrete structures, as well as other modeling tools, such as copying or creating IFC files. The system components come with the TS environment. Additionally, TS has AutoConnection, which creates automatically connections between steel parts by defined rules. These rules have not been developed and it is only for steel connections.

Moreover, there are custom components that can be company's, fabricator's or user's own component. The amount of custom components is not known. Some of the custom components can be found at Tekla Warehouse and others are only in companies' or user's own folders.

The user might find it difficult to find the right component, or even use a wrong one due to the large number of system components within the program. Additionally, maintaining this large amount of components is expensive, and also, some of the old components are difficult to maintain. TS contains AutoConnection feature to automate connections for steel structures but it is unclear how widely the feature is now used, and what is the usability of the feature. These issues are known but they have not been studied before.

## 1.3 Aim of the research

The main target of the research is to find the status of the current system components, and to define and evaluate improvement proposals for near and far future. The set target is to be met, by answering the following research questions.

1. Which areas of the components needs development and what are the problems?
2. How to improve the components?
3. Is it possible to reduce the amount of system components or possibly remove them?

## 1.4 Outline of the thesis

To cover the components' current use and problems, both, quantitative and qualitative research methods were used. A qualitative method, open interview with an engineering office was selected instead of a quantitative question form in order to avoid leading participants' answers, and to have the possibility to reveal new important aspects of components. A quantitative method was used to determine the most started components in automatic user feedback -programs' data and in different TS environments. TS system components' properties and starting frequencies in AUF-data were inspected. Additionally, total amount, and the different types of components in real-life models were counted. With these studies, the current state of TS components were covered. Information of the current state and main problems were used to develop, and examine the possible improvement ideas. The ideas are divided in two groups; the ones that improve the functionality with the current components, and one idea of a new component concept.

The main theoretical background is presented in the beginning of the thesis. It consists of TS software development history, and an explanation of the TS components' functionalities. After that the research methods mentioned earlier are described more in

detail. The following chapters present the results of each method, and the related discussion. At the end, all the results are summarized.

# 2. TEKLA STRUCTURES (TS)

In this chapter, software and its components are presented. Starting with development history and continuing through user interfaces to components purpose and functionality.

## 2.1 Development history

Structural engineering software Xsteel was launched in 1993 for steel engineers. Based on Xsteel, Tekla Structures (TS) was launched in 2004 and in TS most of the users are still steel engineers. After the launce, Tekla has released the developed main version every year. In 2011, Tekla became a part of Trimble but software name remained as TS. At the beginning of 2016, Tekla was rebranded as Trimble. For the customer, the biggest change was the new user interface (UI). The old UI in TS 21 and new UI in TS 2016 is shown in Figure 2.1. Additionally, in TS 2016 *Applications & components* catalog moved to side pane but component dialog boxes or functionalities did not change. [7]

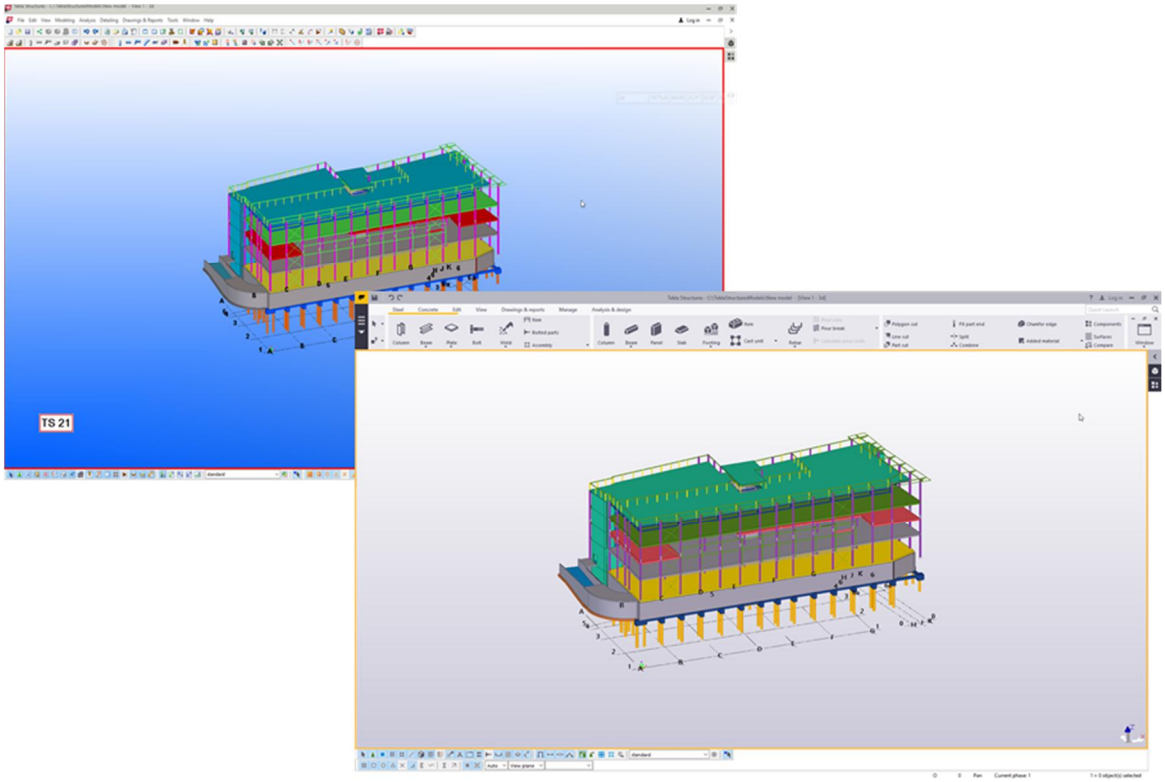


***Figure 2.1.*** *User interface of TS 21.1 and rebranded view of TS 2016i.*

## 2.2 Localization

TS localization aims to respond to the local demands of the program to increase user experience and make working with software more efficient. This is done with technical localization called environments and with language localization.

TS have more than thirty environments that have their specific settings and information for each region for example default settings for components. TS 2016 version environments contain over 700 modeling components. The exact amount of component depends on the environment, for example, default environment contains 732 different components and UK environment contains 735 different components in component catalog. Most of the components are the same depending on the environment. TS 2016 version environment installations from March until July 2016 are listed by most used environment:

1. Default project
2. Blank project
3. US imperial
4. UK
5. France
6. Netherlands
7. China
8. US metric
9. Germany
10. Australasia
11. South-East-Asia
12. Russia
13. Korea
14. Finland
15. Italy
16. Middle East
17. Sweden
18. India
19. Norway
20. Japan
21. Poland
22. Spain
23. South Africa
24. Brazil
25. Switzerland
26. Portugal
27. Czech Republic
28. South America (Spanish)
29. Hungary

Most frequently installed environment to TS 2016 is default environment which is developed for the customer who does not have their own country or region specific environment. The second most installed environment is blank environment, where user can create and define their own specific settings and save it. Blank environment contains only generic content and everything else can be downloaded from Tekla Warehouse or from the users' own files. The Blank project comes with TS software installation and other environments can be downloaded from Tekla Warehouse. Most installed country or region based environments were the US imperial, France and Netherlands.

## 2.3 Tekla Warehouse

Tekla Warehouse is TS BIM storage. Basically, TS capability is extended by Tekla Warehouse. It contains a wide range of applications, custom components, parts, profiles, materials, bolts and many more. In addition, users can share content with colleagues using network collections. To use local and network collections TS 20.1 SR1 or newer version is required. Tekla Warehouse can be used online or with TS. [8]

Tekla Warehouse contains TS user content, suppliers and fabricators content to model more efficiently. Some engineering offices, suppliers or fabricators have software engineers who design and develop features for the company use and another way is to buy these. The content can be basically private or public and local or global. The content can be browsed online (Figure 2.2) and some content is also available offline.

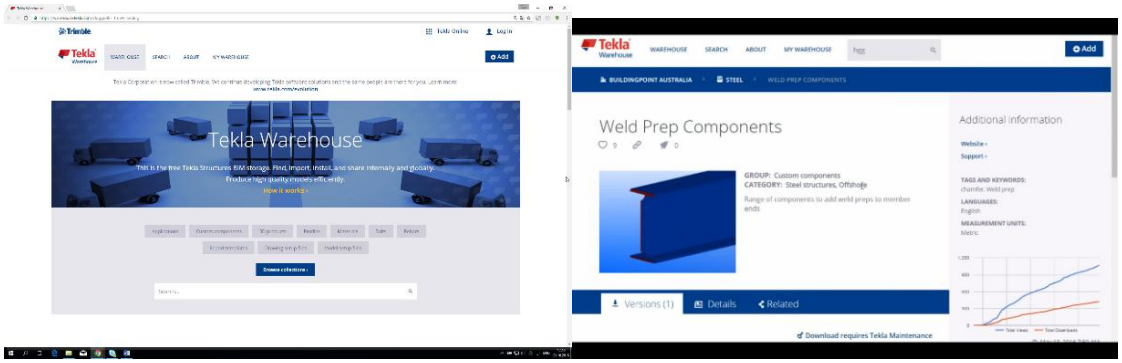


***Figure 2.2.*** *Tekla Warehouse online and content.*

## 2.4 Components

Component is a single unit that consists of modeling objects. Object can be for example item, part, or construction line. Modeling and especially detailing are easier and faster with components. In TS components can be grouped by the purpose of the component creator of the component or development method. [9]

First, components can be grouped into five main categories based on what they are used for. These are connection components, detail components, detailing components, custom parts and custom seams. This type of grouping is used in TS *Applications & components* catalogs' default groups that are explained below.[9]

Second, components can be grouped into system components and custom components by the creator of the component. System components are included in a TSs configuration and user can modify the component from the component properties. One of the benefits of system components contain intelligence to adapt to the changes in the model. Custom components are created by user and they can be used the similar way as system

components. In the custom component editor, user can create intelligent components that automatically response to changes in model. [9]

Third, components can be grouped by the development method. Most and oldest components have been made by using TS' own developer kit whereas the newest components are plug-in components. New plug-ins, macros, extensions and applications can be created with Tekla Open API™. It is implemented using Microsoft® .NET Framework technology and developed by Tekla. With Tekla Open API user can develop applications and additional functionality on the Tekla modeling platform integrate it into TS' own environment. [9]

The first grouping by the purpose of the components could be the most significant to user. Since the first grouping is used in TS *Applications & components catalog* groups, and the creation of the new component depends on the purpose of the component. The second grouping is important in assessing the differences and importance of system and custom components to user. The last group is more of technical background of the components which is important for component developers.

## 2.5 Applications & components catalog

Components can be found in the *Applications & components* catalog that is located in the side pane of TS. Catalog contains different TS components and groups depending on TS environment used. TS environments contain system components but customers might have made company environments that may also contain custom components.

The *Applications & components catalog* has two types of groups: default groups and predefined groups. In Figure 2.3 the default groups are written on a light grey background and predefined groups on a white background. All TS configurations contain default groups and predefined groups depend on environment. The user can modify the catalog by hiding or creating new groups and subgroups. Nevertheless, default type of groups' content cannot be change by removing or adding, a component or a group. User can only hide the default groups and the default components. The hidden groups and components are shown when hidden items' check box at the bottom of the catalog is checked. The *Applications & components* catalog groups are by default saved in a file in the model folder.

The topmost group, "Recent" is a default group that contains the most recently used twelve components and applications. The following default group is "Ungrouped items", containing imported components not assigned to group and other components and applications that are not in any predefined groups. The rest of the default groups are divided by the purpose of the components, except the custom seam is placed in connection group.

The catalog view can be changed using the component catalog top buttons. The compact view shows only small thumbnail pictures and the catalog view shows components' names and component type symbols. User can add the thumbnail pictures to the components.

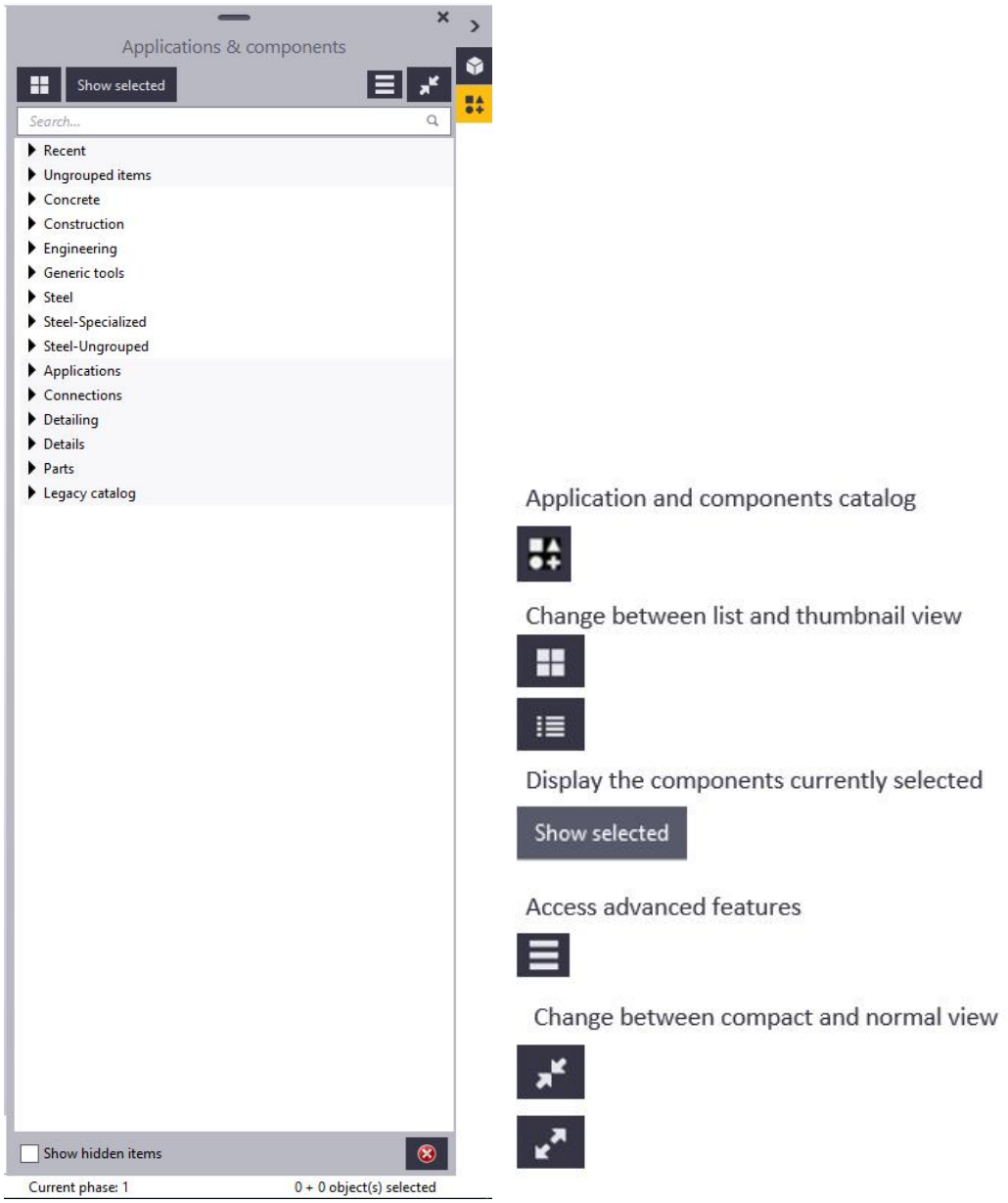


***Figure 2.3.*** *TS default environment's Applications & components catalog and icons*

Components can be searched in the catalog by browsing the groups or with the search box. User can search components by numbers that will show exact results or number results can be extended for partial numeric matches with wildcards (*, ?, [ ]). For non-numeric search, the results are always partial matches. The search shows the entered search term that has a match or partial match with a component name, description or tag. To improve the search user can define tags and description for the components.

## 2.6 Component dialog box

Component properties can be modified in component dialog box shown in Figure 2.4 that can be opened from *Application & components catalog* or from the model clicking the existing components' symbol. Properties are organized in tabs and sometimes in buttons.

The tabs can be Picture tab, Plates tab, Stiffeners, General etc. and buttons are usually for welds, like in End plate (144) component dialog box in Figure 2.4. Most of the system components have first Picture tab which purpose is to show the created parts and parts selection order to create the component. In the component dialog box, the parts that component creates are yellow and parts already existing are blue.

The tabs contain variable boxes and drop down menus to modify the component. There are two type of variables: the parametric variables to define object properties and distance variables such as bolt distance or distance between two plates.

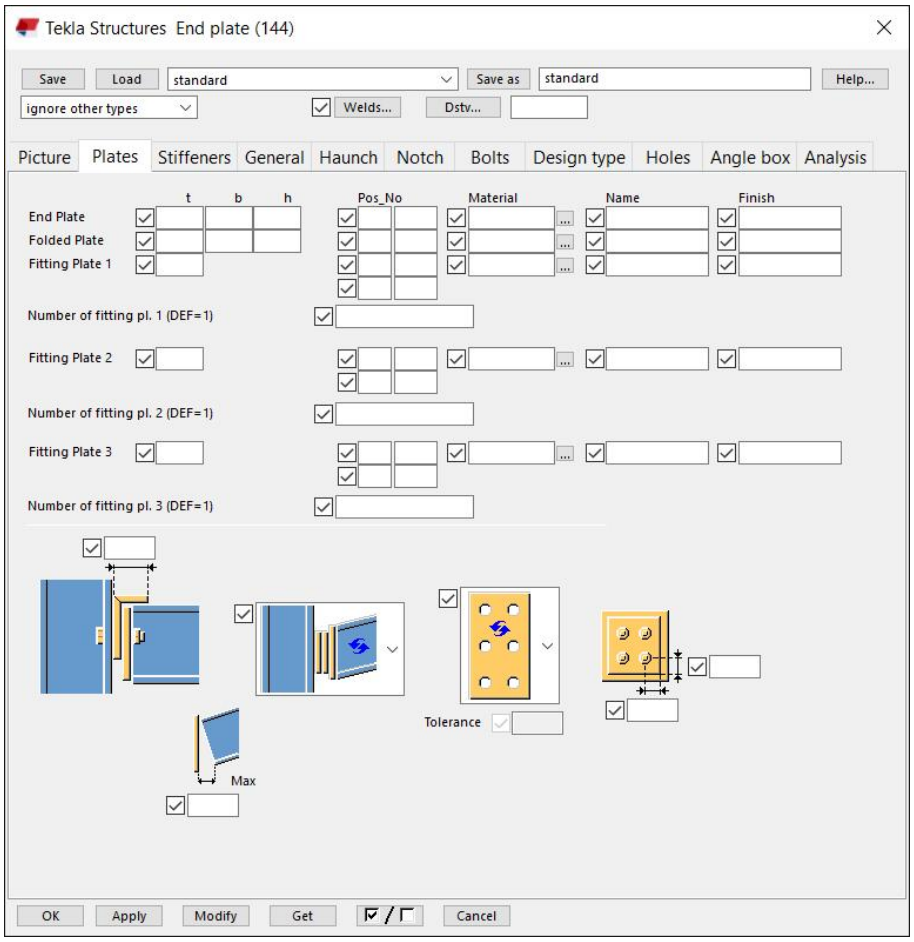


***Figure 2.4.*** *TS system component dialog box*

The default values are optimized depending on the object or objects they are attached to. Currently, the default values are not visible in TS system component dialog boxes before or after creating the component. For some steel components, values can be checked and edited from the joints.def file. Otherwise, after creating the component, default values can be viewed from the model. User can use own or other predefined settings for the component from the upper part of the dialog box using load and save buttons.

A dropdown menu contains sometimes pictures, which have options for creating a component with AutoDefault rules , AutoConnection rules  or user defined option

without a symbol. Usually in Picture tab component might have the up direction symbol  which indicates the connection or detail components position to current work plane, and if needed the default up direction can be changed on General tab. [10]

Each custom component has a dialog box like system components and it can be edited in a custom component editor shown in Figure 2.5. User can add images, tabs and list to facilitate change component properties.

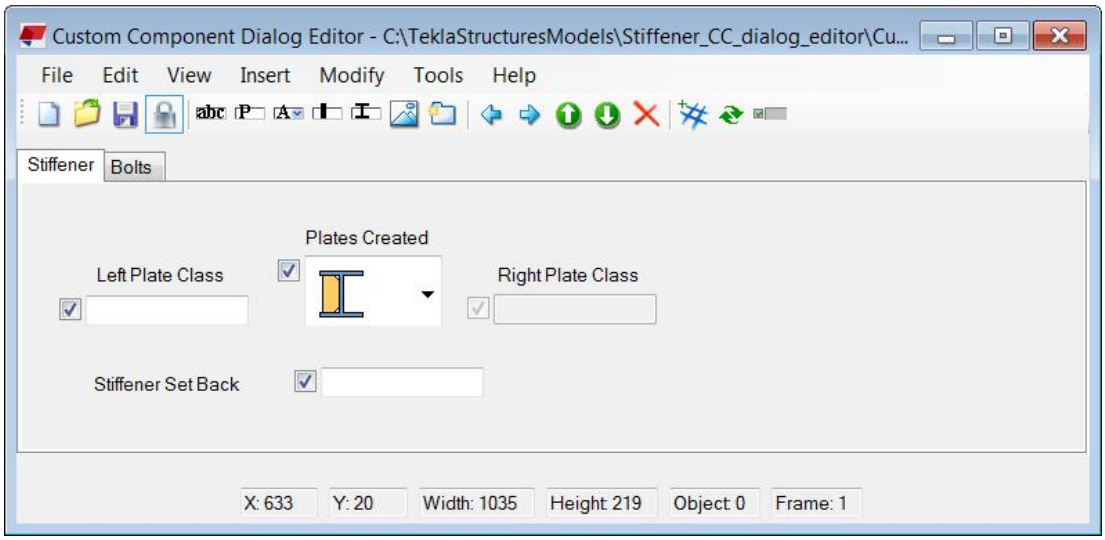


***Figure 2.5.*** *Custom component dialog editor*

## 2.7 Modeling components

There are three different ways to create a component: selecting the component from application and component catalog, using AutoConnection or with Current connection command. After creating a component, it can be copied, modified, exploded or removed.

A component can be inserted into a model in several ways depending on the purpose of the component. The purposes are divided into five basic types that are also default groups in the component catalog. The connection components are created by selecting first the main part and then one or more secondary parts. Detail components are automatically connected to components' main part to selected location. Detailing components creates the assembling component objects for building a structure. Detailing components does not always have the main part and secondary parts like other component groups. Custom part is a part that cannot be created by using any existing part command or part profile. A good example of a custom part is Cross plate profile (S33) macro that creates a built-up straight beam from plates that are welded together. Last group is custom seams that creates a seam between parts like Sandwich Wall Vertical Seam. The *Applications &*

*components catalog* default groups are divided to these groups, but custom seams can be found from connections group. [9]

Creating components using AutoConnection tool creates similar connections for similar framing conditions. First user needs first select connecting parts from the model and then define AutoConnection rule group or advanced tab. With AutoConnection user can create connection to whole model by selecting all parts in the model. [11]

Creating components using a current component command is like copying similar component to other places in the model. For example, user creates End plate (144) connection system component, user can use after that current component command and select parts where the End plate (144) connection is created with last used properties. Array of objects (29) component is a tool for copying modeling objects or components along a selected line. By modifying the original object of the Array of objects (29) all the objects in the array are modified. [12]

After creating a component, TS shows a component symbol for the connection and detail type of component. The symbol can be green, yellow or red as shown in Figure 2.6. The symbol color presents the component status. The green color means that component was created successfully. The yellow symbol means that component was created but it has problems like bolts or holes have edge distance that is less than default value. The red symbol means that component was not created which can occur when some properties are incorrect like some connection components only work with specific profiles. [13]

***Figure 2.6.*** *Connection and detail components' color symbols the component creation status. (Green-successfully, Yellow-created but has problems, and Red-not created)*

Detailing components symbol is a blue circle with letter M inside shown in Figure 2.7. Detailing components does not have connection and detail components colors that indicates if the component was created successfully. [13]

***Figure 2.7.*** *Detailing component symbol*

Component properties can be changed in component dialog box. If the component properties need to be changed, it can be done by opening the component dialog box and by loading new settings or by adding wanted changes manually into a dialog box. If the component does not meet the user's requirements after the modifications, user can explode the component. After exploding the component, component parts become single

modeling parts that can be modified separately. Usually, it is useful to use some basic component even though you won't be able to finish it with the component tools.

Moreover, user can use a system or a custom component to make a new custom component by exploding a similar component and set the objects to suit the need. However, after exploding a system component, modeling objects lose their intelligence. Still, as mentioned before, in custom component dialog editor user can add rules and measures to the custom component. After creating the custom component, the new component is placed on *Applications & components catalog*. The custom component can be a connection, detail, part or seam type of a component. [14]

By combining components, user can create nested components where original components become the sub-components of the nested component. Additionally, not only components can be added but also the model objects can be included in the nested component. A nested component is more advanced type of a custom component than the standard custom component that contains only model objects. [15]

# 3. METHODS AND MATERIAL

In this chapter, research methods and material are presented. Both quantitative and qualitative methods are used to gather the information about TS components. The qualitative part of this research includes an open group interview for TS users in an engineering company and individual discussions with the participants after the interview process. The quantitative data analysis is composed from automatic user feedback (AUF)-data. The analysis results are compared with real-life customer models with components. This analysis gives a good idea of TS current components' usability. Based on the results of TS components' current usability study, possible improvement ideas are presented. In the end, the problems and improvement proposals are reviewed using a component survey.

## 3.1 Interview of one structural engineer company

The main target of the one group interview with actual users is to collect their experiences of TS components. Interview was an open interview in order to reveal most important issues without leading the conversation. Before the interview, the participants were told that the purpose is to collect experiences about TS components and the individuals can tell what they want about the TS components. The structure of the interview was that each participant could tell their own experiences on the components. A few specific questions for participant subject were made but mainly the participants defined the content of the interview.

The engineering company had not yet started to use TS version 2016. The interview was recorded for later review. Interviewees' work tasks varied from structural engineers to BIM developer in the structural engineer office. Moreover, participants had a different experience with TS, one had worked with TS since Xsteel and another had a couple of year experience with TS. After the interview, the main problems were collected and for some issues specifications were asked by email.

## 3.2 Data analysis

AUF-data is collected globally from TS users who have agreed to participate in the AUF-program. The data collects information about the used commands, but however it does not collect identified data from user so it is impossible to know how many user sends the data. In this study, data was collected from January 2013 to June 2016.

The data collected is saved to the user feedback log that consists of three chapters shown in Figure 3.1. First chapter in the user feedback log is basic information for example, the TS version, language and environment. Second chapter is the information of the user's

computer such as RAM and operation system version. Third chapter is the user's log where first column is a timestamp, after which there is the used command and its' additional information in the parenthesis.

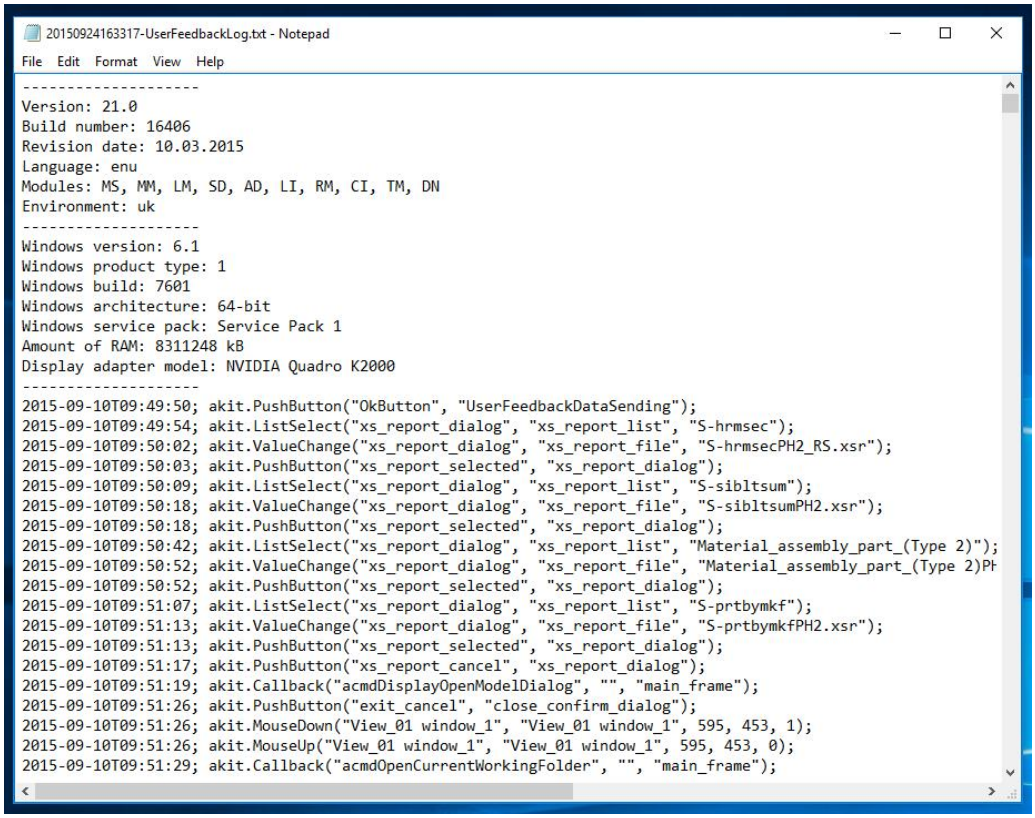


***Figure 3.1.*** *Example of a user feedback log*

Before using the data, the log files are converted from txt to .csv, so that the data analytic program can use it correctly. By adding the basic data of TS and computer from the top of the log file to rows with like user's log. After conversion, components starting command, "akit.CommandStart-command", are extracted from the data. This extracted data is analyzed and visualized using the data analysis program, Power BI shown in Figure 3.2. In Power BI, parameters 1 and 2 together identify the component.

| DateTime | Command | Param1 | Param2 | Param3 | Param4 | TSVersion | TSBuild | Language | Modules | Environment | All command and parameter |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.7.2014 16.25.13 | akit.CommandStart | ail_create_plugin | ExportIFC | main_frame | | 20.0.3 | 13586 | enu | MS, MM, LM, SD, CD, AD, LI, RM, CI, TM, PM, DN | sweden | ail_create_plugin, ExportIFC |
| 11.8.2014 17.10.56 | akit.CommandStart | ail_create_plugin | ExportIFC | main_frame | | 20.0.4 | 14376 | enu | MS, MM, LM, SD, CD, AD, LI, RM, CI, TM, PM, DN | sweden | ail_create_plugin, ExportIFC |
| 11.8.2014 17.24.13 | akit.CommandStart | ail_create_plugin | ExportIFC | main_frame | | 20.0.4 | 14376 | enu | MS, MM, LM, SD, CD, AD, LI, RM, CI, TM, PM, DN | sweden | ail_create_plugin, ExportIFC |
| 12.5.2014 13.13.37 | akit.CommandStart | ail_create_plugin | ExportIFC | main_frame | | 20.0 Service Release 2 | 13396 | enu | MS, MM, LM, SD, CD, AD, LI, RM, CI, TM, PM, DN | sweden | ail_create_plugin, ExportIFC |
| 12.5.2014 13.16.09 | akit.CommandStart | ail_create_plugin | ExportIFC | main_frame | | 20.0 Service Release 2 | 13396 | enu | MS, MM, LM, SD, CD, AD, LI, RM, CI, TM, PM, DN | sweden | ail_create_plugin, ExportIFC |
| 20.8.2014 15.16.22 | akit.CommandStart | ail_create_plugin | ExportIFC | main_frame | | 20.0.3 | 13586 | enu | MS, MM, LM, SD, CD, AD, LI, RM, CI, TM, PM, DN | sweden | ail_create_plugin, ExportIFC |
| 20.8.2014 15.24.38 | akit.CommandStart | ail_create_plugin | ExportIFC | main_frame | | 20.0.3 | 13586 | enu | MS, MM, LM, SD, CD, AD, LI, RM, CI, TM, PM, DN | sweden | ail_create_plugin, ExportIFC |
| 20.8.2014 15.38.34 | akit.CommandStart | ail_create_plugin | ExportIFC | main_frame | | 20.0.3 | 13586 | enu | MS, MM, LM, SD, CD, AD, LI, RM, CI, TM, PM, DN | sweden | ail_create_plugin, ExportIFC |

***Figure 3.2.*** *Filtered data in Power BI desktop data analyze program.*

The Power BI file was related with the excel file that linked the components' identification in log file to readable names in TS. All the custom components that are created by user does not get any number, consequently the frequency of users' custom component cannot be identified from this data. Since the AUF data comes only from small

part of the users, it cannot be generalized for all TS users. AUF-data is also used in Chapter 6 to compare the use of multiple similar components.

## 3.3 Similar components

TS system components contain multiple similar components of which end plate and stiffener components are studied. These components were selected because both of the components were frequently used in AUF-data and contained similar components. Component helps, component dialog boxes, discussion forum and modeling the components was used to gather information.

The component properties, starting frequency in AUF-data and component dialog box contents are compared and studied in Chapter 6. Each of the studied component's properties are summarized in tables shown in Appendix 1.

## 3.4 Real-life models

Five real-life customer construction project models, three precast concrete models and two steel models were analyzed to identify and calculate the different components used. Purpose of these case models is to inspect how components are used in real projects. First four of the case models were chosen from Tekla BIM Awards models that are models send by customers to Trimble's competition and the fifth steel model was from Tekla support cases where customers ask help for their problems. The main selection criterion for the case models was that the model was is not exploded and contains components. The models were from Finland, Germany and US. The custom components of the real-life case models are presented in Appendix 2.

## 3.5 Improvement proposals

Improvement ideas are presented for current TS component problems. For current system components, the main ideas can be divided into proposals for catalog, dialog box and component modeling. One aim was to find possibilities to combine the current system and custom components for the new components concept.

## 3.6 Survey of component problems and improvement ideas

Last phase of the component study was a survey of problems experienced in the use of current component tools and the development of potential improvement ideas. The survey results are presented as a whole. The survey was sent to Tekla Structures offices in Australia, Canada, Finland, India, Netherlands, Sweden, UK and US. The offices were asked to answer themselves and also to forward the survey to their customers.

Additionally, link to survey was added into Tekla discussion forum. The survey is presented in Appendix 3.

Structure of the survey consists of four parts. First part defines what part of the component creation needs improvement. Second part evaluates the problems of the current TS system components. Third part evaluates the usefulness of proposed improvement ideas. Last part defines the work background with TS such as a job, the latest used TS version and used environments. Additionally, feedback from the survey is collected as well.

# 4. INTERVIEW

In this chapter, the results of the open interview are presented. The comments and problems of component catalog, component dialog box, modeling the component and, developers approach on components are presented and analyzed separately in the following sections.

## 4.1 Component catalog problems and ideas

Two main problems concerning on *Applications and components* catalog were:

1. User does not know which search term to use.
2. A novice user does not know which component to use.

First problem depend on the component name, tags and description that component catalog search uses to find the matching search terms. For example, user wants to create ,a hole in the hollowcore concrete slab and uses “hole” in search term. The search result does not give the right component because the wanted component name contained “opening” instead of “hole”.

Second problem is quite common with steel components that have similarly named components in component catalog, causing extra work for new user to find a proper component by browsing or requires assistant from more experienced user. One of the experienced users says that if he needs to choose from multiple similar components, he chooses the newest component based on the component’s layout. However, there is big difference between steel and concrete users for selecting a component. At interviewed company, for pre-cast-concrete, user has company’s modeling guide which instructs which component to use. In contrary, steel designers did not have guides in that company and because of the long history of steel modeling the amount of steel component is huge.

First problem could be fixed with some kind of search term list. The engineers’ improvement idea for component catalog is to create group or folder, called “day bag”, where user could drag and drop currently needed components from component catalog. In TS version 2016 and 2016i, it is possible to create group and use drag and drop to add components.

## 4.2 Component dialog box problems and ideas

Problems concerning component dialog box were:

1. Default values are not visible in the object variable boxes.
2. Component dialog box contains all the object properties and therefore many variable boxes that might startle especially a novice user.
3. Pictures and labels next to variable box, in component dialog box, do not clearly indicate which variable box belongs to a certain object in the component.
4. The plates (or other parts) have different names in component dialog boxes and help.
5. Difficult to get a full picture of the component's properties because of the division into many tabs.
6. When entering a material value for a plate in a connection, it should be possible to indicate that the value should apply to all the plates in the connection.
7. The current tab arrangement is not logical to steel engineers' needs because the most important is to check numbering series, material, profile (size) and name of the part, bolts and welds.

As presented in Chapter 2.6 component dialog box does not show the default values. A few steel components' the default values can be seen and changed from join.def file. After creating the component with default values the component properties need to be checked from the model.

The second problem concerns mainly a novice user who is working with components that create many modelling objects. Therefore, the component dialog box has many part properties and distance variables.

The third problem is also for complex components; user cannot be certain which part the variable belongs. For example, components with many plates or other similar parts have a picture of a plate without a label or unclearly named label next to variable box such as "plate 1", "plate 2".

The fourth problem, components have help where the used names are based on Tekla Structures Glossary and in component dialog box the names do not always follow the glossary names. Additionally, a few of the component's help are using other names that glossary.

In fifth problem, for user sometimes it is useful to see all the component variables at the same time. For example, user can check and modify component's materials and geometry properties easily. This is related to the sixth problem where used could adjust for example, the material value for all component part in one place.

In last problem, the most important information in component dialog box is not easily accessible. For example, steel components' weld properties are behind the button.

Possible improvement for component dialog box problems, are a simple user interface that should consistently by every step become more precise instead of jumping into the

detailed properties of the components. Second, possibility to customize the user interface as much as possible and ability to see all component properties at one glance. For steel engineers' requirements was that the most important information should more easily accessible and in the first tabs.

## 4.3 Problems and ideas for component modeling

Problems concerning modelling of components are:

1. User needs to explode the component to finish.
2. All components should have such default values that when you create the component the result is something reasonable.
3. Components cause numbering conflicts.
4. There are old fabricator items on component catalog.
5. Users should not make their own components.

First problem and improvement ideas are presented in Chapter 4.6 and fifth problem and possible improvement ideas are presented in Chapter 4.7.

In second problem the component does not create anything. Reason for this might be invalid default values or that the component does not work with selected part.

Fourth problem is fabricators old items on component catalog which might end up in the model. An idea to improve the accurate fabricators data could be fabricators files that contains the current product specifications, for example, Sketchup -file. Each fabricator updates their own files to offer the current product specifications, for example, Peikko changed SBKL plate to Welda plate and these could be changed in file.

Fifth case were not supported. The engineering company's wishes to standardize the use of components among designers, not everyone to make own components. Actually, engineering company wants to guide all designers to use the same component to same detail or connections. The used components should be company's custom components, fabricators custom components or TS's system components.

The company's steel custom components are special steel components for industrial buildings and the components are really good for that situation but are not flexible for other situations. Group of designers that knows how the component works use these components.

In pre-cast-concrete modeling most of the used components are company's custom components or BEC-project components. Opinion of Flooring Layout tool, especially, in TS version 21 was liked and envied by steel designers because of a direct modification in a component. The direct modification is the mode where the model objects can be

modified by using handles. In the future, similar components were hoped so steel components as well.

One wish from the engineer was to remove all old components and code new workable components. The other wish was to fix the main bugs from the current components. Developers' ideas for current and new components are presented next.

## 4.4 Software developers comments

The software developers' point of view of the most relevant and important issues related to components and component modeling:

1. "Open source" thinking with component code as much as possible to get rid of components' small flaws easily.
2. Offering components for user using the selected framing condition.
3. In the future, there should be co-operation with structural engineering office developers to improve the usability of the new component tools.

