MAKING OF WELDED CONSTRUCTIONS FROM 3D SKETCHES THROUGH 3D MODELS TO THE FINAL PRODUCT

Ivica Lacković, Slaven Šimunić

Key words: *Welded, construction, sketch, plane, model, 3D, Autodesk, Inventor, weld, comparison, drawing, material, manufacturing, dimensional control, assembly, finished product.*

Abstract:

Future of making welded constructions rests on using tools for 3D modeling. Autodesk Inventor is one of those tools which contains a large base of standardized parts, like beams (HEA, HEB etc.), bolts, nuts, tubes, valves and etc. Base can be adapted and configured according to the user and user requirements. Beside large base of standardized parts, Inventor contains additional modules that makes easier to build complex welded constructions. This module is called Design Frame. Design Frame starts by defining fixed point for basis of each 3D mode, geometry plane and a sketch. Sketch contains lines which transforms to beams, tubes or any other part that is contained in the base of standardized parts. Beams added with Design Frame can be shaped, connected and welded to make a model that is a valid copy of the construction made in real life. Each item is ready to be displayed in making 2D documentation for manufacturing in real life. Finished product than can be compared to 3D model, 2D documentation with emphasis on dimensional control.

1 INTRODUCTION

In the past, welded constructions have been made from drawings that have been done with hand, or in the near past with 2D software. In each of these cases materials that have been used in making welded constructions had to be adapted while the construction is made. Especially joints had to be done and adapted when created. New software solutions are allowing the design engineer to adapt positions of the construction in virtual environment. This kind of engineering is saving time and money in making of welded constructions, because all (or almost all) problems can be solved in a virtual environment. 3D models are becoming a standard in making of constructions, because of several reasons. First, view of the construction for the design engineer makes easier design. Second, workshop and montage site can examine the construction in advance and decide how to position, rotate, pick equipment for manufacture and montage purposes. Third, other participants in the process of making welded constructions can view, adapt to and make use of 3D model so that welded construction has the possibility to be made with as few mistakes possible. In this paper all stages of making welded construction will be addressed, from start and sketch to finished manufactured construction that has been created on montage site.

2 SOFTWARE SOLUTION

Software solution that will be described is Autodesk Inventor. Autodesk Inventor is a middle to high range software solution that can cover all needs for the design and making of welded constructions. Autodesk Inventor can create 3D models and assemblies, 2D documentation for manufacturing and has the possibility to create calculations and simulations of created models with finite element methods to check the design and correct possible mistakes in the design before the constructions reaches manufacturing and montage phase.

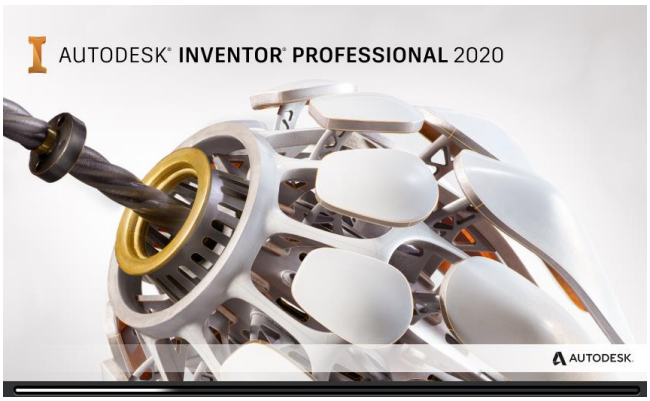

Figure 1. Autodesk Inventor introduction screen

Autodesk Inventor incorporates „project“ technology that separates project files to help the design engineer to save all project files to one location and to be able to manage files easier.

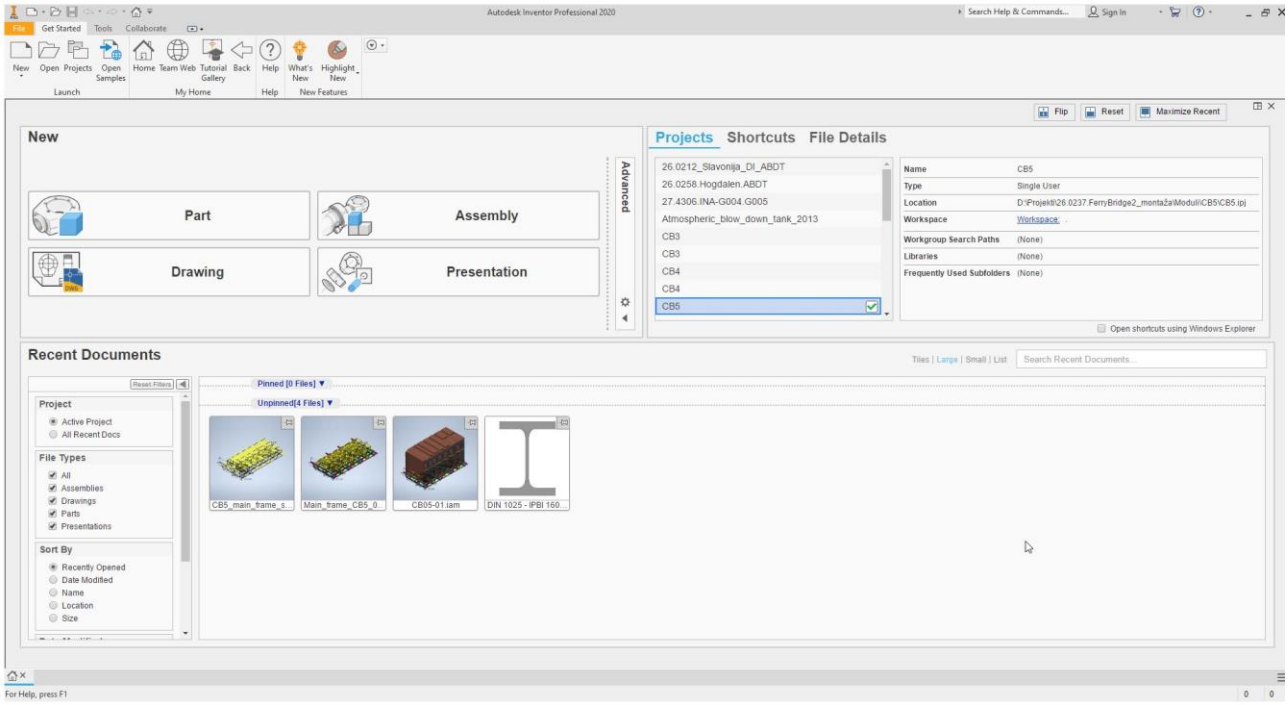

Figure 2. Autodesk Inventor – project selection window

Inventor will display a warning if the design engineer is using the files outside of the project. Using files outside of the project is not recommended, because of collaboration with other parties, inside and outside of the project company.

Inventor can use multiple standards to be able to cover standards used across the world. Upon installation, Inventor can be adapted to the standard that the design engineer will use for the project.