Developers' improvement idea for the components was the possibility to fix current components' problems. Additionally, totally new components should be developed from a smaller child component that could be part of a mother component. Furthermore, components could contain visual guidance to such as 3D pre-view of a component that shows which part or dimension of the component is editing.

## 4.5 Tekla Warehouse

Typically, users use the component catalog components and only company's BIM coordinator browses and might add new components from Tekla Warehouse to company environment. Some of the users who download updates like import or export tools from Tekla Warehouse might find and try new components. On the other hand, user might try new interesting components, after it is presented in Trimble's event or webinar.

Improvement possibilities for finding new components in Tekla Warehouse. First, improvement idea was to add the advertisement of new components to component catalog so that user does not need to enter the Tekla Warehouse. The second idea, component catalog would as well show the possible components from Tekla Warehouse.

## 4.6 Exploding component

After the interview main reasons for exploding the components was uncertain and additional information were asked via email. The answer to exploding the component is explained with a workflow diagram shown in Figure 4.1 and explained below.

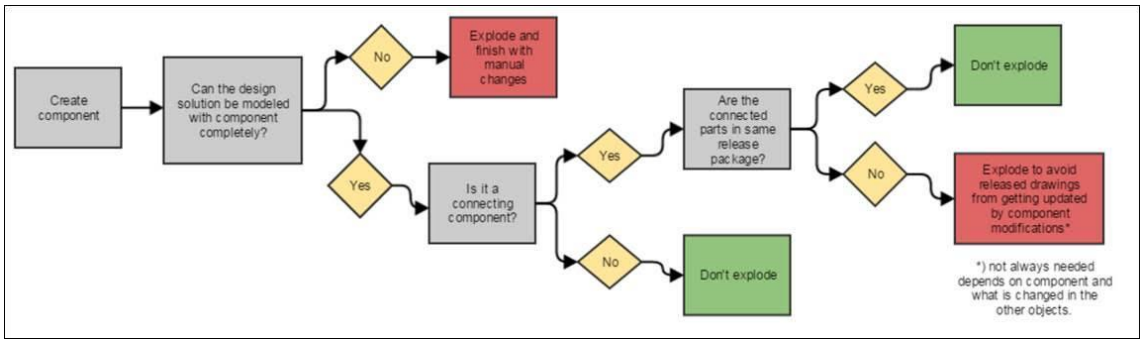


***Figure 4.1.*** *Workflow for exploding the component [16]*

Component exploding cases can be distributed into two cases. First case, user cannot completely finish the design with a component. Some components do not have enough modification options geometry or notches or enough reinforcement spacing options. This happens especially with the complex connections, where one component is created and then exploded to finish the connection details. Tekla system concrete reinforcement tools such as Edge and Corner Reinforcement (62) does not work for all geometry. Other reason for not been able to finish with the component when user selects the wrong component from the similarly named and pictured components.

In second case, a connection component is exploded if connecting parts belong to a different release package. Because quite often columns belong to a different release package than beams, which means that the columns might already be on construction site when the beams are still designed. Therefore, if the beam size is changed, it will update the connection component between beam and the column and it might update the column pictures. To avoid changes in the column, the connection component is exploded.

Improvement ideas to avoid exploding the component. First, problem is fixed with improved geometry modification for components that was said to be one of the main problems with TS system components. For example, more geometry and spacing options are needed for concrete column and beam reinforcement stirrups. Currently especially the column top additional reinforcement stirrup options are not sufficient.

## 4.7 Numbering problems and ideas

As previously said, components cause problems to numbering. Next some of the possible numbering problems and ideas are presented.

Numbering Case 1: Elements are copied from the first floor to sixth floor. The second floor element is the first copy and it gets a different number than the first element. Nevertheless, the following copies from third to sixth floor get the same number as the first copied element on second floor.

Numbering Case 2: With Floor layout tool, it is not possible to make changes to numbering settings afterwards and if changes have been modified with direct modification the numbering will not transmit to other component objects. Numbering should transmit and there should be an option to leave or overwrite the direct modification.

Numbering Case 3: One casting part contains six to ten components which should have one number and adjust in one place. As well, Tekla's -1 rule is not good because then other element might get a wrong number. This happens when a designer does not change the numbering property from a component. The casting part should automatically attach to the main part so it would not create the numbering conflict.

Numbering Case 4: In model sharing, some of the elements numbering changed later because of added casting part. Causing the numbering problem that is not for a typical structural engineer to return the numbering. Numbering has to be done again so that the element numbers are returned to match the previous numbering. One possible solution for the numbering problem could be the possibility to lock the numbering of casting parts so that if the part is changed it will not change the number.

Numbering Case 5: In model sharing, some of the elements are finished and send to fabrication and same time there are unfinished elements which might later change the numbering. One solution could be, automated numbering with users' individual marks and so one designer's numbering would not effect on the other designer's numbering. This might cause that elements could get same numbers. Other solution could be the possibility to limit numbering to section, floor or even one element level.

Numbering Case 6: Nowadays, construction sites and factories, such as an element factory, order reports from structural engineers. For example, rebar should have individual numbers so that each element's rebar lists could be filtered or the construction site wants to order a list of steel parts of one section or floor.

In conclusion, there should be an option for a limited numbering, especially, in a big project with multiple structural designers. Number the model without conflicts and sub-objects know in which part it belongs.

# 5. AUF-DATA ANALYSIS

In this chapter, most frequently started TS components are reviewed by the year and environment. Additionally, later AUF-data is used to compare the use of similar components in Chapter 6.

## 5.1 The starting frequencies of the components

Different types of components and total frequency of started component command are presented in Table 5.1. The total frequency of a started component has raised from 2013 to 2014 and 2015 frequency is less than 2014 but higher than 2013. Data from 2016 is only from a half of a year, therefore, it seems to rise at least to 2015 years' level.

***Table 5.1.*** *Different and frequency of started components by year in AUF data.*

| | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|
| Different components | 1319 | 1499 | 1340 | 1307 |
| Frequency of started components | 107 308 | 441 160 | 336 408 | 154 055 |

Most frequently used components in Tekla are the TS' own developer kit components that are the joint, detail and macros shown in Table 5.2. The plug-ins are created with the newest development method, Tekla Open API™. Totally different type of components is created over 2000 and this does not contain the custom component created by the user.

***Table 5.2.*** *Different development methods of components 01/2013-06/2016*

| | **Different** | **Frequency** |
|---|---|---|
| Joint (ail_create_joint...) | 771 | 430 568 |
| Macro (ail_create_macro) | 441 | 165 886 |
| Plug-in (ail_create_plugin) | 792 | 110 591 |
| Detail (ail_create_detail) | 131 | 79 742 |
| **Total** | **2135** | **786 787** |

The different development method changes by the year are shown in Figure 5.1. The older joint, detail and macro components' starting frequencies changes are similar in AUF-data and on the contrary the newer plugin components' frequency slightly increases every year. Even in 2016 that data is only from half year the starting frequency has increased compared with last year.

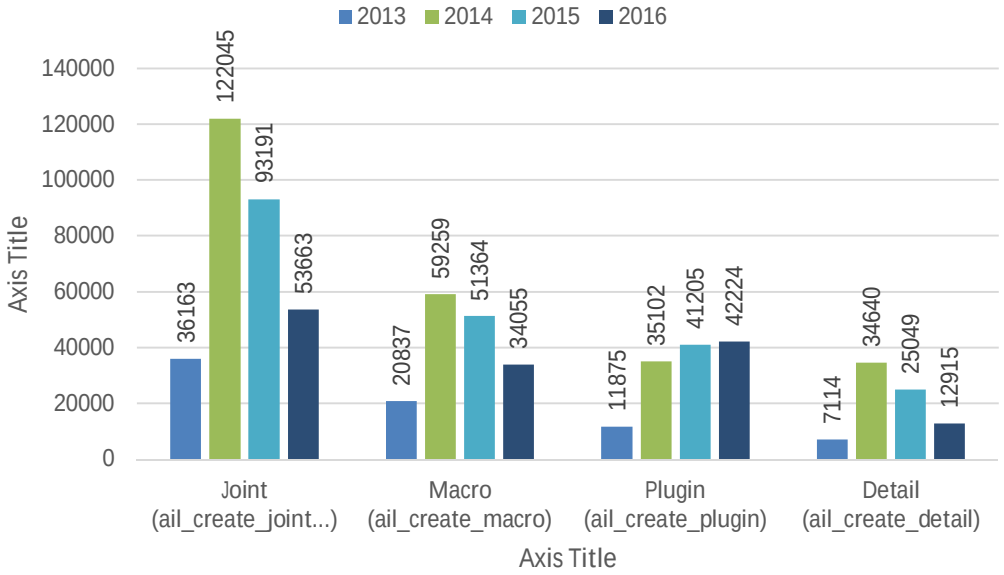


***Figure 5.1.*** *Frequency of different (development method) components*

Next, the 30 most frequently started components in AUF data is shown in Table 5.3 components by the year from January 2013 to June 2016. Two of the topmost components are users' custom components and current components because these commands do not get a unique number in data depending on the created component.

Next the topmost component in all environments is End plate (144). However, Table 5.3 contains other end plate connection components; Stiffened End plate (27) is seventh, End plate (101) is thirteenth and End plate (29) is fourteenth of the most frequently started components. Additionally, End plate (1002) detail component is the eighth most started components from all component commands. The list contains only one concrete component that is the Floor Layout placed on 24$^{th}$ in the list. Other that steel or concrete components are Export IFC plugin that is fifth. On the top of the list reached as well one custom component that is mainly used in Netherland environment.

***Table 5.3.*** *The 30 most frequently used component starting commands*

| | **Sum of Starting frequency** | **Year** | | | | |
|---|---|---|---|---|---|---|
| | **Component name** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | Custom component | 21674 | 120740 | 81212 | 5432 | 229058 |
| 2 | Current component | 9011 | 66812 | 43695 | 5681 | 125199 |
| 3 | End plate (144) | 1952 | 12896 | 10251 | 3887 | 28986 |
| 4 | Cranked beam (41) | 1597 | 9905 | 5821 | 1947 | 19270 |
| 5 | Export IFC | 1362 | 5723 | 5644 | 4081 | 16810 |
| 6 | Bolted gusset (11) | 1290 | 6360 | 6027 | 1932 | 15609 |
| 7 | Stiffened End plate (27) | 824 | 5534 | 4828 | 2120 | 13306 |
| 8 | End plate detail (1002) | 1075 | 5878 | 4577 | 1283 | 12813 |
| 9 | Shear plate simple (146) | 733 | 5039 | 3837 | 2230 | 11839 |
| 10 | Clip angle (141) | 785 | 5159 | 3408 | 1982 | 11334 |
| 11 | Stiffeners (1003) | 854 | 5419 | 3831 | 1183 | 11287 |
| 12 | End plate (101) | 514 | 2945 | 2673 | 2489 | 8621 |
| 13 | End plate (29) | 824 | 2981 | 2288 | 1022 | 7115 |
| 14 | Base plate (1042) | 557 | 2594 | 2135 | 1823 | 7109 |
| 15 | Multiple stiffeners (1064) | 518 | 3334 | 1830 | 995 | 6677 |
| 16 | Railings (S77) | 457 | 2771 | 2288 | 1000 | 6516 |
| 17 | Joining plates (14) | 479 | 2588 | 2294 | 1006 | 6367 |
| 18 | Stanchions (S76) | 604 | 2344 | 2243 | 1038 | 6229 |
| 19 | Base plate (1004) | 709 | 2130 | 1742 | 1191 | 5772 |
| 20 | Fitting (13) | 635 | 2528 | 1631 | 746 | 5540 |
| 21 | Tube gusset (20) | 331 | 2163 | 2107 | 851 | 5452 |
| 22 | DWG profile to library | 278 | 2879 | 1114 | 909 | 5180 |
| 23 | Stanchion weld (85) | 349 | 2414 | 1520 | 843 | 5126 |
| 24 | Floor layout | 272 | 837 | 1469 | 2158 | 4736 |
| 24 | U.S. Base plate (1047) | 503 | 1911 | 1140 | 1060 | 4614 |
| 26 | ail_create_detail, 90001029 | 339 | 1982 | 1421 | 516 | 4258 |
| 27 | Stairs (S71) | 337 | 1916 | 1174 | 817 | 4244 |
| 28 | Array of objects (29) | 227 | 1917 | 1341 | 670 | 4155 |
| 29 | Macro 4 - I-Beam to I-Beam running parallel | 475 | 1756 | 1255 | 669 | 4155 |
| 30 | Haunch (40) | 572 | 1385 | 1021 | 1168 | 4146 |

Above is presented mainly the steel components. Next the thirty most frequently started concrete components are presented in Table 5.4.

***Table 5.4.*** *The most frequently started concrete components between 01/2013-06/2016*

| | Sum of starting frequency | Year | | | | |
|---|---|---|---|---|---|---|
| | **Component name** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | Floor layout | 272 | 837 | 1469 | 2158 | 4736 |
| 2 | Mesh bars | | 403 | 1431 | 1631 | 3465 |
| 3 | Slab bars (18) | 477 | 1117 | 978 | 793 | 3365 |
| 4 | Rectangular column reinforcement (83) | 406 | 829 | 837 | 1021 | 3093 |
| 5 | Rebar Shape Catalog | 378 | 604 | 577 | 1388 | 2947 |
| 6 | Wall Layout | | | 150 | 2718 | 2868 |
| 7 | Embedded anchors (8) | 114 | 572 | 756 | 1167 | 2609 |
| 8 | Beam reinforcement (63) | 390 | 484 | 683 | 787 | 2344 |
| 9 | Sandwich and double wall | 227 | 823 | 744 | 544 | 2338 |
| 10 | Sandwich wall window | 142 | 907 | 792 | 444 | 2285 |
| 11 | Pad footing reinforcement (77) | 211 | 602 | 539 | 841 | 2193 |
| 12 | Wall To Wall Connection | 65 | 422 | 1088 | 499 | 2074 |
| 13 | Hole generation (32) | 129 | 675 | 509 | 705 | 2018 |
| 14 | Edge and corner reinforcement (62) | 193 | 647 | 769 | 390 | 1999 |
| 15 | Lifting anchor (80) | 138 | 772 | 642 | 430 | 1982 |
| 16 | Corbel reinforcement (81) | 351 | 338 | 505 | 536 | 1730 |
| 17 | Reinforcement mesh array in area (89) | 334 | 544 | 422 | 410 | 1710 |
| 18 | Concrete stairs (65) | 141 | 667 | 435 | 448 | 1691 |
| 19 | Columns - automated reinforcement layout (57) | 228 | 488 | 504 | 409 | 1629 |
| 20 | Opening in wall (4) | 65 | 541 | 666 | 339 | 1611 |
| 21 | Wall panel reinforcement | 84 | 297 | 503 | 703 | 1587 |
| 22 | Floor Tool | 130 | 533 | 378 | 502 | 1543 |
| 23 | Slab reinforcement tool | 239 | 413 | 317 | 535 | 1504 |
| 24 | Wall Rails | 99 | 915 | 259 | 196 | 1469 |
| 25 | Modeling of floor bay (66) | 198 | 666 | 313 | 259 | 1436 |
| 26 | Rebar Coupler | 26 | 341 | 543 | 523 | 1433 |
| 27 | Stairwells and elevator shafts (90) | 172 | 332 | 333 | 491 | 1328 |
| 28 | Strip footing (75) | 201 | 361 | 243 | 502 | 1307 |
| 29 | Stirrup reinforcement (67) | 112 | 621 | 289 | 280 | 1302 |
| 30 | Hollowcore reinforcement strands (60) | 179 | 393 | 412 | 304 | 1288 |

The most frequently started concrete component is Floor layout that was the only concrete component in the thirty most frequently started component table of all components. During the first six months of 2016 the most frequently started concrete component was the new Wall layout tool that frequency was over 2700. The frequency of started concrete components has increased every year.

## 5.2 Components by environment

Previously, components are shown as total and next started components in different environments are inspected. The frequencies of the started components are shown in Table 5.5, which shows that the top four environments are the US imperial, Netherlands, UK and Default environment.

***Table 5.5.*** *Components' starting frequency by environment between 01/2013-06/2016*

| | **Sum of starting frequency** | **Year** | | | | |
|---|---|---|---|---|---|---|
| | **Environment** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | US imperial | 26761 | 104959 | 59120 | 23108 | 213948 |
| 2 | Netherlands | 17516 | 71238 | 61502 | 19625 | 169881 |
| 3 | UK | 8852 | 50698 | 36330 | 24386 | 120266 |
| 4 | Default | 9867 | 24176 | 35833 | 18843 | 88719 |
| 5 | France | 6235 | 25886 | 23044 | 9031 | 64196 |
| 6 | Sweden | 7258 | 32202 | 17808 | 1850 | 59118 |
| 7 | Germany | 3400 | 25497 | 22526 | 5566 | 56989 |
| 8 | Australasia | 3977 | 14078 | 7359 | 4610 | 30024 |
| 9 | Finland | 1572 | 13423 | 11813 | 2906 | 29714 |
| 10 | US metric | 3508 | 12135 | 4300 | 3343 | 23286 |
| 11 | Poland | 6627 | 3825 | 5928 | 4081 | 20461 |
| 12 | Brazil | 957 | 5631 | 6592 | 2342 | 15522 |
| 13 | Norway | 1232 | 9477 | 2360 | 2288 | 15357 |
| 14 | Italy | 1422 | 3613 | 5940 | 1998 | 12973 |
| 15 | South Africa | 358 | 5452 | 3819 | 2404 | 12033 |
| 16 | Middle East | 1337 | 3085 | 4483 | 1681 | 10586 |
| 17 | Japan | 55 | 4241 | 2275 | 3356 | 9927 |
| 18 | Russia | 1468 | 4977 | 1378 | 1935 | 9758 |
| 19 | India | 1025 | 3017 | 2395 | 3042 | 9479 |
| 20 | Hungary | 952 | 2578 | 3400 | 2267 | 9197 |
| 21 | South-East Asia | 560 | 2917 | 1417 | 3938 | 8832 |
| 22 | Switzerland | 16 | 2136 | 4081 | 2549 | 8782 |
| 23 | Korea | | 18 | 2847 | 3993 | 6858 |
| 24 | Portugal | 469 | 3677 | 1529 | 158 | 5833 |
| 25 | Czech | 36 | 2461 | 1919 | 1410 | 5826 |
| 26 | Netherlands enu | 684 | 3000 | 1872 | 72 | 5628 |
| 27 | China | 688 | 2114 | 330 | 272 | 3404 |
| 28 | Denmark | 46 | 2707 | 406 | 105 | 3264 |
| 29 | Blank project | | 6 | 1041 | 1628 | 2675 |
| 30 | Austria | 399 | 849 | 864 | 331 | 2443 |
| 31 | Spain | 25 | 528 | 964 | 292 | 1809 |
| 32 | South America | 6 | 541 | 705 | 171 | 1423 |
| 33 | Taiwan | | | | 394 | 394 |
| | **Grand Total** | **106624** | **438160** | **334516** | **153983** | **1033283** |

The top environments changes by the year, for example, in first six months in 2016 the top environment was Default, in 2015 it was Netherlands, and in 2014 and 2013 it was the US imperial. Next, these environments top components are presented.

The topmost environment, U.S. imperial thirty most frequently started components are presented in Table 5.6. Extremely the most used component command is custom component command which was used around 10 times often than the first system component except in 2016. Most used steel components are Clip angle (141) and shear plate simple (146). Last component in the list is the Cast-in plate (1069) component that is the only concrete component in the list.

***Table 5.6.*** *US imperial 30 topmost components*

| | **Sum of Starting frequency** | **Year** | | | | |
|---|---|---|---|---|---|---|
| | **Component name** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | Custom component | 4750 | 40684 | 18189 | 791 | 64414 |
| 2 | Current component | 985 | 11435 | 6745 | 763 | 19928 |
| 3 | Clip angle (141) | 488 | 3583 | 1704 | 933 | 6708 |
| 4 | Shear plate simple (146) | 468 | 3103 | 1798 | 982 | 6351 |
| 5 | Cranked beam (41) | 389 | 2629 | 1126 | 383 | 4527 |
| 6 | Railings (S77) | 191 | 1738 | 1028 | 595 | 3552 |
| 7 | U.S. Base plate (1047) | 319 | 1427 | 765 | 681 | 3192 |
| 8 | End plate detail (1002) | 386 | 1453 | 911 | 424 | 3174 |
| 9 | Stanchions (S76) | 200 | 1292 | 870 | 651 | 3013 |
| 10 | Export IFC | 158 | 1115 | 905 | 567 | 2745 |
| 11 | Two sided clip angle (143) | 107 | 988 | 602 | 241 | 1938 |
| 12 | Bolted gusset (11) | 555 | 709 | 355 | 299 | 1918 |
| 13 | End plate (144) | 236 | 480 | 329 | 445 | 1490 |
| 14 | Wraparound gusset cross (60) | 353 | 568 | 262 | 264 | 1447 |
| 15 | Stiffeners (1003) | 162 | 760 | 352 | 170 | 1444 |
| 16 | Stairs (S71) | 73 | 721 | 299 | 267 | 1360 |
| 17 | Fitting (13) | 171 | 503 | 562 | 121 | 1357 |
| 18 | Joist to beam, type 1 (160) | 79 | 609 | 489 | 167 | 1344 |
| 19 | Round tube (23) | 103 | 708 | 455 | 65 | 1331 |
| 20 | U.S. Base plate connection (71) | 117 | 639 | 357 | 159 | 1272 |
| 21 | Base plate (1042) | 105 | 540 | 255 | 244 | 1144 |
| 22 | Railing plane to plane (90) | 60 | 371 | 440 | 271 | 1142 |
| 23 | Z pan (S74) | 86 | 555 | 253 | 223 | 1117 |
| 24 | Layout Point Plugin | 90 | 432 | 175 | 339 | 1036 |
| 25 | Wall Rails | 38 | 728 | 135 | 86 | 987 |
| 26 | Stanchions - Railings - Kick plates (S86) | 26 | 547 | 255 | 87 | 915 |
| 27 | Brace corner simple (49) | 148 | 478 | 240 | 40 | 906 |
| 28 | IDS4-SeatingConnection_With_Shims | | | 853 | | 853 |
| 29 | Full depth (184) | 146 | 446 | 180 | 78 | 850 |
| 30 | Cast-in plate (1069) | 80 | 456 | 214 | 83 | 833 |

The second environment, Netherland thirty most frequently started components are presented in Table 5.7. Netherlands the End plate (144) is second in most started components. The concrete components have not reached in top thirty components in Netherland environment. Export IFC is the eleventh on the list and array of objects (29) reaches the thirteenth place.

***Table 5.7.*** *Netherlands 30 topmost components*

| | **Sum of Starting frequency** | **Year** | | | | |
|---|---|---|---|---|---|---|
| | **Component name** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | Custom component | 2724 | 9815 | 14332 | 427 | 27298 |
| 2 | End plate (144) | 712 | 7937 | 5740 | 1447 | 15836 |
| 3 | Current component | 1845 | 8673 | 4309 | 697 | 15524 |
| 4 | Stiffened end plate (27) | 522 | 4001 | 3071 | 755 | 8349 |
| 5 | Bolted gusset (11) | 311 | 2692 | 2496 | 669 | 6168 |
| 6 | Cranked beam (41) | 397 | 3285 | 2017 | 254 | 5953 |
| 7 | End plate detail (1002) | 330 | 2171 | 1373 | 383 | 4257 |
| 8 | Stanchion weld (85) | 177 | 1755 | 1138 | 286 | 3356 |
| 9 | Multiple stiffeners (1064) | 234 | 1633 | 982 | 396 | 3245 |
| 10 | Stiffeners (1003) | 252 | 1596 | 914 | 158 | 2920 |
| 11 | Export IFC | 221 | 1016 | 912 | 711 | 2860 |
| 12 | Joining plates (14) | 161 | 1345 | 1068 | 222 | 2796 |
| 13 | Array of objects (29) | 44 | 794 | 650 | 237 | 1725 |
| 14 | End plate (29) | 335 | 608 | 474 | 75 | 1492 |
| 15 | Seating (39) | 126 | 555 | 547 | 168 | 1396 |
| 16 | Two sided end plate (142) | 41 | 632 | 486 | 208 | 1367 |
| 17 | Shear plate simple (146) | 30 | 446 | 511 | 285 | 1272 |
| 18 | Haunch (40) | 89 | 465 | 287 | 356 | 1197 |
| 19 | Base plate (1004) | 160 | 603 | 244 | 182 | 1189 |
| 20 | Stub (1011) | 117 | 522 | 214 | 309 | 1162 |
| 21 | Radial array tool | 6 | 418 | 564 | 11 | 999 |
| 22 | Partial stiff end plate (65) | 53 | 333 | 244 | 197 | 827 |
| 23 | Two sided end plate (24) | 32 | 402 | 282 | 8 | 724 |
| 25 | Stanchions (S76) | 93 | 319 | 196 | 24 | 632 |
| 25 | Base plate (1042) | 42 | 251 | 255 | 83 | 631 |
| 26 | Seating (3) | 25 | 242 | 264 | 88 | 619 |
| 27 | Profile cross-section from plate (10) | 95 | 196 | 253 | 54 | 598 |
| 28 | Railings (S77) | 99 | 292 | 172 | 20 | 583 |
| 29 | Stairs (S71) | 50 | 336 | 154 | 37 | 577 |
| 30 | Embedded anchors (8) | | | 312 | 180 | 492 |

The third environment, UK thirty most frequently started components are presented in Table 5.8. In UK environment contains quite many steel cladding support components such as Metsec, HiSpan and METL-CON components. The most frequently started end

plate connection is End plate (101), second is End plate (27) and End plate (144) is third end plate connection. The concrete components have not reached in top thirty components.

***Table 5.8.*** *UK 30 topmost components*

| | Sum of Starting frequency | Year | | | | |
|---|---|---|---|---|---|---|
| | **Component name** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | Current component | 1518 | 12428 | 10033 | 1447 | 25426 |
| 2 | Custom component | 822 | 5875 | 4613 | 344 | 11654 |
| 3 | End plate (101) | 430 | 2526 | 2253 | 2334 | 7543 |
| 4 | Portal bracing (105) | 281 | 1512 | 421 | 855 | 3069 |
| 5 | Cranked beam (41) | 264 | 1429 | 836 | 228 | 2757 |
| 6 | Base plate (1042) | 149 | 850 | 669 | 820 | 2488 |
| 7 | Stiffened end plate (27) | 96 | 753 | 474 | 817 | 2140 |
| 8 | End plate (144) | 64 | 677 | 572 | 387 | 1700 |
| 9 | End plate (29) | 142 | 1043 | 344 | 144 | 1673 |
| 10 | Two sided end plate (115) | 77 | 731 | 347 | 403 | 1558 |
| 11 | Shear plate (103) | 102 | 738 | 409 | 173 | 1422 |
| 12 | Fitting (13) | 85 | 692 | 609 | 34 | 1420 |
| 13 | Export IFC | 79 | 474 | 332 | 285 | 1170 |
| 14 | End plate detail (1002) | 137 | 472 | 408 | 129 | 1146 |
| 15 | Metsec Cold rolled sleeved (102) | 69 | 524 | 201 | 345 | 1139 |
| 16 | Stiffeners (1003) | 66 | 632 | 276 | 163 | 1137 |
| 17 | Eaves haunch (102) | 85 | 393 | 145 | 443 | 1066 |
| 18 | Joining plates (14) | 76 | 305 | 246 | 297 | 924 |
| 19 | Manlock beam (1033) | 17 | 742 | 126 | 10 | 895 |
| 20 | Bolted gusset (11) | 30 | 370 | 308 | 178 | 886 |
| 21 | DWG profile to library | 27 | 496 | 113 | 159 | 795 |
| 22 | Tube gusset (20) | 18 | 352 | 296 | 91 | 757 |
| 23 | Floor layout | 1 | 11 | 37 | 688 | 737 |
| 24 | Metsec Diagonal Ties (27) | 76 | 370 | 179 | 105 | 730 |
| 25 | Metsec Std. Anti-Sag Bay (23) | 65 | 345 | 149 | 82 | 641 |
| 26 | Zinc coating hole (S61) | 10 | 148 | 441 | 2 | 601 |
| 27 | RebarShapeCatalog | 9 | 14 | 68 | 487 | 578 |
| 28 | Apex haunch (106) | 36 | 240 | 89 | 206 | 571 |
| 29 | Brace Middle Tubes and plate (144) | 2 | 20 | 7 | 479 | 508 |
| 30 | HiSpan side rail supports (51) | 19 | 278 | 196 | | 493 |

The fourth environment, Default thirty most frequently started components are presented in Table 5.9. The default environment's most of the listed components are concrete components that were not in US. End plate (144) is the topmost steel component that is twelfth.

***Table 5.9.*** *Default 30 topmost components*

| | Sum of Starting frequency | Year | | | | |
|---|---|---|---|---|---|---|
| | **Component name** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | Custom component | 2136 | 5458 | 9124 | 388 | 17106 |
| 2 | Export IFC | 351 | 826 | 1130 | 891 | 3198 |
| 3 | Current component | 110 | 1233 | 1393 | 338 | 3074 |
| 4 | Floor layout | 235 | 477 | 852 | 369 | 1933 |
| 5 | Mesh bars | | 262 | 1072 | 348 | 1682 |
| 6 | Detailing Manager | | | | 1376 | 1376 |
| 7 | Wall To Wall Connection | 41 | 125 | 672 | 99 | 937 |
| 8 | Wall Layout | | | 132 | 662 | 794 |
| 9 | Sandwich and double wall | 101 | 268 | 235 | 188 | 792 |
| 10 | Sandwich wall window | 55 | 255 | 298 | 161 | 769 |
| 11 | Lifting anchor (80) | 8 | 312 | 273 | 128 | 721 |
| 12 | End plate (144) | 32 | 187 | 306 | 194 | 719 |
| 13 | Mesh Bars by area | | 180 | 374 | 143 | 697 |
| 14 | Rectangular column reinforcement (83) | 81 | 167 | 266 | 164 | 678 |
| 15 | Rebar Shape Catalog | 88 | 149 | 239 | 148 | 624 |
| 16 | Edge and corner reinforcement (62) | 32 | 120 | 378 | 87 | 617 |
| 17 | Rebar Coupler | 16 | 198 | 324 | 66 | 604 |
| 18 | Slab bars (18) | 95 | 129 | 242 | 90 | 556 |
| 19 | Beam reinforcement (63) | 57 | 75 | 273 | 148 | 553 |
| 20 | Tube gusset (20) | 30 | 180 | 162 | 180 | 552 |
| 21 | Form Face Creator For Pours | | | 2 | 549 | 551 |
| 22 | Wall panel reinforcement | 45 | 130 | 210 | 162 | 547 |
| 23 | Embedded anchors (8) | 9 | 64 | 258 | 179 | 510 |
| 24 | Modeling of slab area (88) | 43 | 59 | 310 | 86 | 498 |
| 25 | Formwork Panel | | | | 486 | 486 |
| 26 | Corbel connection (14) | 79 | 178 | 187 | 41 | 485 |
| 27 | Shear plate simple (146) | 82 | 173 | 134 | 85 | 474 |
| 28 | Pad footing reinforcement (77) | 47 | 74 | 192 | 145 | 458 |
| 29 | Railing plane to plane (90) | 3 | 429 | 17 | 5 | 454 |
| 30 | End plate detail (1002) | 27 | 188 | 158 | 41 | 414 |

The topmost environments are selected because it contains most of the data. Additionally, the Germany and Finland environments components are inspected because later studied case models are using these environments.

***Table 5.10.*** *Finland thirty most frequently started components*

| | **Sum of Starting frequency** | **Year** | | | | |
|---|---|---|---|---|---|---|
| | **Row Labels** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | Custom component | 618 | 8081 | 5860 | 56 | 14615 |
| 2 | 3D cut (10) | 346 | 961 | 51 | | 1358 |
| 3 | Export IFC | 27 | 232 | 463 | 261 | 983 |
| 4 | Current component | 18 | 152 | 508 | 5 | 683 |
| 5 | Lifting anchor (80) | 7 | 306 | 153 | 17 | 483 |
| 6 | Array of objects (29) | 14 | 158 | 203 | 14 | 389 |
| 7 | End plate detail (1002) | 1 | 24 | 324 | 16 | 365 |
| 8 | Floor layout | 31 | 70 | 199 | 52 | 352 |
| 9 | Sandwich wall window | 16 | 222 | 85 | 13 | 336 |
| 10 | AI_Vaijerilenkki | | | | 323 | 323 |
| 11 | Wall To Wall Connection | 6 | 205 | 58 | 50 | 319 |
| 12 | Edge and corner reinforcement (62) | 6 | 196 | 44 | 2 | 248 |
| 13 | Sandwich and double wall | 18 | 94 | 59 | 32 | 203 |
| 14 | Corbel connection (14) | 10 | 11 | 129 | 39 | 189 |
| 15 | Fitting (13) | | 152 | 11 | 22 | 185 |
| 16 | Rebar Set Creator Proto | | 179 | | | 179 |
| 17 | Slab bars (18) | 50 | 86 | 32 | 9 | 177 |
| 18 | Wall panel reinforcement | 15 | 72 | 45 | 40 | 172 |
| 19 | Lifting Inserts | 1 | 115 | 30 | 18 | 164 |
| 20 | ail_create_macro, S7 | | 139 | 8 | 3 | 150 |
| 21 | Mesh Bars by area | | 24 | 96 | 26 | 146 |
| 22 | Railing beam to plane (89) | 2 | 135 | 1 | 1 | 139 |
| 23 | Corbel reinforcement (81) | 6 | 44 | 71 | 18 | 139 |
| 24 | Mesh bars | | 35 | 72 | 29 | 136 |
| 25 | Reinforcement mesh array in area (89) | 11 | 63 | 46 | 13 | 133 |
| 26 | Cranked beam (41) | | 88 | 17 | 19 | 124 |
| 27 | Floor Tool | 2 | 83 | 21 | 16 | 122 |
| 28 | Stanchion weld (85) | 7 | | 107 | 6 | 120 |
| 29 | Rectangular column reinforcement (83) | 6 | 47 | 41 | 15 | 109 |
| 30 | Export 3D DWG DFX | 5 | 37 | 46 | 14 | 102 |
| | **Grand Total** | **1245** | **12205** | **8974** | **1247** | **23671** |

First, the Finland environment thirty most frequently started components are presented in Table 5.10 are mainly concrete components. The starting frequencies of the components by the year are mainly low and contains dispersion.

***Table 5.11.*** *Germany thirty most frequently started components*

| | | Year | | | | |
|---|---|---|---|---|---|---|
| | **Component name** | **2013** | **2014** | **2015** | **2016** | **Grand Total** |
| 1 | Current component | 786 | 7066 | 5094 | 432 | 13378 |
| 2 | Custom component | 288 | 3094 | 4663 | 2 | 8047 |
| 3 | End plate (144) | 132 | 1298 | 679 | 211 | 2320 |
| 4 | Stiffeners (1003) | 109 | 778 | 407 | 68 | 1362 |
| 5 | Stiffened end plate (27) | 17 | 429 | 331 | 412 | 1189 |
| 6 | Stanchions (S76) | 134 | 111 | 673 | 122 | 1040 |
| 7 | Railing plane to plane (90) | 76 | 375 | 425 | 11 | 887 |
| 8 | Bolt Group Creator | | | 831 | 8 | 839 |
| 9 | Joining plates (14) | 30 | 332 | 198 | 208 | 768 |
| 10 | Clip angle (141) | 28 | 363 | 353 | 14 | 758 |
| 11 | Cranked beam (41) | 77 | 305 | 260 | 107 | 749 |
| 12 | Railings (S77) | 22 | 71 | 539 | 107 | 739 |
| 13 | Seating (3) | 67 | 446 | 202 | 14 | 729 |
| 14 | Training example (15) | 110 | 229 | 248 | 103 | 690 |
| 15 | Manlock beam (1033) | | 604 | 83 | | 687 |
| 16 | Stairs (S71) | 73 | 243 | 214 | 83 | 613 |
| 17 | Bolted gusset (11) | | 232 | 240 | 50 | 522 |
| 18 | Export IFC | 5 | 150 | 162 | 186 | 503 |
| 19 | Unfold surface (21) | 11 | 97 | 26 | 311 | 445 |
| 20 | Base plate (1004) | 32 | 154 | 155 | 68 | 409 |
| 21 | Battering connection (13) | 2 | 129 | 24 | 245 | 400 |
| 22 | Haunch (40) | 111 | 151 | 64 | 72 | 398 |
| 23 | Kickplate (S75) | 2 | 18 | 325 | 41 | 386 |
| 24 | Partial stiff end plate (65) | 16 | 191 | 142 | 31 | 380 |
| 25 | End plate (29) | 10 | 143 | 145 | 62 | 360 |
| 26 | Auto bolt | 3 | 273 | 70 | 7 | 353 |
| 27 | Metal Sheet Box | | | 339 | 5 | 344 |
| 28 | End plate (101) | 12 | 112 | 205 | 10 | 339 |
| 29 | End plate detail (1002) | 13 | 177 | 99 | 21 | 310 |
| 30 | Wall Layout | | | 2 | 302 | 304 |

The Germany environment thirty most frequently started components are presented in Table 5.11. The current component is the most frequently started component command and the End plate (144) is the third. Almost all of the components are steel components and only two components are concrete components. The concrete components are the new wall layout component that was released into TS version 2016 and battering connection (13).

# 6. SIMILAR COMPONENTS

This chapter continues using AUF data to compare similar components, as well as, the properties of the components. TS has many components that by name and sometimes also by the thumbnail picture are the same or the difference is minimal. It raised the question: what is the difference between these similar components and which should I use? To clarify the current situation, it was decided to study these similar component properties and frequency in AUF and environment differences in AUF. Components' comparison tables and frequencies by environment and environments' component frequencies are presented in Appendix 1.

Many of the component names contain, for example, "End plate" and if we make a search with term "End plate" and sort the result by the type, we get eighteen connection system components, five detail system components and one detailing system component. This similar case happens with other components too. Reason for this is that components have been made many years to improve and fix problems with older components but still the old components are kept, because some users might still use these old components. In some cases, the new component does not fit in all cases where the old component fits. Next a few of these similar components are inspected. First similar End plate connection type of components, then the stiffener components and last gusset type of components.

## 6.1 End plate components

End plate connection components are used to create connection between a beam and a column or a beam and a beam. The connection creates end plate and other plates depending on the component.

As presented earlier with search term "End plate" user gets 18 connection type of components shown in Figure 6.1. From these End plate connection components can be distributed into seven of one sided end plate connection components, five two sided end plate connection components.

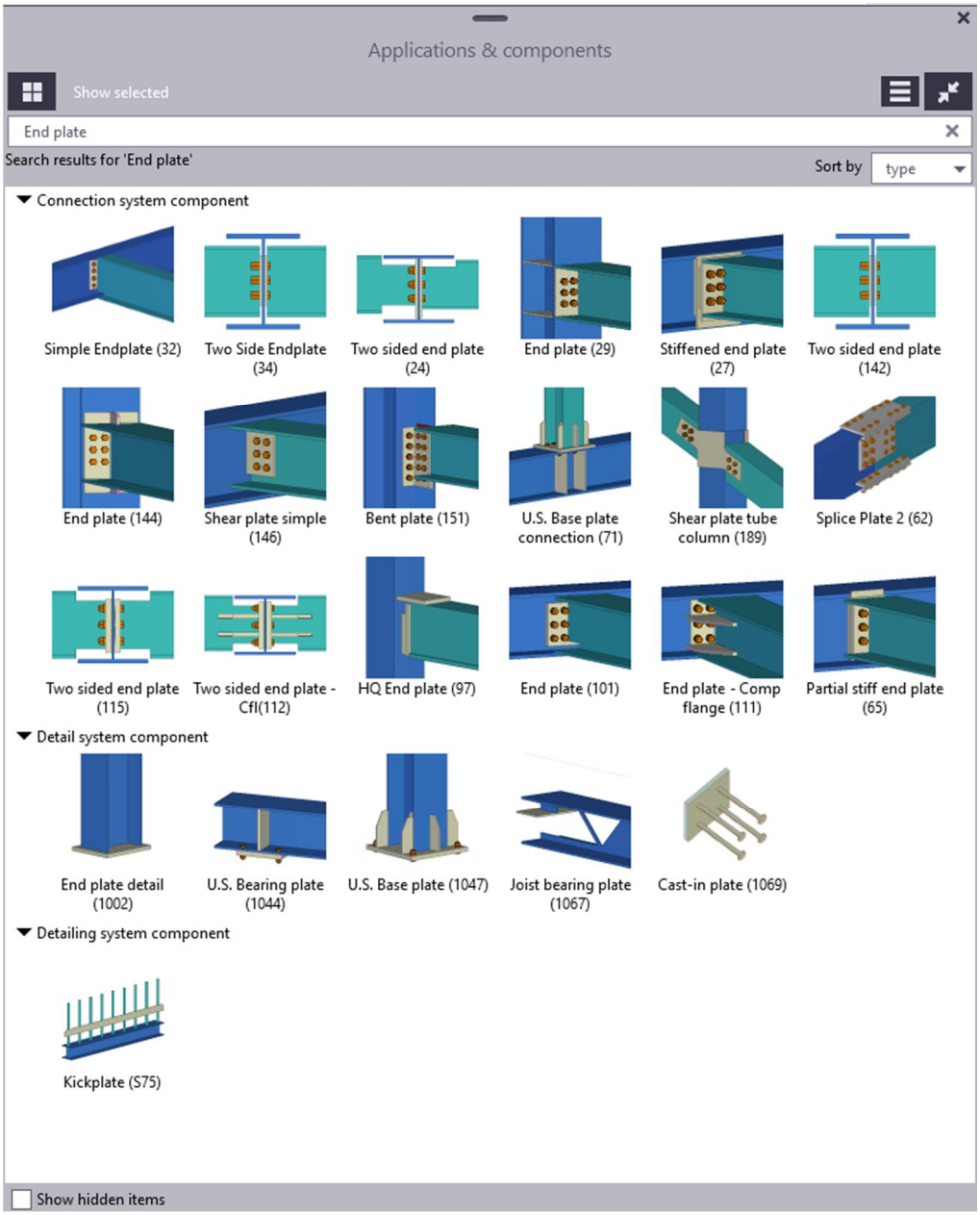


***Figure 6.1.*** *Search result of "End plate"*

First, one sided end plate connection components are studied. The frequency of started components is presented in Figure 6.2. The End plate connection (144) is most frequently started one sided end plate connection component in AUF-data from January 2013 to June 2016. Two almost equally less used components are Simple plate (32) and End plate – compensation flange (111).

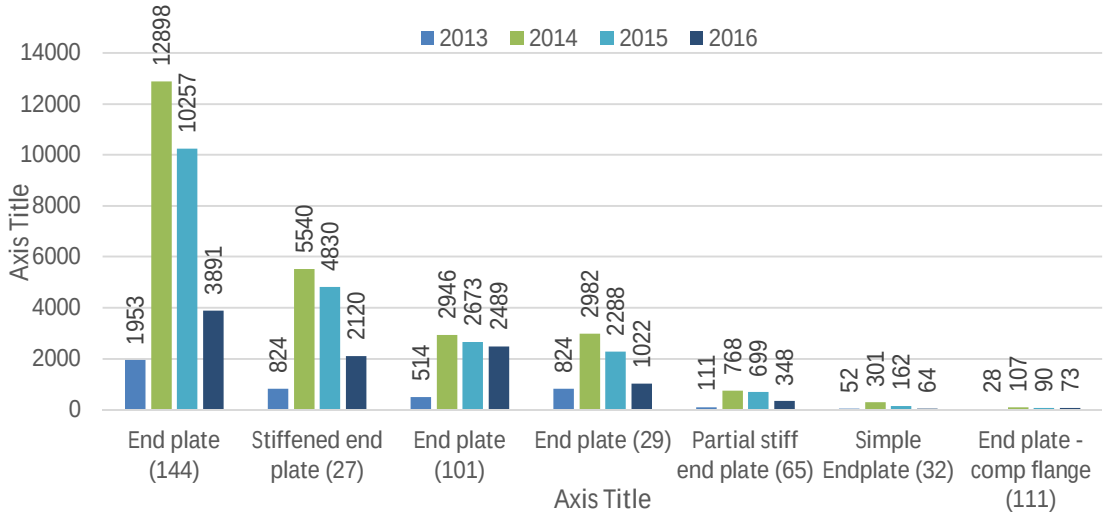


***Figure 6.2.*** *One sided end plate connection components*

The top five environments in a component starting frequencies are Netherlands (44%), UK (22%), France (8%), Germany (6%) and US imperial 4% that are shown in Table A1.3 and more specifically in Table A1.5-Table A1.9. Compared with other environments in Netherland End plate (144) were used over 50% of all environments started components (Table A1.4). All the other top five environment End plate (144) were the most frequently started component besides in UK, End Plate (144) was the third and End Plate (101) was the first and End plate (27) was the second. In other four environments, the End Plate (101) was only fourth or fifth.

The End plate (144) fits on most end plate connection use cases. Only things that cannot be created with the component that can be created with another end plate component are T-shaped connection that can be modelled with stiffened end plate (27) and compensating flange plates that can be modelled with End plate - comp flange (111). Consequently, one sided end plate connections could be reduced from six to three components. One possible problem of removing components is that there are still users that are using that component. For example, End plate (101) frequency is high in UK besides it can be modelled with End plate (144) with simple end plate and bolt connections End Plate is easier to use. End plate (144) component dialog box might seem too complex to use with many property boxes in all the tabs. If the usability of End Plate (144) would be as simple as with End Plate (101), there would be no problem. If it would be possible to add compensating plates and T shaped plate to End plate (144) without making it more complex, that could be the only one sided end plate connection component. The summaries of one sided end plate connection components' properties are presented in Table A1.1 and in Table A1.2.

Next, two sided end plate connection components are inspected. The frequencies of two sided end plate connection components are presented in Figure 6.3. The starting frequencies have been divided on a different component more evenly than on one sided

end plate connection components. The most frequently started two sided end plate connection component is Two sided end plate (142). The less frequently started components are Two Side Endplate (34) and Two sided end plate – Cfl (112).


***Figure 6.3.*** *Two sided end plate connection components*

The top five environments are UK (36%), Netherlands (32%), US imperial (6%), Germany (5%) and France (5%) shown in Table A1.12. The most used environments are the same as one sided end plate connection components, but the order is different. All the other top five environment Two sided end plate (142) were the most frequently started component besides UK it is the third and Two sided end plate (115) is the first and Two sided end plate (24) was the second. One interesting point is that in Netherlands Two sided end plate (34) is not used at all. The top five environments two sided end plate connection components are presented in Table A1.13, Table A1.14, Table A1.15, Table A1.16 and Table A1.17.

From all of one sided end plate connection components Two sided end plate (142) is the most frequently started component and it fits on most end plate connection use cases. Two sided end plate (115) and Two sided end plate (34) can be modelled with Two sided end plate (142) component. With the Two sided end plate (24) is possible to model seating plate that is not possible with Two sided end plate (142). Similarly, with one sided end plate case, the end plate connection with a compensating flange plates is modeled with a specific component, Two sided end plate – Cfl (112).

Within this comparison of one and two sided end plate connection type of TS system components. The amount of current component could be limited from twelve to six components. Also if the complex components are improved to cover two of the less used components' properties only one component to one situation could be possible to implement at least at this case. The summaries of two sided end plate connection components' properties are presented in Table A1.10 and Table A1.11.

## 6.2 Stiffener components

Stiffener connection components are used to create connection between a beam and a column or a beam and a beam. The connection creates stiffeners and other plates depending on the component. Stiffener detail components are used to create stiffeners to selected part in the model.

Stiffener components are connection or detail type of components, seven stiffener detail components and eight connection system components results from catalog search shown in Figure 6.4. From the name or the picture new user cannot know, what is the difference between the Column with stiffeners (186), Column with stiffeners (188), Column with stiffeners S (187) or Column with stiffeners W (182). Other stiffener connection components are Beam with stiffeners (129), Welded column with stiffeners (128), Gusset stiffeners (171) and stiffener seating (12).


***Figure 6.4.*** *Search result with stiffener in Applications & components catalog*

### 6.2.1 Stiffener connection components

According to Figure 6.5, differences between the detail connection components use are minimal. The topmost started stiffener connection component from 2013 to 2015 is Column with stiffeners (186). In 2016, the top most stiffener connection component is Column with stiffener W (182).

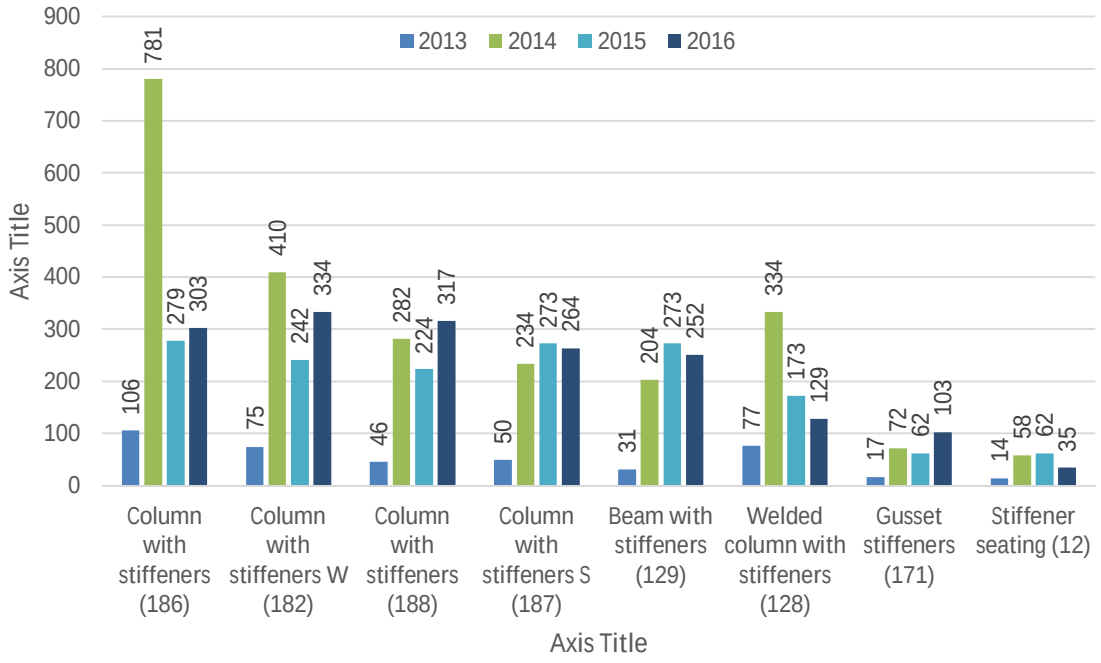


***Figure 6.5.*** *Started stiffener connection components in AUF 2013-2016*

The top five environments are US imperial (35%), UK (12%), Default (8%), Japan (7%) and south-east Asia (3%) shown in Table A1.20. The top environments differ from end plate connection components. In US and UK environments top stiffener connection components were (186), and (188). However, in Japan Column with stiffener W (182) and Column with stiffener S (182) are the top components. In all top five environments the stiffener seating has the lowest frequency. Stiffener seating total frequency is 168 and topmost year frequency was fourteen in Sweden environment in 2015. A similar case is with a gusset stiffener but with the gusset stiffener in 2016 frequency was thirty-seven in UK and twenty in US imperial environment. The top four environments' stiffener connection components starting frequencies are presented in Table A1.21, Table A1.22, Table A1.23 and Table A1.24.

A beam to a column, stiffener connections are (186), (188), (187), (182) and (128). A beam to a beam stiffener connection is Beam with stiffeners (129). From stiffener connection components Stiffener seating (12) is a seating type of connection between a beam and a column where a stiffener is welded between column flanges and the stiffener is bolted to beam's lower flange. Additionally, Gusset stiffeners (171) component creates

two or three stiffener plates and the welds to existing gusset plate and a column or a beam. The same structure could be modeled as well with Standard gusset detail (1065) that creates gusset plate and stiffener plates to the selected point of a beam or a column. Column with stiffener (186) and Column with stiffener (188) create a square shear tab is welded to the main part. Compared with Column with stiffener W (182) and Column with stiffener S (187) that created a shaped shear tab. However, Column with stiffener (188) and Column with stiffener (182) creates weld backing bars. The summaries of stiffener connection components' properties are presented in Table A1.18 and Table A1.19.

After observing the properties of the stiffener connection component, there are four quite similar components: Column with stiffener (186). Column with stiffener (188). Column with stiffener S (187), and Column with stiffener W (187). Because these components create a little different solution, all of these four components are still needed. Nevertheless, adding weld backing bars optional for Column with stiffener (186) and Column with stiffener W (182). It would be possible to remove other two components. According to AUF-data above the stiffener connection with square shear tab is common in US imperial and UK environments. In contrary stiffener connection with a shaped shear tab is common in Japan environment.

In TS 2016 default steel connection groups have selected Beam with stiffeners (129) for a beam to beam stiffener connection, and Column with stiffeners (186) and Column with stiffeners (188) for beam to column connections. The Welded column with stiffeners (128) is located into generic building group. Other stiffener connections are located in steel specialized group which directs stiffener connection use in towards selected components.

In conclusion of stiffener connection components, component catalog contained eighth connection type of stiffener components from which four are clearly different: a beam to a beam connection, stiffener seating connection, the gusset stiffeners and a welded connection. Last four were observed above and with a little change four could be limited into two components and possibly with improvement into one component.

### 6.2.2 Stiffener detail components

Stiffener detail has two mainly started components Stiffeners (1003) and Multiple Stiffeners (1064) shown in Figure 6.6. Other stiffener detail components' frequencies are marginal compared with these two components.

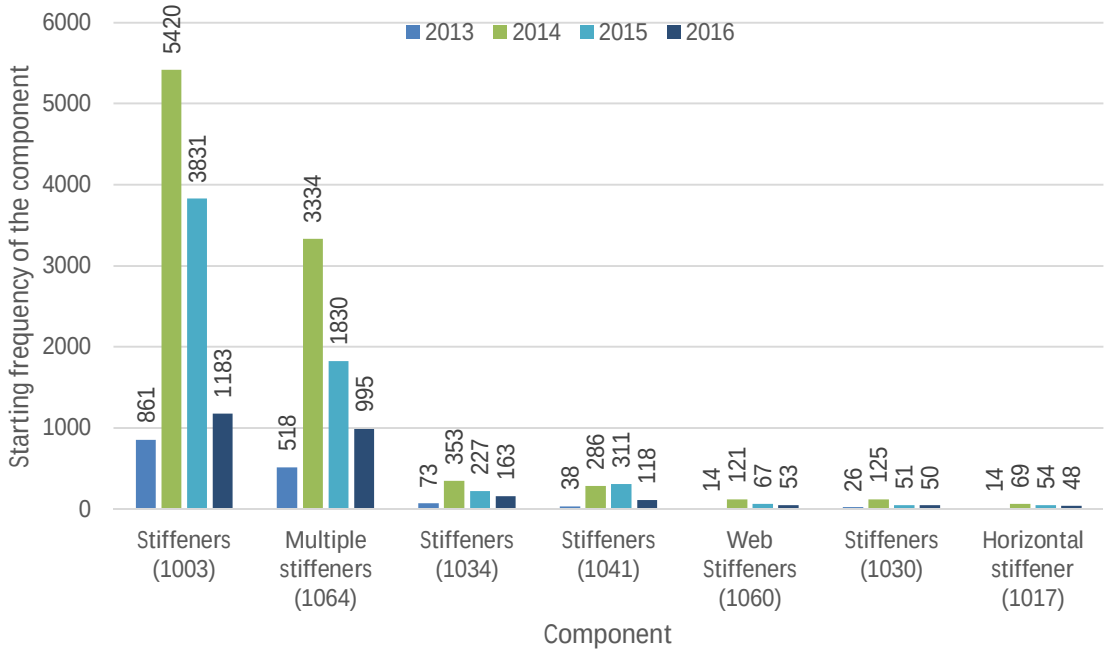


***Figure 6.6.*** *Started stiffener detail components in AUF 2013-2016*

Top five environments are Netherlands (%), US imperial (%), UK (%), Germany (%) and France (%) are shown in Table A1.27. All the top five environments are the same as with end plate connection components are presented in Table A1.28 - Table A1.33. Stiffeners (1003) is clearly the most started component of detail components in other top five environment besides in Netherlands the top detail component is Multiple Stiffeners (1064), and Stiffeners (1003) is the second. The most used component in Japan is Multiple Stiffener (1064). According to AUF-data seems like Stiffeners (1003) and Multiple Stiffeners (1064) are the most important components for the user. Compared with end plate connection components in Japan stiffener detail components is the sixth of most components started environments. In Japan, the topmost component was clearly Multiple Stiffeners (1064) that was started 1009 times and other detail components only 62 times. Most of the data from Japan is from 2014 that was also the year of most data of stiffener detail components.

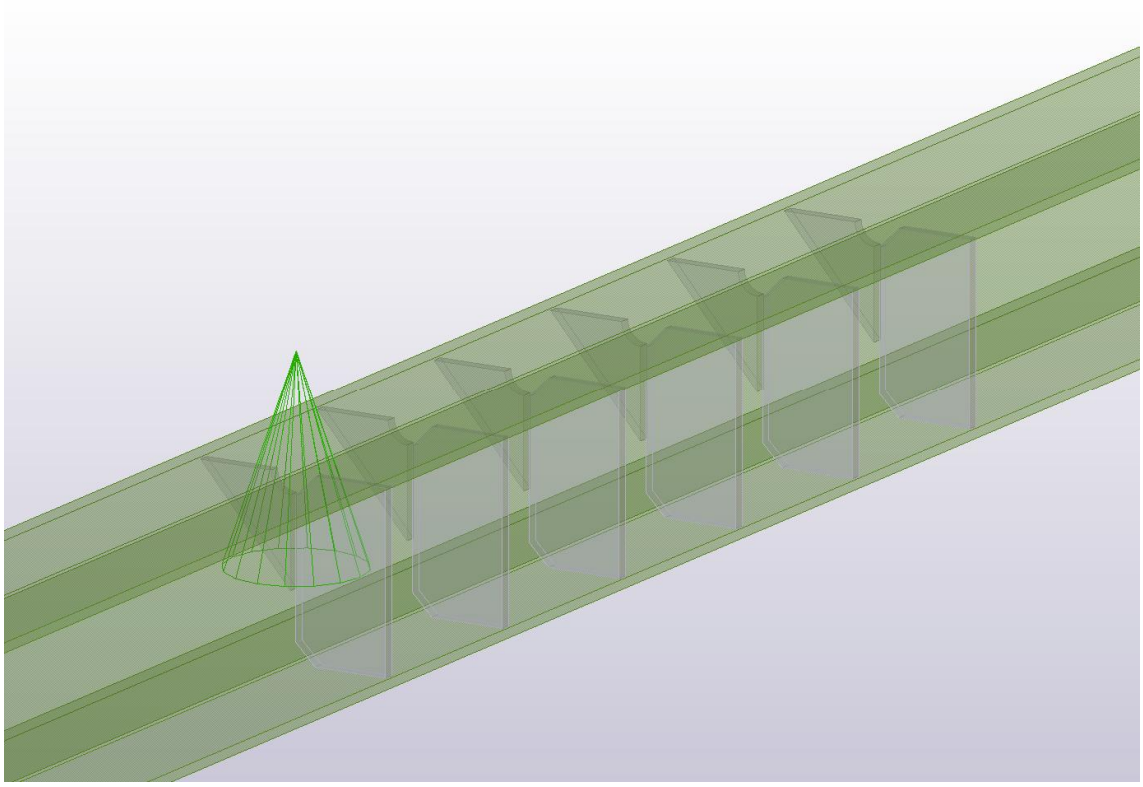

***Figure 6.7.*** *Example of different geometry and chamfer options in Multiple Stiffeners (1064)*

First four stiffener detail components are similar and last three are for more specific cases. Multiple Stiffeners (1064) creates one or more stiffener plates at selected point and contains comprehensive geometry and chamfer options for stiffeners shown in Figure 6.8. The stiffener plates can be skewed and geometry options cover simpler stiffener components, such as Stiffeners (1003) and Stiffener (1041) options. Multiple stiffener (1064) geometry cover almost Stiffener (1034) options besides weld preparations for stiffener plates. Stiffeners (1003) fits to typical I-profile stiffeners that can be skewed and with a minimal chamfer option the component dialog box is simple because there are not many options that might startle the user. However, if Multiple Stiffener (1064) is created with default values, the created component is the same as Stiffeners (1003). Stiffener detail components' helps are mostly incomplete and do not clearly present what are the modification options for the Stiffeners and limitations of the components. Luckily, stiffener detail components are one of the simpler components. The summaries of stiffener connection components' properties are presented in Table A1.25 and Table A1.26

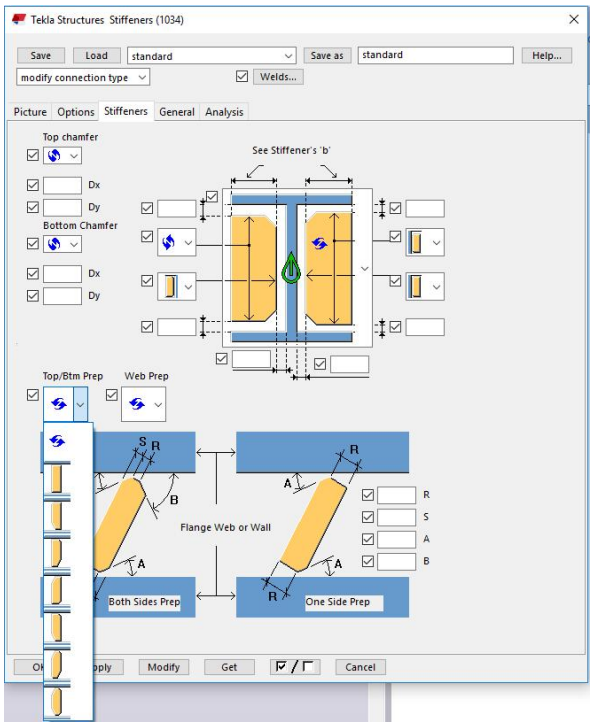


***Figure 6.8.*** *Weld preparation in Stiffener (1034)*

Last three stiffener detail components differ clearly from the stiffener components presented above. First, Stiffener (1030) creates stiffeners outside the column or beam at selected point. Stiffeners have chamfer options and the position options from a picked point. Second, Web stiffeners (1060) component creates stiffener plates or angles around a hole in the profile web. Third, Horizontal stiffeners (1017) component creates horizontal stiffeners to a beam.

In conclusion, first four of stiffener detail components can be limited into two components Multiple Stiffener (1064) and Stiffener (1034). However, Stiffener (1034) component is not as much started component as Multiple stiffener (1034), comparing these components starting frequencies. If the weld preparations option, shown in Figure 6.8, is not that important to users, it could be added as advanced options for Multiple Stiffeners (1064). The last three detail components are clearly different from that cannot be easily combined to other stiffener cases. So in the end stiffener detail components could be limited from seven to four or five.

# 7. REAL-LIFE MODELS

TS case models were selected from available models and the target was to find models that were detailed and contained components. From these models the amount of system and custom components were counted. In addition, information about the exploded components were collected. The recorded case models' custom components are presented in Appendix 2.

## 7.1 Case model 1

First case model is a seven storey high hotel in Southern Finland. Structures were modeled with TS version 16.0.2 and the level of detailing was high even though the TS version was quite old. Building structures shown in Figure 7.1 were mainly precast concrete with composite columns and additional exterior steel structures and reinforced CIP concrete in foundations.

The model contains over 13 500 part type of objects and a large amount of steel parts. Despite the structures are mainly precast elements, one roof billboard structure contains almost 200 steel parts. Furthermore, one eaves console at the roof level is built of three steel parts and there are around 206 steel eaves console in the building.

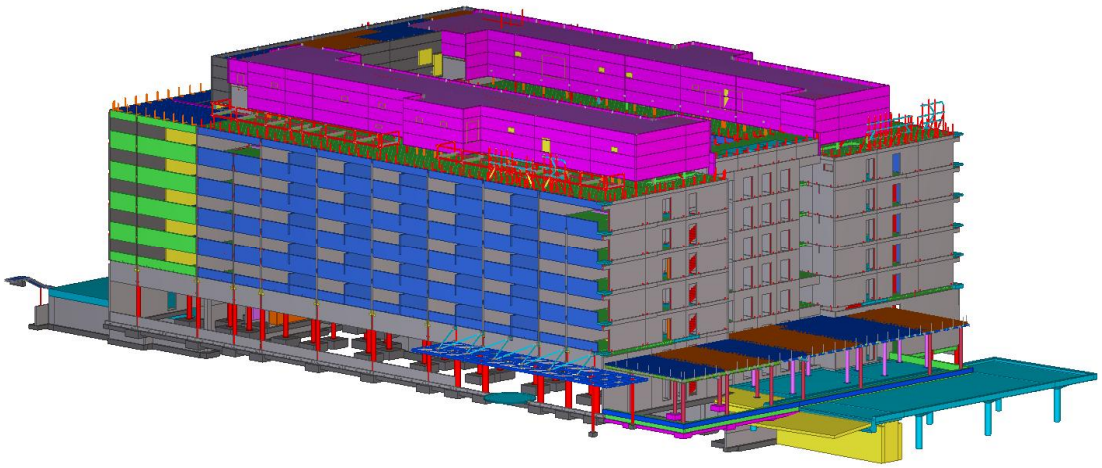

***Figure 7.1.*** *Case model 1*

There are ninety-eight different type of components in the model. The components are reported in Table 7.1. Custom steel components have the most noticeable amount of different components. After a closer look into the custom steel components, the components are very similar. This might be because user's custom components do not have the intelligence as the system component to adapt different situations if the user has

not defined these in a custom component editor. It follows that only one custom component fits in one situation. For example, there are two different custom connections for upper right and upper left connections and the same for a lower right and left connections. Nevertheless, there are no custom concrete components in the model and only eight different system concrete components.

Table 7.1 shows total of 3839 components used in the model. The most used components are system concrete components that are presented later. Second used components are custom steel components and third used are system steel components. In addition, there are few other system components. There are in total more steel components than concrete components.

***Table 7.1.*** *Components in Case model 1 components divided by creator and material.*

| | Total | Different | AVG |
|---|---|---|---|
| System concrete components | 1726 | 8 | 216 |
| Custom concrete components | 4 | 1 | 4 |
| System steel components | 876 | 20 | 44 |
| Custom steel components | 1060 | 67 | 16 |
| Other system components | 173 | 2 | 87 |
| All | 3839 | 98 | 39 |

If we divide the total amount of components with different components, we get the average use of one component that is for all 39. The average use of the component is presented in Table 7.1. The highest average use is with system concrete component's that is 216 which is almost 5 times higher than steel system components value 44. Custom steel components average use is only 16 and custom concrete components have the lowest value 4. For steel connections there are a lot of different custom components and there is a great potential to reduce the number of similar components.

Case model 1 system concrete components distribution is presented in Figure 7.2. There are three components that point out on used concrete system components. These are Slab bars (18), Lifting anchor (80) and Edge and corner (62) components. Especially 711 Slab bars (18) components and 612 Lifting Anchor (80) components appears often therefore these components seem to be useful for the user and have the needed functionalities. The concrete custom components are presented in Table A2.1.

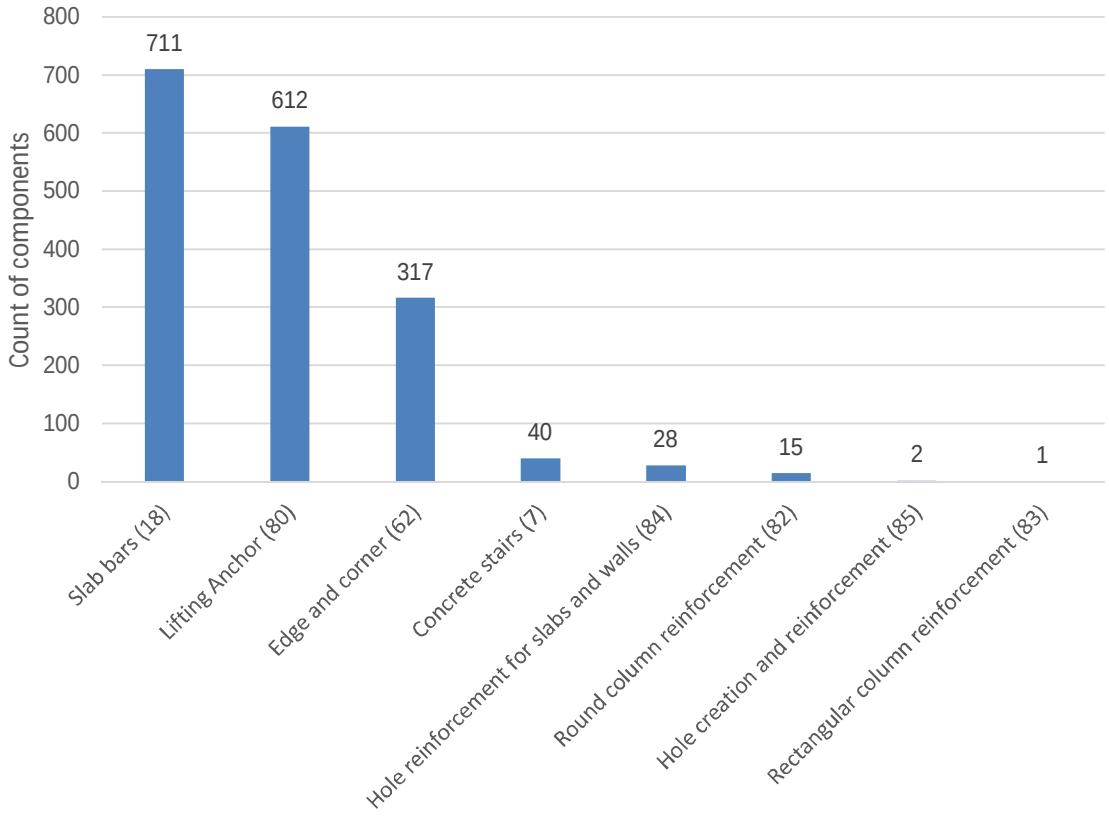


***Figure 7.2.*** *Case model 1, system concrete components*

System steel component distribution is presented in Figure 7.3. The most common steel system component in the model is Portal bracing (105) that was found 252 times in the model. There are Shear plate (103) and End plate detail (1002) components. Fitting (13). Stiffeners are modeled with two different detail component Stiffeners (1003) used five times and Stiffener (1041) used four times. The custom steel components are presented in Table A2.2. There are many custom components that are named similarly, for example, “Ipe330+330+putki” and “Ipe330+330+putki_2”. These are basically the same components but the only difference are the connection directions.

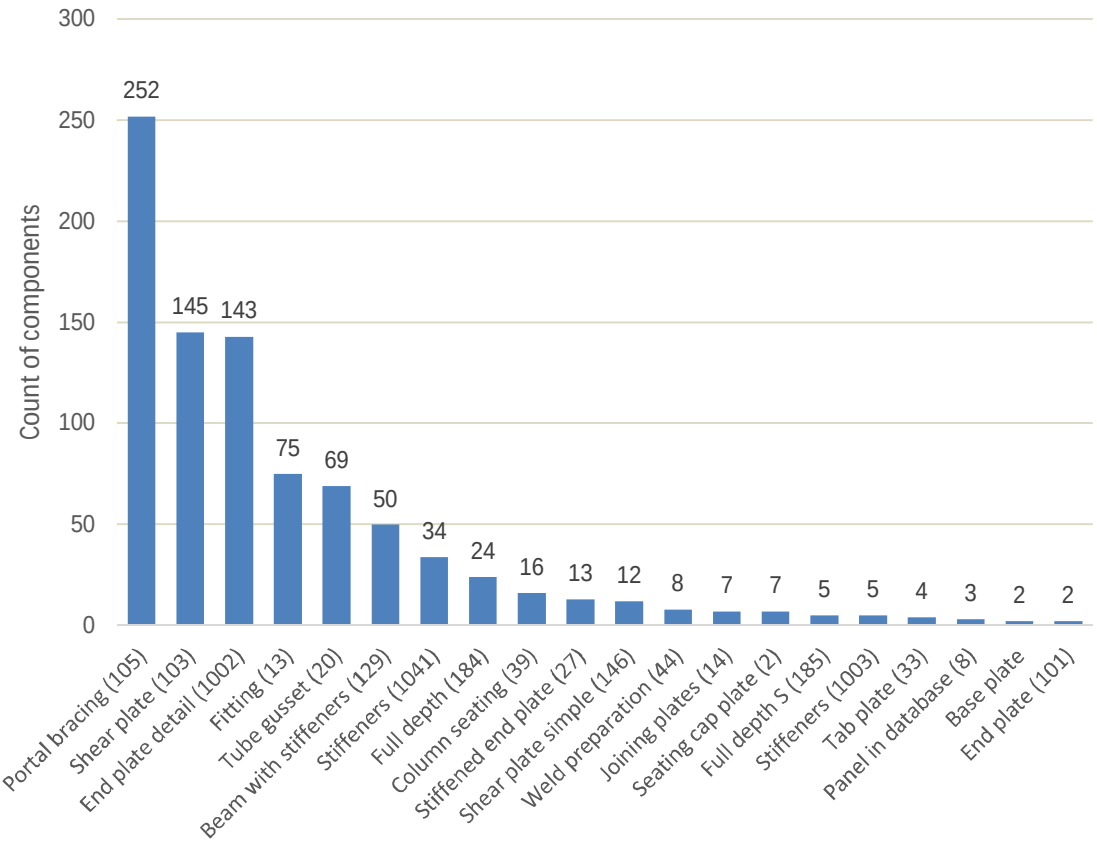


***Figure 7.3.*** *Case model 1, system steel components*

The rest of the components used in the model are Array of objects (29) and Create hole around the part (92) shown in Table 7.2. The model contains 164 Create hole around the part (92) component and 4 Array of objects (29) components. Additionally, five Array of objects (29) components are included in other component. So in total model contains nine Array of objects (29) components.

***Table 7.2.*** *Other components in Case model 1*

| | Other system components | Pieces |
|---|---|---|
| 1 | Array of objects (29) | 9 |
| 2 | Create hole around part (92) | 164 |
| 2 | Total | 173 |

## 7.2 Case model 2

Second case model is a large precast multi-functional building. Building structure shown in Figure 7.4 is mainly precast like sandwich elements and hollowcore slabs and foundation is cast-in-place concrete. Structures were modeled with TS version 21.0 in Finland environment. The model contains over 9 778 part type of objects.

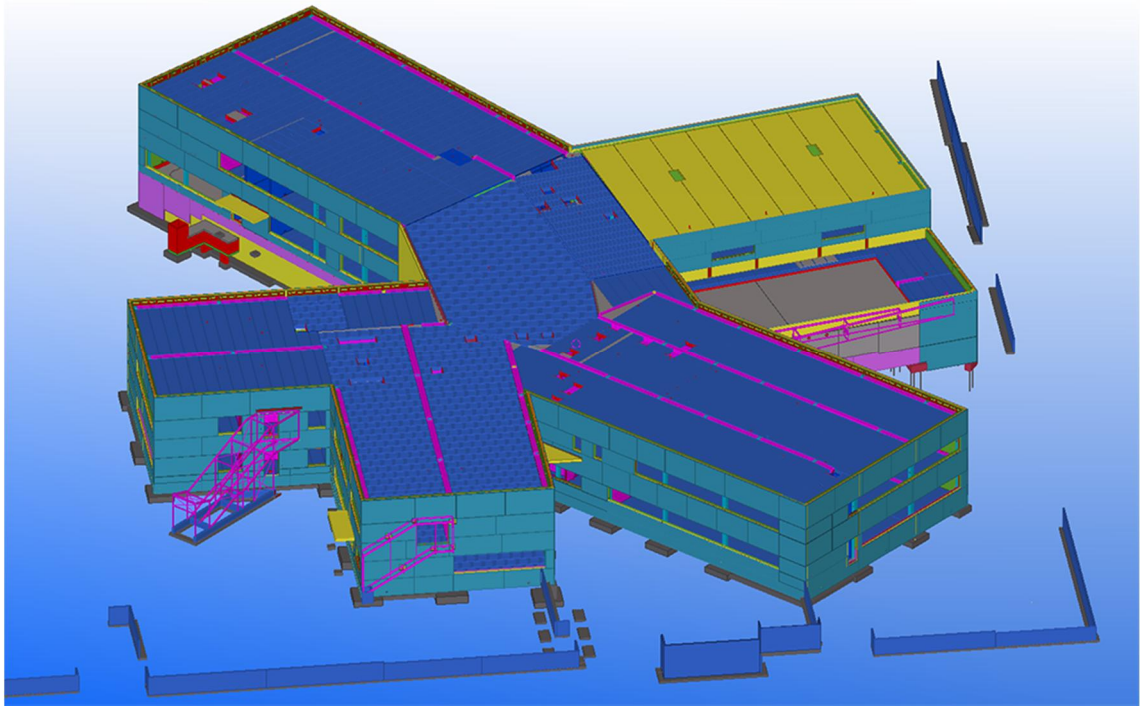

***Figure 7.4.*** *Case model 2.*

There are thirty-seven type of different components in the model. The components are reported in Table 7.3. The model contains fifteen different system concrete component, eighteen different custom concrete components, two different system steel components and two different other components. The distribution of different components is concentrated on concrete components that is the main structure of the building.

In Table 7.3, majority of total 3915 components are concrete components of which 2068 are custom concrete components that is casting part component in another component. From total amount of components only ten are system steel components. On the contrary, the model contains totally 913 system concrete components, 2672 custom concrete components and 320 other components. Additionally, there are no custom steel components.

***Table 7.3.*** *Components in Case model 2 divided by creator and material.*

| | Total | Different | AVG |
|---|---|---|---|
| System concrete components | 913 | 15 | 61 |
| Custom concrete components | 2672 | 18 | 148 |
| System steel components | 10 | 2 | 5 |
| Custom steel components | 0 | 0 | 0 |
| Other system components | 320 | 2 | 160 |
| Total | 3915 | 37 | 106 |

If we divide the total amount of components with different components, we get the average use of one component that is for all 106 times. The average use of the component is presented in Table 7.3. The highest average use is with other components, that is 160. Concrete system components value 61 and custom concrete components' value is 148. System steel components have the lowest value of 5.

The distribution of the system concrete components is presented in Figure 7.5. The topmost component is Hole generation (32). However, Lifting Anchor (80), Slab bars (18) and Edge and corner (62) components are as well quite often used, compared with last eleven concrete system components which appear from one to eighteen components in the model. The concrete custom components are presented in Table A2.3.