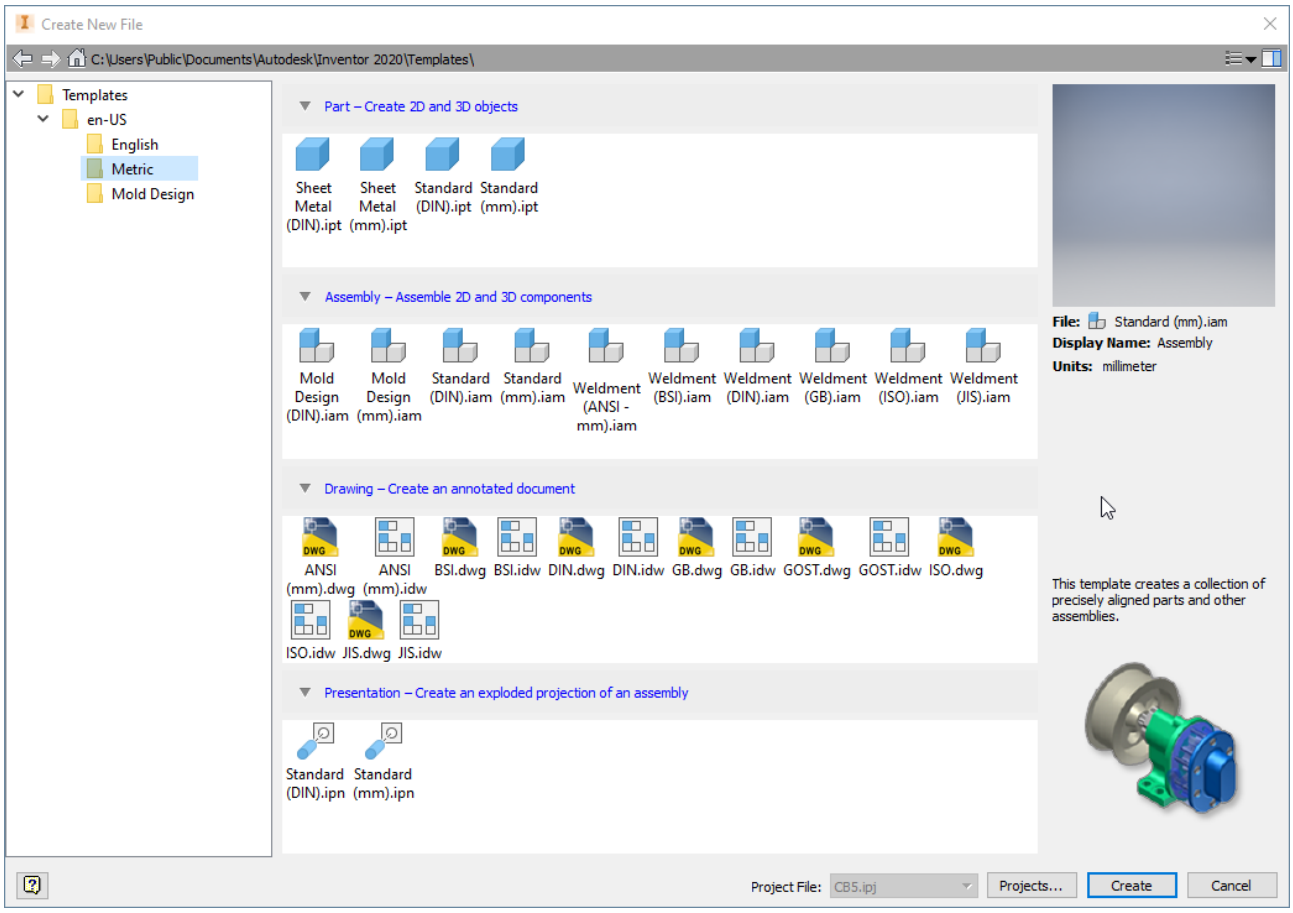

Figure 3. Creation of files with use of standard for the project

Autodesk Inventor with standard sketch tools, 3D model tools and annotation tools has a complete set of tools for finite elements method, for calculations and simulation. Next figures display sketch, 3D models and other modules that can be used in Inventor.

Figure 4. Autodesk Inventor – sketch tools

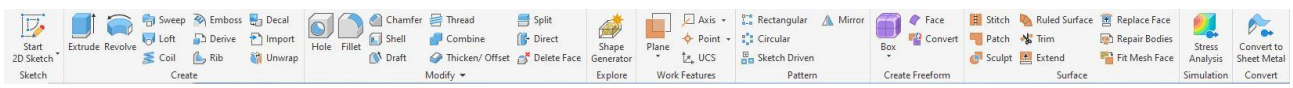

Figure 5. Autodesk Inventor – 3D model tools

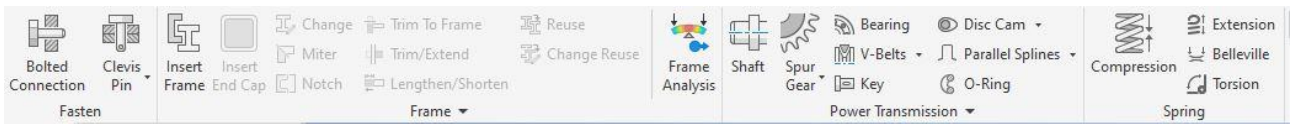

Figure 6. Autodesk Inventor – assembly module tools

Autodesk Inventor has a big content center database that helps design engineers to make 3D models and welded constructions. This database contains parts from all available standards. Some items in the database are completely defined, example: nuts, bolts, valves, bearings. Other items like beams HE-A and HE-B are used with the feature that can be adapted with length to fit all welded constructions.

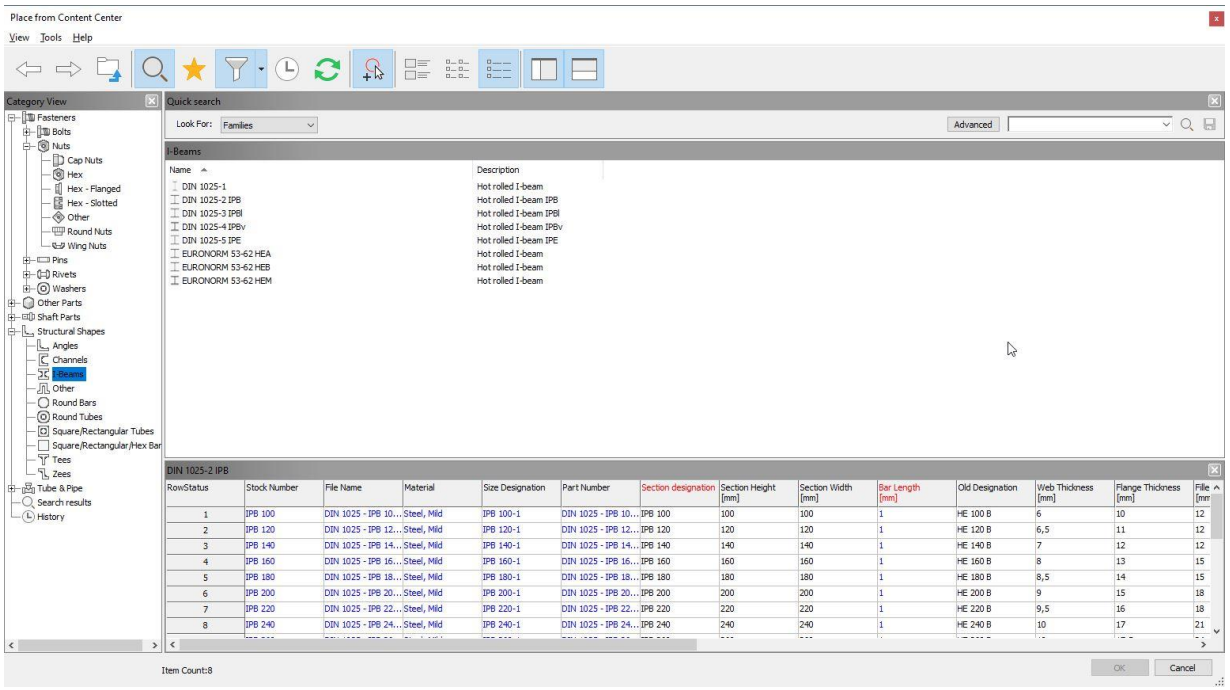

Figure 7. Autodesk Inventor – content center, beams, acc. standard DIN 1025

After creation of 3D model, 2D drawing can be created to display assembly drawings or drawing of each item, for manufacturing or montage purposes.

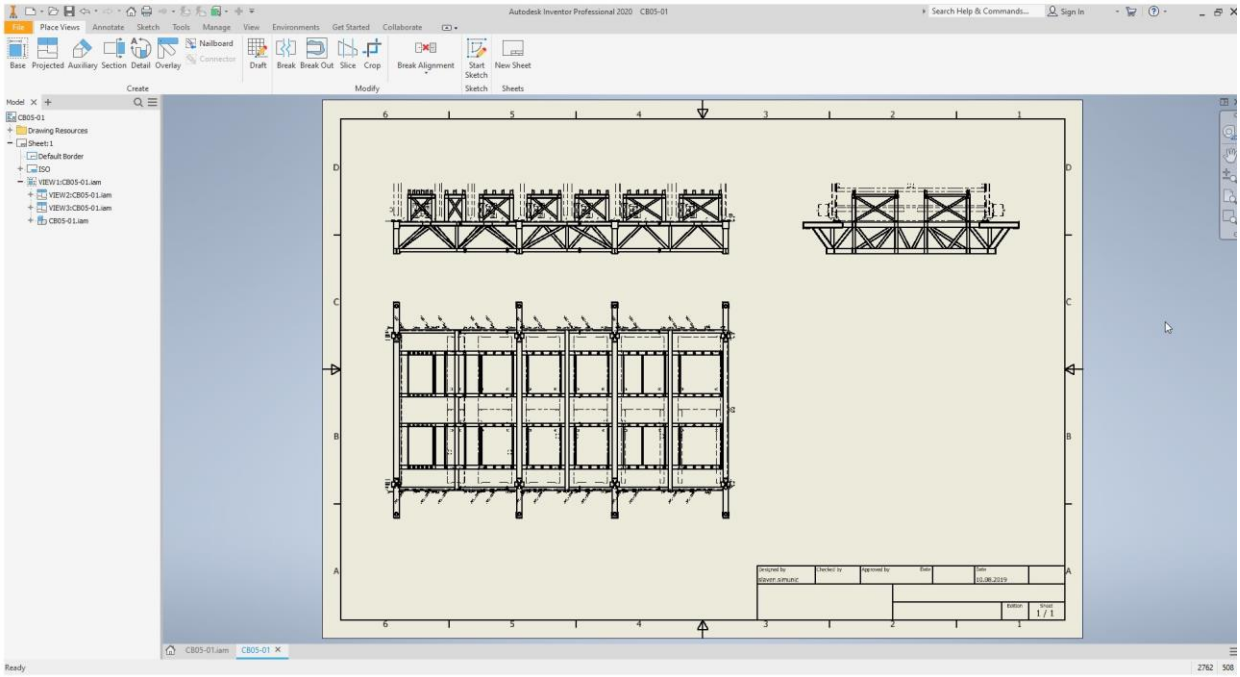

Figure 8. Autodesk Inventor – 2D drawing

3 MAKING OF WELDED CONSTRUCTION

3.1 Data analysis and basic design

The client delivers basic ideas and parts of design with requests for construction and montage. Parts of this dana is the 3D model of the requested part. According to this part and weight analysis basic design for the welded construction begins.

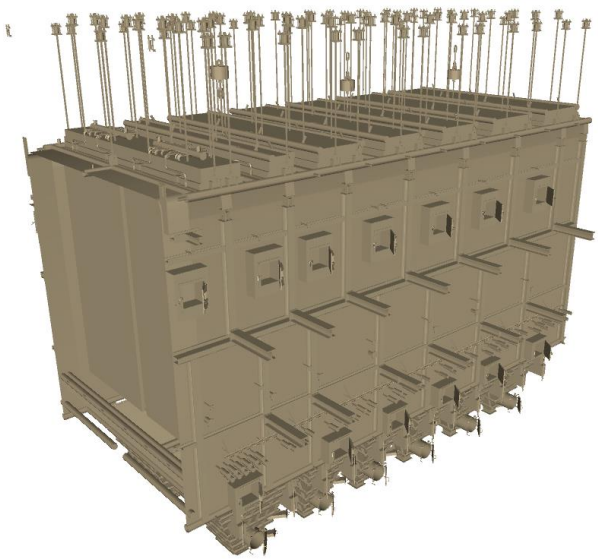

Figure 9. Basic model for design of welded construction

After analyzing the data received basic design can start. Basic design will be done in a few steps, that will be described later in the text.

3.2 Basic design – calculation, technical report

Basic design includes making a technical report, calculation for the welded construction. This technical report will reflect bearing load, construction design and materials to be used in making the construction. Every part of this construction has to be calculated to make sure that the construction can withstand bearing load of the part that needs to be lifted. This technical report with 3D model that represents the load that needs to be lifted will be used to create 3D model of the welded construction.

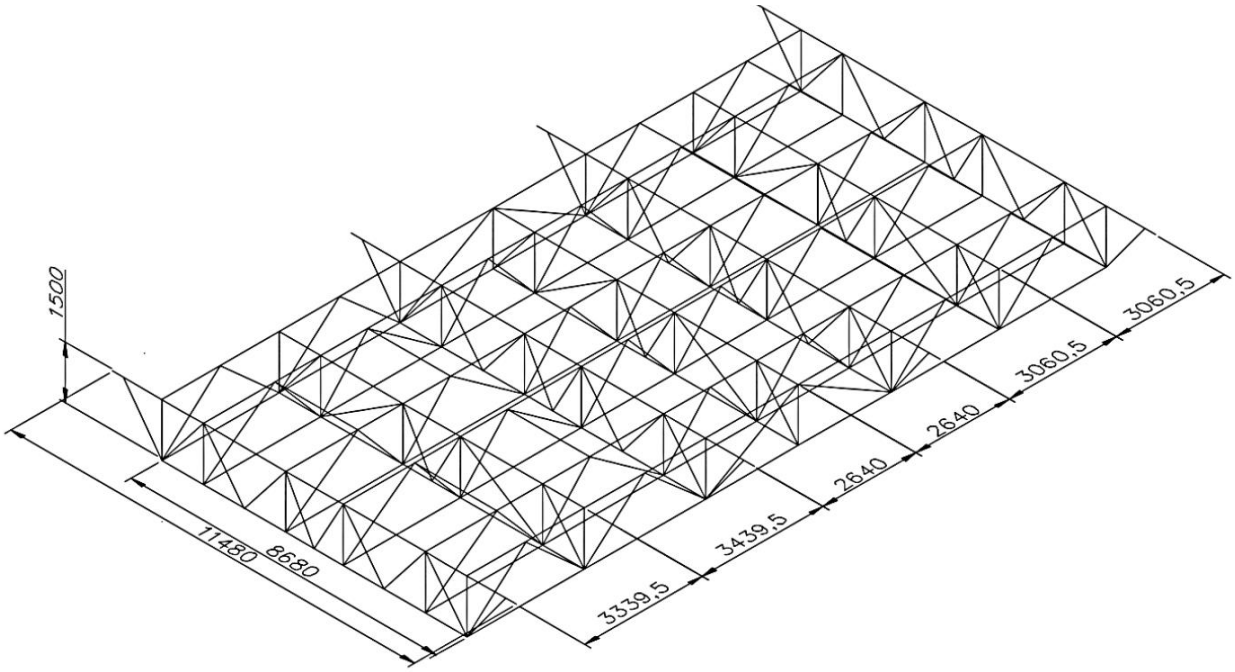

Figure 10. Technical report – wire frame model

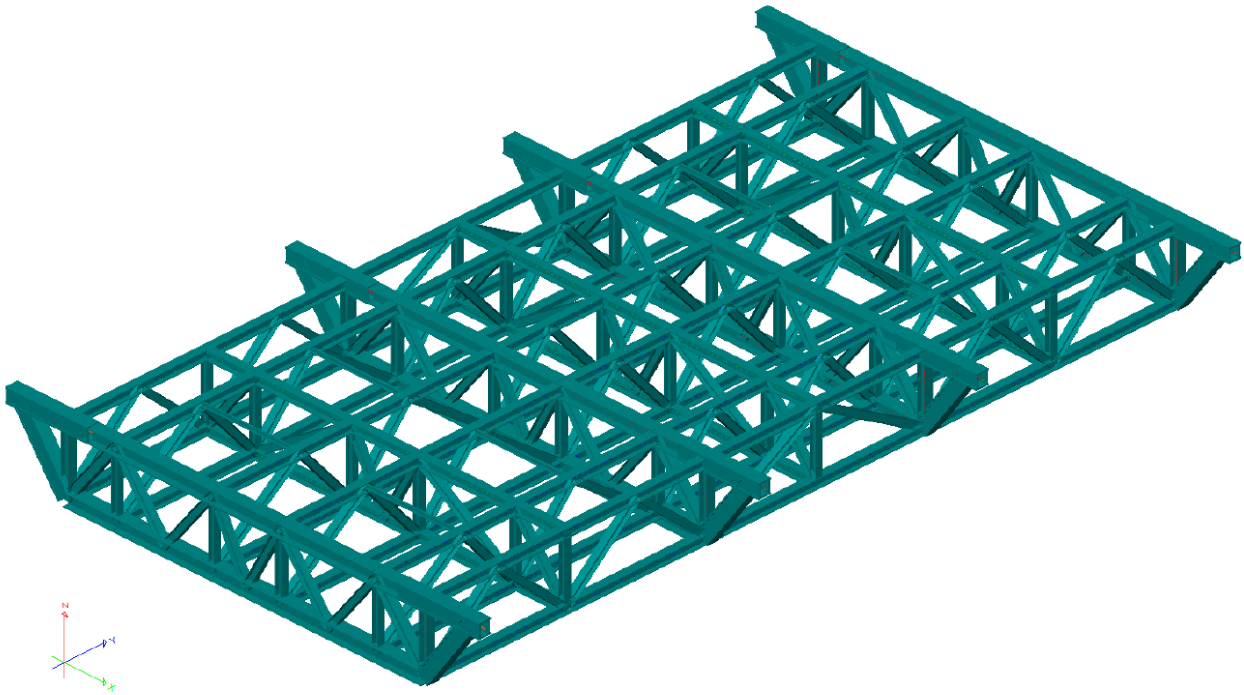

Figure 11. Technical report – beam orientation

Technical report also gives data regarding parts of the construction. For easier understanding this data is represented in section views. Each section view describes part of the welded construction and gives data for welding. Figures below describe one of these sections and gives welding details that will allow for bearing load to be lifted.