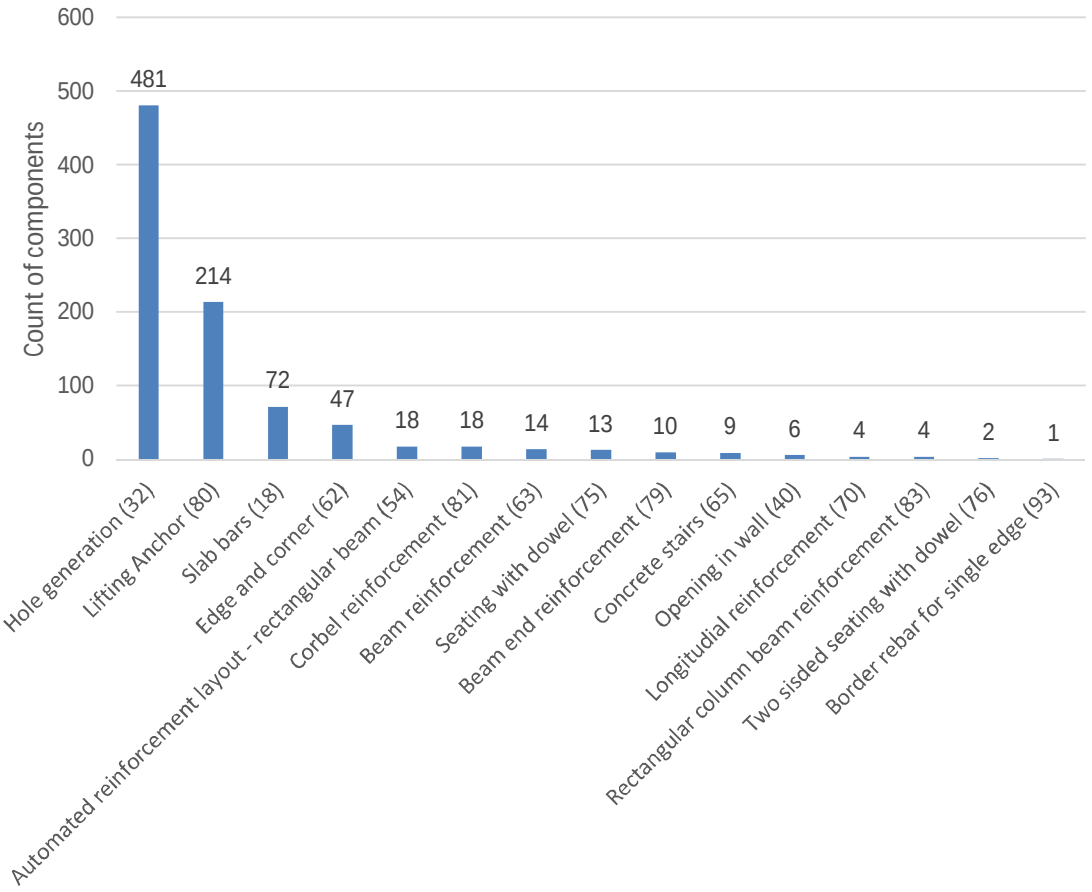


***Figure 7.5.*** *System concrete components in Case model 2*

The model contains two different type of system steel components presented in Table 7.4. There are only eight Base plate (1042) components and two Stairs (S85) components.

***Table 7.4.*** *System steel components in Case model 2*

| | System steel components | Pieces |
|---|---|---|
| 1 | Base plate (1042) | 8 |
| 2 | Stairs (S82) | 2 |
| 2 | Total | 10 |

In the end, other components are Array of objects (29) and Create hole around the part (92) presented in Table 7.5. There are 297 create hole around the part (92) component and 21 Array of objects (29) components.

***Table 7.5.*** *Other components in Case model 2*

| | Other components | Pieces |
|---|---|---|
| 1 | Array of objects (29) | 23 |
| 2 | Create hole around the part (92) | 297 |
| 2 | Total | 320 |

## 7.3 Case model 3

Case model 3 is a shopping center in Finland, shown in Figure 7.6. The shopping center consists of a renovated part and a new expansion which have their own models. First, the renovated part's model is studied and then the new part of the shopping center.

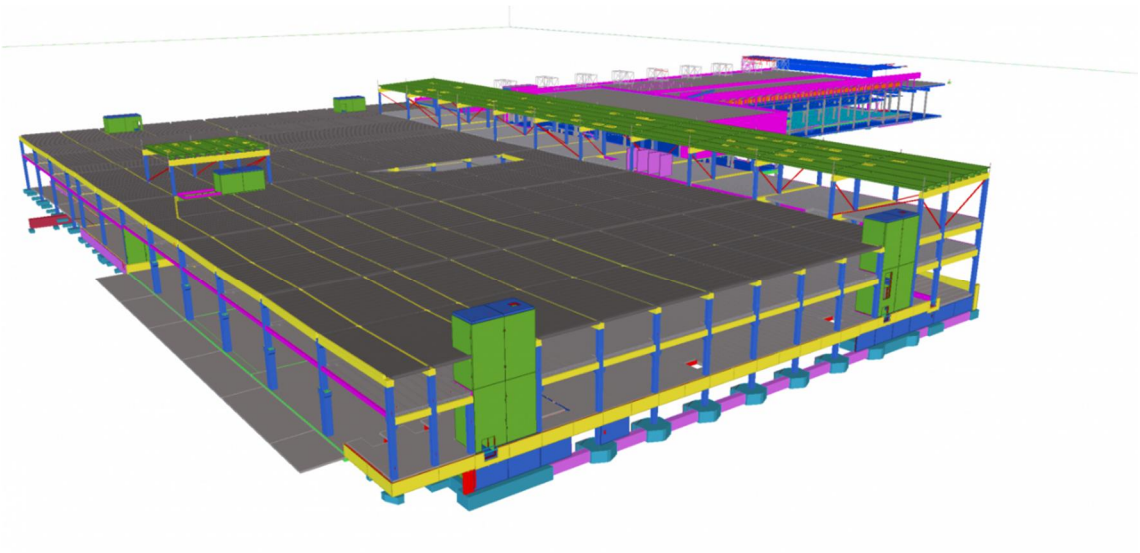

***Figure 7.6.*** *Case model 3.*

### 7.3.1 Case model 3A

Case model 3A is the renovated part of the shopping and the model is shown in Figure 7.7. It was modeled with TS version 19. The model contains precast, composite and steel structures with cast-in-place foundation. Moreover, there are steel trusses, hollowcore

concrete slabs, precast walls and composite columns. The model contains 23 332 part type of objects, 1 697 connection type of objects and 10 696 reinforcement bar type of objects.

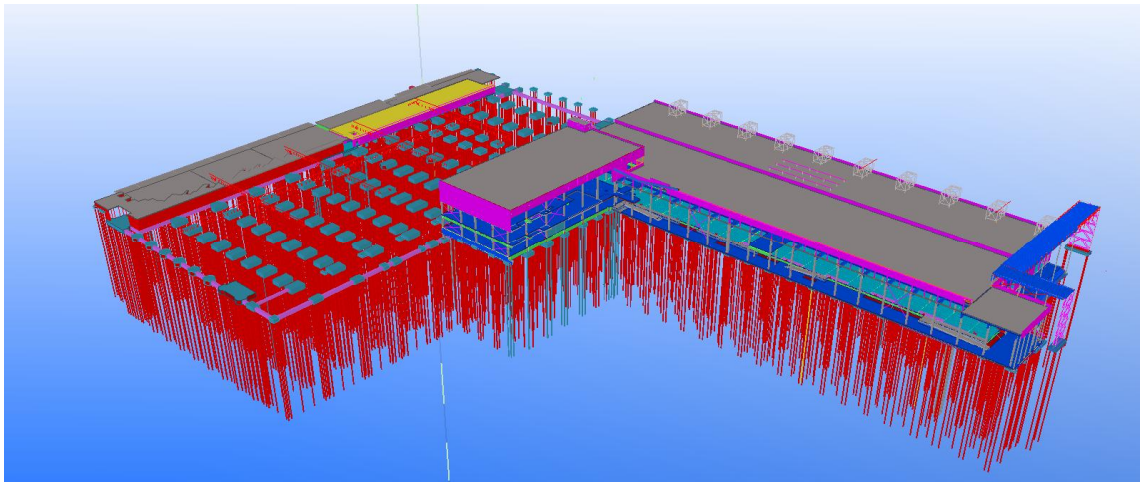

***Figure 7.7.*** *Case model 3A*

The model contains twenty-five different type of components that are presented in Table 7.6. There are fourteen different system steel components one custom steel components. However, other contained only one to four different type of components. There are three different system concrete components and six custom concrete components. Only one other system component Array of objects (29) that was used 431 time.

Case model 3A has 2533 components plus 774 components inside another component which mean there are totally 3307 components in the model. The concrete structures have components inside the component, which are called nested components. For example, in this model in component components are Array of objects (29) and fabricators casting steel parts. The top components are the system steel components that model contain 1635 and custom concrete components are in a second place that model contained 609. Model trusses contain 143 custom steel connection components. In component components were two different custom concrete components that model contained 380 plus 22 pieces and Array of objects (29) 371 pieces.

***Table 7.6.*** *Components in Case model 3A divided by creator and material.*

| | Total | Different | AVG |
|---|---|---|---|
| System concrete components | 87 | 3 | 29 |
| Custom concrete components | 911 | 6 | 152 |
| System steel components | 1635 | 14 | 117 |
| Custom steel components | 143 | 1 | 143 |
| Other system components | 431 | 1 | 431 |
| Total | 3207 | 25 | 128 |

The average use of one type of component is 110 for all components in the model which is the highest with custom concrete components and the lowest with system concrete components. There is only one type of custom steel component that is used in trusses connection 143 times. The average use of system steel components is quite high for fourteen different components. Other system components were only Array of objects (29) that model contained 59 in model and 372 in a component.

Case model 1 system concrete components distribution is presented in Table 7.7. The model contained only three different system concrete components, concrete stairs (65) and Hole generation (32) and concrete stairs (7). Two of the three components are stair components. The older stair component; concrete stairs (7) was used twelve times. The concrete custom components are presented in Table A2.4.

***Table 7.7.*** *System concrete components in Case model 3A*

| | System concrete components | Pieces |
|---|---|---|
| 1 | Hole generation (32) | 69 |
| 2 | Concrete stairs (7) | 12 |
| 3 | Precast stairs (65) | 6 |
| 3 | Total | 87 |

The system steel components' distribution is presented in Figure 7.8. The most common steel system components in the model are Fitting (13) and End plate detail (1002). There are two different stiffener details Stiffener (1003) and Stiffener (1064). Additionally, the model contains two similar one sided end plate connections End plate (144) and End Plate (27). The steel custom components are presented in Table A2.5.

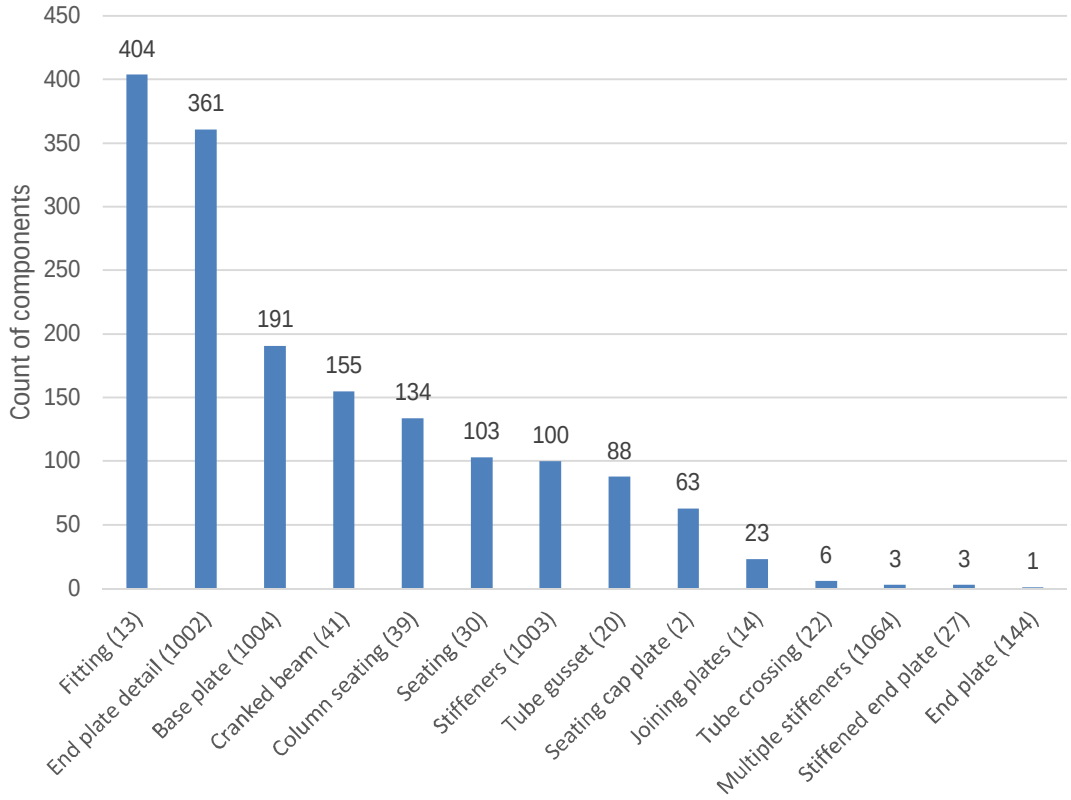


***Figure 7.8.*** *System steel components in Case model 3A*

### 7.3.2 Case model 3B

Case model 3B is expansion part of the shopping center. Structures were modeled with TS version 19. The model contains over part type of objects. Building structures shown in Figure 7.9 are hollowcore concrete slabs, columns, beams and foundation is cast-in-place concrete.

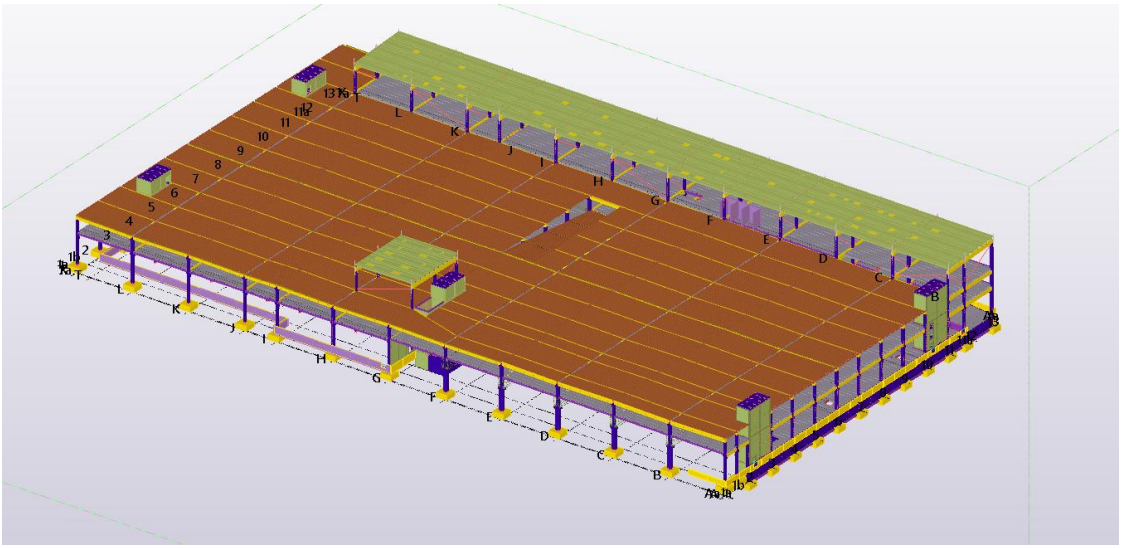

***Figure 7.9.*** *Case model 3B*

There are nineteen different type of components in the model which are presented in Table 7.8. There are ten different custom concrete components, seven different system concrete components and one other system component. There are no steel components.

In total, model contains 2771 components and the majority of the components are system concrete components presented in Table 7.8. There are 764 custom concrete components and 158 other system components that summed up together is less than amount of system concrete components in the model.

***Table 7.8.*** *Case model 3B components*

| | Total | Different | AVG |
|---|---|---|---|
| System concrete components | 1849 | 7 | 264 |
| Custom concrete components | 764 | 10 | 76 |
| System steel components | 0 | 0 | 0 |
| Custom steel components | 0 | 0 | 0 |
| Other system components | 158 | 2 | 79 |
| Total | 2771 | 19 | 146 |

The average use of one component in the model is 146 times. This is the highest in system concrete components and the lowest with custom concrete components and other system components. Even with the lowest average use 76 seems quite high for one component.

Model system concrete components are shown above in Figure 7.10. The most used component is corbel reinforcement (81) that is used 1128 times in the model. Rectangular column reinforcement (83) was used 286 times, slab bars (18) 182 times, Edge and Corner (62) 145 times and Lifting anchor (80) 115 times. The rarest connection components were Beam reinforcement (63) and Corbel connection (14).

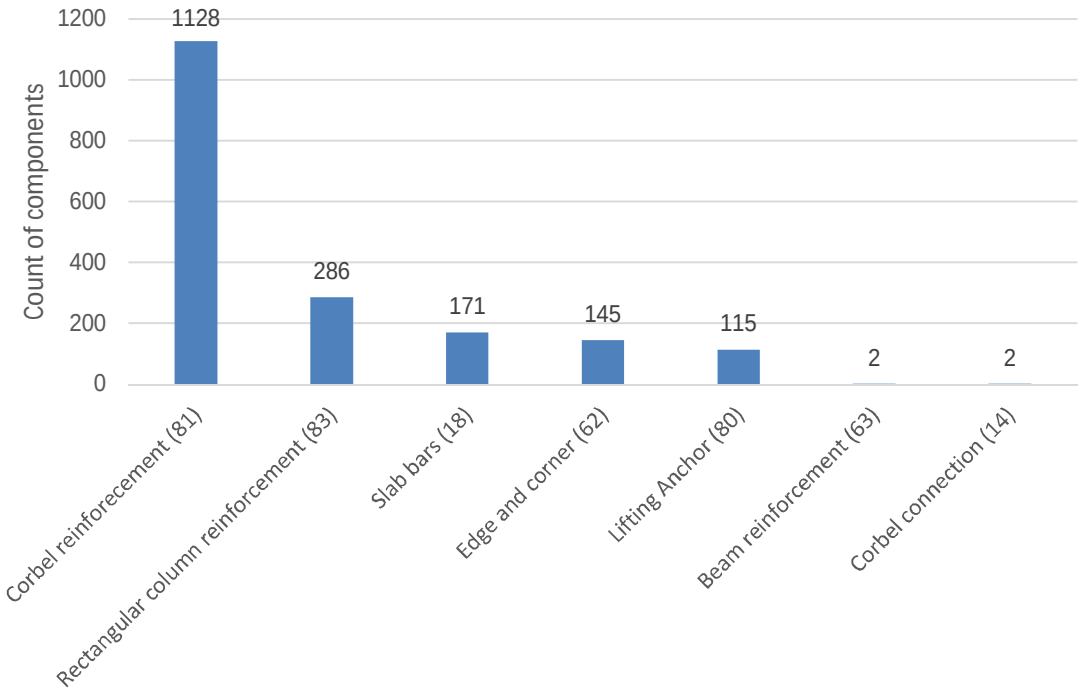


***Figure 7.10.*** *System concrete components in Case model 3B*

Model contains 1370 corbels and 1128 Corbel reinforcement (81) components. Therefore, almost all have been reinforced with the component shown in Figure 7.11. There were a few different corbel sizes and still most of the reinforcement were modeled with the component and it was not exploded.

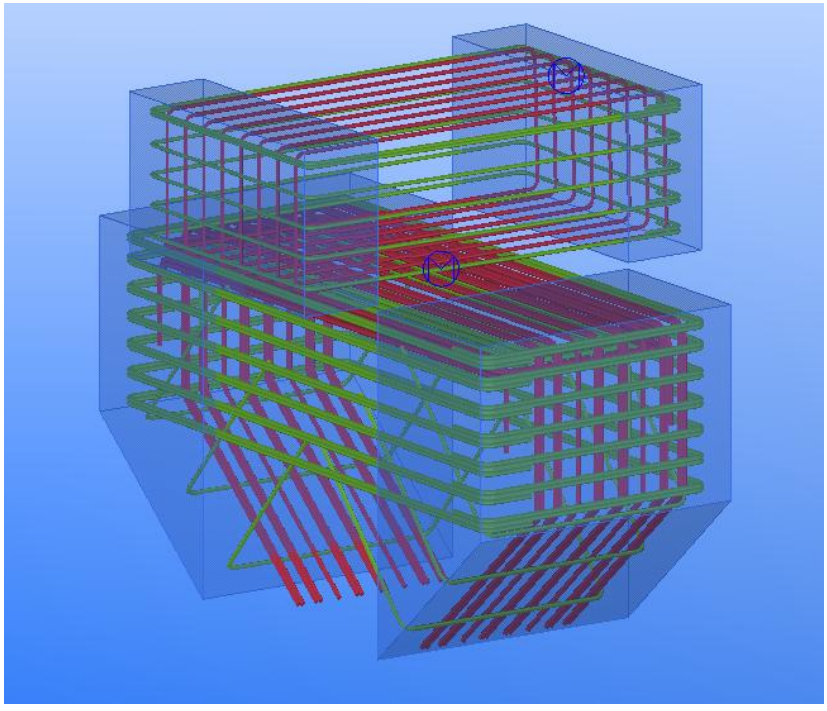

***Figure 7.11.*** *Reinforcement with corbel reinforcement (81)*

Three different cases, where a component had been exploded or modeled without a component are shown in Figure 7.12. The picture on left shows the situations where the topmost stirrup 1 reinforcement group should be in two groups that have different stirrup reinforcement bar shape. In the middle and right picture, consoles have different geometry which is not possible to model with Console reinforcement (81) component.

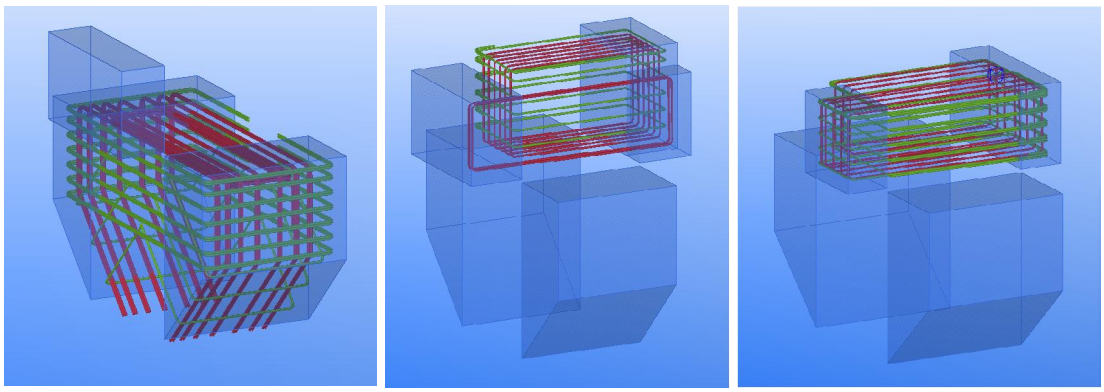

***Figure 7.12.*** *Three console reinforcement without component.*

One interesting point is that model contains only two Corbel connection (14) components that creates the corbel connection between the column and beam. This connection design is used many times in the model which seems like the component have been exploded in most of the times. However the corbel reinforcement is frequently used in the model. So one possible reason for exploding the component might be because it is a connection component and user does not want to any changes to column if the beam is chances.

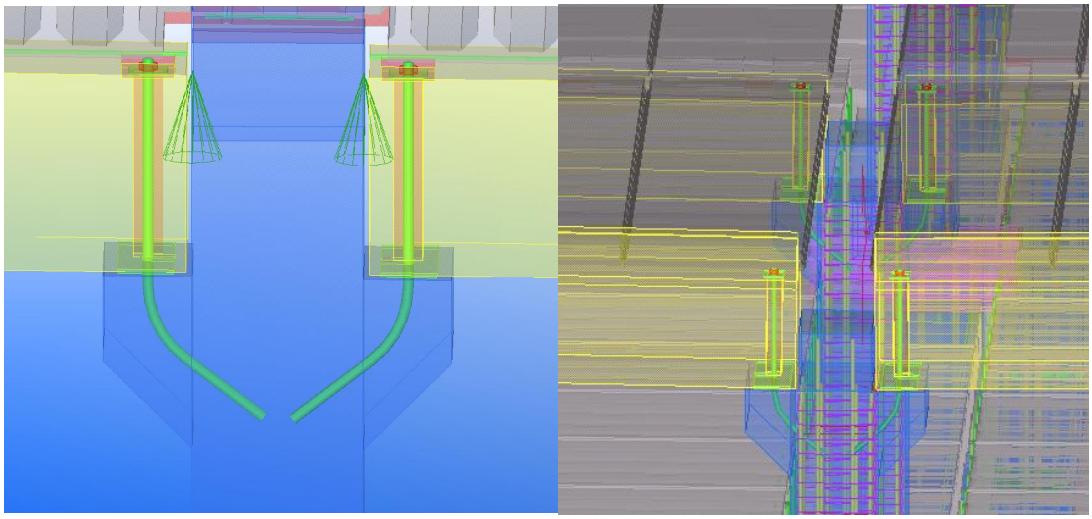

***Figure 7.13.*** *Corbel connection (14) component*

Columns 416 in the model and 286 rectangular column reinforcement (86). Column reinforcement (86) component have been used several times in the model. As can be seen in Figure 7.14 the column reinforcement can be modeled with rectangular column reinforcement (86) component. The below picture of column reinforcement cannot be

modeled with the rectangular column reinforcement (86) component because it has the thicker stirrup reinforcement in the middle of the column.

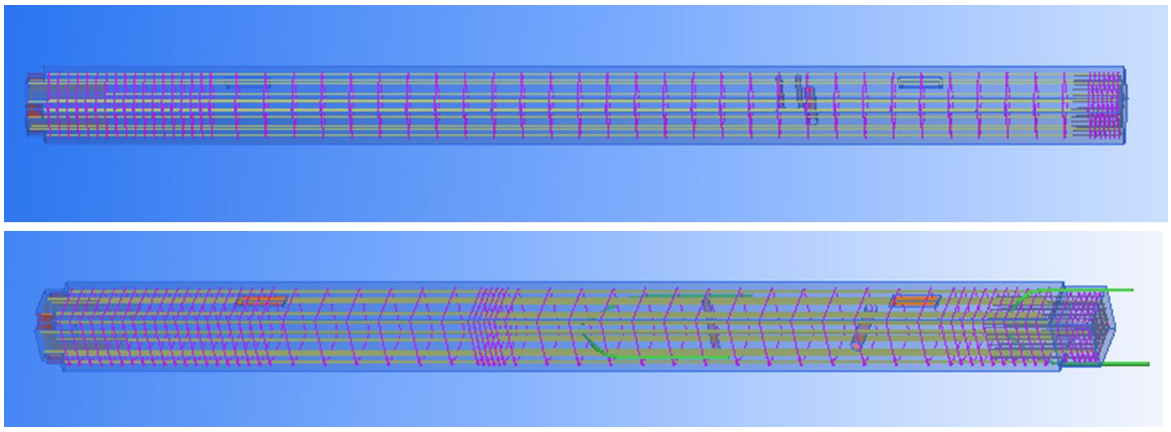

***Figure 7.14.*** *Column reinforcement modeled with a component (above) and without a component (below).*

The beam reinforcements are with two similar precast beams. The rest 463 beams are pre-stressed concrete beams which reinforcement has not been modeled. The model contains 324 precast concrete slabs (hollowcore concrete slabs or TEK-slabs are not included) and walls. These precast elements contain the 182 Slab Bars (18), 156 Edge and Corner (62) and 126 Lifting Anchor (80) components. Custom concrete components were used to model precast elements and element custom seams and casting parts shown in Table A2.6.

In Table 7.9 is presented other system components that were Array of objects (29) and Create hole around the part (92). Array of objects (29) was used mainly with casting parts and Create hole around the part was used between concrete column and slab.

***Table 7.9.*** *Other system components in Case model 3B*

| | Other system components | Pieces |
|---|---|---|
| 1 | Array of objects (29) | 146 |
| 2 | Create hole around the part (92) | 12 |
| 2 | Total | 158 |

## 7.4 Case model 4

Case model 4 is steel structured speedway in US. Structures were modeled with TS version 20.1. The model contains over 23 400 part type of objects. Building structures shown in Figure 7.15 are steel structures and foundation is cast-in-place concrete. Concrete foundation, slabs and walls contain reinforcing bar type of objects over 41 000 pieces.

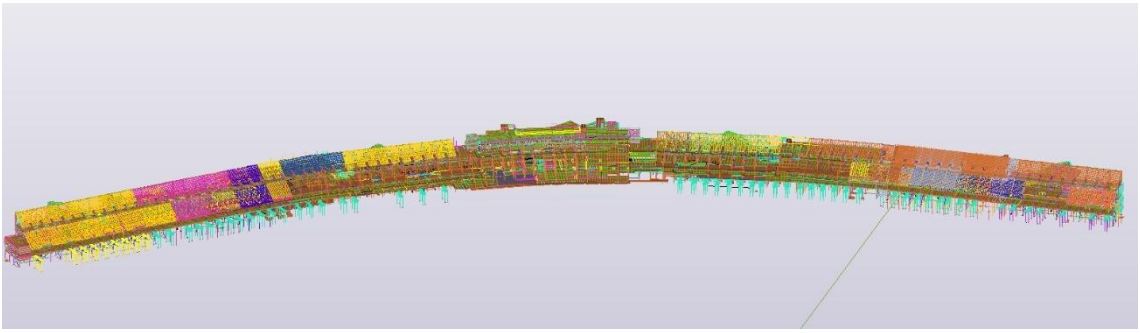

***Figure 7.15.*** *Case model 4*

There are totally 53 949 components presented in Table 7.10. Most of the components are system steel components, second are custom steel components and third are system concrete components, fourth are custom concrete components and last are other system components.

Total amount of component is divided into 463 different type of components shown in Table 7.10. Most of the different components are custom steel components that can be found 343 in the model. Next are concrete custom components that model contains 59 different that are used in foundation reinforcements. There are 57 different system steel components. Rest of the components are three different system components and one other system component.

***Table 7.10.*** *Case model 4 components*

| | Total | Different | AVG |
|---|---|---|---|
| System concrete components | 2344 | 3 | 781 |
| Custom concrete components | 602 | 59 | 10 |
| System steel components | 48210 | 57 | 846 |
| Custom steel components | 3236 | 343 | 9 |
| Other system components | 159 | 1 | 159 |
| Total | 54551 | 463 | 118 |

Average use of one component is 134 times presented in Table 7.10. It is highest with steel and concrete system components. Custom steel components average use is only nine that is only about 1% of system steel components average use. In addition, the system concrete components average use is much higher than the custom concrete components.

The concrete system components are presented in Figure 7.16. Most of the concrete system components are Stirrup reinforcement (67) components that are mainly modeled and not exploded with a component. Rectangular column reinforcement (83) is presented. Additionally, model contains custom concrete components. The custom concrete components are mainly simple rebar groups or meshes in cast-in-place concrete foundations.

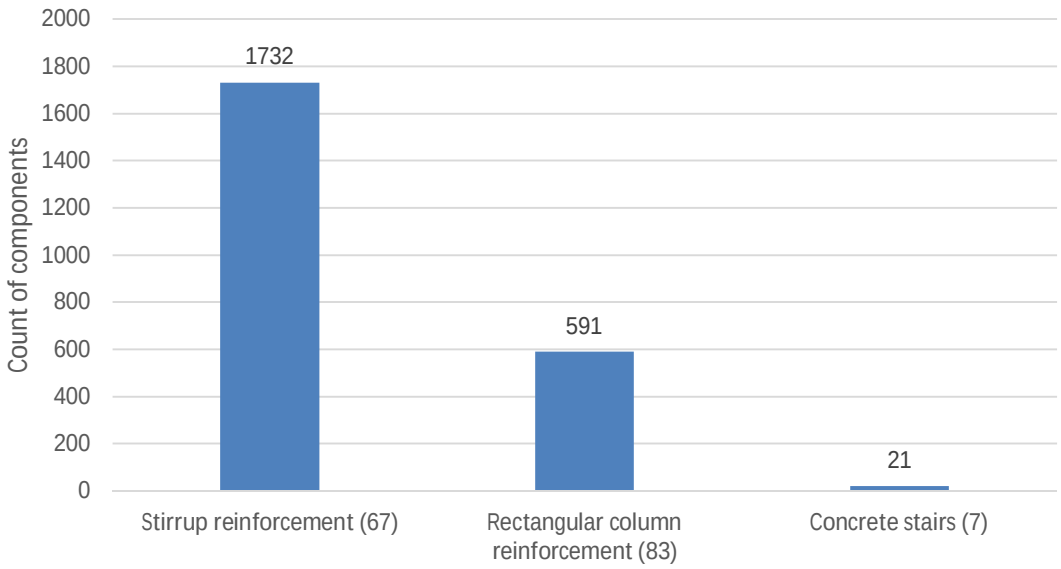


***Figure 7.16.*** *Concrete system components in case model 4*

Extremely most of the steel components are Shear plate simple (146) connections presented in Figure 7.17. Second is the round tube (23) and third is fitting (13). There are over twenty steel components that can be found under ten pieces on the model which is really small amount compared to top components that can be found over a thousand in the model.


***Figure 7.17.*** *System steel components in Case model 4*

There are totally 3843 Stiffener components that are divided into four detail components and four connection components. The most used stiffener detail component is Stiffener (1003) shown in Figure 7.18. Other stiffener detail components which all could have been modeled with Multiple Stiffener (1064). Only the one horizontal stiffener component in the model could have not been modeled with multiple stiffener (1064).

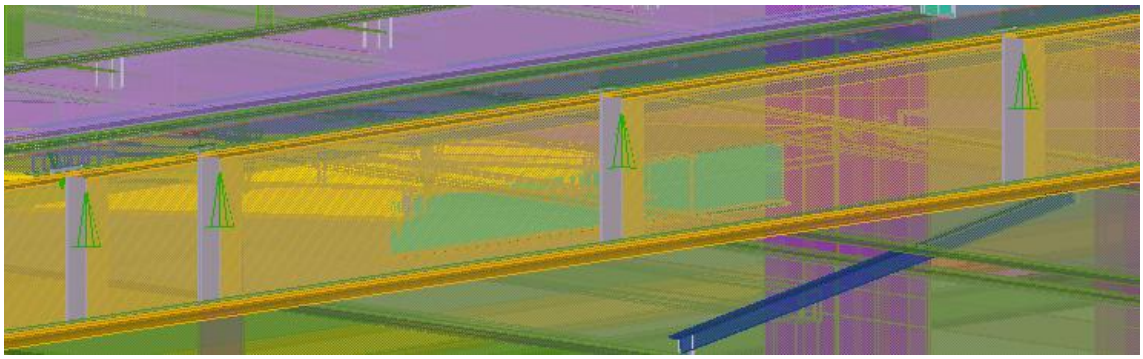

***Figure 7.18.*** *Stiffeners (1003)*

Additionally, the model contains all four different type of Stiffener connection components that were studied in Chapter 6.2. The most used stiffener connection component is Column with stiffener (186) shown in Figure 7.19 that creates rectangular shear tab and does not create weld backing bars or weld preparations.

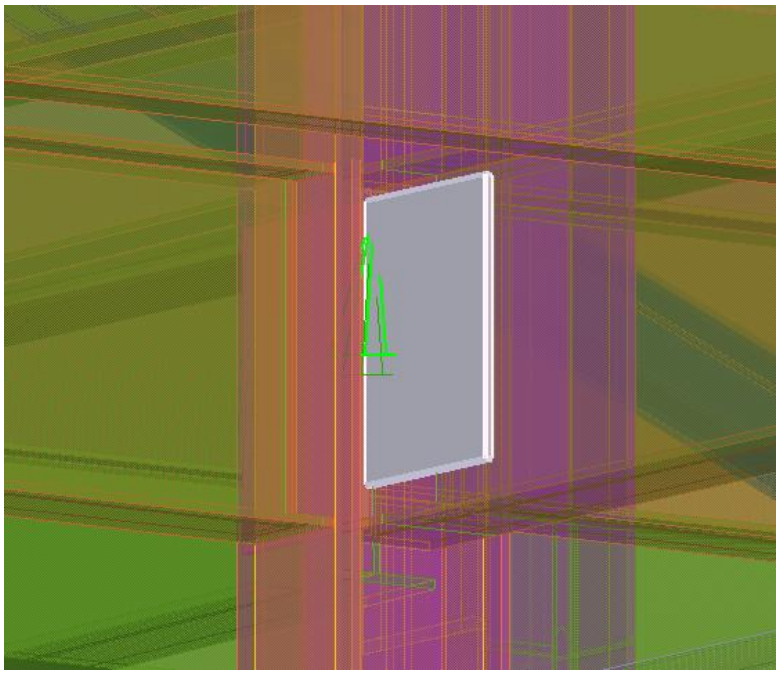

***Figure 7.19.*** *Stiffener connection (186)*

## 7.5 Case model 5

Last case model is quite simple steel structure shown in Figure 7.20. It is modeled with TS version 20.0 Service Release 4 and environment was Germany. The model contains 1314 part type of objects. The industrial building length is 29.4 meters, width 26.2 meters and height is 7.4 meters.

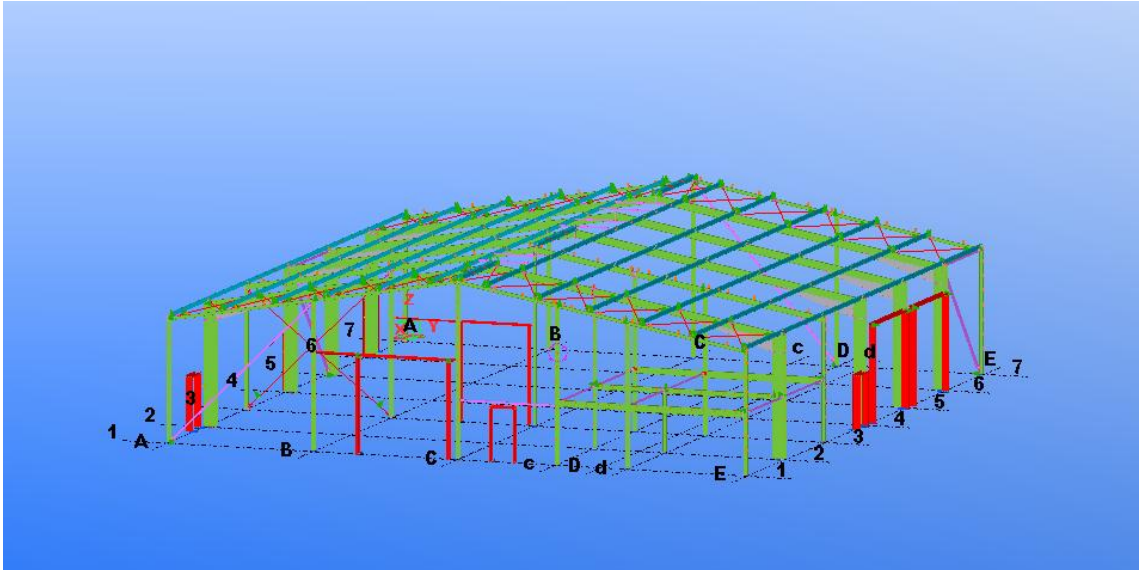


***Figure 7.20.*** *Case model 5*

The model contains totally 166 components, which are all system steel component shown in Table 7.11. The most used component was Tube gusset (20) and the second was Turnbuckle connection (126). In total, six different component were used.