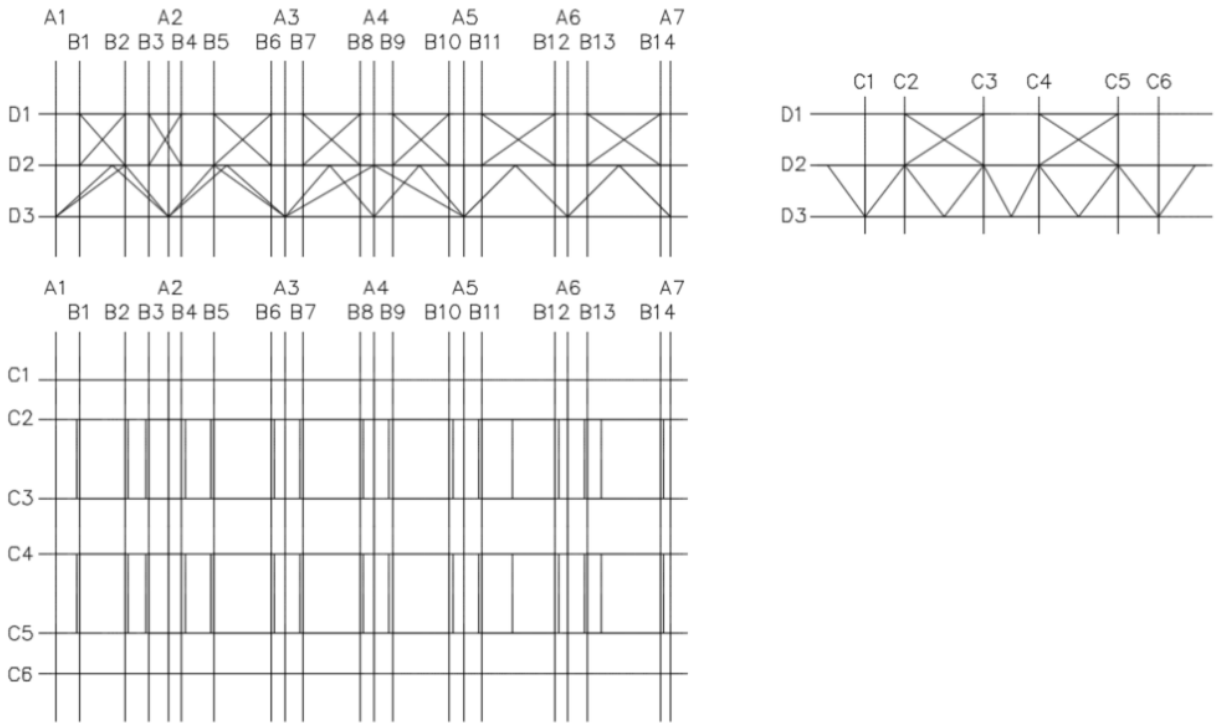

Figure 12. Technical report – sections positioning

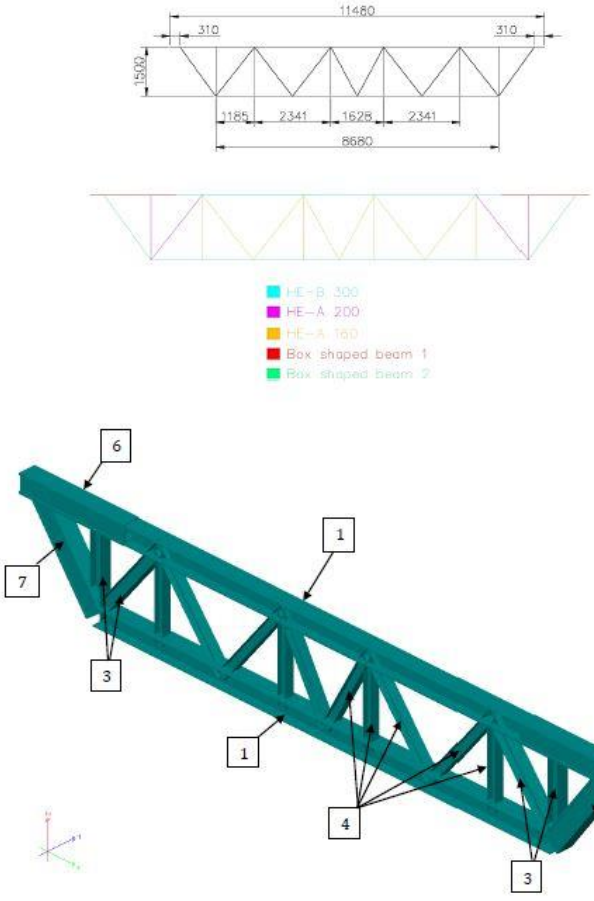

Figure 13. Technical report – section description

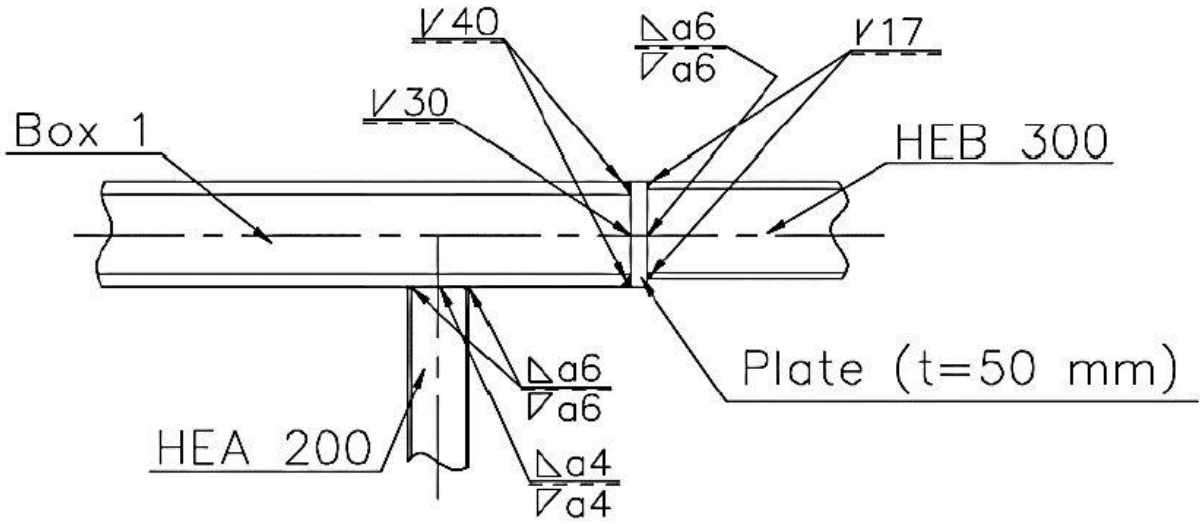

Figure 14. Technical report – welding details

3.3 Basic design – sketch

Before any sketching can be done, the design engineer has to determine one point that will be common for all participants in the design and which will represent fixed point of the model. All other participants have to obey this selected point in order to have a model that can be inserted in multiple working software platforms. After this point, main model reference geometry is determined. Axis, planes, points are inserted and marked to be clear of each reference usage in the model.

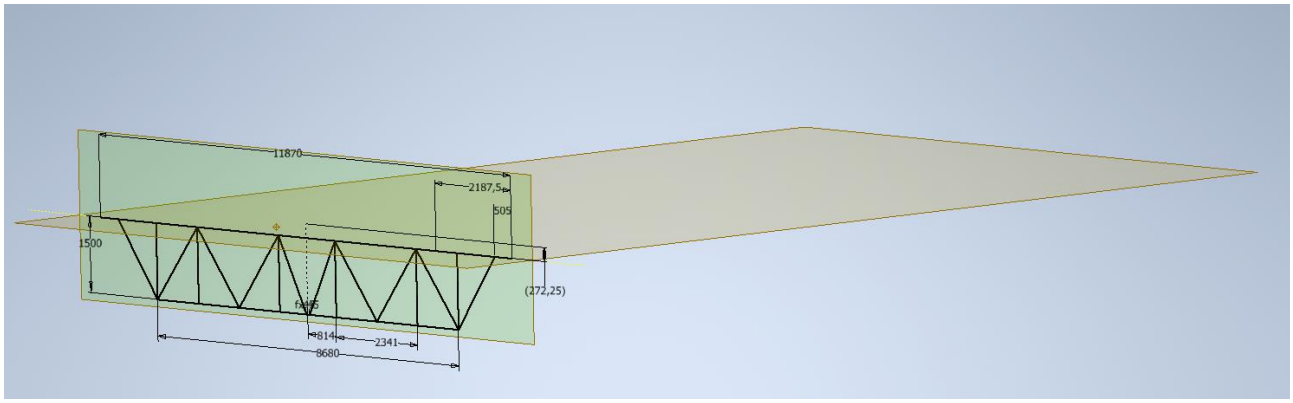

Figure 15. Basic design – sketch

Figure 15 displays two basic reference geometries – planes and fixed point. The text above and figure 13 displays section from technical report, and figure 15 is sketch from Inventor. Each section is processed, technical report is main guide line that is used in creating sketches. Final product looks like figure 16. All sections from technical report are processed in Inventor and are ready for the next step.