***Table 7.11.*** *Case model 5, system steel components*

| | System steel components | Pieces |
|---|---|---|
| 1 | Tube gusset (20) | 92 |
| 2 | Turnbuckle connection (126) | 50 |
| 3 | End plate (29) | 8 |
| 4 | Seating (39) | 8 |
| 5 | Seating cap (37) | 4 |
| 6 | Stiffeners (1003) | 4 |
| 6 | Total | 166 |

The case model's system steel components were quite often AUF data from January 2013 to June 2016. The ranking of all the components was for Stiffeners (1003) 12, End plate (29) 14, Tube gusset (20) 22, Seating (39) 32, Seating cap (37) 212 and last Turnbuckle (126) 222 from 2273 components.

## 7.6 Conclusion of case models

The case models had different structures and purposes. In addition, Case models were modeled with different TS version from TS version 16 to TS version 21. There are different components between the models depending on the building structures.

In the concrete models, the typical concrete components were Lifting Anchor (80), Slab bars (18) and Edge and corner (62). In addition, the reinforcement components were widely used but in some cases, there were not enough options for stirrup reinforcements, so the component was exploded or the reinforcement was modeled individually. The case model 4 contained great amount of stirrup reinforcement (67) component that was used in concrete foundations.

In the steel models and in concrete models additional steel structures, there are larger amount of different steel components than concrete components. The largest of these case models, case model 4, contains large amount of steel components that could have been designed with fewer amount of different kind of components. The case model 5 is good example of simple model that is modeled by one engineer and it does not contain similar components.

# 8. IMPROVEMENT PROPOSAL

In this chapter, the improvement proposals for TS components are presented. First improvement proposals concentrates on how to improve current components. Then idea of totally new components is presented. Both aspects have their advantages and disadvantages that are listed in this chapter.

## 8.1 Current components' improvement

Next current components' improvement proposals are presented. In the first part the proposal for component catalog improvements to search and to choose a right component are presented. Then the improvement proposal for component dialog box and in the third part the proposals for modeling a component are proposed.

### 8.1.1 Comprehensive search

Improving the component search tool would help the new users to find the correct components easier. Currently, it is possible to give tags to components and this way make the component search easier. This concept requires deeper look for the differences of the components to provide real help in finding the right component.

First proposal is the comprehensive search that could work like the filters in web stores. The comprehensive search goal is to help user to find the best fitting component for selected situation. For example, User could filter steel components with different options as shown in draft pictures in Figure 8.1. Nonetheless, search would still have the open search field. Both of the proposals contain the same possibilities to check but on the left side draft the options are in dropdown and on the right side draft options are in check boxes.

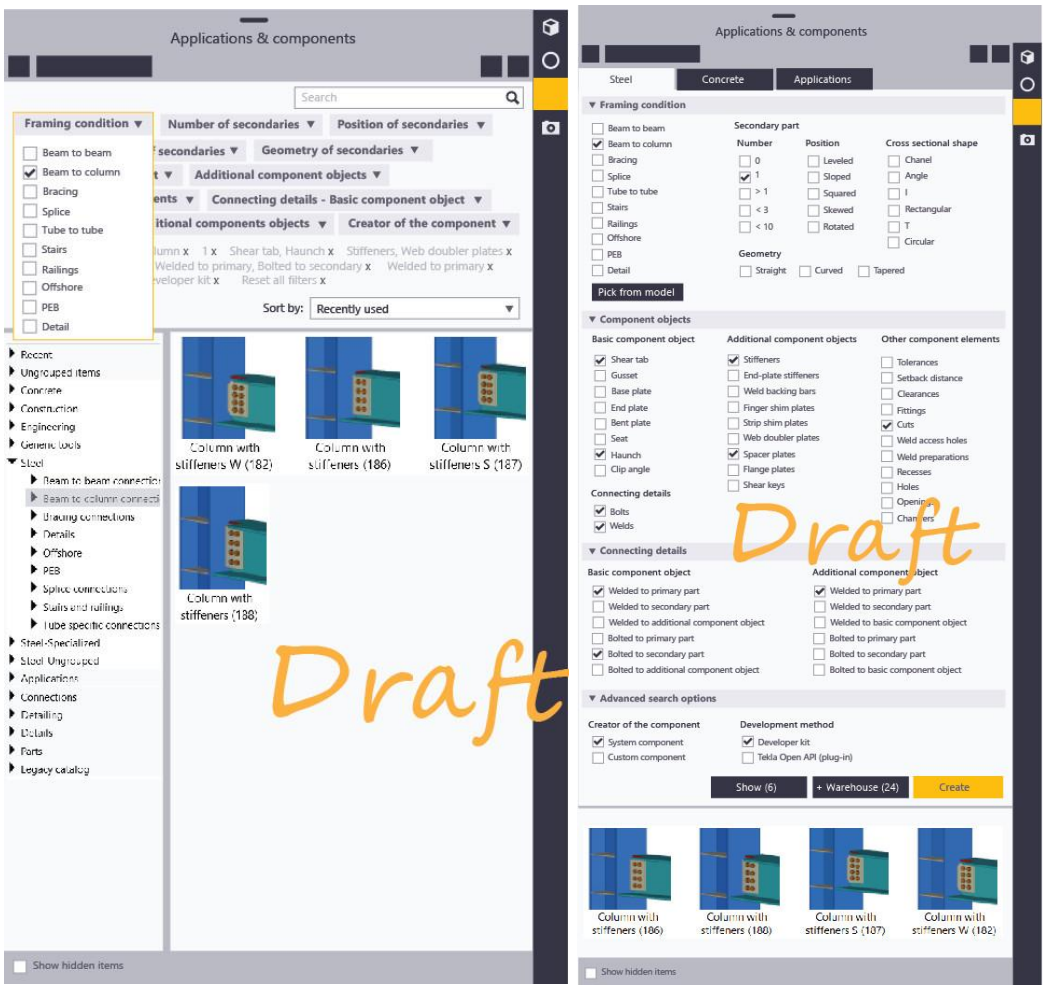


***Figure 8.1.*** *Comprehensive search drafts for steel components [17]*

The filtering options for steel components could be in groups that could be framing condition, component objects, connecting details and advanced search options. These groups could be minimized if wanted.

First group, the framing condition can be checked from the model or from the comprehensive search options. In Figure 8.1, for example, the framing condition ‘Beam to column’ is selected from comprehensive search options but the beam and the column can be selected from the model and press pick from the model. With only this selection catalog would show all the possible components for beam to column connection components. Second group, created objects, lists all the possible basic component objects, additional component objects and other component elements, which are the division of steel component objects in Tekla Structures glossary. In Figure 8.1, for example, created objects are shear tab, haunch, stiffeners, spacer plates, cuts, bolts and welds. Third group, connecting detail, lists the possible connecting details between different parts. With these selections can be selected if the basic component objects are welded or bolted to selected part. Last is advanced search options that are creator of the component and development method. The creator options are system and custom components, and the development methods are a.kit and plugin.

The second proposal for component catalog search is a tree view from component catalog groups on a left side draft picture in Figure 8.1. The tree view could be used together with the comprehensive search.

### 8.1.2 Sort and view options for component catalog results

In this chapter, the improvement proposals target is to provide more information to select the right component. These are provided with a sort option and with a new view option.

Next, two features for component catalog sort options that could be combined with comprehensive search are introduced. First, customized catalog by environment could show the suitable components for selected framing condition that could be modified by environment. Second, user's modeling history with components could be used to suggest the right component. Current *Applications & components* catalog contains recent group that shows recently used components. The history could be useful to combine with selected part or parts from the model and component catalog could show the recently used component in the selected framing condition. These features could be used in a component catalog sort option.

Current component catalog contains three view options: the compact thumbnail view, thumbnail view with a component name and the list view of the component names. However, in some cases it would be useful to have a view of component properties. The new view option could show the picture, description, objects created, type and tags of the component as shown in Figure 8.2. There could also be some other information and user could define what information would be shown.


***Figure 8.2.*** *New view option [17]*

### 8.1.3 Component dialog box

Improvements to component dialog box should speed up and help the modeling process. A more visual dialog box would also improve the usability. The help and information can be included in component dialog box and in the model.

One improvement would be to show the default values on the text boxes. The component could also have a 3d guidance that could indicate which plate properties will be modified by highlighting the part. In addition, if the property is dimension that would be shown as well. The 3d guidance could be in the model or in a preview window of the component.

Component dialogs box should only show necessary information first and contain tabs to show and hide more detailed information. Several components have similar properties that should as well have an identical user interface. For example, stiffener plate's component dialog box tabs would all be similar with each other.

### 8.1.4 Modeling component

New components can be created with AutoConnection, current component command or by selecting a component from the component catalog. With history usage the catalog could suggest components for a selected part or parts.

Model with direct modification improves the component flexibility in different situations but it also requires the option to save the direct modifications to later use.

## 8.2 New component concept

In a new component concept, the connection or detail could be a group of smaller components. The main goal would be to have one component to one specific situation.

### 8.2.1 Requirements for new component concept

The main requirement for component concept is still to facilitate and fasten modeling. For the component adjustment this means that it is to model chances and possibility to save component values for later use.

This could be done with exact components for one specific detail. For example, there would be only one component for stiffeners, end plate and shim plate. These components could be used as “End plate detail” or with another component to combine current “End plate connection” with stiffener, bolt and weld components which could be added to the configuration. TS could contain pre-grouped connection components which could be used, edited or make new ones from the beginning. Edited and new component groups can be saved to component catalog.

The component contains the typical information and requirements for that part such as end plate is a component object that represents a plate welded perpendicular to the end of the part.

### 8.2.2 How to create a new component group

Different ways to create new component group might be many. Below, three different options to create a new component are presented.

First, option is to use drag and drop components from component catalog to a model and save later the component group for later use. Second option is to use other visual method such as visual modeling that is used in architectural software Rhino. Third option is tree structure that is used in AutoConnection Setup dialog box. The components related the part, for example, stirrup reinforcement.

Possibility to chance values in organizer or list type of view. As well as visual guidance to show the modified group set. For example, to define spacing between the modeling parts.

### 8.2.3 Advantages of new component concept

The advantages of the new components compared with the current components would be the flexibility for different situations and possibility to add and remove component's parts from the component. The new way of combining an intelligent small component into bigger groups would make it easier to fix problems in the small component than in a bigger component.

The possible problems would be to figure out the right way to save the component groups and construct the user interface of the component so that it contains all the necessary information without being too complex. Additionally, planning and implementation of the new component concept, whatever it would be like, requires a lot of work. It is therefore important to assess the benefits of the new component concept over the current components carefully before the implementation of the new concept.

# 9. SURVEY OF COMPONENTS

In this chapter, web survey of components' problems and improvement ideas results are presented. The current components' properties are presented in Chapter 2 and the problems found at the interview are reported in Chapter 4. The results of the survey consist of four parts. In the first part the participants' work background with TS is presented. In the second part, the system component, custom component and AutoConnection use and development needs are presented. Then, the problems of the components and finally the improvement proposals results are presented.

The problems and improvement proposals were rated from 1 to 5. At the problem statements 1 means "Not a problem" and 5 means "A big problem", and at the improvement proposals 1 means "useless" and 5 means "useful". Nest to the survey results.

## 9.1 Work background with TS

The totally 81 people answered the survey, 43 were structural designers, modelers or detailers, 35 were working as a developer, other technical job or as a support person and two were working in both jobs and one did not answer the question.

The survey starts with a question: In general sense, how useful are the current components? In Figure 9.1, can be seen that in general current components are rated as useful. Only two has answered 2 that is closer to useless and 31% has answered in the middle of useless and useful. The overall average opinion of the TS components in general is 3.90.

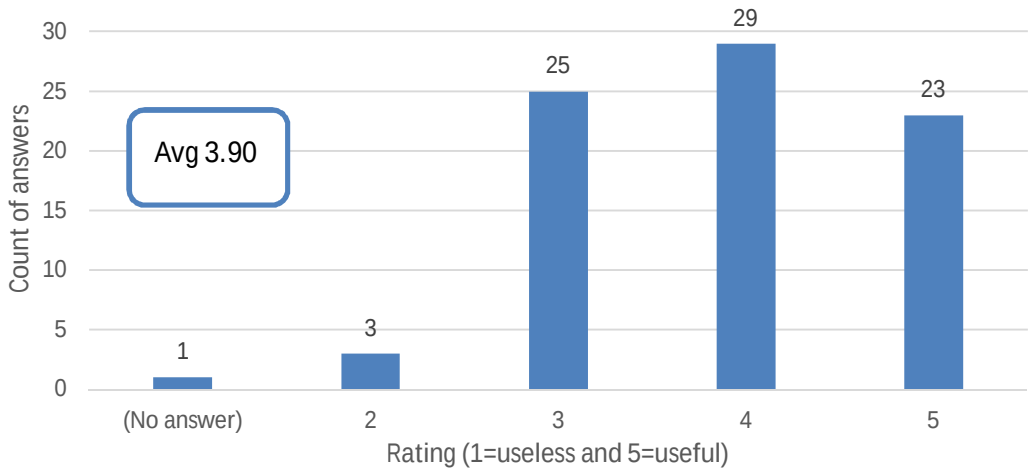


***Figure 9.1.*** *How useful are the current components? (1=useless and 5=useful)*

The newest used version is presented in Figure 9.2. From the figure can be seen that 37 has used TS 21 and 32 has used TS 2016. Only ten participants were using the TS version 20 and only two were using TS version 19 or older.

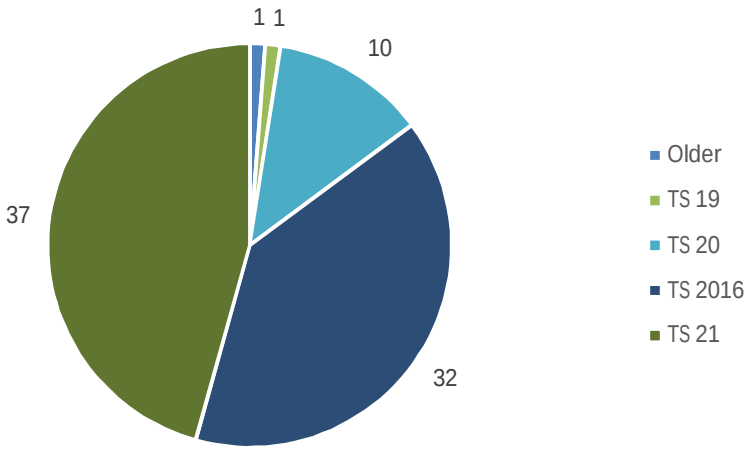


***Figure 9.2.*** *The latest used TS environment.*

The participants' used environments are presented in Figure 9.3. In the survey it was possible to select the maximum of three environments. All choose at least on environment and eighteen choose two environments and twenty-four choose three environments. The topmost environment among the survey is the US imperial that used 65 of the participants. The second is company's environment that used 25 of the participants. India, the US metric and Finland were used over ten participants and UK, default, Netherlands and ´France were used under ten times.

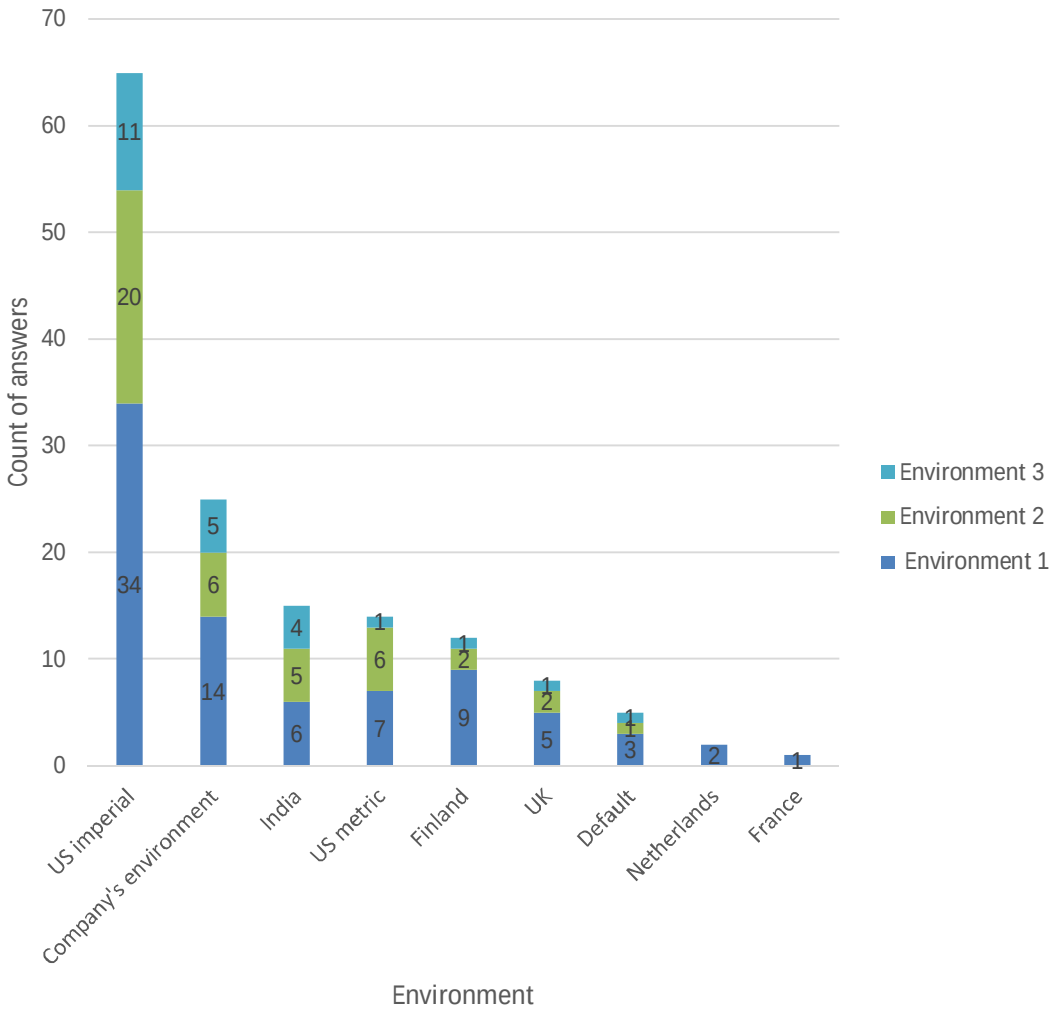


***Figure 9.3.*** *Used Environments*

## 9.2 Development areas

Next the use of system components, custom components and AutoConnection is defined. Then, the satisfaction and development needed are defined. First, in Figure 9.4 is shown how satisfied people were with the usability of system components. Most of the participants were satisfied or thought that the system components are good but need a little improvement. However, 19 people were not satisfied with the system components.

Two did not know and one did not answer that might be because they were not familiar what were meant with the “system components”.

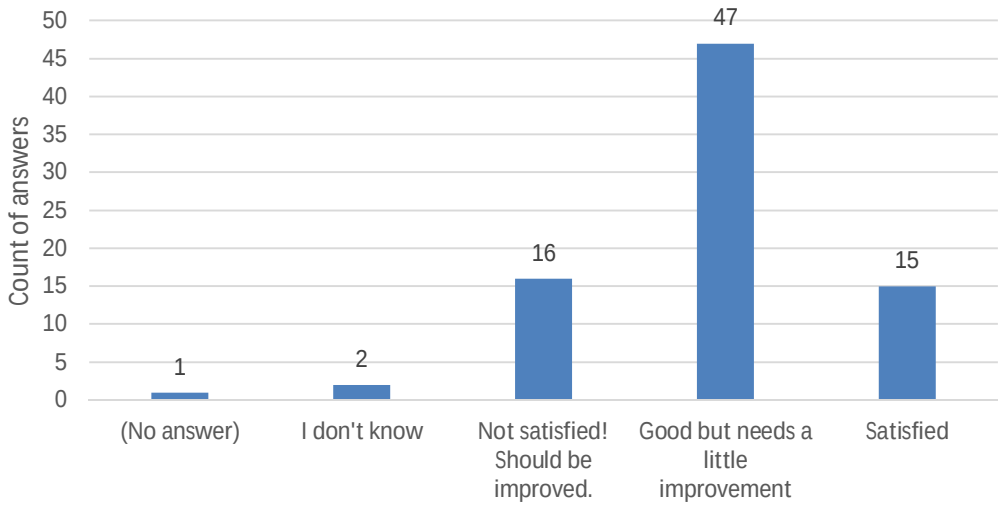


***Figure 9.4.*** *How satisfied are you with the usability of system components?*

Comments concerning the system components were:

- Regarding on system components, it depends, some are fine, some need a little work and others need a lot of work.
- A lot of components and only some of them work properly. In detailing components cannot have any shortage or they become useless
- Direct modification should be included more in components
- System components need to correct! For example, in cast-in-plate (1069) connection component, we are not able to change two different material grades to embed plate and shear tab. Also, every brace connection needs a rounded slot option that is not in the system components (11), (57), (59), (60).

Totally 79 of 81 people has used the custom components. The satisfaction of the custom component editor is presented in Figure 9.5. The amount of “Satisfied!” answers is fifteen that is almost 19% of the answers. However, the rest of the votes are more focus in “Not satisfied!” than “Good but need a little improvement”. Additionally, seven of the participants has not used the custom component editor and one did not answer the question.

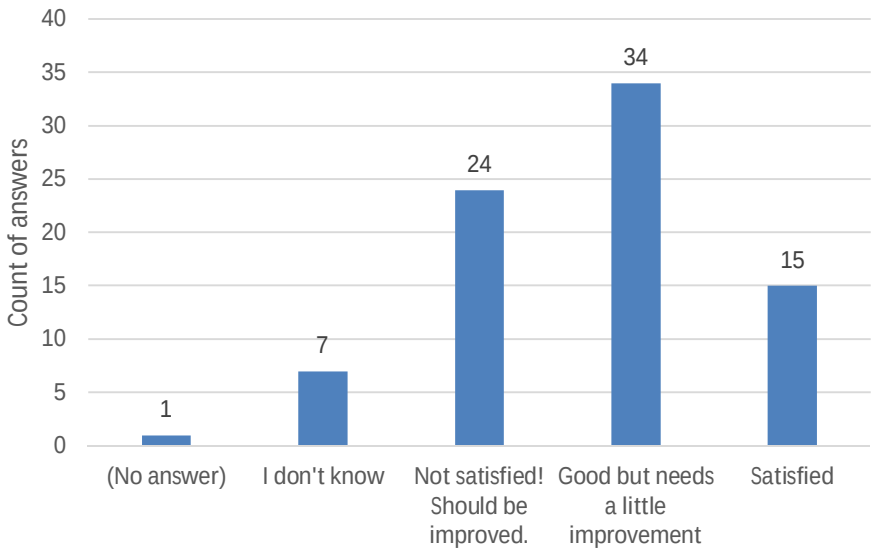


***Figure 9.5.*** *How satisfied you are with custom component editor?*

Comments concerning the custom component editor were:

- There are minor things that could be improved within the custom component editor, by I consider myself an expert in it, not a typical user.
- Add bolt template to custom component editor
- Improvements would provide a huge benefit for us!
- Custom component editor should have lines or something that would have an option to use direct modification!

A little over half of 81 people in the survey have used in. In Figure 9.6, is presented the satisfaction on AutoConnection. First, can be seen that 34 did not use AutoConnection or did not answer the question. Only eight of the 49 that used AutoConnection were satisfied with it. The rest were divided into 23 that thought it is good but needs a little improvement and 18 that were not satisfied.

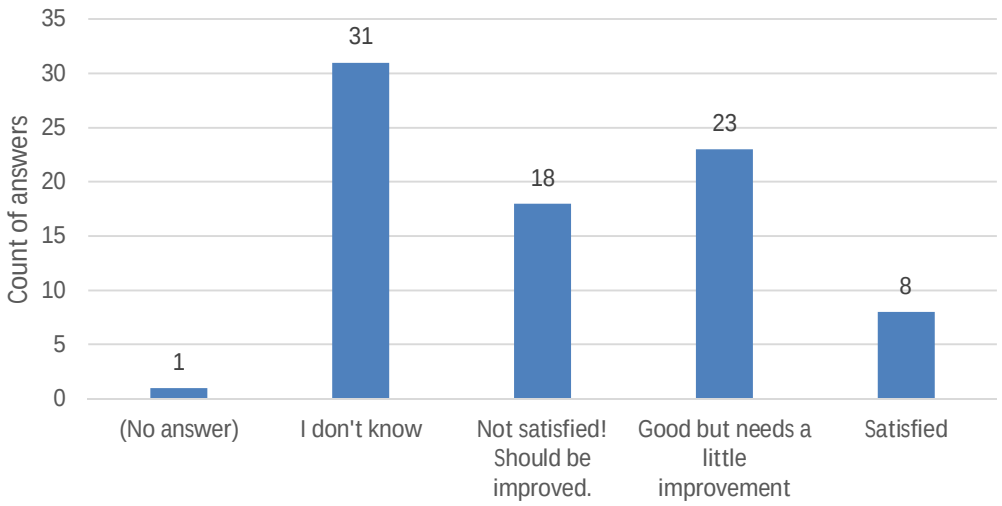


***Figure 9.6.*** *How satisfied you are with AutoConnection?*

Comments concerning the AutoConnection were:

- Need to work for seam components.
- Not that useful in precast connection.
- We use AutoConnection in frame structures but not in misc jobs.
- AutoConnection is very powerful but at the same time its not user friendly.
- Ok for what it is but if we incorporate some connection design into it, that would be awesome.
- Improvements would provide a huge benefit for us!

## 9.3 Component problems

Next, people have rated some of the components' problems. Totally, seven problem statements were presented that were rated from 1 "Not a problem" to 5 "Big problem" and there was a possibility to add comments.

First problem statement is ""I don't know which term to use in the search field" and results are presented in Figure 9.7. The average rate is 2.3 that means it is not a problem for most of the people. Only one of the participants has rated it as a big problem compared with twenty-three that says it is not a problem. One of the comments were that the new users will find it difficult which might be the reason why people who answered the survey might be quite experienced users.

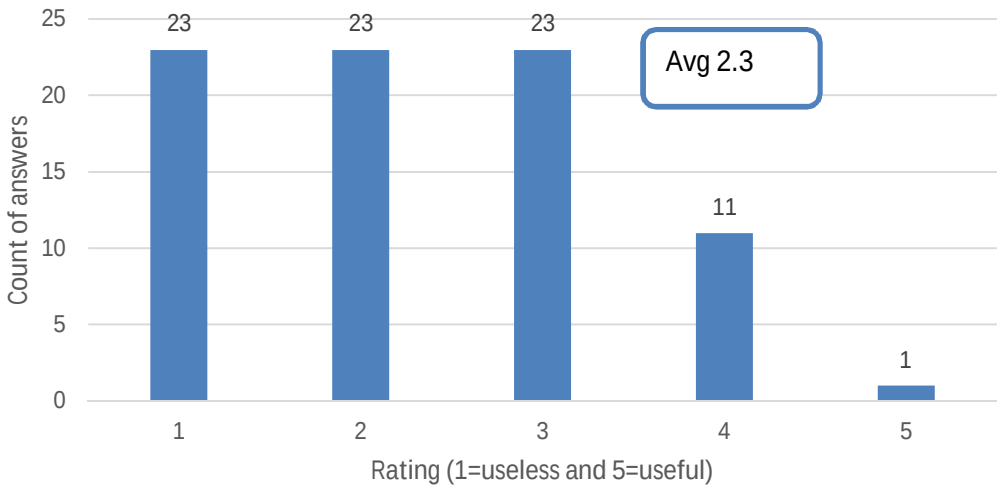


***Figure 9.7.*** *Problem 1:" "I don't know which term to use in the search field." (1=Not a problem, 5=Big problem)*

The second problem statement is "The catalog contains many similar components. I don't know which component to use." and the rating result are presents in Figure 9.8.

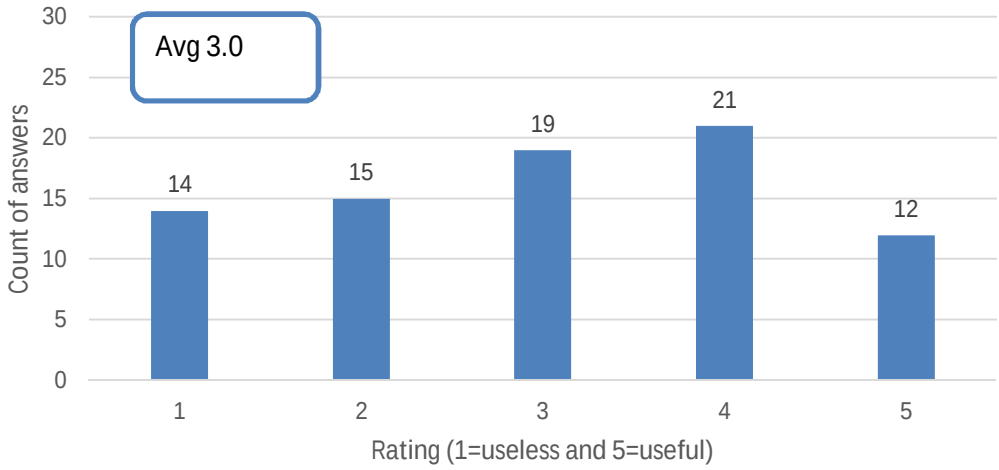


***Figure 9.8.*** *Problem 2:" The catalog contains many similar components. I don't know which component to use." (1=Not a problem, 5=Big problem)*

The comments concerning the problem were:

- In general, there are many similar components to do the same task but not one full fills all the requirements.
- In a similar connection, different users might use a different component in the same model.
- If we open the macro and test, we are able to understand the differences.

- It seems as if many components could incorporated as a less of them. For example, I have only used one base plate (1047) component and haven't touched the others in years
- This is big problem for beginners who are just starting to look at these components and they have no idea which one to use and then they get habit to use the wrong ones. So placing components that are updated regularly in a special place and the ones that have not been used in years to be hided.
- Improve graphic
- There are lots of components that do the same thing but slightly different in the system.

The third problem statement is "The dialog box contains so many properties. I don't know if I need to fill them all in." and the ratings are presents in Figure 9.9. The average rating is 3.0 that have been divided evenly.

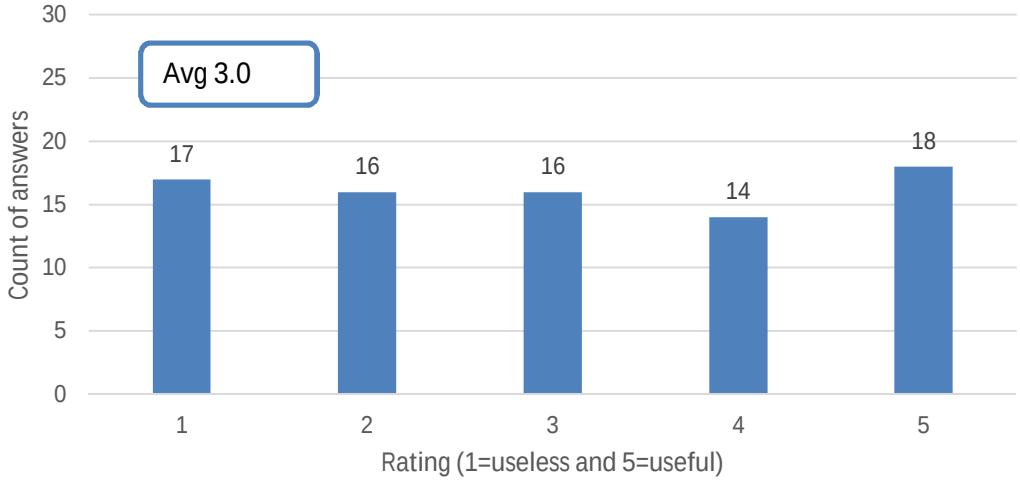


***Figure 9.9.*** *Problem 3: "The dialog box contains so many properties. I don't know if I need to fill them all in." (1=Not a problem, 5=Big problem)*

The comments concerning the problem were:

- This is problem with a beginner. The experienced users know what to do and more options for the component is better.
- Could be improved with better instructions on what the field controls
- Sometimes it is not clear which parameters are needed
- Even with empty boxes the component should do something "reasonable". After that it is easier to modify the component for required result.

The fourth problem statement is “It's difficult to know which dialog text box or picture modifies each component part.” and the rating result are presents in Figure 9.10.

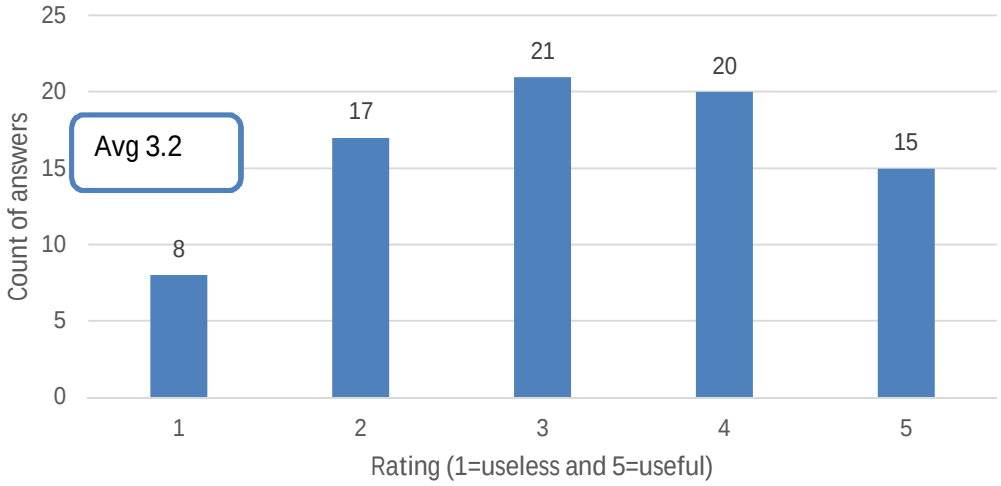


***Figure 9.10.*** *Problem 4: “It's difficult to know which dialog text box or picture modifies each component part.” (1=not a problem, 5=Big problem)*

The comments concerning the problem were:

- Depends on the component
- More of the problem when you need to combine settings from multiple tabs to achieve a desired result.
- Main rule: setting on the first page is strongest
- I usually try something quick and see what it does if I am not sure
- There should be better labeling and explanation
- This should be improved
- Clearer component dialogs, so trial and error method would not be needed. Especially, to adjust the bolt locations

The fifth problem statement is “I need to explode the component to finish the design” and the rating result are presents in Figure 9.11. Exploding the component is kept more as a problem than previous problems. The average rating is 3.6.

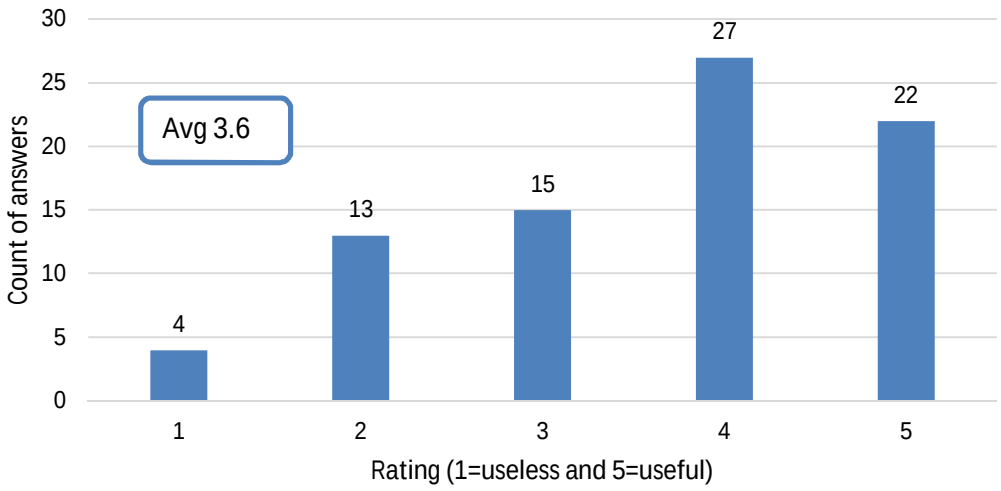


***Figure 9.11.*** *Problem 5: "I need to explode the component to finish the design." (1=not a problem, 5=Big problem)*

The comments concerning the problem were:

- This a big problem only because users feel they should not have to explode it.
- It depends on the component.
- For stairs and railings!
- Partially a problem, partially a benefit to the power of Tekla
- Many problems!
- If the model changes, the workload is big with exploded components.
- Sometimes in brace connections, stairs and the ladder need to explode to achieve the design.
- Yes, this is probably one of the major problems with the system component I run into because once you do this and you need to revise something it becomes a real pain.
- Connections are not taking in to account the new complex connections.
- This is a big problem, and every company I have worked for all do the same. The problem lies in that we can produce drawings and issue into fabrication, but if the component regenerates it can send all the numbers all over the place. Users tend to set numbers for a whole area after it has been modeled not as they do the connections through the component dialogs. Further to this, components may only let you set the part prefix and not the assembly prefix. I appreciate the assembly prefix is null and void for a welded plate, but I still want to set it how I want. The solution would be to have an advanced option that removes any link between numbering/prefixes with the components.
- All the parameter cannot be achieved and it takes more time.

The sixth problem statement is “I don't know the component's default values” and the rating result are presents in Figure 9.12. This was the second biggest problems presented in the survey

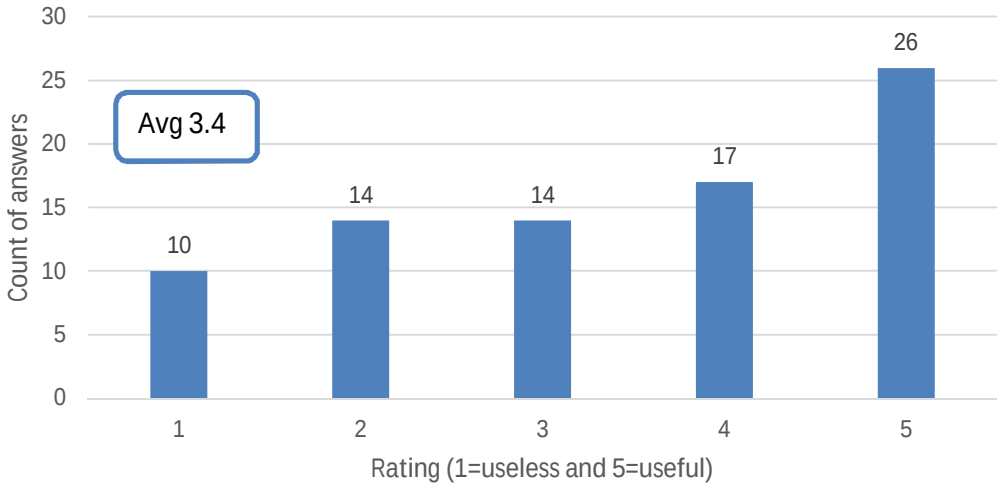


***Figure 9.12.*** *Problem 6: “I don't know the component's default values.”(1=not a problem, 5=Big problem)*

The comments concerning the problem were:

- You can load AutoDefaults but it does not enter all the values. It would be nice to be able to load what Tekla is actually using.
- There is no problem them being blank before the connection is applied, but they should be filled in afterwards when you double click to start modifying.
- Yes it is nice that when you use custom components once it is applied you can see the default values and work yourself backwards through how it was working.
- It is not so big a problem since one can still make their own defaults/standard settings and have those used when working with projects.
- If the default values are displayed, it will be useful.
- In a component dialog default values should be seen and checked.
- If I knew the defaults and the defaults are what I want, I don't have to change them. Since I do not know what they are, I have to enter what I want in every field which could be unnecessary if I knew the default values.

The seventh problem statement is “I don't know if there is something new for me to try in the Tekla Warehouse.” and the rating result are presents in Figure 9.13. This was rated as a third biggest problem.

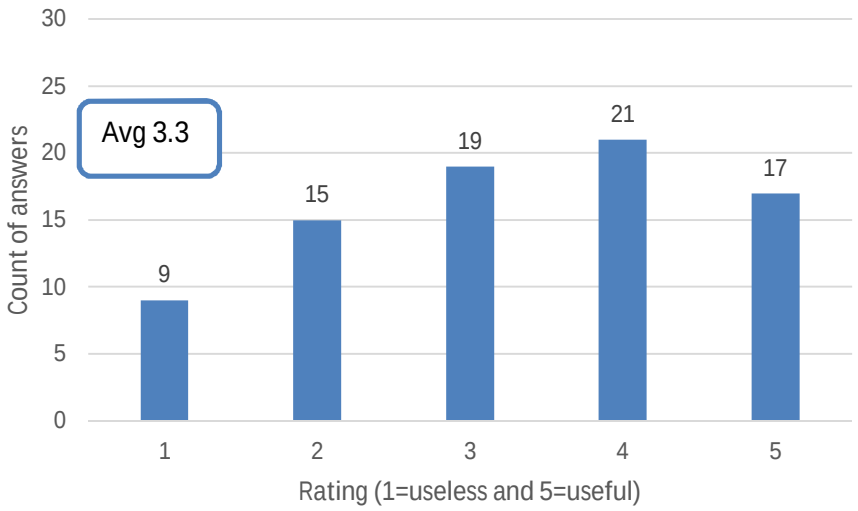


***Figure 9.13.*** *Problem 7: "I don't know if there is something new for me to try in the Tekla Warehouse." (1=not a problem, 5=Big problem)*

The comments concerning the problem were:

- It would be nice to have a newsletter of newly added extensions. Not the updated ones, but the just added extensions.
- Not sure if this is a problem. What is in the Warehouse? It would be nice to be able to get notifications of updates on some of the applications.
- If the warehouse updates available automatically in Tekla, that would be great!
- Many user experiences that finding the right component is almost impossible from the Warehouse because you need to know the name of the extension to find it.

Other problems that people have encountered with components are presented next. One of problem is that the components can do more than what they appear and user might keep looking although the component would have been the right for the situation but the thumbnail picture did not tell that. Some people think that the complex connections are easier to make without a component because the system components fit only for the simple cases. Other problems listed were:

- Components do not export to IFC as components, all the individual parts make the IFC difficult to work with.
- There are enough parameters for BIM-purposes. For example, IFC-storey, many UDA:s should be copied from the main part. Class attribute is missing in many components.
- If a component is created with loaded drop-down menu presets, when you select the component later it should list which preset was used at the top.
- No proper help file available and some help files removed since user assistance came.
- Bolts and welds needs to work better in the component.

- Problems and the improvement proposals for the exacting system component.
- The custom component editor and the custom components' functionalities have many problems. For example, Custom component bindings do not work correctly in case connecting member changes.
- AutoConnection needs development.

In conclusion, the biggest problem is exploding the component, the default values are not shown in the component dialog boxes and users does not know Tekla Warehouse content. All of the problem average ratings were between 2.6 and 3.6.

## 9.4 Improvement proposals

Next some proposals for components were presented. First a few improvement proposals for component catalog are presented. Then couple improvement proposals on modeling the component.

The rating of the comprehensive search is presented in Figure 9.14. The average rating is a little bit over average and so on the useful side. Most of the people preferred dropdown instead of check boxes.

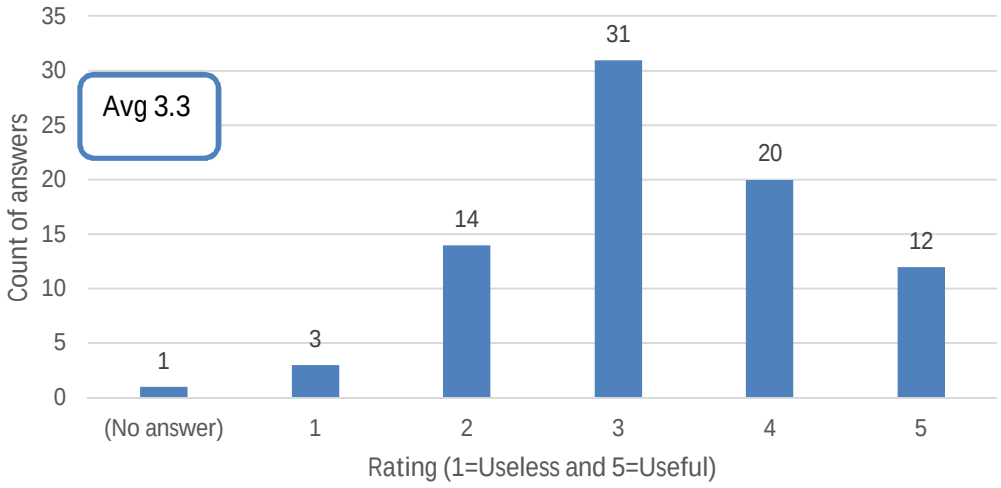


***Figure 9.14.*** *Usefulness of the comprehensive search (1=Useless and 5=Useful)*

The rating of the comprehensive search is presented in Figure 9.15. The average rating is 3.2 that is a little bit less than with the comprehensive search.

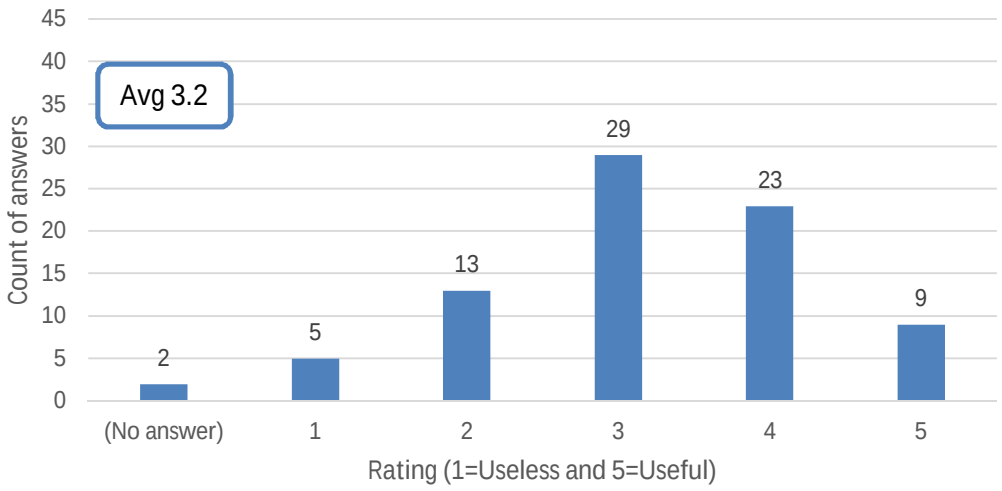


***Figure 9.15.*** *Component catalog search tree view. (1=Useless and 5=Useful)*

The comments concerning the comprehensive search options were:

- I like my most used components in a toolbar so I can get to them and apply them easily and quickly. Thank you for now allowing me to customize the ribbon toolbar to put them back where they should be, but why are no icons available there.
- I like the idea of improving the search but my fear is that with so many options it will be overwhelming and more confusing than before.
- I have been a user for 17 years. If you reduced the number of redundant components, then the user should learn the software for what is appropriate instead of searching be criteria. When someone is searching a "beam to column" connection and what they really need to do is to think outside the box and utilize a girt connection or something that would never have been grouped under 'beam to column" criteria. I get this is likely to help new people, but learning what components you have is ten times better than a search box in my opinion.
- If it is fast, then I bet there is no bigger problem. Still, I have missed the toolbars from previous TS versions.
- Looks too complicated for quick and easy search.
- I am not a fan of tree views. Miss the structure of the old component catalog. When the whole tree is visible, it takes up useless space.
- The whole list should be looked through at least once anyway.
- This is nice but I can already say you will base a lot of these terms off the description and name of the component. Well a lot of the components can be used in many different situations. For example, I need a wood bucket condition what would I search? I am going to get the result 0, which component will work, 146, full depth shear, etc.... This is a GREAT idea do not get me wrong, I am just saying it is going to be hard to narrow down the right results without really spending

some time talking to USERS and US (Support or sales persons) to identify what each component can be used for. Until then the categories work just fine

- This is over complicating things. Reducing the number of components and combining the ones that only have 1 or 2 extra options would make things easier.

The rating of the including Tekla Warehouse content in search is presented in Figure 9.16. The average rating is 4.0 and mainly people liked this option. Only concerns were about people working offline, if it slows down the search and checkbox to disable this.

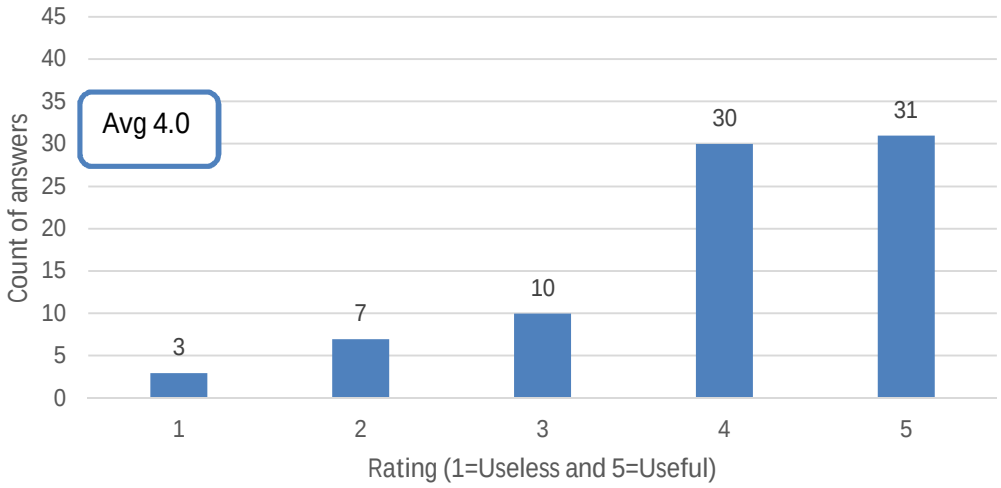


***Figure 9.16.*** *The component catalog search would also show Tekla Warehouse content (1=Useless and 5=Useful)*

The comments concerning the improvement proposal were:

- This is a useful idea; however, I feel more of the extensions should be put in to the core product so this would not be needed as much.
- As an idea this is good, but in real life I am afraid that it makes searches even more complicated.
- As long as one would be able to filter out a component in the Warehouse that are not built for the environment one is using.
- Great solution!
- I like the idea, but please make a checkbox to disable this.
- It would help us to be always updated with new TS features.
- Maybe all of the Warehouse components without being loaded could always be in our local list so if you just happen to see one that might work or something you could download and install then. From the sound of your question if you do not use the search feature then you would not see the Warehouse content?
- Not everyone is working online all the time.
- Now this would be great but only if I can download it from TS too. That means I do not have to open Warehouse in a separate window.

- Should be optional.
- There should be a checkbox for this option as well
- This is a useful idea, however I feel more of the extensions should be put in to the core product so this wouldn't be needed as much.
- This would really help and make more use of Warehouse.
- Without slowing search…

The rating of the new view option is presented in Figure 9.17. The average rating is 3.5 and mainly people liked this option but some preferred more visual pictures for the component than more text.

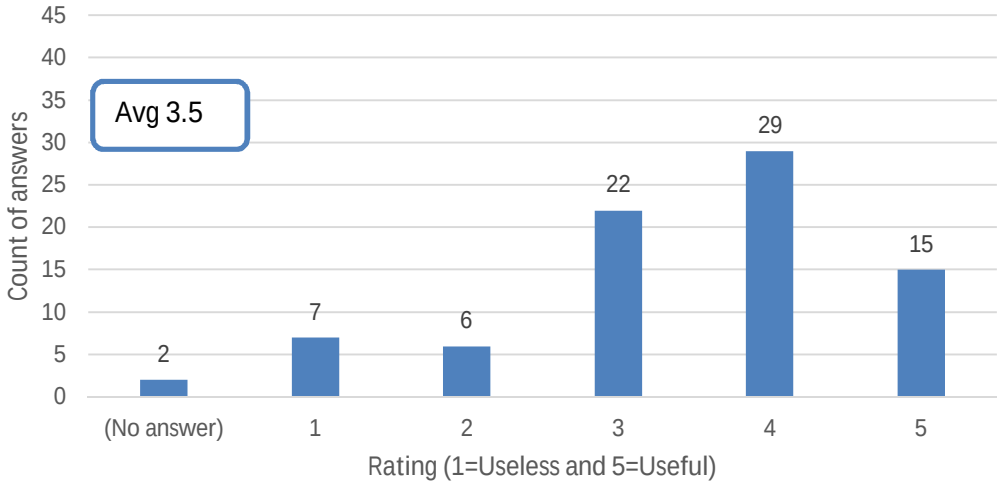


***Figure 9.17.*** *The new view option would show picture, description, objects created, tags and type. (1=Useless and 5=Useful)*

The comments concerning the improvement proposal were:

- Too much information the customer would not read all this especially when they are all so similar.
- I do not like this, mainly because people do not want extra stuff they already know crowding their space. Now if you make it where when we search we have an option to display it this way or just thumbs or names then that would be okay
- I like the additional information shown in the *Applications & components* catalog but users will also want the ability to hide that information. As long as there is a show/hide option then that would be helpful
- People like pictures, so bombarding them with words is not as effective as having different images.
- The pictures shown would need to describe the functionality better, and show different use cases.

The rating of the component catalog results sort option is presented in Figure 9.18. The average rating is 3.6 and mainly people liked this option and comments preferred it would be good for a basic user.

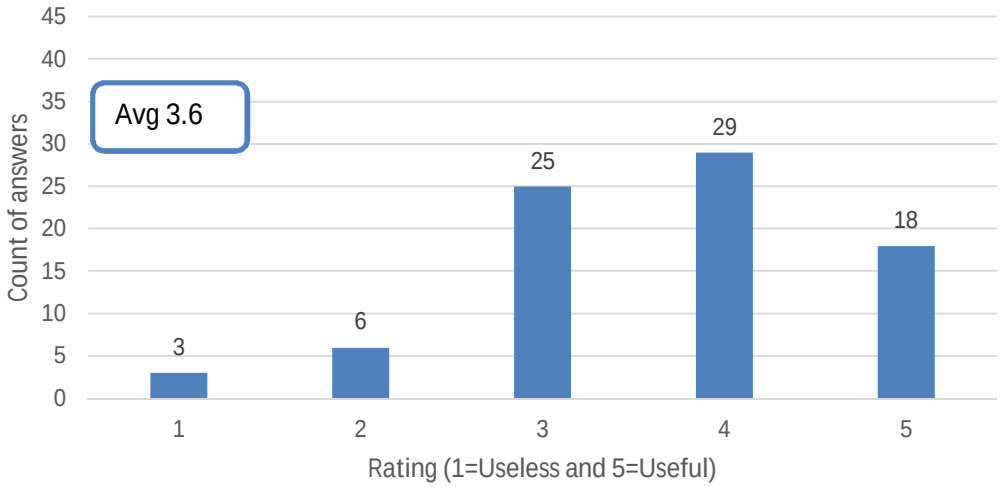


***Figure 9.18.*** *Sort component catalog search results.*

The comments concerning the improvement proposal were:

- Looks like one for the basic users. Cannot see the benefits for one who already is familiar with the components he/she uses daily or which are grouped in the folder structure depending on the modeling cases.
- The favorite could also be done for fast selection. You should make a shortcut for opening a fast select "pie chart" where you select your preset tools. You would have your own "toolbox" only one shortcut away. Selecting the components for your toolbox should work on drag and drop way. This could be compared with modern games where you can change your tool or weapon by using a shortcut key. This tool could even identify what part are you detailing or modeling Two examples:

    1. You have two beams selected-->shortcut key-->point and select one of your preselected components for detailing beam to beam connection
    2. Concrete beam selected-->shortcut key--> point reinforcement--> point Stirrups-->"Okay which component?")

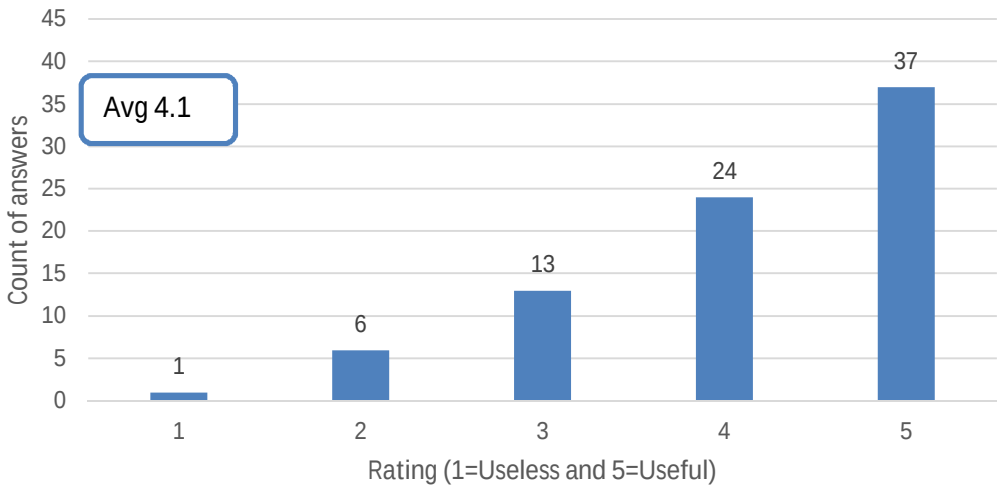


***Figure 9.19.*** *The ability to define the shape, chamfers and geometrical information in the model.*

The rating of the ability to define the shape, chamfers and geometrical information in the model is presented in Figure 9.19. The average rating is 4.1 and mainly people liked this option and concerns is that the modifications could be saved for later use.

The comments concerning the improvement proposal were:

- Absolutely! What you see is what you get!
- Dependent on industry. Steel fabrication uses a lot of standardized shapes that do not benefit from this as much as others.
- Direct modification is a great tool, combining the functionality this has in the component mode with the normal object model for rotation would be good.
- Not quite sure how this would work to be fair, but so far other than modifying polygon plates I find direct modification to be complete let down with enough flaws to prevent me wanting to persevere with it any further.
- Please make this possible!
- So what you modify in the model would be accepted and read into the System Components? Yes please.
- This is a big issue with custom components. Often I need to reference another part not in the component to modify the component parts.
- Very useful in the components where it has been implemented. It is just a bit hard sometimes to pick the right modification option. It would be nice to see steel components have similar controls where suitable.

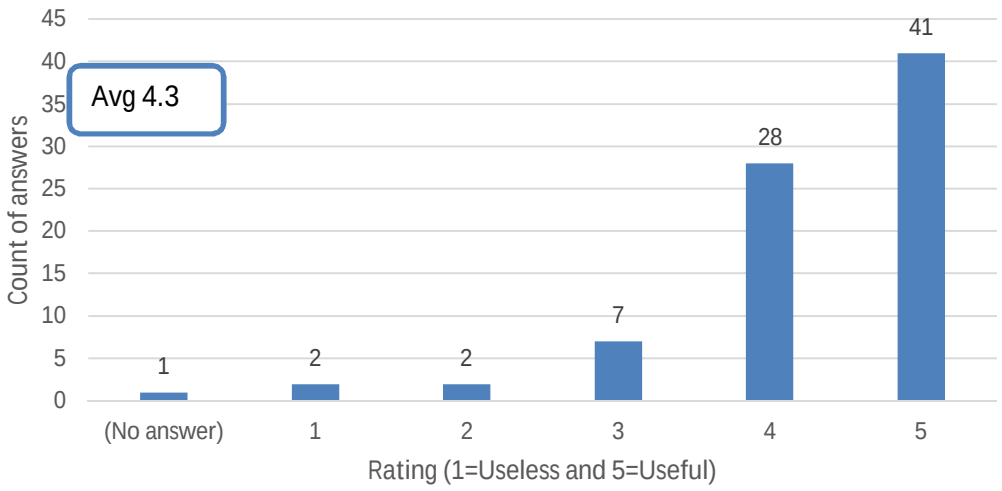


***Figure 9.20.*** *3D guidance: Highlights the modified part in the model.*

The rating of the including 3D guidance in components is presented in the Figure 9.20. The average rating is 4.3 and most of the people thought it would be useful.

The comments concerning the improvement proposal were:

- Awesome!
- It would be useful to track the changes.
- Original style = Rollower highlight + NO smooth line + No DirectX rendering!
- This sounds good, although I am dubious as to whether this will be instant and sleek or result in time penalties.
- This sounds nice, but some components have fields that affect all the parts inside a component, so not sure it would practical for all component fields

Other improvements were that the current components' problems would be fixed. Additionally, the custom component editor, AutoConnection should be improved. In conclusion, the improvement proposals were liked and people hoped that these would be implemented so that the concerns where taking account.

# 10. CONCLUSION

In this project, the components of Tekla Structures were studied. One target was to define the situation of the current system components. This was done by interviewing users, browsing component data, studying real-life models and concluded with a survey that reached 81 TS users globally. The second target was to define and evaluate the possible improvement proposals and plans for future development, including short and long term proposals.

## 10.1 Current situation

The current situation of the components, is that people are relatively satisfied with them. Regardless, the system components contains some minor problems that weaken the usability and should be fixed. Most of the people who participated in the survey, had used custom components but not the custom component editor. The AutoConnection feature is not that often used feature, as only around half of the 81 people surveyed, had used it, and they feel that the feature requires further development. The main problems found in this research are described below.

Exploding the component got the highest rating of the problems with 3.6 score. The scale used in the survey was from 5 to 1, where 5 means “a big problem” and 1 means “not a problem”. Based on the survey, exploding the component without a good reason should be prevented. This is because the work for making the changes, especially to exploded connection components, is huge in comparison with unexploded connections. That is why exploding the component should be prevented, and the issues that lead to this should be fixed. One main reason for exploding the component, is that the modeler cannot finish the design without exploding the component. Other purposes are to prevent the unwanted change marks, or problems in the numbering. These issues are illustrated in case model 3B where the column reinforcement is exploded, or modelled, without a component because the components’ stirrup options do not have enough options to finish the design.

The component catalog search contained two problems, which concerns more a novice user than experienced one. Firstly, there are many similar components in the component catalog and the user does not know which one to use. This problem was mentioned during the interview, and its average rate was 3.0 in the survey. In some cases, none of the found components contain all the options to finish the design. Additionally, the user might learn to use the wrong component, and so the model might contain two different components for the same design. The second problem in the component catalog search is that it is not always easy to know which search term to use, because the components do not contain

descriptions or tags that could help the search. On the contrary, the experienced users can find the component even with the component number.

The component dialog box contains three problems. The most important issue with the component dialog box is that the default values are not shown, and this got the second highest rating, 3.4, of the components' problems in the survey. The other issues that scored highly, are mainly problems related to a novice user. The second problem, the component dialog box contains many options that might startle the user. And lastly, it was found that in some cases, it is difficult to know which dialog text box, or picture modifies each component part.

Tekla Warehouse is not familiar to all users, and the ones who have used it, stated that it is difficult to find useful things from there. One major issue is the search, where the search term needs to be the components name in order to find it.

## 10.2 Improvement proposals

The second target of this research, was to define and evaluate improvement proposals. First of all, all the users wished that the minor problems within the components should be fixed. And also it was clear that all of the system components should not be removed, because users found the components useful.

One solution for the huge amount of similar components, would be the removal of the useless components. For example, only two or three of the end plate connection components would be needed, if these components would be improved a little. If there are only the best components available, the user cannot choose "a wrong one". This could be a problem for those users who were working with the removed component, and it should be taken into account if some of the components would be removed.

The most useful proposal was that the modified part would be highlighted in the model. This got 4.4 average rating in the survey and was suggested in the interview as well. The ability to define the shape, chamfers, and geometrical information in the model was rated as a second most useful proposal. The requirement for this functionality to be useful, would be the possibility to save the defined modifications for later use.

The improvement proposal of the component catalog contains a comprehensive search tool. The search tool equipped with a tree view was liked but people thought that it looks complex. Regarding the comprehensive search options, it was found that most of the people preferred dropdown options more than checkboxes. Component catalog search, including Tekla Warehouse content, was found useful. Additionally, people wanted the possibility to hide Tekla Warehouse content, and it was found important that the feature does not slowdown the search.

There are three improvement proposals for component dialog box. Firstly, the component dialog box should have a consistent UI for the similar parts and elements. In the interviews people found customized component dialog box useful. In the survey people wished more information about component properties, and better help for component dialog boxes.

In general, the UI should be more consistent, and contain more information and guidance for the user. However, for more experienced users, the possibility to show less should be possible. The engineering company's developers' called for the "open source" thinking to get the minor component problems fixed faster.

The last improvement proposal is the new component concept where the components would be assembled from smaller components. There would be only one component to a certain specific detail. In general, people who participated in this study have been pleased that the component problems are studied, and developed.

## 10.3 Research usability and future studies

This research gives wide knowledge of current usability issues and a strong base for components' renewal process. Within these results the usability of the current components can be improved, and the further development can be implemented to a long term plans.

In the future, information on how the components are used in building projects can be collected from almost all of the users that are using TS 2016i, or a newer version. This data shows accurately what components are really used, and which of the components are not. In comparison with AUF-data this user data will be more accurate and reliable. Additionally, there is an ongoing master's thesis project that concentrates on finding component usability problems from the AUF-data using algorithms.

Next steps of the development are the custom component editor, and AutoConnection development. Additionally, specifications about the exploding reasons are collected, and concentrated on the numbering issues. One idea for the far future development plans would be a new component concept.

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# APPENDIX 1: SIMILAR COMPONENTS' PROPERTIES AND STARTING FREQUENCIES BY THE ENVIRONMET

## ONE SIDED END PLATE CONNECTION COMPONENTS

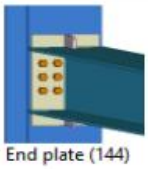
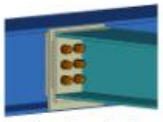
| |  End plate (144) |  Stiffened end plate (27) |  End plate (101) |
|---|---|---|---|
| **AUF** | 2016 -1.<br>2015 -1.<br>2014 -1.<br>2013 -1. | 2016 -3.<br>2015 -2.<br>2014 -2.<br>2013 -2/3. | 2016 -2.<br>2015 -3.<br>2014 -4.<br>2013 -4. |
| **Use for** | • Beam-to-beam end plate connection. The secondary part can either be leveled or sloped, or squared or skewed. There are several notching options. • Beam-to-beam end plate connection. Extended plate with or without haunch plates.<br>• End plate connection to a column flange or web. The secondary part can either be leveled or sloped, or squared or skewed.<br>• Full depth end plate connection to a column flange or web. The secondary part can either be leveled or sloped, or squared or skewed.<br>• End plate connection to a column web. Extended plate with haunch plates.<br>• End plate connection to a column flange with column stiffener.<br>• Column end plate connection. The secondary part is rotated. | • Two beams using an end plate at secondary beam end and a **T-shaped plate construction** consisting of a stiffener and a plate. Plates are connected with bolts. This connection can not be used for connections between beams and columns. | • Beam to beam connection with a bolted end plate<br>• Beam to column connection with bolted end plate |
| **Objects created** | • End plate<br>• Bent plate<br>• Shim plates (optional)<br>• Stiffeners (optional)<br>• Haunch plates (optional)<br>• Holes<br>• Bolts<br>• Seat angles<br>• Welds<br>• Cuts | • End plate<br>• Front plate (optional)<br>• Shim plates (optional)<br>• Stiffeners (optional)<br>• Haunch plates (optional)<br>• Holes<br>• Bolts<br>• Seat angles<br>• Welds | • End plate<br>• Bolts<br>• Welds<br>• Cuts |
| **Selection order** | 1. Select the main part (beam or column).<br>2. Select the secondary part (beam). | 1. Select the main part (beam).<br>2. Select the secondary part (beam). | 1. Select the main part (beam or column).<br>2. Select the secondary part |
| **Dialog content** | 1. Picture tab<br>2. Plates tab<br>3. Stiffeners tab<br>4. General tab<br>5. Haunch tab<br>6. Notch tab<br>7. Bolts tab<br>8. Design tab<br>9. Holes tab<br>10. Angle box tab<br>11. Analysis tab | 1. Picture tab<br>2. Parts tab (similar as plates tab in (144))<br>3. Parameters tab<br>4. General tab<br>5. Bolts tab<br>6. Holes tab<br>7. Design tab<br>8. Analysis tab | 1. Picture tab<br>2. End plate tab<br>3. General tab<br>4. Notch tab<br>5. Bolts tab<br>6. Design tab<br>7. Analysis tab |
| **Notes** | • SINGLE END PLATE CONNECTION MACRO 144 REQUIRES SEATING PLATE OPTION like in macro 29. Because macro 144 have better parameters like haunch plates, notch customization comparing to macro 29 as shown in attached pictures. | | • component does not use the setting from options for numbering. (Testtrack – low priority)<br>• No option to round out edges in 101 (one sided) |

***Table A1.1.*** *One sided end plate connection components properties (part 1/2)*

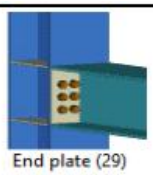
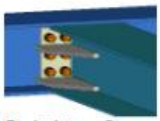
|  End plate (29) |  End plate - Comp flange (111) |  Partial stiff end plate (65) |  Simple Endplate (32) | |
|---|---|---|---|---|
| 2016 -4.<br>2015 -4.<br>2014 -3.<br>2013 -2/3. | 2016 -6.<br>2015 -7.<br>2014 -7.<br>2013 -7. | 2016 -5.<br>2015 -5.<br>2014 -5.<br>2013 -5. | 2016 -7.<br>2015 -6.<br>2014 -6.<br>2013 -6. | **AUF** |
| • Beam-to-column end plate connection.<br>• Beam-to-beam end plate connection.<br>• End plate connection with a shim plate and a seat angle.<br>• End plate connection with stiffeners. | • Connection with an end plate and compensating flanges.<br>• Connection with an end plate and compensating flange plates. The secondary beam is sloped. | Creates a beam-to-beam endplate connection. The connection includes the endplate on the secondary beam, a stiffener plate and a connection front plate at the main beam. In addition, stiffener plates can be added to both sides, a bottom plate can be added to the bottom of the main stiffener plate and shim-fitting plates can be included in the connection. | • Beam-to-beam end plate connection.<br>• Beam-to-column (flange/web) end plate connection.<br>• Sloping, skewed, rotated | **Use for** |
| • End plate<br>• Shim plate<br>• Stiffener<br>• Seat (plate or angle) | • End plate<br>• Compensating flange plates<br>• Bolts<br>• Welds<br>• Cuts | • End plate<br>• Front plate<br>• Shear plate<br>• Stiffener<br>• Fitting plate<br>• Bottom plate<br>• Holes<br>• Welds<br>• Bolts | • End plate<br>• Shear plate<br>• Stiffener<br>• Fitting plate<br>• Bottom plate<br>• Holes<br>• Welds<br>• Bolts | **Objects created** |
| 1. Select the main part (beam or column).<br>2. Select the secondary part | 1. Select the main part (beam).<br>2. Select the secondary part (beam). | 1. Select the main part (beam).<br>2. Select the secondary part (beam). | 1. Select the main part (beam or column).<br>2. Select the secondary part | **Selection order** |
| 1. Picture tab<br>2. Parts tab<br>3. Parameters tab<br>4. General tab<br>5. Bolts tab<br>6. Notch tab<br>7. Design tab<br>8. Analysis tab | 1. Picture tab<br>2. Parts tab<br>3. General tab<br>5. Notch tab<br>6. Bolts tab<br>7. Design tab<br>8. Analysis tab | 1. Picture tab<br>2. Parts tab<br>3. Parameters tab<br>4. General tab<br>5. Bolts tab<br>6. Holes tab<br>7. Design tab<br>8. Analysis tab | 1. Picture tab<br>2. Parts tab<br>3. Parameters tab<br>4. General tab<br>5. Bolts tab<br>6. Stiffeners tab<br>7. Copes tab<br>8. Design tab<br>9. Analysis tab | **Dialog content** |
| | | | 0 | **Notes** |

***Table A1.2.****One sided end plate connection component (part 2/2)*

| Environment | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| netherlands | 1633 | 12933 | 9595 | 2496 | **26657** |
| uk | 746 | 5112 | 3760 | 3800 | **13418** |
| france | 574 | 1583 | 2226 | 676 | **5059** |
| germany | 198 | 2184 | 1520 | 733 | **4635** |
| usimp | 306 | 882 | 564 | 751 | **2503** |
| default | 72 | 426 | 547 | 288 | **1333** |
| australasia | 39 | 465 | 325 | 219 | **1048** |
| southafrica | 45 | 315 | 240 | 226 | **826** |
| sweden | 122 | 247 | 300 | 39 | **708** |
| switzerland | | 46 | 528 | 80 | **654** |
| czech | | 144 | 344 | 50 | **538** |
| poland | 165 | 76 | 140 | 76 | **457** |
| italy | 24 | 132 | 135 | 62 | **353** |
| hungary | 39 | 63 | 161 | 37 | **300** |
| india | 82 | 103 | 32 | 73 | **290** |
| portugal | 20 | 144 | 105 | 1 | **270** |
| middle_east | 76 | 77 | 68 | 48 | **269** |
| se_asia | 53 | 79 | 44 | 70 | **246** |
| brazil | 27 | 76 | 88 | 54 | **245** |
| usmet | 38 | 72 | 41 | 69 | **220** |
| norway | 9 | 149 | 34 | 21 | **213** |
| finland | 4 | 17 | 38 | 35 | **94** |
| austria | 6 | 7 | 56 | 23 | **92** |
| denmark | | 73 | 5 | 4 | **82** |
| russia | 10 | 48 | 7 | 8 | **73** |
| korea | | | 25 | 46 | **71** |
| spain | 5 | 48 | 4 | | **57** |
| blank_project | | 1 | 25 | 10 | **36** |
| china | 12 | 19 | 3 | 1 | **35** |
| southamerica | | 6 | 19 | 6 | **31** |
| common | | 5 | 11 | | **16** |
| japan | | | | 1 | **1** |
| **Total** | **4305** | **25532** | **20990** | **10003** | **60830** |

***Table A1.3.*** *All started one sided end plate connection by the environment 01/2013-06/2016*

| Environment | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| netherlands | 712 | 7937 | 5740 | 1447 | **15836** |
| france | 312 | 812 | 1163 | 298 | **2585** |
| germany | 132 | 1298 | 679 | 211 | **2320** |
| uk | 64 | 677 | 572 | 387 | **1700** |
| usimp | 236 | 480 | 329 | 445 | **1490** |
| australasia | 19 | 328 | 296 | 156 | **799** |
| default | 32 | 187 | 306 | 194 | **719** |
| southafrica | 45 | 306 | 160 | 180 | **691** |
| sweden | 75 | 89 | 239 | 39 | **442** |
| poland | 102 | 53 | 64 | 70 | **289** |
| se_asia | 52 | 63 | 37 | 59 | **211** |
| hungary | 31 | 55 | 106 | 18 | **210** |
| middle_east | 68 | 29 | 52 | 30 | **179** |
| brazil | 10 | 43 | 67 | 54 | **174** |
| italy | 1 | 98 | 30 | 43 | **172** |
| portugal | 15 | 70 | 77 | 1 | **163** |
| india | 5 | 64 | 32 | 58 | **159** |
| switzerland | | 8 | 121 | 14 | **143** |
| usmet | 14 | 51 | 19 | 47 | **131** |
| norway | 8 | 53 | 28 | 9 | **98** |
| czech | | 53 | 4 | 33 | **90** |
| austria | 4 | 6 | 47 | 21 | **78** |
| russia | 8 | 44 | 6 | 8 | **66** |
| korea | | | 14 | 33 | **47** |
| spain | 1 | 39 | | | **40** |
| finland | | 10 | 11 | 17 | **38** |
| china | 6 | 19 | 2 | 1 | **28** |
| southamerica | | 6 | 16 | 6 | **28** |
| blank_project | | 1 | 22 | 3 | **26** |
| denmark | | 12 | 1 | 4 | **17** |
| common | | 5 | 11 | | **16** |
| japan | | | | 1 | **1** |
| **Total** | **1952** | **12896** | **10251** | **3887** | **28986** |

***Table A1.4.*** *End plate (144) by environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| End plate (144) | 712 | 7937 | 5740 | 1447 | **15836** |
| Stiffened end plate (27) | 522 | 4001 | 3071 | 755 | **8349** |
| End plate (29) | 335 | 608 | 474 | 75 | **1492** |
| Partial stiff end plate (65) | 53 | 333 | 244 | 197 | **827** |
| End plate (101) | 9 | 49 | 61 | 17 | **136** |
| End plate - comp flange (111) | 2 | 5 | 5 | 5 | **17** |
| **Total** | **1633** | **12933** | **9595** | **2496** | **26657** |

***Table A1.5.*** *One sided end plate connection components in Netherland environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| End plate (144) | 312 | 812 | 1163 | 298 | **2585** |
| End plate (29) | 88 | 504 | 699 | 270 | **1561** |
| Stiffened end plate (27) | 135 | 158 | 265 | 73 | **631** |
| Partial stiff end plate (65) | 16 | 37 | 66 | 19 | **138** |
| End plate (101) | 12 | 56 | 8 | 8 | **84** |
| End plate - comp flange (111) | 5 | 8 | 16 | 6 | **35** |
| Simple Endplate (32) | 6 | 8 | 9 | 2 | **25** |
| **Total** | **574** | **1583** | **2226** | **676** | **5059** |

***Table A1.6.*** *One sided end plate connection components in France environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| End plate (144) | 132 | 1298 | 679 | 211 | **2320** |
| Stiffened end plate (27) | 17 | 429 | 331 | 412 | **1189** |
| Partial stiff end plate (65) | 16 | 191 | 142 | 31 | **380** |
| End plate (29) | 10 | 143 | 145 | 62 | **360** |
| End plate (101) | 12 | 112 | 205 | 10 | **339** |
| End plate - comp flange (111) | 5 | 7 | 10 | 7 | **29** |
| Simple Endplate (32) | 6 | 4 | 8 | | **18** |
| **Total** | **198** | **2184** | **1520** | **733** | **4635** |

***Table A1.7.*** *One sided end plate connection components in Germany environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| End plate (101) | 430 | 2526 | 2253 | 2334 | **7543** |
| Stiffened end plate (27) | 96 | 753 | 474 | 817 | **2140** |
| End plate (144) | 64 | 677 | 572 | 387 | **1700** |
| End plate (29) | 142 | 1043 | 344 | 144 | **1673** |
| Partial stiff end plate (65) | 6 | 63 | 102 | 80 | **251** |
| Simple Endplate (32) | 8 | 29 | 8 | 29 | **74** |
| End plate - comp flange (111) | | 21 | 7 | 9 | **37** |
| **Total** | **746** | **5112** | **3760** | **3800** | **13418** |

***Table A1.8.*** *One sided end plate connection components in UK environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| End plate (144) | 236 | 480 | 329 | 445 | **1490** |
| End plate (29) | 39 | 145 | 86 | 289 | **559** |
| Simple Endplate (32) | 9 | 185 | 97 | 4 | **295** |
| End plate (101) | 9 | 39 | 22 | 7 | **77** |
| Partial stiff end plate (65) | 4 | 15 | 15 | 1 | **35** |
| End plate - comp flange (111) | 4 | 13 | 5 | 5 | **27** |
| Stiffened end plate (27) | 5 | 5 | 10 | | **20** |
| **Total** | **306** | **882** | **564** | **751** | **2503** |