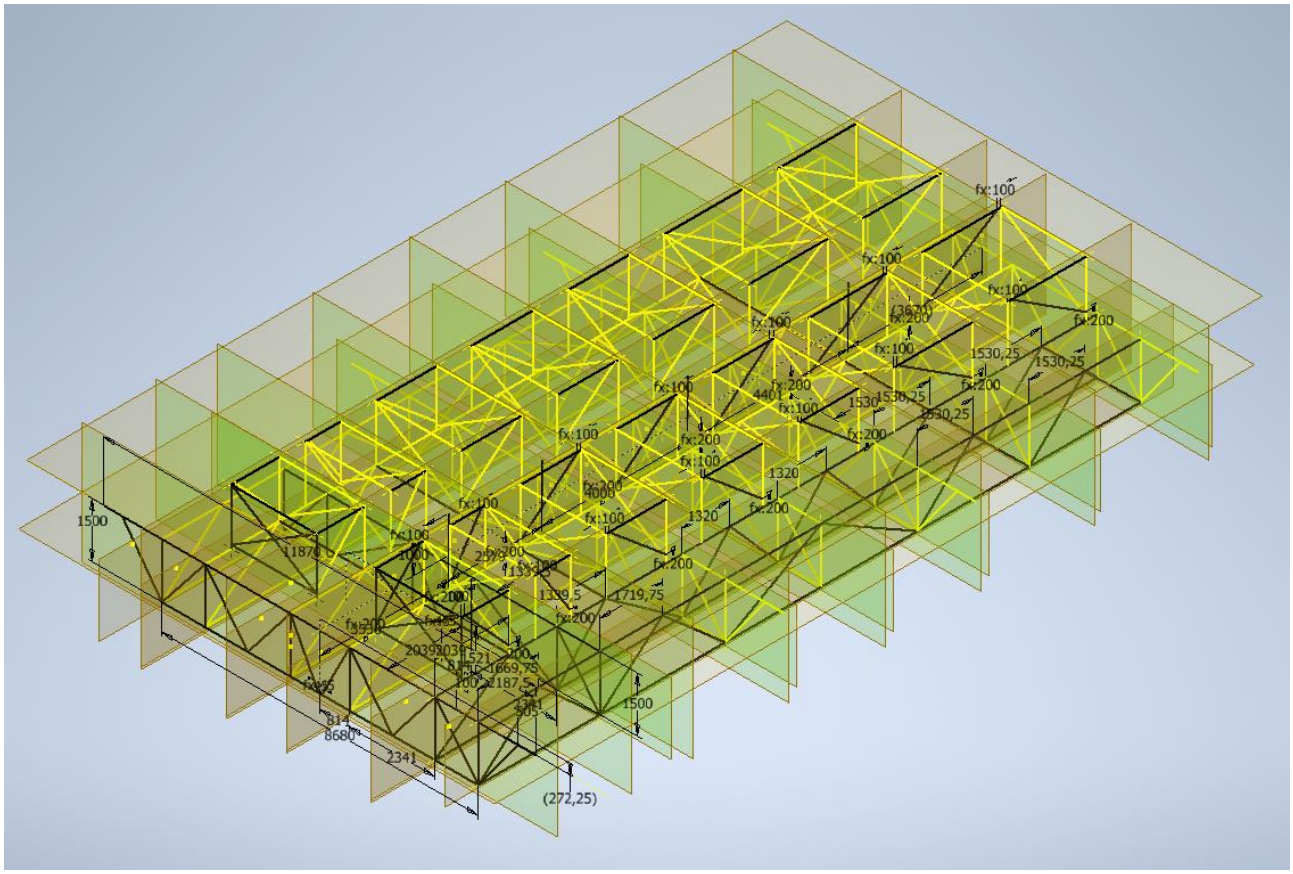

Figure 16. Basic design – sketches and reference geometry

Figure 16 displays numerous sketches and reference planes that are used for creation of wireframe sketch of the welded construction. Every single sketch uses reference geometry, points, axes in case that a change of design is required. If a change in design happens, change will reflect the whole model.

3.4 Basic design – frame generation

Autodesk Inventor uses module called Frame generation, which uses content center database to create beams. Sketch is used for geometry properties and content center to insert shape of the selected beam. If a change in the sketch design or geometry happens, frame generator will automatically update the frame and generated beams.

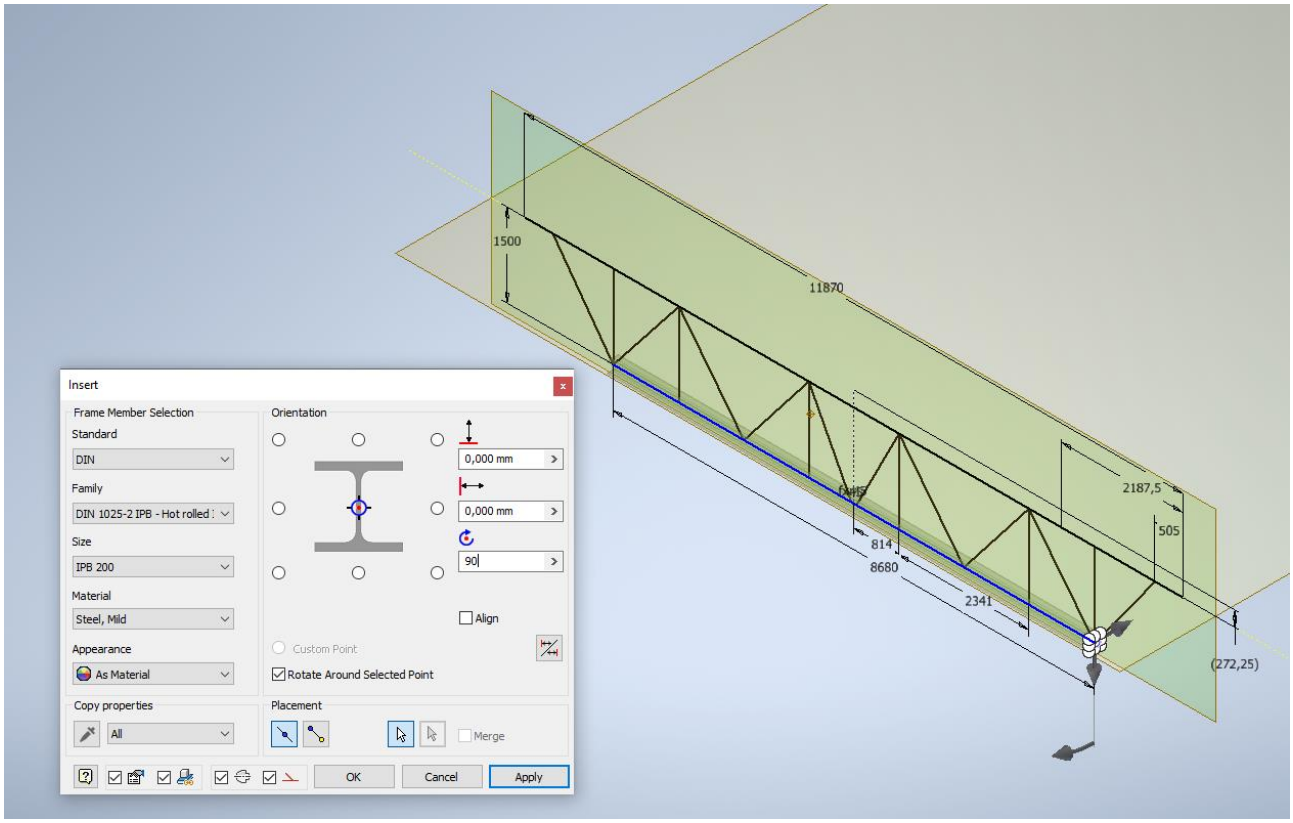

Figure 17. Autodesk Inventor – frame generation

Once the frames are inserted, frame generator has multiple tools that can shape inserted beams to allow for positions to be shaped. Shaped positions will be displayed later in 2D drawings for manufacturing. Frame generator adapts end of beams and inserted frame so manufacturing is possible.

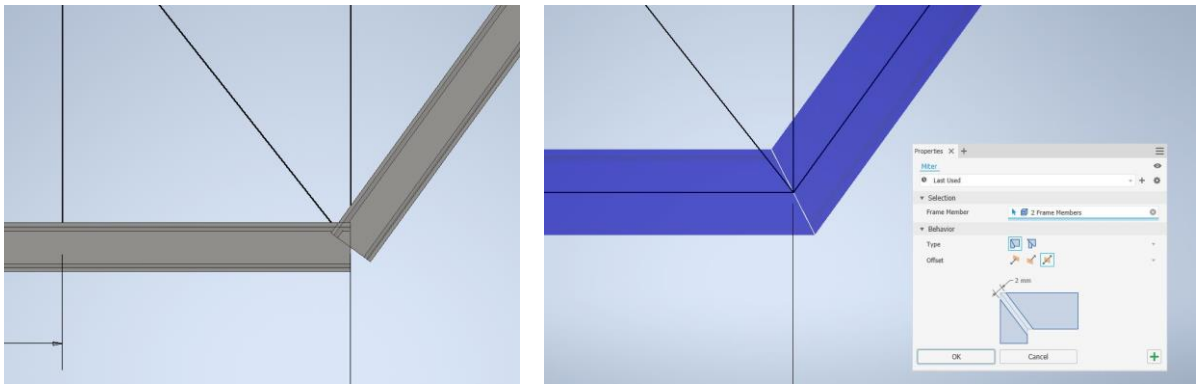

Figure 18. Frame generator – left image, two beams after insertion, right image – end of beams shaped to fit each other for welding

Frame generator has multiple tools that will allow end treatment of welded construction. Next figure will display what tools can be used for end shape treatment.