***Table A1.9.*** *One sided end plate connection components in US imperial environment*

# TWO SIDED END PLATE CONNECTION COMPONENTS

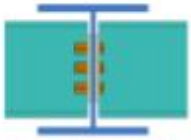
| |  Two sided end plate (142) |  Two sided end plate (115) |
|---|---|---|
| **AUF** | 2016 -1.<br>2015 -1.<br>2014 -1.<br>2013 -1. | 2016 -2.<br>2015 -3.<br>2014 -2.<br>2013 -3 |
| **Use for** | • connects two beams to a beam or to a column using bolted end plates. One bolt group goes through all the three parts.<br>• The secondary parts can be leveled and/or sloped.<br>• The secondary parts can be square and/or skewed.<br>• End plate connection with two secondary parts and with a haunch plate.<br>• End plate connection with two secondary parts at different heights. | • connects two beams to a beam or a column using end plates. The end plates are welded to the secondary beams and bolted to the main part (beam or column)<br>• End plates with two secondary beams. Automatic notching for bolt clearance.<br>• A square and a skewed secondary beam.<br>• End plates with two sloped secondary beams. Various notching options.<br>• End plates with two secondary beams. Safety connection. |
| **Objects created** | • End plate<br>• Shim plates<br>• Haunch plates<br>• Holes<br>• Bolts<br>• Welds<br>• Cuts | • End plate<br>• Bolts<br>• Welds<br>• Cuts |
| **Selection order** | 1. Select the main part (beam or column).<br>2. Select the 1. secondary part (beam).<br>3. Select the 2. secondary part (beam).<br>4. Middle mouse button ends selection. | 1. Select the main part (beam or column).<br>2. Select the 1. secondary part (beam).<br>3. Select the 2. secondary part (beam).<br>4. Middle mouse button ends selection. |
| **Dialog content** | 1. Picture tab<br>2. Plates 1 tab<br>3. Plates 2 tab<br>4. General tab<br>5. Haunch tab<br>6. Notch tab<br>7. Bolts tab<br>8. Design tab<br>9. Holes tab<br>Welds button | 1. Picture tab<br>2. End plates tab<br>3. General tab<br>4. Notch tab<br>5. Bolts tab<br>6. Design tab<br>Welds button |

***Table A1.10*** *Two sided end plate connections' properties (part 1/2)*

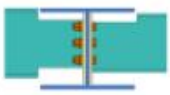
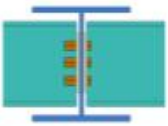
|  Two sided end plate (24) |  Two Side Endplate (34) |  Two sided end plate - Cfl(112) | |
|---|---|---|---|
| 2016 -4.<br>2015 -2.<br>2014 -3<br>2013 -2. | 2016 -3.<br>2015 -4.<br>2014 -4.<br>2013 -4. | 2017 -5.<br>2015 -5.<br>2014 -5.<br>2013 -5. | **AUF** |
| • connects two beams to a column or to a beam using a bolted end plate. One bolt group goes through all the three parts. This connection is created and used in the same way as End plate (29) connection.<br>• Beam-to-column end plate connection.<br>• Beam-to-beam end plate connection.<br>• End plate connection with shim plates and a seat angle.<br>• **NOT** connecting a beam to a column flange. | • Similar to single sided end plate (32) . Secondary member picked 1st will have priority in common values. Beams connect to column web | • connects a beam to two beams using end plates with compensating flange plates. The end plates are welded to the secondary beams and bolted to the main beam.<br>• Secondary beams are sloped. | **Use for** |
| • End plate<br>• Seat (plate or angle)<br>• Shim plates<br>• Stiffeners<br>• Bolts<br>• Welds<br>• Cuts | • End plates<br>• Bolts<br>• Welds<br>• Cuts | • End plate<br>• Compensation flange plates<br>• Bolts<br>• Welds<br>• Cuts | **Objects created** |
| 1. Select the main part (beam or column).<br>2. Select the 1. secondary part (beam).<br>3. Select the 2. secondary part (beam).<br>4. Middle mouse button ends selection. | 1. Select the main part (beam or column).<br>2. Select the 1. secondary part (beam).<br>3. Select the 2. secondary part (beam).<br>4. Middle mouse button ends selection. | 1. Select the main part (beam or column).<br>2. Select the 1. secondary part (beam).<br>3. Select the 2. secondary part (beam).<br>4. Middle mouse button ends selection. | **Selection order** |
| 1. Picture tab<br>2. Parts tab<br>3. Parameters tab<br>4. General tab<br>5. Notch tab<br>6. Bolts tab<br>7. Design tab<br>Welds button | 1. Picture tab<br>2. Parts tab<br>3. Parameters tab<br>4. General tab<br>5. Bolts tab<br>6. Copes 2 tab<br>7. Copes 3 tab<br>8. Design tab<br>Welds button | 1. Picture tab<br>2. Parts tab<br>3. General tab<br>4. Notch tab<br>5. Bolts tab<br>8. Design tab<br>Welds button | **Dialog content** |
| | | | **Notes** |

***Table A1.11.*** *Two sided end plate connections' properties (part 2/2)*

| Environment | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| uk | 106 | 991 | 802 | 540 | **2439** |
| netherlands | 77 | 1052 | 777 | 221 | **2127** |
| usimp | 164 | 86 | 84 | 70 | **404** |
| germany | 9 | 202 | 117 | 18 | **346** |
| france | 122 | 52 | 95 | 69 | **338** |
| default | 8 | 103 | 72 | 31 | **214** |
| southafrica | 4 | 69 | 27 | 72 | **172** |
| australasia | 3 | 87 | 32 | 10 | **132** |
| poland | 15 | 22 | 24 | 27 | **88** |
| sweden | 23 | 26 | 21 | 4 | **74** |
| brazil | | 16 | 20 | 14 | **50** |
| norway | 7 | 38 | 1 | 1 | **47** |
| india | 13 | 18 | 2 | 11 | **44** |
| usmet | 10 | 21 | 4 | 6 | **41** |
| portugal | 6 | 22 | 6 | 1 | **35** |
| hungary | | 5 | 11 | 7 | **23** |
| se_asia | 11 | 2 | 2 | 8 | **23** |
| middle_east | 6 | 14 | | 1 | **21** |
| switzerland | | 10 | 5 | 4 | **19** |
| czech | | | | 17 | **17** |
| italy | | 1 | 8 | 7 | **16** |
| russia | 1 | 1 | 1 | 11 | **14** |
| china | 7 | 3 | | | **10** |
| finland | | | 3 | 7 | **10** |
| blank_project | | | | 5 | **5** |
| denmark | | 3 | | | **3** |
| korea | | | 1 | 2 | **3** |
| austria | | | 1 | 1 | **2** |
| japan | | | | 2 | **2** |
| spain | | | 2 | | **2** |
| **Total** | **592** | **2844** | **2118** | **1167** | **6721** |

***Table A1.12.*** *All started two sided end plate connection by environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Two sided end plate (115) | 77 | 731 | 347 | 403 | **1558** |
| Two sided end plate (24) | 22 | 155 | 219 | 49 | **445** |
| Two sided end plate (142) | 6 | 59 | 189 | 43 | **297** |
| Two Side Endplate (34) | 1 | 32 | 39 | 41 | **113** |
| Two sided end plate - Cfl (112) | | 14 | 8 | 4 | **26** |
| **Total** | **106** | **991** | **802** | **540** | **2439** |

***Table A1.13.*** *Two sided end plate connection components in UK environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Two sided end plate (142) | 41 | 632 | 486 | 208 | **1367** |
| Two sided end plate (24) | 32 | 402 | 282 | 8 | **724** |
| Two sided end plate (115) | 2 | 17 | 4 | 1 | **24** |
| Two sided end plate - Cfl (112) | 2 | 1 | 5 | 4 | **12** |
| **Total** | **77** | **1052** | **777** | **221** | **2127** |

***Table A1.14.*** *Two sided end plate connection components in Netherlands environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Two sided end plate (142) | 57 | 49 | 49 | 64 | **219** |
| Two Side Endplate (34) | 43 | 18 | 26 | 5 | **92** |
| Two sided end plate (24) | 46 | 9 | 3 | 1 | **59** |
| Two sided end plate (115) | 9 | 7 | 5 | | **21** |
| Two sided end plate - Cfl (112) | 9 | 3 | 1 | | **13** |
| **Total** | **164** | **86** | **84** | **70** | **404** |

***Table A1.15.*** *Two sided end plate connection components in US imperial environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Two sided end plate (142) | 6 | 167 | 68 | 17 | **258** |
| Two sided end plate (24) | 1 | 23 | 27 | | **51** |
| Two sided end plate (115) | | 7 | 12 | | **19** |
| Two sided end plate - Cfl (112) | 1 | 3 | 6 | | **10** |
| Two Side Endplate (34) | 1 | 2 | 4 | 1 | **8** |
| **Total** | **9** | **202** | **117** | **18** | **346** |

***Table A1.16.*** *Two sided end plate connection components in Germany environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Two sided end plate (142) | 122 | 43 | 74 | 50 | **289** |
| Two sided end plate (115) | | 4 | 8 | 7 | **19** |
| Two sided end plate (24) | | 3 | 6 | 3 | **12** |
| Two sided end plate - Cfl (112) | | 1 | 7 | 2 | **10** |
| Two Side Endplate (34) | | 1 | | 7 | **8** |
| **Total** | **122** | **52** | **95** | **69** | **338** |

***Table A1.17.*** *Two sided end plate connection components in France environment*

# STIFFENER CONNECTION COMPONENT

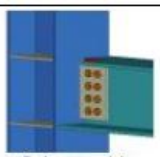
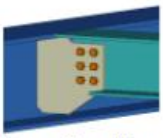
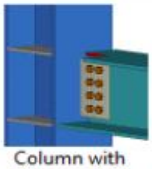
| |  Column with stiffeners (186) |  Beam with stiffener (129) |  Column with stiffeners (188) |  Welded column with stiffeners (128) |
|---|---|---|---|---|
| **AUF** | 2016 -3.<br>2015 -1.<br>2014 -1.<br>2013 -1. | 2016 -5.<br>2015 -2./3.<br>2014 -6.<br>2013 -6. | 2016 -2.<br>2015 -5.<br>2014 -4.<br>2013 -5. | 2016 - 6.<br>2015 - 6.<br>2014 - 3.<br>2013 - 2. |
| **Use for** | connects a beam to a column with a square shear tab. The shear tab is welded to the main part web and stiffeners, and bolted to the secondary part web. The secondary beam can be leveled or sloped. | connects a beam to another beam with a bolted and welded shear tab. The connection can be used at the back of a U-profile. The secondary beam can be leveled or sloped and/or skewed. | connects a column to a beam with a square shear tab. The shear tab is welded to the main part web and stiffeners, and bolted to the secondary part web. The secondary beam can be level or sloped. | Creates a welded beam to column connection. By default, creates the necessary notches in the secondary beam flanges and web. The secondary beam can be level or sloped. Stiffener plates on the opposite side of the column web are optional. |
| **Objects created** | • Shear tabs (1 or 2)<br>• Stiffeners<br>• Hauch platetes<br>• Web doubler plate<br>• Weld backing bars<br>• Bolts<br>• Welds<br>• Cuts | • Shear tabs (1 or 2)<br>• Stiffeners<br>• Hauch platetes<br>• Bolts<br>• Welds<br>• Cuts | • Shear tabs (1 or 2)<br>• Stiffeners<br>• Hauch platetes<br>• Web doubler plate<br>• Weld backing bars<br>• Bolts<br>• Welds<br>• Cuts | • Stiffeners<br>• Web doubler plate<br>• Weld backing bars<br>• Bolts<br>• Welds<br>• Cuts |
| **Selection order** | 1. Select the main part (column).<br>2. Select the secondary part ( beam). | 1. Select the main part (column).<br>2. Select the secondary part ( beam). | 1. Select the main part (column).<br>2. Select the secondary part ( beam). | 1. Select the main part (column).<br>2. Select the secondary part ( beam). |
| **Dialog content** | 1. Picture<br>2. Plates<br>3. Stiffeners<br>4. General<br>5. Haunch<br>6. Notch<br>7. Bolts<br>8. Doubler plate<br>9. Design<br>10. Analysis | 1. Picture<br>2. Plates<br>3. Stiffeners<br>4. General<br>5. Bolts<br>6. Notch<br>7. Haunch<br>8. Design<br>9. Analysis | 1. Picture<br>2. Plates<br>3. Stiffeners<br>4. General<br>5. Haunch<br>6. Notch<br>7. Bolts<br>8. Beam cut tab<br>9. Doubler plate<br>10. Design<br>11. Analysis | 1. Picture<br>2. Plates<br>3. Stiffeners<br>4. General<br>5. Haunch<br>6. Notch<br>7. Bolts<br>8. Beam cut tab<br>9. Doubler plate<br>10. Design<br>11. Analysis |
| **Notes** | | | | |

***Table A1.18.*** *Stiffener connection components' properties (part 1/2)*

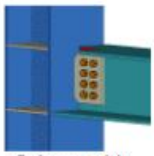
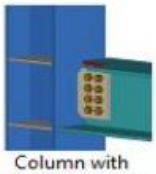
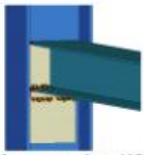
|  Column with stiffeners S (187) |  Column with stiffeners W (182) |  Gusset stiffeners (171) |  Stiffener seating (12) | |
|---|---|---|---|---|
| 2016 - 4.<br>2015 -2./3.<br>2014 - 5.<br>2013 -4. | 2016 - 1.<br>2015 - 4.<br>2014 - 2.<br>2013 - 3. | 2016 -7.<br>2015 -7/8.<br>2014 -7.<br>2013 - 7. | 2016 - 8.<br>2015 -7/8.<br>2014 -8.<br>2013 -8. | **AUF** |
| connects a column to a beam with a shaped shear tab. The shear tab is welded to the main part web and stiffeners, and bolted to the secondary part web. The secondary beam can be leveled or sloped. | connects a column to a beam with a shear tab. The shear tab is welded to the main part and bolted to the secondary part web. The secondary beam can be leveled or sloped. | • Creates 2 or 3 (default) stiffener plates and welds them to an existing gusset plate and a beam or column. Options to chamfer the gusset plate and stiffeners.<br>• Beam or column: I, C, tube, RHS | • create seating, stiffener and end plate | **Use for** |
| • Shear tabs (1 or 2)<br>• Stiffeners<br>• Hauch platetes<br>• Web doubler plate<br>• Bolts<br>• Welds<br>• Cuts | • Shear tabs (1 or 2)<br>• Stiffeners<br>• Hauch platetes<br>• Web doubler plate<br>• Weld backing bars<br>• Bolts<br>• Welds<br>• Cuts | • Stiffeners | • Stiffeners<br>• Seat<br>• End plate<br>• Bolts<br>• Welds | **Objects created** |
| 1. Select the main part (column).<br>2. Select the secondary part ( beam). | 1. Select the main part (column).<br>2. Select the secondary part ( beam). | 1. Gusset plate<br>2. Beam or column | 1. Select the main part (beam or column).<br>2. Select the point where the stiffener plates will go.<br>Selecting the point creates the stiffeners. | **Selection order** |
| 1. Picture<br>2. Stiffeners<br>3. Beam cut<br>4. General<br>5. Notch<br>9. Doubler plate<br>10. Design<br>11. Analysis | 1. Picture<br>2. Plates<br>3. Stiffeners<br>4. General<br>5. Haunch<br>6. Notch<br>7. Bolts<br>8. Beam cut tab<br>9. Doubler plate<br>10. Design<br>11. Analysis | 1. Picture<br>2. Parts<br>3. Chamfer<br>4. General<br>5. Analysis | 1. Picture<br>2. Parts<br>3. Parameters<br>4. General<br>6. Bolts<br>5. Design type<br>6. Analysis | **Dialog content** |
| | | | | **Notes** |

***Table A1.19.*** *Stiffener connection components' properties (part 2/2)*

| Environment | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| usimp | 189 | 905 | 355 | 708 | **2157** |
| uk | 3 | 330 | 242 | 166 | **741** |
| default | 19 | 120 | 207 | 132 | **478** |
| japan | | 219 | 35 | 194 | **448** |
| se_asia | 17 | 78 | 12 | 98 | **205** |
| korea | | | 98 | 98 | **196** |
| france | 3 | 96 | 77 | 19 | **195** |
| netherlands | 12 | 79 | 56 | 47 | **194** |
| australasia | 44 | 66 | 65 | 16 | **191** |
| germany | 16 | 57 | 66 | 23 | **162** |
| poland | 25 | 15 | 86 | 25 | **151** |
| usmet | 7 | 49 | 20 | 50 | **126** |
| italy | 19 | 47 | 39 | 2 | **107** |
| sweden | 17 | 42 | 35 | 6 | **100** |
| norway | 3 | 52 | 7 | 31 | **93** |
| middle_east | 9 | 23 | 48 | 2 | **82** |
| russia | 4 | 44 | 5 | 18 | **71** |
| finland | 3 | 3 | 23 | 28 | **57** |
| brazil | 1 | 24 | 23 | 5 | **53** |
| china | 19 | 25 | | 6 | **50** |
| hungary | 2 | 4 | 13 | 30 | **49** |
| czech | | 34 | 8 | 2 | **44** |
| spain | | 30 | 4 | | **34** |
| switzerland | | 6 | 16 | 9 | **31** |
| portugal | | 9 | 16 | 3 | **28** |
| india | 3 | 13 | 5 | 5 | **26** |
| blank_proj... | | | 8 | 10 | **18** |
| southafrica | | 2 | 6 | 3 | **11** |
| southamer... | | | 6 | | **6** |
| denmark | | 3 | 2 | | **5** |
| austria | | | 2 | | **2** |
| romania | | | | 1 | **1** |
| **Total** | **415** | **2375** | **1585** | **1737** | **6112** |

***Table A1.20.*** *All started stiffener connection by environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Column with stiffeners (186) | 74 | 452 | 81 | 107 | **714** |
| Column with stiffeners V (182) | 41 | 143 | 113 | 289 | **586** |
| Column with stiffeners (188) | 22 | 95 | 30 | 232 | **379** |
| Beam with stiffeners (129) | 13 | 78 | 44 | 40 | **175** |
| Column with stiffeners S (187) | 29 | 64 | 62 | 9 | **164** |
| Welded column with stiffeners (128) | | 46 | 12 | 11 | **69** |
| Gusset stiffeners (171) | 5 | 21 | 8 | 20 | **54** |
| Stiffener seating (12) | 5 | 6 | 5 | | **16** |
| **Total** | **189** | **905** | **355** | **708** | **2157** |

***Table A1.21.*** *Stiffener connection components in US imperial environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Column with stiffeners (186) | | 126 | 49 | 40 | **215** |
| Welded column with stiffeners (128) | | 92 | 39 | 26 | **157** |
| Column with stiffeners (188) | 1 | 51 | 93 | 9 | **154** |
| Beam with stiffeners (129) | | 17 | 26 | 49 | **92** |
| Gusset stiffeners (171) | | 6 | 8 | 37 | **51** |
| Column with stiffeners V (182) | | 27 | 15 | 1 | **43** |
| Column with stiffeners S (187) | 2 | 9 | 12 | 1 | **24** |
| Stiffener seating (12) | | 2 | | 3 | **5** |
| **Total** | **3** | **330** | **242** | **166** | **741** |

***Table A1.22.*** *Stiffener connection components in UK environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Beam with stiffeners (129) | 1 | 14 | 81 | 79 | **175** |
| Column with stiffeners S (187) | 6 | 50 | 43 | 3 | **102** |
| Column with stiffeners (186) | 1 | 18 | 31 | 41 | **91** |
| Column with stiffeners (188) | 1 | 7 | 23 | 3 | **34** |
| Welded column with stiffeners (128) | 2 | 15 | 6 | 2 | **25** |
| Column with stiffeners V (182) | 5 | 6 | 9 | 2 | **22** |
| Gusset stiffeners (171) | 2 | 9 | 9 | 1 | **21** |
| Stiffener seating (12) | 1 | 1 | 5 | 1 | **8** |
| **Total** | **19** | **120** | **207** | **132** | **478** |

***Table A1.23.*** *Stiffener connection components in Default environment*

| Component name | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Column with stiffeners S (187) | 25 | 15 | 140 | **180** |
| Column with stiffeners V (182) | 154 | 8 | 8 | **170** |
| Column with stiffeners (188) | 22 | 9 | 5 | **36** |
| Column with stiffeners (186) | 14 | | 17 | **31** |
| Welded column with stiffeners (128) | | 3 | 20 | **23** |
| Beam with stiffeners (129) | 1 | | 4 | **5** |
| Gusset stiffeners (171) | 2 | | | **2** |
| Stiffener seating (12) | 1 | | | **1** |
| **Total** | **219** | **35** | **194** | **448** |

***Table A1.24.*** *Stiffener connection components in Japan environment*

# STIFFENER DETAIL COMPONENTS

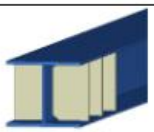
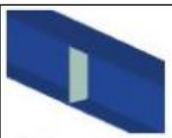
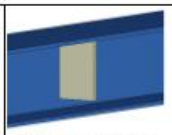
| |  Stiffeners (1003) |  Multiple Stiffeners (1064) |  Stiffeners (1034) |  Stiffeners (1041) |
|---|---|---|---|---|
| **AUF** | 2016 -1.<br>2015 -1.<br>2014 -1.<br>2013 -1. | 2016 -2.<br>2015 -2.<br>2014 -2.<br>2013 -2. | 2016 -3.<br>2015 -4.<br>2014 -3.<br>2013 -3. | 2016 -4.<br>2015 -3.<br>2014 -4.<br>2013 -4. |
| **Use for** | • Stiffener plate detail to column or beam (I-profiles).<br>• Stiffeners can be skewed<br>• Chamfers option to web side of stiffeners | • create multiple stiffeners with specified gap parameters to I- C- and U-profiles.<br>• Rectangular or triangular stiffener plates<br>• Chamfer options for all stiffener corner<br>• Stiffeners can be skewed. | • One stiffener or multiple stiffeners with special gap parameters to beam or column<br>• Stiffeners can be skewed or rotated<br>• I-, T-, C- and U-profiles<br>• Many chamfer options for all corners<br>• Weld preparation options for stiffeners | • rectangular or triangular stiffener plates on one or both sides of a beam or a column.<br>• I-profiles |
| **Objects created** | • Stiffeners<br>• Welds | • Stiffeners<br>• Welds | • Stiffeners<br>• Welds | • Stiffeners<br>• Welds |
| **Selection order** | 1. Select the main part (beam or column).<br>2. Select the point where the stiffener plates will go.<br>Selecting the point creates the stiffeners. | 1. Select the main part (beam or column).<br>2. Select the creation point. (A point on beam or column by projecting point to the beam.) | 1. Select the main part (beam or column).<br>2. Select the creation point. (A point on beam or column by projecting point to the beam.) | 1. Select the main part (beam or column).<br>2. Pick the point where the stiffener plates will go.<br>Picking the point creates the stiffeners. |
| **Dialog content** | 1. Picture<br>2. Parts<br>3. Parameters<br>4. General<br>5. Design type<br>6. Analysis | 1. Picture<br>2. Parts<br>3. Parameters<br>4. General<br>5. Stiffeners<br>6. Design type<br>7. Analysis | 1. Picture<br>2. Options<br>3. Stiffeners<br>4. General<br>5. Analysis | 1. Picture<br>2. Parts<br>3. General<br>4. Analysis |
| **Notes** | - Only simple stiffener details | - Default stiffeners detail is same as Stiffener (1003).<br>- Options for chamfers.<br>- Does not create the Weld preparations (as Stiffener (1034)). | - Can be used to model simple stiffeners too.<br>- Options tab is similar as Parts tab<br>- Complex view & minimal help | - Simple connection with limited geometry options |

***Table A1.25.*** *Stiffener detail components' properties (part 1/2)*

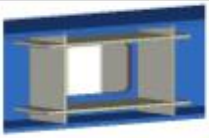
|  Stiffeners (1030) |  Web Stiffeners (1060) |  Horizontal stiffener (1017) | |
|---|---|---|---|
| 2016 -6.<br>2015 -7.<br>2014 -5.<br>2013 -5. | 2016 -5.<br>2015 -5.<br>2014 -6.<br>2013 -6./7. | 2016 -7.<br>2015 -6.<br>2014 -7.<br>2013 -6./7. | **AUF** |
| • creates stiffeners to a picked point of a beam or column. (outside) | • This detail creates stiffener plates or angles around a hole in the profile web.<br>• There are no limitations to the position of the part to be detailed.<br>• The expected profile type is **H(I) or Channel**. The stiffeners will be welded to the main part. | • Creates four horizontal stiffener plates to a picked point of a beam. | **Use for** |
| • Stiffeners<br>• Welds | • Stiffeners<br>• Welds<br>• Hole (rectangular, circle) | • Stiffeners<br>• Welds | **Objects created** |
| 1. Select the main part (beam or column).<br>2. Select the creation point. (A point on beam or column by projecting point to the beam.) | 1. Select the main part (beam or column).<br>2. Any point (the hole will be at the vertical direction of this point) | 1. Select the main part (beam).<br>2. Select the point where the stiffener plates will go.<br>Selecting the point creates the stiffeners. | **Selection order** |
| 1. Picture<br>2. Parts<br>3. Parameters<br>4. General<br>5. Analysis | 1. Picture<br>2. Parts<br>3. Stiffener type<br>4. General<br>5. Design type<br>6. Analysis | 1. Picture<br>2. Parts<br>3. General<br>4. Analysis | **Dialog content** |
| | | | **Notes** |

***Table A1.26.*** *Stiffener detail components' properties (part 1/2)*

| Environment | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| netherlands | 490 | 3301 | 1919 | 568 | **6278** |
| usimp | 275 | 1233 | 732 | 447 | **2687** |
| uk | 70 | 808 | 411 | 409 | **1698** |
| germany | 114 | 854 | 506 | 96 | **1570** |
| france | 89 | 522 | 609 | 261 | **1481** |
| japan | | 838 | 206 | 27 | **1071** |
| sweden | 105 | 385 | 321 | 17 | **828** |
| australasia | 38 | 272 | 222 | 202 | **734** |
| default | 20 | 265 | 313 | 115 | **713** |
| czech | | 88 | 178 | 78 | **344** |
| norway | 27 | 189 | 69 | 46 | **331** |
| usmet | 55 | 160 | 53 | 42 | **310** |
| poland | 112 | 40 | 97 | 51 | **300** |
| italy | 9 | 99 | 101 | 14 | **223** |
| switzerland | | 60 | 123 | 9 | **192** |
| middle_east | 28 | 57 | 97 | 9 | **191** |
| se_asia | 7 | 77 | 39 | 28 | **151** |
| portugal | 14 | 78 | 31 | 22 | **145** |
| hungary | 27 | 24 | 72 | 20 | **143** |
| southafrica | | 51 | 77 | 15 | **143** |
| finland | | 19 | 68 | 14 | **101** |
| brazil | 12 | 41 | 29 | 17 | **99** |
| china | 17 | 70 | 1 | 4 | **92** |
| denmark | | 70 | 10 | 1 | **81** |
| spain | | 71 | 8 | | **79** |
| india | 3 | 16 | 21 | 20 | **60** |
| korea | | | 9 | 49 | **58** |
| russia | 22 | 17 | 3 | 10 | **52** |
| southamer... | | 1 | 22 | | **23** |
| austria | | 1 | 9 | 9 | **19** |
| blank_proj... | | | 5 | 7 | **12** |
| common | | | 10 | | **10** |
| romania | | | | 3 | **3** |
| **Total** | **1534** | **9707** | **6371** | **2610** | **20222** |

***Table A1.27.*** *All started stiffener detail components by environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Multiple stiffeners (1064) | 234 | 1633 | 982 | 396 | **3245** |
| Stiffeners (1003) | 252 | 1596 | 914 | 158 | **2920** |
| Stiffeners (1041) | 4 | 29 | 12 | 9 | **54** |
| Stiffeners (1030) | | 37 | 2 | 3 | **42** |
| Web Stiffeners (1060) | | 5 | 6 | 2 | **13** |
| Horizontal stiffener (1017) | | 1 | 3 | | **4** |
| **Total** | **490** | **3301** | **1919** | **568** | **6278** |

***Table A1.28.*** *Stiffener detail components in Netherlands environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Stiffeners (1003) | 162 | 760 | 352 | 170 | **1444** |
| Multiple stiffeners (1064) | 80 | 235 | 208 | 178 | **701** |
| Stiffeners (1034) | 11 | 139 | 49 | 38 | **237** |
| Stiffeners (1041) | 11 | 66 | 102 | 33 | **212** |
| Stiffeners (1030) | 5 | 10 | 8 | 15 | **38** |
| Web Stiffeners (1060) | 3 | 14 | 9 | 12 | **38** |
| Horizontal stiffener (1017) | 3 | 9 | 4 | 1 | **17** |
| **Total** | **275** | **1233** | **732** | **447** | **2687** |

***Table A1.29.*** *Stiffener detail components in US imperial environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Stiffeners (1003) | 66 | 632 | 276 | 163 | **1137** |
| Multiple stiffeners (1064) | 2 | 56 | 84 | 168 | **310** |
| Web Stiffeners (1060) | | 74 | 12 | 8 | **94** |
| Stiffeners (1034) | 1 | 18 | 20 | 29 | **68** |
| Stiffeners (1041) | 1 | 17 | 17 | 17 | **52** |
| Horizontal stiffener (1017) | | 8 | 1 | 18 | **27** |
| Stiffeners (1030) | | 3 | 1 | 6 | **10** |
| **Total** | **70** | **808** | **411** | **409** | **1698** |

***Table A1.30.*** *Stiffener detail components in UK environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Stiffeners (1003) | 109 | 778 | 407 | 68 | **1362** |
| Stiffeners (1041) | 2 | 18 | 44 | 9 | **73** |
| Stiffeners (1034) | 3 | 13 | 33 | 16 | **65** |
| Multiple stiffeners (1064) | | 25 | 11 | 3 | **39** |
| Horizontal stiffener (1017) | | 12 | 8 | | **20** |
| Stiffeners (1030) | | 8 | 3 | | **11** |
| **Total** | **114** | **854** | **506** | **96** | **1570** |

***Table A1.31.*** *Stiffener detail components in Germany environment*

| Component name | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|
| Stiffeners (1003) | 63 | 408 | 564 | 223 | **1258** |
| Stiffeners (1041) | 2 | 40 | 23 | 11 | **76** |
| Stiffeners (1034) | 16 | 30 | 5 | 17 | **68** |
| Multiple stiffeners (1064) | 6 | 21 | 9 | 7 | **43** |
| Stiffeners (1030) | | 14 | 5 | | **19** |
| Horizontal stiffener (1017) | 1 | 9 | 2 | 2 | **14** |
| Web Stiffeners (1060) | 1 | | 1 | 1 | **3** |
| **Total** | **89** | **522** | **609** | **261** | **1481** |

***Table A1.32.*** *Stiffener detail components in France environment*

| Component name | 2014 | 2015 | 2016 | **Total** |
|---|---|---|---|---|
| Multiple stiffeners (1064) | 816 | 178 | 15 | **1009** |
| Stiffeners (1003) | 13 | 18 | 8 | **39** |
| Web Stiffeners (1060) | 6 | 5 | | **11** |
| Stiffeners (1041) | | 3 | 2 | **5** |
| Stiffeners (1030) | 3 | | | **3** |
| Stiffeners (1034) | | 1 | 2 | **3** |
| Horizontal stiffener (1017) | | 1 | | **1** |
| **Total** | **838** | **206** | **27** | **1071** |

***Table A1.33.*** *Stiffener detail components in Japan environment*

# APPENDIX 2: CUSTOM COMPONENTS IN CASE MODELS

| | Custom concrete components | Pieces |
|---|---|---|
| 1 | EB_KKT100 | 4 |
| 1 | Total | 4 |

***Table A2. 1.*** *Case model 1 custom concrete components*

| | Custom steel components | Pieces |
|---|---|---|
| 1 | Pilari_palkki_mainos | 160 |
| 2 | HEB+HEB hitsausliito | 66 |
| 3 | vedenpoisto_aukko | 48 |
| 4 | Levy_ja_reiät | 44 |
| 5 | Päätylevyliitos_main | 44 |
| 6 | Liitos | 36 |
| 7 | Liitos_oikea | 36 |
| 8 | Pohjalevy_AMu | 36 |
| 9 | Pulttiliitos_Amu | 36 |
| 10 | IPE360+putki | 35 |
| 11 | Vinoliitos_Vva | 34 |
| 12 | Päätylevy_vino_Amu | 33 |
| 13 | Palkki palkki liitos | 32 |
| 14 | Päätylevyliitos | 32 |
| 15 | Uretaani reikä | 32 |
| 16 | Vedenpoistoreikä | 32 |
| 17 | IPE180+IPE180 hitsi | 22 |
| 18 | IPE200+IPE200 hitsi | 22 |
| 19 | pilarinpääty2 | 18 |
| 20 | HQ+pilari2 | 15 |
| 21 | IPE_TUBE_IV_KONEEN_J | 14 |
| 22 | Levy_ja_reiät_2 | 12 |
| 23 | PC_IW_IW_GR_09 | 12 |
| 24 | Vedenpoistoreiät | 12 |
| 25 | Vesir | 11 |
| 26 | Vetotankokiristin | 11 |
| 27 | pilarinpääty | 10 |
| 28 | tuulipilari+IPE_2 | 10 |
| 29 | Kiinnityspiste_Tuuli | 9 |
| 30 | tuulipilari+IPE | 9 |
| 31 | Kiinnityspiste_Kanta | 8 |
| 32 | Pilaripääty-L-teräks | 8 |
| 33 | Ritilän_tolppa | 8 |
| 34 | beam_beam_IV_koneenj | 6 |
| 35 | Kulmateräkset | 6 |

| | | |
|---|---|---|
| 36 | POHJALEVY_REIÄLLÄ | 6 |
| 37 | päätylevy | 6 |
| 38 | vetotankoalap1 | 6 |
| 39 | vetotankoyp2 | 6 |
| 40 | Pilari+Ipe330liitos | 5 |
| 41 | Päätylevy | 5 |
| 42 | vetotankoalap2 | 5 |
| 43 | vetotankoyp1 | 5 |
| 44 | IPE330+tuulipilari | 4 |
| 45 | JK+PILASTERI | 4 |
| 46 | Pikkuk_vetit_ap2 | 4 |
| 47 | Pikkuk_vetot_ap1 | 4 |
| 48 | Pikkuk_vetot_yp1 | 4 |
| 49 | Pikkuk_vetot_yp2 | 4 |
| 50 | pilari+L-teräs | 4 |
| 51 | Putkipilari+L-teräs2 | 4 |
| 52 | seinäalapää | 4 |
| 53 | PC_IW_IW_GR_07 | 3 |
| 54 | kulmaliitos | 2 |
| 55 | Kulmaliitos2 | 2 |
| 56 | REISI_POHJA | 2 |
| 57 | tuulipilari+IPE330 | 2 |
| 58 | Ipe330+330+putki | 1 |
| 59 | Ipe330+330+putki_2 | 1 |
| 60 | Ipe360+330+putki | 1 |
| 61 | Ipe360+330+putki_2 | 1 |
| 62 | Kulmateräkset_2 | 1 |
| 63 | Pikkuk_vetot_ap3 | 1 |
| 64 | Pikkuk_vetot_ap4 | 1 |
| 65 | Pikkuk_vetot_yp4 | 1 |
| 66 | Pikkuk_yp5 | 1 |
| 67 | Pilari_reisilankku | 1 |
| 67 | Total | 1060 |

***Table A2. 2.*** *Case model 1 custom steel components*

| | Custom concrete components | Pieces | Notes |
|---|---|---|---|
| 1 | BecSandwich | 233 | No symbol |
| 2 | PC_IW_IW_GR_06 | 73 | |
| 3 | SoclePanel | 55 | No symbol |
| 4 | PC_CO_IW_001 | 54 | |
| 5 | PC_BE_D_003 | 45 | |
| 6 | PC_IW_IW_GR_09 | 42 | |
| 7 | PC_IW_IW_GR_07 | 31 | |
| 8 | PC_CO_BE_GR_05 | 18 | |
| 9 | RVK-100 LISÄRAUDOITUS | 18 | |
| 10 | PC_CO_BE_GR_04 | 13 | |

| | | | |
|---|---|---|---|
| 11 | SORTIM_CP_PW_2 | 7 | |
| 12 | WallToWallConnection | 6 | |
| 13 | Foundation_Column | 2 | |
| 14 | SORTIM_PW_1 | 3 | |
| 15 | WallPanelReinforcement | 2 | |
| 16 | PC_EW_D_001 | 1 | |
| 17 | SORTIM_CP_PW_3 | 1 | |
| 18 | EB_PD | 2068 | casting part |
| 18 | Total | 2672 | |

***Table A2. 3.*** *Case model 2 custom concrete components*

| | Custom concrete components | Pieces |
|---|---|---|
| 1 | DEHA_6000-5-0240_+raud_Puuvilla | 226 |
| 2 | FMC_Dowel | 189 |
| 3 | PC_HC_D_001 | 130 |
| 4 | FMCG_C_Saumaraudat_palkissa | 64 |
| 5 | EB_PD | 280 |
| 6 | EB_P2KL300 | 22 |
| 6 | Total | 911 |

***Table A2.4.*** *Case model 3A custom concrete components*

| | Custom steel components | Pieces |
|---|---|---|
| 1 | KPM4 | 143 |
| 1 | Total | 143 |

***Table A2.5.*** *Case model 3A custom steel components*

| | Custom concrete components | Pieces |
|---|---|---|
| 1 | 00_sokkelikiinnitys | 175 |
| 2 | Foundation-column | 167 |
| 3 | EB_PD | 158 |
| 4 | PC_BE_D_005 | 107 |
| 5 | PC_HC_D_001 | 103 |
| 6 | PC_IW_IW_GR_09 | 22 |
| 7 | PC_IW_IW_GR_07 | 20 |
| 8 | E_AV_004 | 6 |
| 9 | E_AV_003 | 5 |
| 10 | pg_DB_D_web_holes | 1 |
| 10 | Total | 764 |