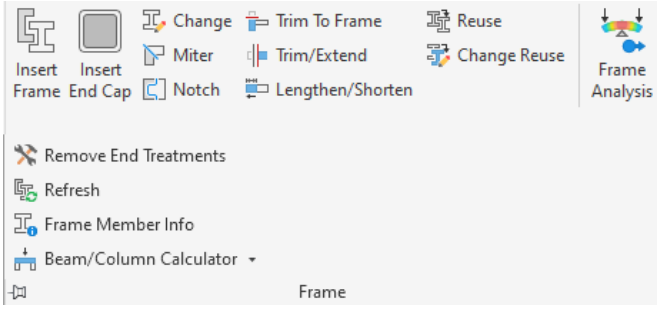

Figure 19. Frame generator – tools

After all sketches and frames have been inserted, with all ends treated, welded construction is ready to be examined and processed towards 2D documentation creation. Next figure will display finished welded construction.

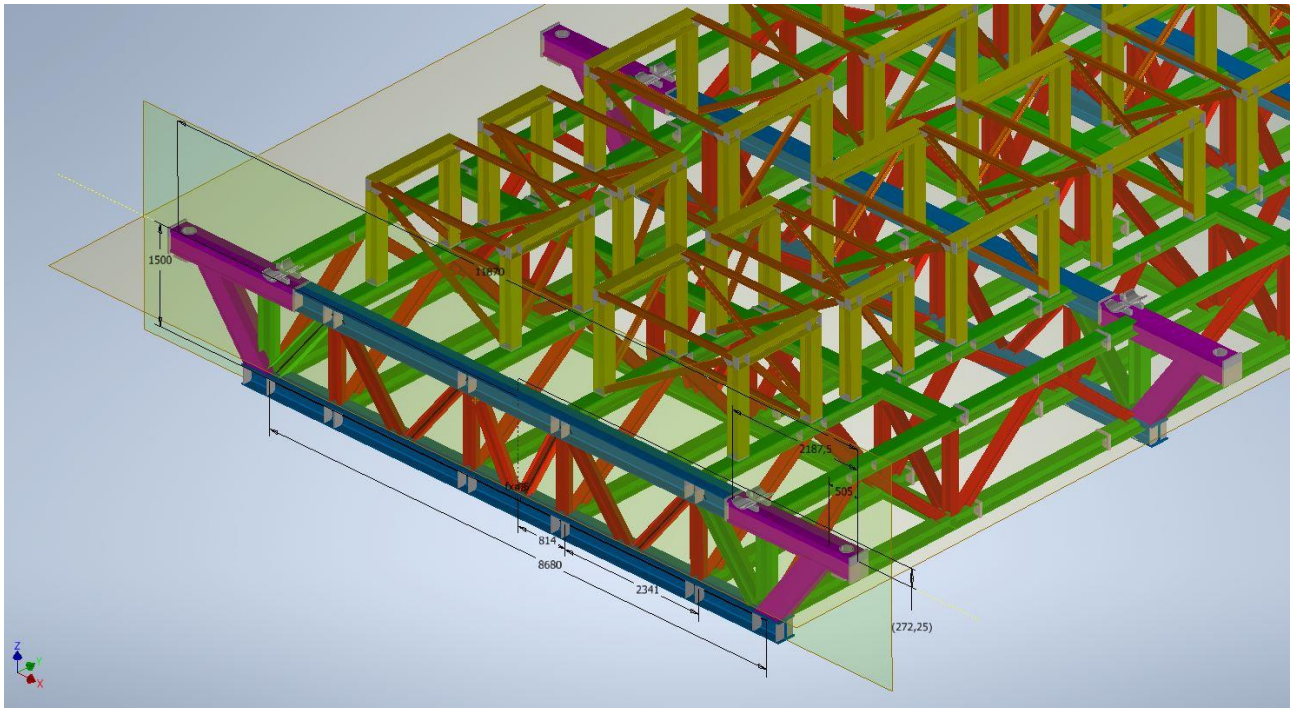

Figure 20. Finished welded construction with all elements inserted

Ass seen in the figure 20, different beams have been inserted in different colors, color coding, so that the design engineer can easily distinguish each beam type. Also frame generator has a function called frame member info that displays all data for the selected beam. Next figure will display such information.

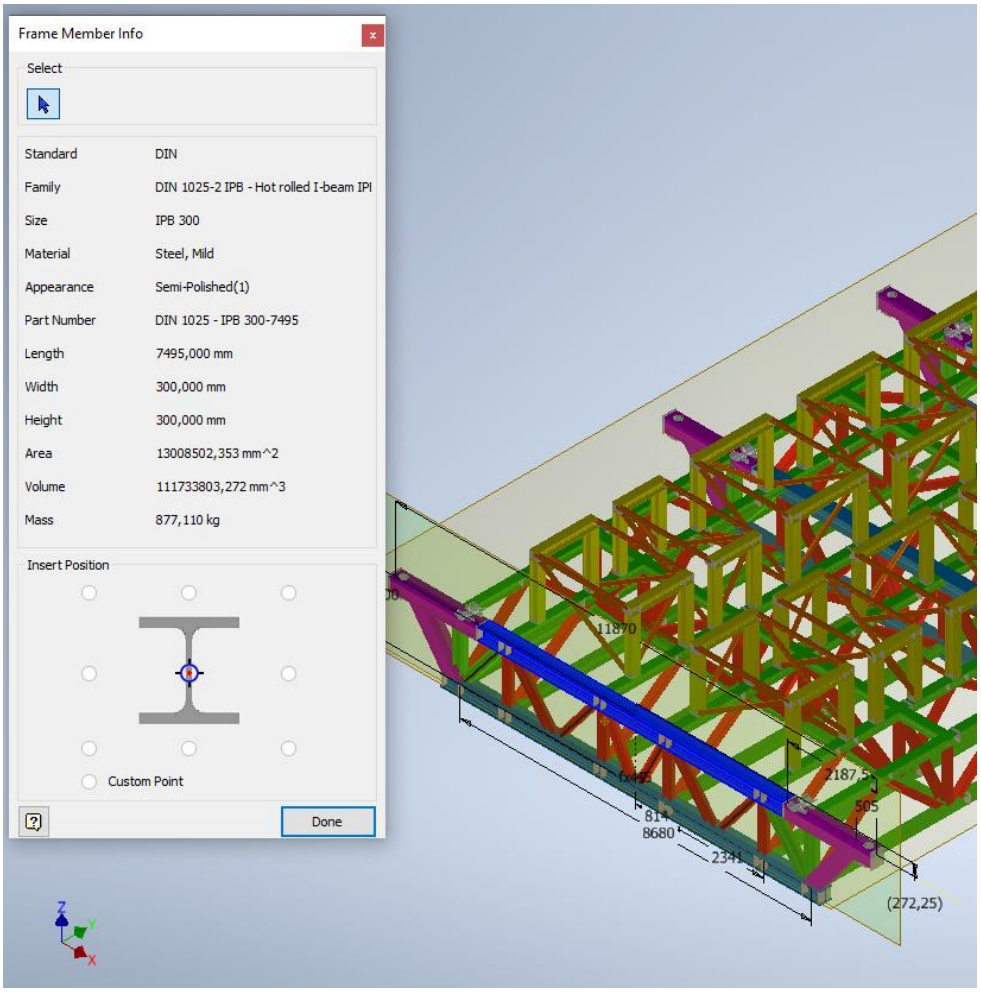

Figure 21. Frame generator – frame member info

3.5 Basic design – insertion of reference parts

Welded constructions in large amount of cases require from the design engineer to check between the welded construction and other reference parts to make sure that the welded construction will fulfill it’s purpose. For this to be accomplished Inventor has the ability to open large number of different file types.

Usually STP, STEP, SAT, IGS, IGES file types are used to transfer parts between platforms and to check models against each other.

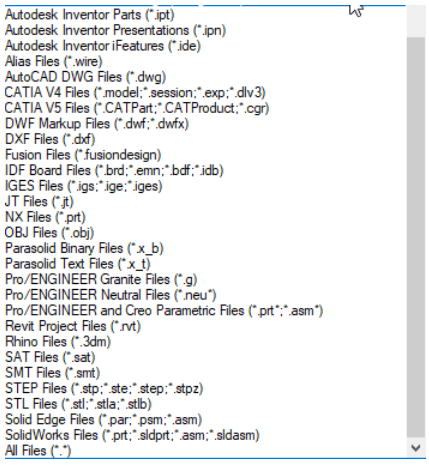

Figure 22. File types

Using STP transfer file, reference part has been inserted in to the model. When inserted properly, the design engineer can check both models, welded construction and reference part. Next figure displays inserted reference part to the model of the welded construction.

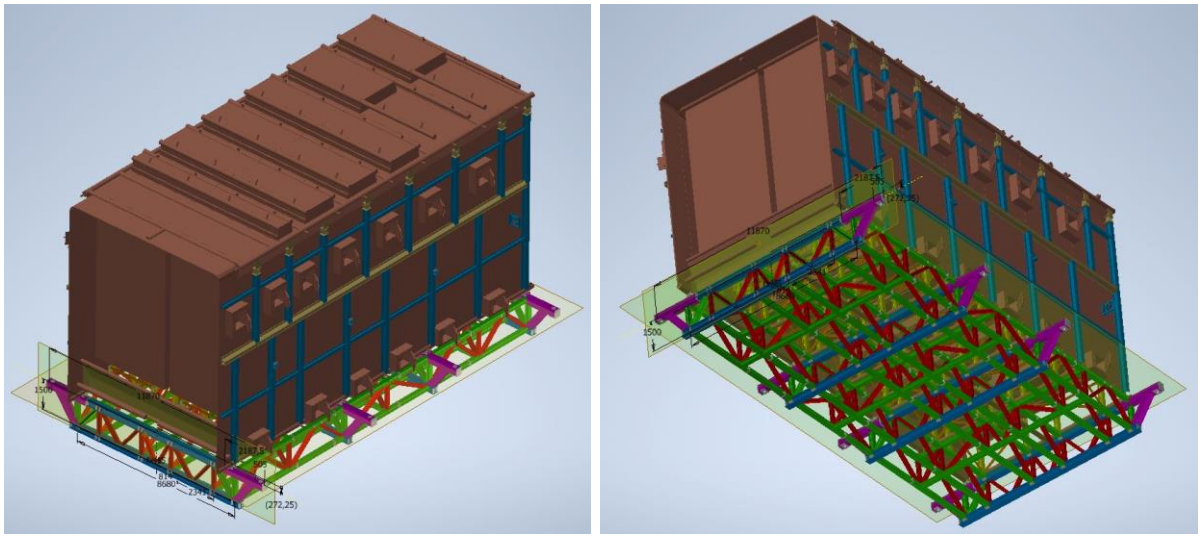

Figure 23. Inserted reference part in to 3D model of welded construction

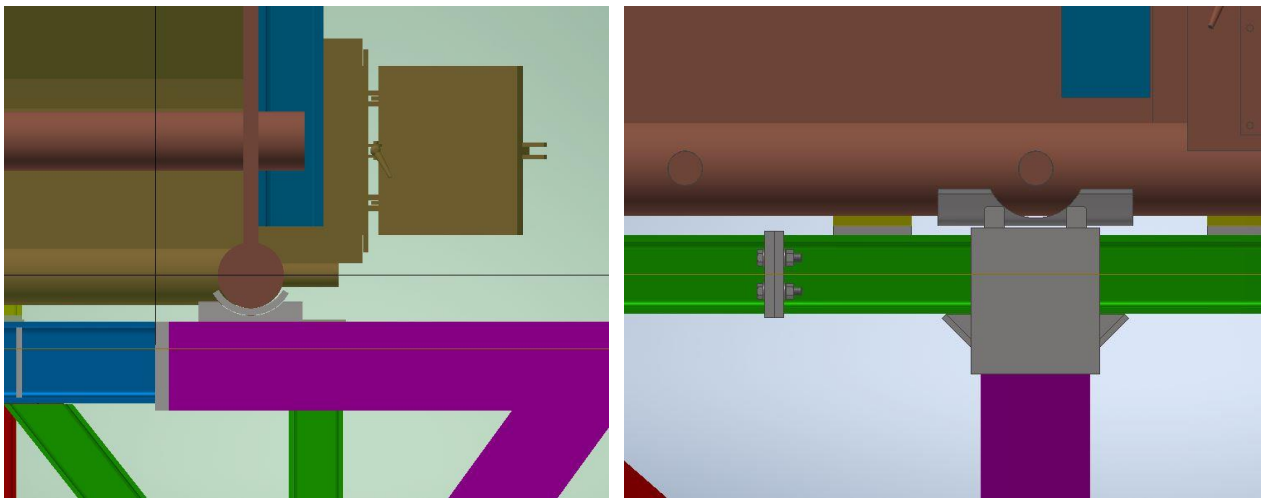

Figure 24. Checking of features against reference parts

Design engineer checks all items against reference parts and gives permit to start with 2D documentation creation.

4 2D DOCUMENTATION

Autodesk Inventor has the ability to create 2D documentation. All items and positions that are inserted in the model will be displayed as assembly sections and individual positions. Next figure displays section of one part of the welded construction and one item detail view.

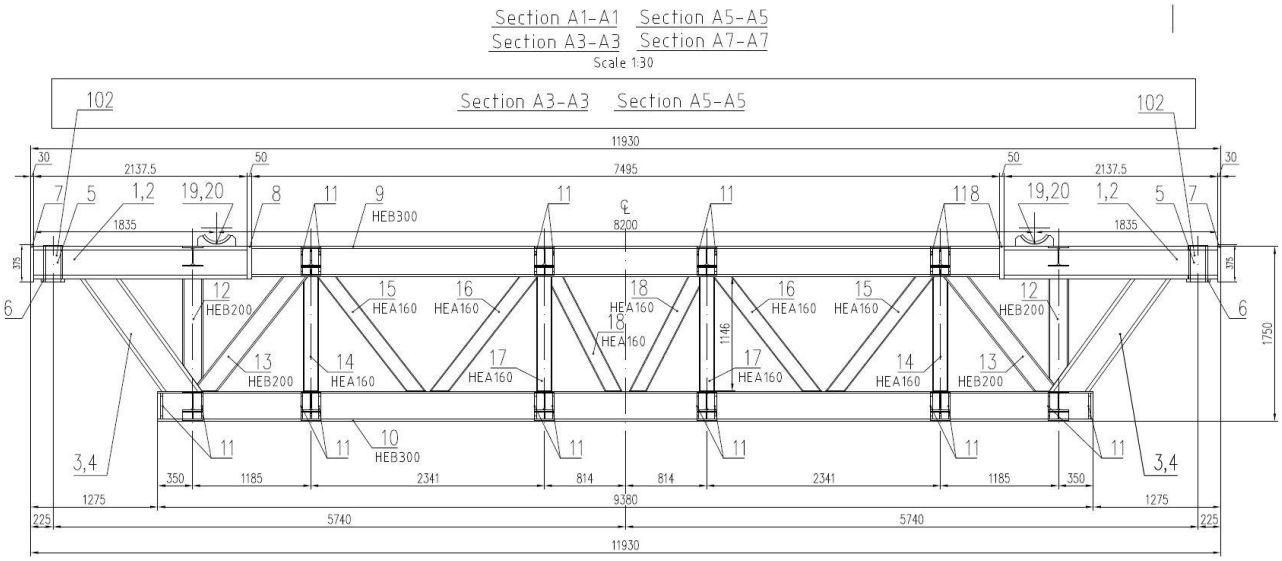

Figure 25. 2D documentation – section view

Figure 26. 2D documentation – detail item 1

After finishing 2D documentation which covers detail views of the welded construction, material tables and welding procedure along with quality control, manufacturing can begin.

5 MANUFACTORING AND SITE ASSEMBLY, MONTAGE

2D documentation and 3D model are supplied to the manufacturer. Beams, sheet plates and rest of the material can be processed to make items required for the finished product. Assembly and subassemblies are made with transport in mind. Regular transport means like trucks are mostly used, but sometimes special trailers have to be used to transport finished sub-assemblies.

Manufacturing produces all items, sub-assemblies and assemblies. After manufacturing, QA / QC has to examine produced parts and decide are they in tolerances or not.

Figure 27. Manufactured sub-assemblies

Figure 28. Section sub-assembly

Figure 27 and 28 display manufactured parts. Next figure will display 3D model of the same, for comparison.