***Table A2.6.*** *Case model 3B custom concrete components*

| | Custom steel components | Pieces |
|---|---|---|
| 1 | BP-1_W8X24 | 642 |
| 2 | CUT-R | 141 |
| 3 | CUT-L | 136 |
| 4 | CHAMFER | 130 |
| 5 | GALV_HSS_8_6 | 104 |
| 6 | Weld_Prep_Flg_V | 82 |
| 7 | BP-3_HSS10X0500 | 72 |
| 8 | BP-4_W14X90 | 72 |
| 9 | PC-03 | 72 |
| 10 | BP-1_W12X65 | 71 |
| 11 | BP-5_W14X159 | 70 |
| 12 | BP-4_W14X82 | 58 |
| 13 | BP-4_W14X120 | 49 |
| 14 | BP-7_W14X120 | 48 |
| 15 | BP-4_W14X99 | 47 |
| 16 | MISC_CUT | 42 |
| 17 | BP-7_W14X109 | 38 |
| 18 | ACCES_BOT_LE | 33 |
| 19 | PC-03T | 32 |
| 20 | ACCES_BOT_RI | 31 |
| 21 | REV_ACCES_HOLE_LEFT | 31 |
| 23 | BP-4_W14X132 | 30 |
| 24 | BP-4_W14X61 | 30 |
| 22 | E02_HSS8x6_BSPL | 30 |
| 25 | REV_ACCES_HOLE_RIGHT | 29 |
| 26 | BEVEL WEB | 21 |
| 27 | BP-5_W14X145 | 21 |
| 28 | BP-7_W14X61 | 18 |
| 29 | BP-4_W14X145 | 17 |
| 30 | HSSBASEPLATE_G4_1 | 17 |
| 31 | BP-2_W10X39 | 16 |
| 32 | BP-4_W14X43 | 16 |
| 33 | K03 ch1 | 15 |
| 34 | K04 ch1 | 15 |
| 35 | BP-7_W14X159 | 14 |
| 36 | BP-4(M)_HSS20X0500 | 13 |
| 37 | BP-4_W14X109 | 13 |
| 38 | BP-5_W14X132 | 13 |
| 39 | HSS_SCREEN_NEW | 13 |
| 40 | BP-4_W14X74 | 12 |
| 41 | BP-5_W14X211 | 12 |
| 42 | BP-9_W14X145 | 12 |
| 43 | BP-9_W14X342 | 12 |
| 44 | C9_W24X76_W14X22 | 12 |
| 45 | K03 ch3 | 12 |

| | | |
|---|---|---|
| 46 | K04 ch3 | 12 |
| 47 | BP-4_W14X53 | 11 |
| 48 | BP-10_W14X283 | 10 |
| 49 | BP-9_W14X257 | 10 |
| 50 | BP-10_W14X233 | 9 |
| 51 | BP-7_W14X145 | 9 |
| 52 | BP-9_W14X211 | 9 |
| 53 | K04 ch2 | 9 |
| 54 | RATE_HOLE(K5) | 9 |
| 56 | B_10_W27X84_W16X26LHS | 8 |
| 57 | B_11W27X84_W16X26 | 8 |
| 58 | BP-10_W14X342 | 8 |
| 59 | BP-10_W14X500 | 8 |
| 60 | BP-5_W14X176 | 8 |
| 61 | BP-9_W14X311 | 8 |
| 62 | BP-9_W14X90 | 8 |
| 55 | EXPAN_WX132_99_211 | 8 |
| 63 | B_10_W33X130_W16X26 | 7 |
| 64 | B_11_W18X35_W8X10 | 7 |
| 65 | BP-10_W14X159 | 7 |
| 66 | BP-10_W14X176 | 7 |
| 67 | BP-7_W14X132 | 7 |
| 68 | BP-9_W14X120 | 7 |
| 69 | PC-1X5-45 | 7 |
| 71 | B_10_W18X35_W12X19 | 6 |
| 72 | B_10_W30X116_W16X26LHS | 6 |
| 73 | B_10_W30X99_W16X26RHS | 6 |
| 74 | B_10_W30X99_W16X26RHS | 6 |
| 75 | B_10W16X31_W8X10 | 6 |
| 76 | B_11_W30X99_W14X22 | 6 |
| 77 | B_11_W36X150_W16X26 | 6 |
| 78 | BP-4_W14X193 | 6 |
| 79 | BP-4_W14X48 | 6 |
| 80 | BP-9_W14X283 | 6 |
| 81 | C8_W24X68_W18X35 | 6 |
| 82 | C8_W30X99_W14X22 | 6 |
| 83 | C8_W8X10_W16X26 | 6 |
| 84 | C9_W30X99_W14X22 | 6 |
| 70 | EXPAN_W14X233_283 | 6 |
| 85 | K03 ch2 | 6 |
| 87 | BP-10_W14X398 | 5 |
| 88 | BP-5_W14X193 | 5 |
| 89 | BP-6_W14X311 | 5 |
| 90 | BP-7_W14X90 | 5 |
| 91 | BP-7_W14X99 | 5 |
| 92 | BP-9_W14X132 | 5 |

| | | |
|---|---|---|
| 93 | BP-9_W14X233 | 5 |
| 94 | C8_W27X84_W18X35 | 5 |
| 95 | C9_W33X118_W14X22 | 5 |
| 96 | CURB CORNERS | 5 |
| 86 | EXPAN_W14X159_211 | 5 |
| 98 | H01 S-418-1 | 5 |
| 97 | H02 S-418 -4 | 5 |
| 99 | B_10_W27X84_W16X26 | 4 |
| 100 | B_10W24X68_W8X10 | 4 |
| 101 | B_11W16X26_W8X10 | 4 |
| 102 | B_11W36X150_W8X10 | 4 |
| 103 | B10_W30X90_W8X10 | 4 |
| 104 | B11_W30X90_W12X19 | 4 |
| 105 | BP-1_W8X35 | 4 |
| 106 | BP-4_W14X159 | 4 |
| 107 | BP-5_W14X120 | 4 |
| 108 | BP-7_W14X193 | 4 |
| 109 | BP-8_W14X120 | 4 |
| 110 | BP-9_W14X193 | 4 |
| 111 | BP-9_W14X426 | 4 |
| 112 | C9_W16X26_W14X22 | 4 |
| 113 | C9_W24X68_W18X35 | 4 |
| 114 | C9_W27X84_W14X22 | 4 |
| 115 | C9_W27X84_W18X35 | 4 |
| 116 | Girt 2 | 4 |
| 117 | H01 S-418-3 | 4 |
| 118 | H02 S-418-2 | 4 |
| 119 | HSS8X6_145 | 4 |
| 120 | K01 Weld Access Hole W18X35 | 4 |
| 121 | PC-2A | 4 |
| 122 | PipeWeldPrep_det | 4 |
| 123 | B_10_W27X84_W14X22LHS | 3 |
| 124 | B_11_W27X84_W14X22RHS | 3 |
| 125 | B_11_W27X84_W18X35 | 3 |
| 126 | B_9_W30X99_W18X35 | 3 |
| 127 | B_9_W33X130_W16X57 | 3 |
| 128 | B_9W16X31_W8X10 | 3 |
| 129 | B_9W16X31_W8X10 | 3 |
| 130 | B10_W12X26_W12X19 | 3 |
| 131 | B11_W27X84_W14X22RHS | 3 |
| 132 | B11_W30X90_W8X10 | 3 |
| 133 | B11_W30X99_W16X26 | 3 |
| 134 | B11_W30X99_W16X26_2 | 3 |
| 135 | BP-10_W14X193 | 3 |
| 136 | BP-4_W14X68 | 3 |
| 137 | BP-6_W14X193 | 3 |

| | | |
|---|---|---|
| 138 | BP-8_W14X176 | 3 |
| 139 | BP-9_W14X109 | 3 |
| 140 | C7_W24X76_W18X35 | 3 |
| 141 | C7_W30X99_W14X22 | 3 |
| 142 | C7_W30X99_W14X22_2 | 3 |
| 143 | C7_W30X99_W16X26 | 3 |
| 144 | C8_W24X68_W8X10 | 3 |
| 145 | C8_W27X84_W14X22 | 3 |
| 146 | C8_W33X118_W18X35 | 3 |
| 147 | C9_W14X22_W10X12 | 3 |
| 148 | C9_W16X26_W8X10 | 3 |
| 149 | C9_W24X68_W8X10 | 3 |
| 150 | C9_W33X118_W18X35 | 3 |
| 151 | H02 S-418-5 | 3 |
| 152 | HSS8X6_W14X120-SEQB03 | 3 |
| 153 | K8_MC_W8X35 | 3 |
| 233 | 1 SLOT | 2 |
| 156 | B_10_W12X30_W8X10 | 2 |
| 157 | B_10_W16X36_W16X26 | 2 |
| 158 | B_10_W18X35_W8X10 | 2 |
| 159 | B_10_W21X44_W16X26 | 2 |
| 160 | B_10_W24X55_W14X22 | 2 |
| 161 | B_10_W24X55_W16X26 | 2 |
| 162 | B_10_W24X55_W16X26RHS | 2 |
| 163 | B_10_W24X55_W21X44 | 2 |
| 164 | B_10_W24X62_W16X26 | 2 |
| 165 | B_10_W24X62_W16X26RHS | 2 |
| 166 | B_10_W24X68_W12X19 | 2 |
| 167 | B_10_W24X76_W16X26RHS | 2 |
| 168 | B_10_W33X130_W24X55 | 2 |
| 169 | B_10W24X68_W18X35 | 2 |
| 170 | B_11_W16X26_W8X10 | 2 |
| 171 | B_11_W18X35_W16X26 | 2 |
| 172 | B_11_W30X99_W16X26 | 2 |
| 173 | B_11_W36X150_W18X35 | 2 |
| 174 | B_11_W36X150_W24X55 | 2 |
| 175 | B_9_W16X31_W8X10 | 2 |
| 176 | B_9_W16X36_W16X26 | 2 |
| 177 | B_9_W18X35_W16X26LH | 2 |
| 178 | B_9_W18X35_W16X36 | 2 |
| 179 | B_9_W18X35_W8X10 | 2 |
| 180 | B_9_W24X55_W16X26 | 2 |
| 181 | B_9_W24X55_W16X26LHS | 2 |
| 182 | B_9_W30X99_W16X26 | 2 |
| 183 | B_9_W33X130_W16X26 | 2 |
| 184 | B10_W12X19_W12X19 | 2 |

| | | |
|---|---|---|
| 185 | B10_W14X22_W12X19 | 2 |
| 186 | B10_W14X22_W8X10 | 2 |
| 187 | B10_W16X31_W12X19 | 2 |
| 188 | B10_W24X62_W12X19 | 2 |
| 189 | B10-W14X109_W18X35-MC_R_FLG | 2 |
| 190 | B11_W18X50_W12X26 | 2 |
| 191 | B11_W24X68_W12X19 | 2 |
| 192 | B11_W30X99_W12X19 | 2 |
| 193 | B9_W14X22_W10X12 | 2 |
| 194 | BP-1_HSS12_750X0375 | 2 |
| 195 | BP-4(M)_24API | 2 |
| 196 | BP-4_W14X370 | 2 |
| 197 | BP-6_W14X283 | 2 |
| 198 | BP-8_W14X159 | 2 |
| 199 | BP-9_W14X159 | 2 |
| 200 | BP-9_W14X176 | 2 |
| 201 | BP-9_W14X398_G2 | 2 |
| 202 | C7_C_W14X120_HSS8X6_2 | 2 |
| 203 | C7_C_W14X132_HSS8X6_2 | 2 |
| 204 | C7_W16X26_W8X10 | 2 |
| 205 | C7_W18X35_W16X26 | 2 |
| 206 | C7_W24X76_W8X10 | 2 |
| 207 | C8_C_W14X120_HSS8X6 | 2 |
| 208 | C8_C_W14X159_HSS8X6 | 2 |
| 209 | C8_C_W14X398_HSS8X6 | 2 |
| 210 | C8_C_W14X61_HSS8X6 | 2 |
| 211 | C8_C_W14X61_HSS8X6_2 | 2 |
| 212 | C8_W14X22_W8X10 | 2 |
| 213 | C8_W18X35_W16X26 | 2 |
| 214 | C8_W18X35_W16X26_2 | 2 |
| 215 | C8_W21X44_W14X22 | 2 |
| 216 | C8_W24X76_W14X22_2 | 2 |
| 217 | C8_W27X84_W14X22_2 | 2 |
| 218 | C8_W30X90_W12X19 | 2 |
| 219 | C8_W30X90_W8X10 | 2 |
| 220 | C9_C_W14X120_HSS8X6 | 2 |
| 221 | C9_C_W14X159_HSS8X6 | 2 |
| 222 | C9_W18X35_W14X22 | 2 |
| 223 | C9_W27X84_W12X19 | 2 |
| 224 | C9_W30X90_W10X12 | 2 |
| 225 | C9-W14X90_W18X35-MC_FLG_R | 2 |
| 226 | CD020E4 | 2 |
| 227 | CURB DOOR HOOK | 2 |
| 228 | CURB T INTERSECTION | 2 |
| 229 | CUTTING | 2 |
| 154 | E1-W14X120_W27X84-MC_L_FLG | 2 |

| | | |
|---|---|---|
| 155 | E1-W14X120_W27X84-MC_R_FLG | 2 |
| 230 | H01 S-418 -4 | 2 |
| 234 | hss8 | 2 |
| 231 | HSS8X6-W14X109 | 2 |
| 232 | HSS8X6-W14X311 | 2 |
| 236 | B_10_W16X26_W16X26RHS | 1 |
| 237 | B_10_W16X31_W16X36 | 1 |
| 238 | B_10_W16X31_W8X10 | 1 |
| 239 | B_10_W16X36_W16X26RHS | 1 |
| 240 | B_10_W16X57_W16X26R | 1 |
| 241 | B_10_W18X35_W16X26RHS | 1 |
| 242 | B_10_W24X55_W18X35RHS | 1 |
| 243 | B_10_W24X55_W21X44LHS | 1 |
| 244 | B_10_W24X76_W16X26 | 1 |
| 245 | B_10_W24X76_W16X26 RHS | 1 |
| 246 | B_10_W24X76_W16X26LHS | 1 |
| 247 | B_10_W30X99_W16X26 | 1 |
| 248 | B_10_W33X130_W16X36 | 1 |
| 249 | B_10_W33X130_W21X44 | 1 |
| 250 | B_11_W24X55_W16X26LR | 1 |
| 251 | B_9_W12X22_W8X10 | 1 |
| 252 | B_9_W12X30_W8X10 | 1 |
| 253 | B_9_W16X26_W16X26 | 1 |
| 254 | B_9_W16X31_W16X57 | 1 |
| 255 | B_9_W16X36_W14X22 | 1 |
| 256 | B_9_W21X44_W16X31 | 1 |
| 257 | B_9_W24X62_W16X36 | 1 |
| 258 | B_9W24X68_W8X10 | 1 |
| 259 | B10_W21X44_W12X26 | 1 |
| 260 | B10_W21X44_W14X22 | 1 |
| 261 | B10_W21X44_W14X22 | 1 |
| 262 | B10_W21X48_W14X22 | 1 |
| 263 | B10_W30X90_W12X19 | 1 |
| 264 | B10_W30X90_W21X44 | 1 |
| 265 | B11_TENSION_W14X90_W14X120 | 1 |
| 266 | B11_W24X62_W24X62 | 1 |
| 267 | B11_W24X62_W24X62_2 | 1 |
| 268 | B11_W30X90_W21X44 | 1 |
| 269 | B11_W30X90_W21X44_2 | 1 |
| 270 | B11_W30X99_W18X40 | 1 |
| 271 | B11_W30X99_W24X62 | 1 |
| 272 | B9_W12X19_W12X19 | 1 |
| 273 | B9_W16X31_W12X19 | 1 |
| 274 | B9_W24X62_W12X19 | 1 |
| 275 | B9_W30X90_W12X19 | 1 |
| 276 | B9-W14X159_W33X130-MC-R-SLP | 1 |

| | | |
|---|---|---|
| 277 | B9-W14X398_W33X130-MC_L | 1 |
| 278 | B9-W14X398_W33X130-MC_R | 1 |
| 279 | B9-W14X61_W12X19-MC_L | 1 |
| 280 | B9-W14X61_W12X19-MC_R | 1 |
| 281 | B9-W14X74_W12X22-MC_L | 1 |
| 282 | B9-W14X74_W12X22-MC_R | 1 |
| 283 | B9-W14X82_W12X30-MC_L | 1 |
| 284 | B9-W14X82_W12X30-MC_R | 1 |
| 285 | B9-W14X82_W16X31-MC_L | 1 |
| 286 | B9-W14X82_W16X31-MC_R | 1 |
| 287 | B9-W14X90_W16X31-MC_L | 1 |
| 288 | B9-W14X90_W16X31-MC_R | 1 |
| 289 | B9-W14X90_W18X35-MC_L | 1 |
| 290 | B9-W14X90_W18X35-MC_R | 1 |
| 291 | BP-10_W14X211 | 1 |
| 292 | BP-3_HSS6X6X3 8F | 1 |
| 293 | BP-4(M)_36API | 1 |
| 294 | BP-4_W14X233 | 1 |
| 295 | BP-6_W14X233 | 1 |
| 296 | BP-7_W14X74 | 1 |
| 297 | BP-7_W14X82 | 1 |
| 298 | BP-7A_W14X193 | 1 |
| 299 | BP-9_W14X370_G2 | 1 |
| 300 | BP-9_W14X455 | 1 |
| 301 | C09_C14_HS7_HS8_BRC | 1 |
| 302 | C7_C_W14X61_HSS8X6 | 1 |
| 303 | C7_C_W14X82_HSS8X6 | 1 |
| 304 | C7_W24X76_W16X26 | 1 |
| 305 | C7_W27X84_W14X22 | 1 |
| 306 | C7_W30X99_W18X35 | 1 |
| 307 | C7-W14X109_W18X35-MC-FLG_R | 1 |
| 308 | C7-W14X120_W18X35-M-FLG-R | 1 |
| 309 | C7-W14X82_W18X35-MC-FLG_R | 1 |
| 310 | C7-W14X90_W18X35-MC_FLG_R | 1 |
| 311 | C8_W30X90_W21X44 | 1 |
| 312 | C8_W30X99_W12X19 | 1 |
| 313 | C8_W30X99_W21X44 | 1 |
| 314 | C8-W14X120_W18X35-M_FLG_R | 1 |
| 315 | C9_C_W14X61_HSS8X6_2 | 1 |
| 316 | C9_W18X35_W16X26 | 1 |
| 317 | C9_W21X44_W14X22 | 1 |
| 318 | C9_W21X44_W16X26 | 1 |
| 319 | C9_W24X62_W16X26 | 1 |
| 320 | C9_W30X90_W12X19 | 1 |
| 321 | C9_W30X90_W21X44 | 1 |
| 322 | C9_W33X118_W12X19 | 1 |

| | | |
|---|---|---|
| 323 | C9_W33X118_W21X44_2 | 1 |
| 324 | C9_W36X1 | 1 |
| 325 | C9_W36X135_W21X44 | 1 |
| 235 | E06-13 | 1 |
| 326 | HSS8X6_W14X132-B3 | 1 |
| 327 | HSS8X6_W14X53 | 1 |
| 328 | HSS8X6-W14X99-B3 | 1 |
| 329 | J-UPPER RAKER | 1 |
| 330 | M-1 | 1 |
| 341 | raker hsss | 1 |
| 331 | RT HOLE_W14X159 | 1 |
| 332 | RT HOLE_W14X211 | 1 |
| 333 | RT HOLE_W14X398 | 1 |
| 334 | SAFETY_WEB | 1 |
| 335 | Strurt connection | 1 |
| 336 | W14X120_W27X84-L-MC | 1 |
| 337 | W14X120_W27X84-R-MC | 1 |
| 340 | W14X61-W30X90_MC-FLG | 1 |
| 338 | W14X68_W12X30-MC-L | 1 |
| 339 | W14X68_W12X30-MC-R | 1 |
| 342 | WLD_PREP_W14X311 | 1 |
| 343 | WLD_PREP_W14X398 | 1 |
| 343 | Total | 3236 |

***Table A2.7.*** *Case model 4 custom steel components*

# APPENDIX 3: SURVEY

## Tekla Structures - Components

Thank you for taking part in this survey!

This survey accompanies master's thesis research being done for Trimble Solutions. The goal is to define the most important development areas for Tekla Structures components by rating the problems and evaluating the improvement ideas.

Your response will only be used for survey purposes and all information supplied will be handled anonymously. The final results are presented as a whole.

The survey will take about 10 minutes.

Survey is open until Friday 16.12.2016.

Please click 'Next' to begin.

## Tekla Structures components

1. **In a general sense, how useful are the current components?**
   *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Useless | ◯ | ◯ | ◯ | ◯ | ◯ | Useful |

2. **Have you created custom components?**
   *Mark only one oval.*

   ◯ Yes
   ◯ No
   ◯ I don't know

3. **Have you used Autoconnection?**
   *Mark only one oval.*

   ◯ Yes
   ◯ No
   ◯ I don't know

4. Comment (optional):

.....

.....

.....

.....

## How satisfied are you with the usability of components?

If you have not used a component, answer I don't know.

5. *Mark only one oval per row.*

| | Satisfied | Good but needs a little improvement | Not satisfied! Should be improved. | I don't know |
|---|---|---|---|---|
| System components | ◯ | ◯ | ◯ | ◯ |
| Custom component editor | ◯ | ◯ | ◯ | ◯ |
| AutoConnection | ◯ | ◯ | ◯ | ◯ |

6. Comment (optional):

.....

.....

.....

## Problem scenarios

Rate the following problems on a scale of 1 to 5.

1 = Not a problem
5 = Big Problem

After all problem scenarios you have a chance to write other problems you have encountered

## Problem: "I don't know which term to use in the search field."

7. **E.g. hole or opening**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not a problem | ◯ | ◯ | ◯ | ◯ | ◯ | Big problem |

8. Comment (optional):

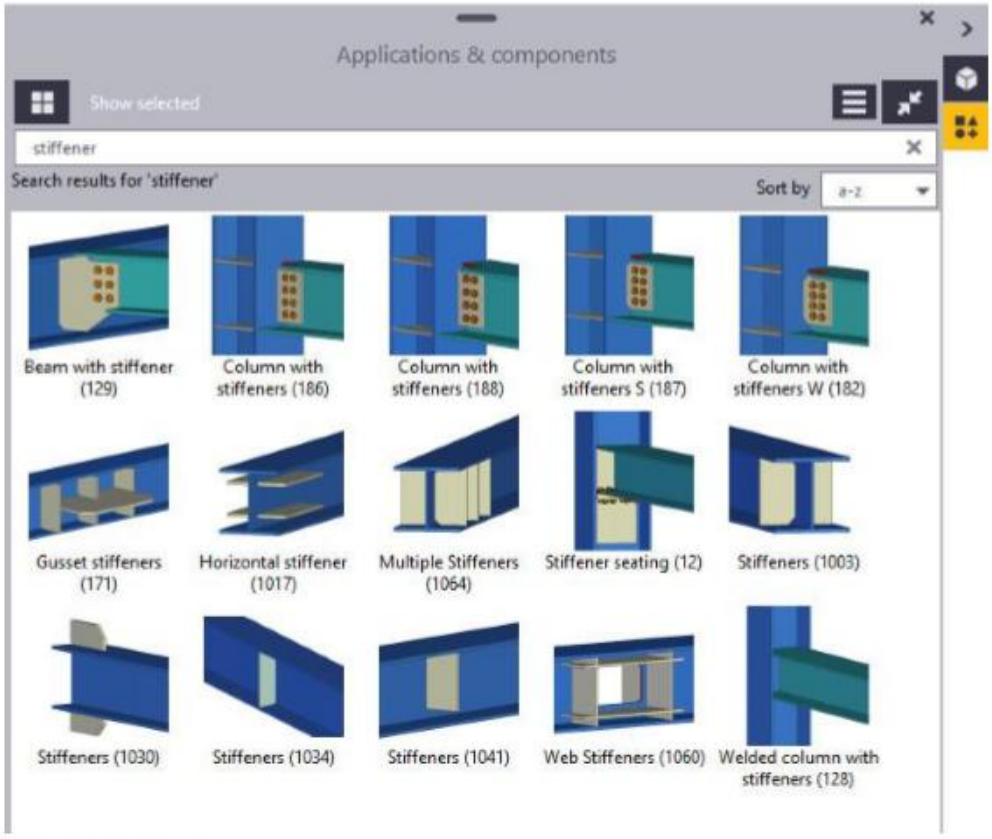
.....

.....

.....

## Problem: The catalog contains many similar components. I don't know which component to use.

9. **E.g. Column with stiffener (186), Column with stiffener (188), Column with stiffener S (187) and Column with stiffener W (182).**




*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not a problem | ◯ | ◯ | ◯ | ◯ | ◯ | Big problem |

10. Comment (optional):

.....

.....

## Problem: The dialog box contains so many properties. I don't know if I need to fill them all in.

11. *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not a problem | ◯ | ◯ | ◯ | ◯ | ◯ | Big problem |

12. Comment (optional):

## Problem: It's difficult to know which dialog text box or picture modifies each component part.

E.g. Pictures do not have labels and sometimes similar plates are only numbered.

13. *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not a problem | ◯ | ◯ | ◯ | ◯ | ◯ | Big problem |

14. Comment (optional):

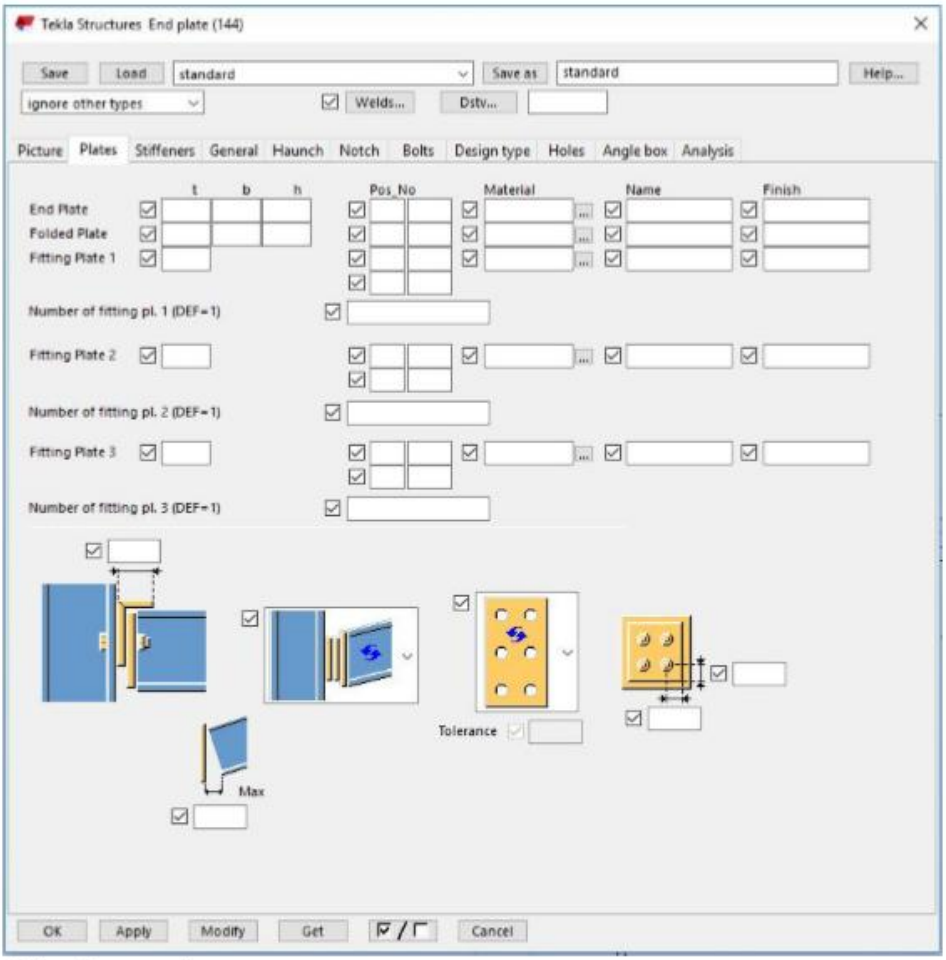
## Problem: I need to explode the component to finish the design.

15. *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not a problem | ◯ | ◯ | ◯ | ◯ | ◯ | Big problem |

16. Comment (optional):

## Problem: I don't know the component's default values.

17. 


*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not a problem | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | Big problem |

18. Comment (optional):

.....

.....

.....

## Problem: I don't know if there is something new for me to try in the Tekla Warehouse.

19. *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not a problem | ◯ | ◯ | ◯ | ◯ | ◯ | Big problem |

20. Comment (optional):

## Please describe any other problems you have encountered with components.

21.

## Improvement ideas

Next you will evaluate the usefulness of presented improvement ideas.

All the pictures are drafts of improvement ideas. Trimble Solutions is not obligated to release any product features or functions included in this survey within any specified time frame, if at all.

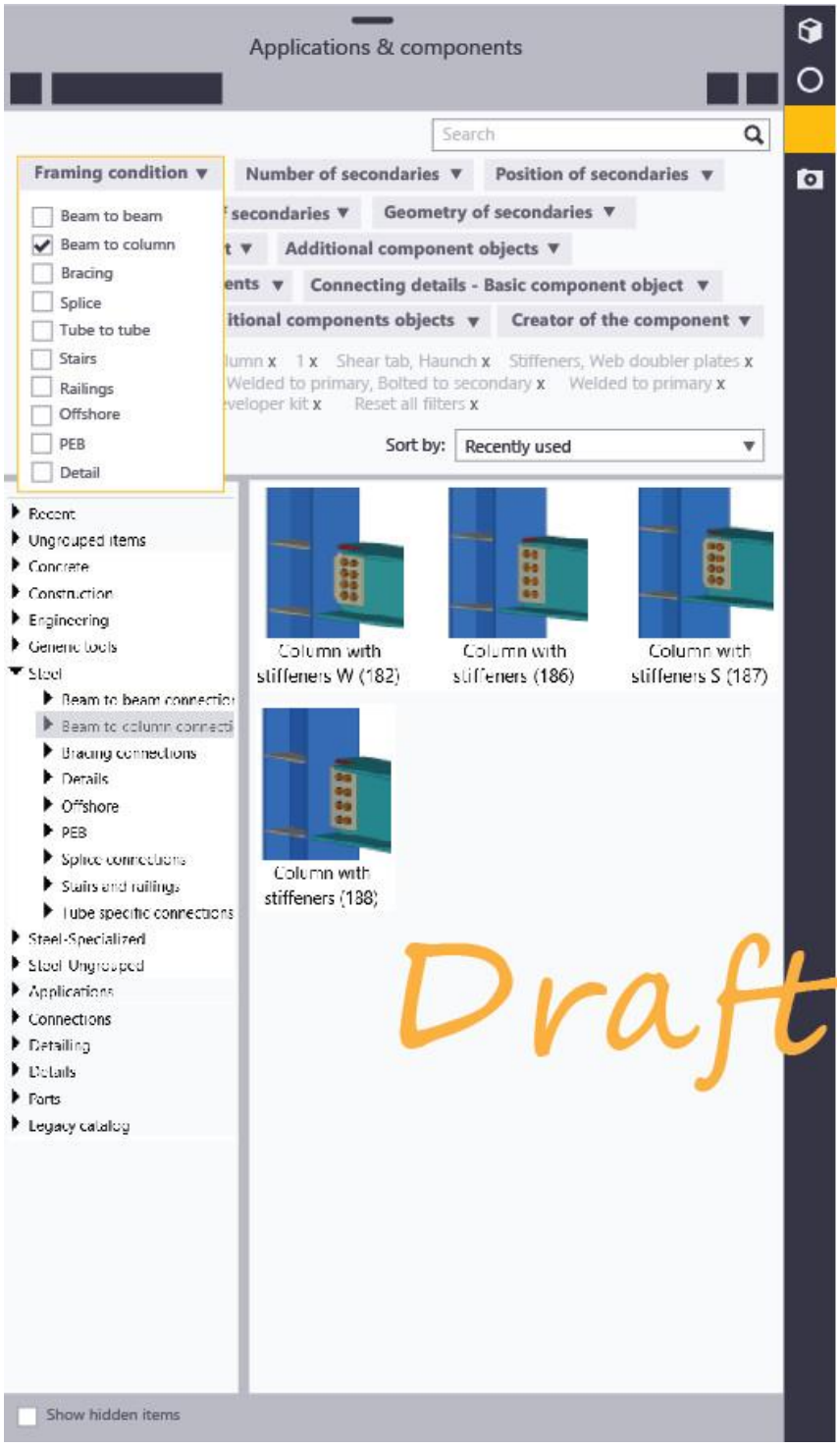
Rate following idea on a scale of 1 to 5.
1 = Useless
5 = Useful

## Option: Component catalog improvement

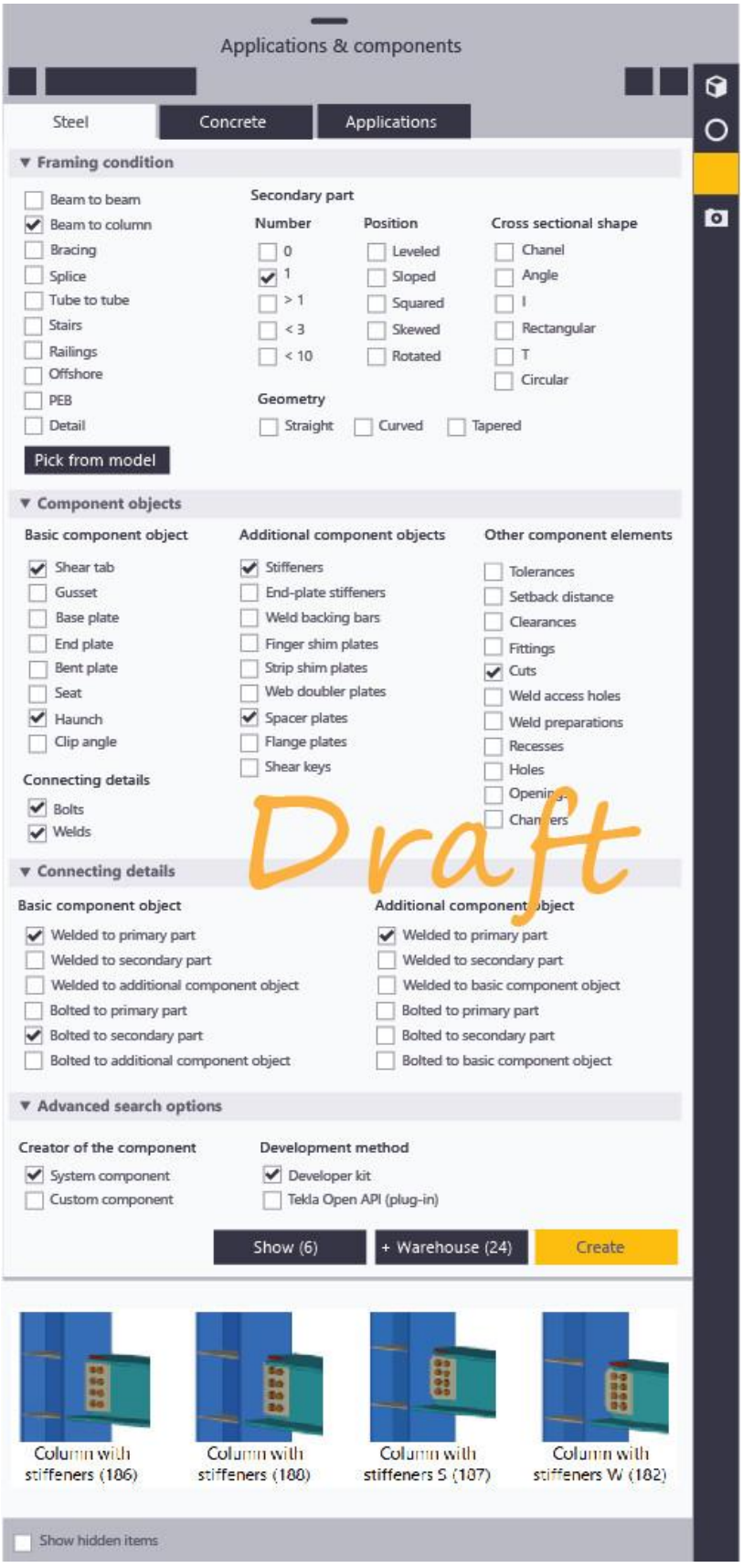
The comprehensive search target of the catalog is to help the user to find the right component.

All selections will filter more the results. Steel components can be filtered by framing condition, created objects, connecting details and advanced options.

## Comprehensive search with drop down



## Comprehensive search with check boxes



22. **How useful is the comprehensive search?**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Useless | ◯ | ◯ | ◯ | ◯ | ◯ | Useful |

23. **Comprehensive search contains the same options in drop down lists and check boxes. Which one do you prefer?**
*Mark only one oval.*

- ◯ Drop down
- ◯ Check boxes

24. **Component catalog search tree view**
On the left side of the drop down list is a draft picture. The tree view of component catalog groups can be used to refine the search.
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Useless | ◯ | ◯ | ◯ | ◯ | ◯ | Useful |

25. Comment (optional):

.....

.....

## Option: Component catalog search would also show Warehouse content.

26. *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Useless | ◯ | ◯ | ◯ | ◯ | ◯ | Useful |

27. Comment (optional):

.....

.....

## Option: New view option for the component catalog.

28. **The new view option would show picture, description, objects created, tags and type.**

| PICTURE | DESCRIPTION | OBJECTS CREATED | TAGS | TYPE |
|---|---|---|---|---|
| | **Column with stiffeners (186)** connects a beam to a column with a square shear tab. The shear tab is welded to the main part web and stiffeners, and bolted to the secondary part web. The secondary beam can be ... | Shear tabs (1 or 2), Stiffeners (optional), Haunch plates (optional), Web doubler plate (optional), Bolts, Welds, Cuts | + | Connection system component |
| | **Column with stiffeners (188)** connects a beam to a column with a square shear tab. The shear tab is welded to the main part web and stiffeners, and bolted to the secondary part web. The secondary beam can be ... | Shear tabs (1 or 2), Stiffeners (optional), Haunch plates (optional), Web doubler plate (optional), Weld backing bars (optional), Bolts, Welds, Cuts | + | Connection system component |
| | **Column with stiffeners S (187)** connects a column to a beam with a shaped shear tab. The shear tab is welded to the main part and bolted to the secondary part web. The secondary beam can be leveled or sloped. | Shear tabs (1 or 2), Stiffeners (optional), Haunch plates (optional), Web doubler plate (optional), Bolts, Welds, Cuts | + | Connection system component |
| | **Column with stiffeners W (182)** connects a column to a beam with a shaped shear tab. The shear tab is welded to the main part and bolted to the secondary part web. The secondary beam can be leveled or sloped. | Shear tabs (1 or 2), Stiffeners (optional), Haunch plates (optional), Web doubler plate (optional), Weld backing bars (optional), Bolts, Welds, Cuts | + | Connection system component |



*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Useless | ◯ | ◯ | ◯ | ◯ | ◯ | Useful |

29. **Option: Sort component catalog search results**

E.g. Sort by environment suggestion, recently used or favorite.

*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Useless | ◯ | ◯ | ◯ | ◯ | ◯ | Useful |

30. Comment (optional):

.....

.....

## Option: Direct modification

31. **The ability to define the shape, chamfers and geometrical information in the model.**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Useless | ◯ | ◯ | ◯ | ◯ | ◯ | Useful |

32. Comment (optional):

.....

.....

.....

.....

## Option: 3D Guidance

33. **Highlights the modified part in the model.**
E.g. Shows which plate you are modifying
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Useless | ◯ | ◯ | ◯ | ◯ | ◯ | Useful |

34. Comment (optional):

.....

.....

.....

## Your work with Tekla Structures

35. **What is your job?**
*Mark only one oval.*

- ◯ Structural designer
- ◯ Developer or other technical engineer
- ◯ Other: .....

36. **Which version of Tekla Structures do you use?**
*Mark only one oval.*

- ◯ TS 2016
- ◯ TS 21
- ◯ TS 20
- ◯ TS 19
- ◯ Older

37. **What environment do you use?**

You can select one to three environments
*Mark only one oval.*

- Other
- Company's environment
- Australasia
- Austria
- Brazil
- China
- Czech
- Default
- Denmark
- Finland
- France
- Germany
- Hungary
- India
- Italy
- Japan
- Korea
- Middle East
- Netherlands
- Netherlands enu
- Norway
- Poland
- Portugal
- Russia
- South-east Asia
- South Afrika
- South America
- Spain
- Sweden
- Switzerland
- Taiwan
- UK
- US imperial
- US metric

38. **What environment do you use?**

You can select one to three environments
*Mark only one oval.*

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- Brazil
- China
- Czech
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- Finland
- France
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- Italy
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- Poland
- Portugal
- Russia
- South-east Asia
- South Afrika
- South America
- Spain
- Sweden
- Switzerland
- Taiwan
- UK
- US imperial
- US metric

## Thank you! Please press 'Submit' to complete the survey.

Thank you very much for your time!

If you have any questions regarding the survey, please contact Iida Kummala.
iida.kummala@trimble.com

## Participant information

If you want to be contacted or participate in other Tekla Structures surveys, add your contact information below.

40. **Name**

.....

41. **Email**

42. **Feedback:**

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