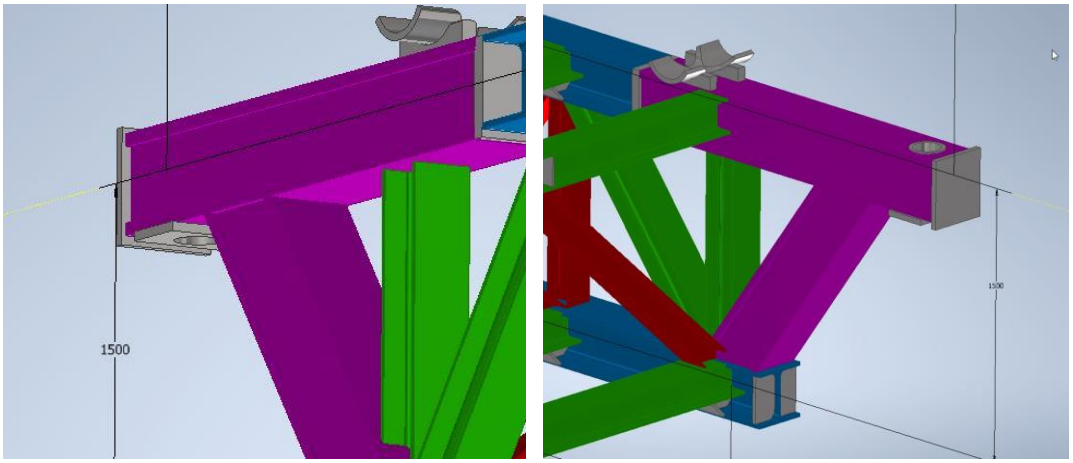

Figure 29. 3D model for comparison to the manufactured items

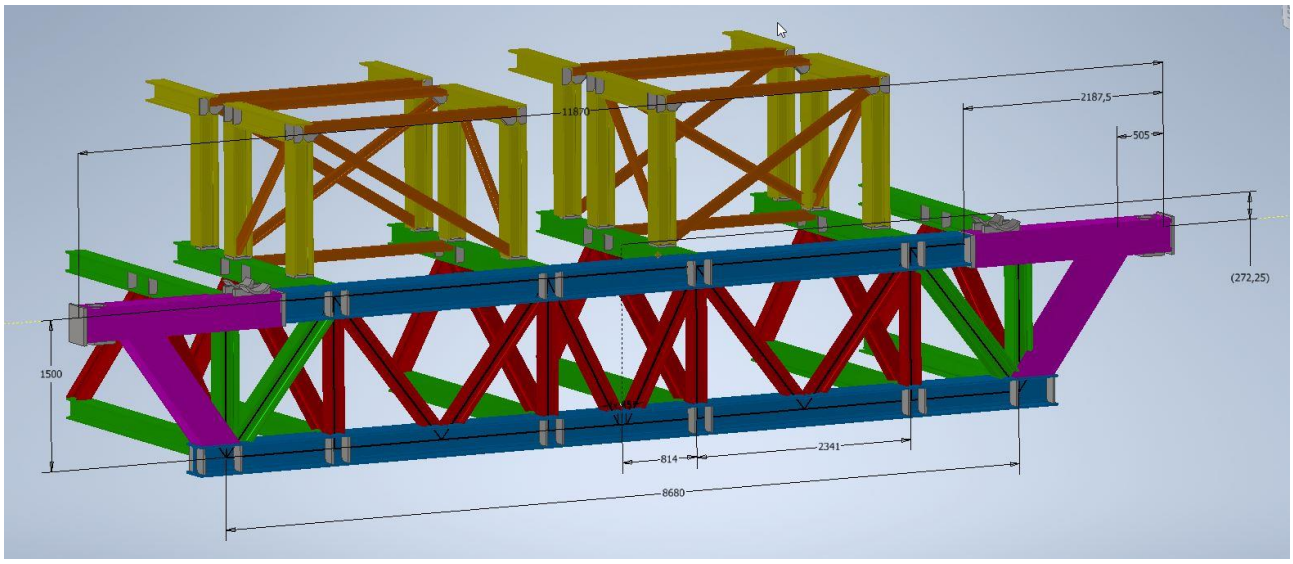

Figure 30. 3D model for comparison to the manufactured sub-assembly

3D model has helped design engineers to eliminate all potential problems, design issues, adaptation in manufacturing and assembly. This kind of construction making has saved time and material. Because of the large scale of this example construction, it had to be transported to montage site in 4 special transports and 2 normal size transports. Final assembly was done on the montage site.

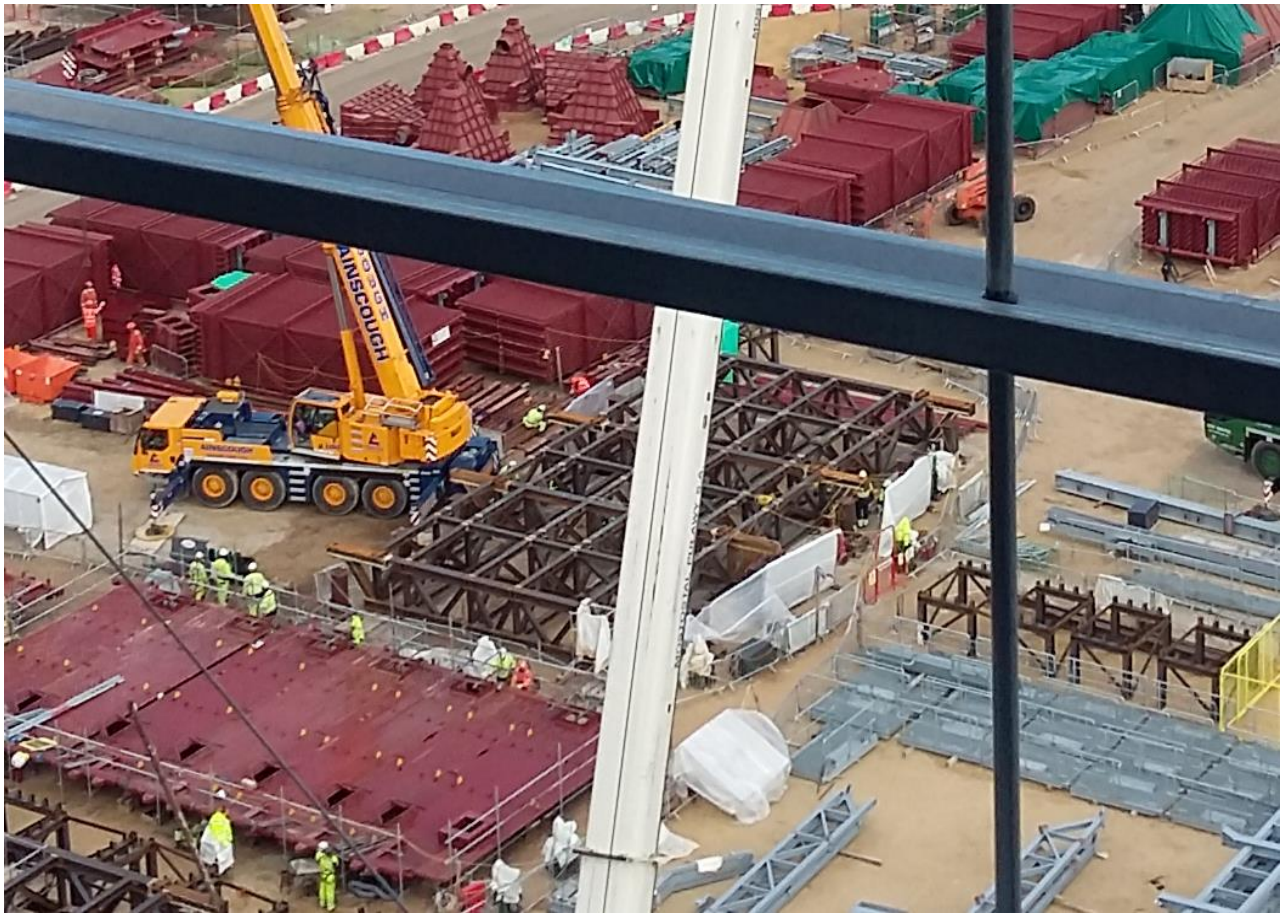

Figure 31. Final assembly - site

Figure 32. Final assembly – reference parts loaded to the welded construction

6 CONCLUSION

3D modeling of this welded construction along with technical report has significantly improved the way construction could have been done. Significant time was saved in the design phase and also in manufacturing and montage. All problems where solved in the design phase, so manufacturing, transport and montage where done with peak times and efficiently.

ACKNOWLEDGEMENT

Acknowledgment belongs to company ĐĐ Termoenergetska postrojenja d.o.o., Dr. M. Budaka 1, Slavonski Brod and to Mr. Plavotić Antun who approved the usage of 3D model, 2D documentation and pictures for the example of making a welded construction.

Also acknowledgment to College of Slavonski Brod (VUSB) in supporting this paper.

7 REFERENCES

[1] Autodesk Inventor 2020 – manual, technical support document Feb, 2019.

[2] EN 1025, Hot rolled products of non-alloy structural steels - Technical delivery conditions (Includes amendment A1:1993), European Committee for Standardization, 2004.