

## Enhanced design and modelling productivity with Parametric design

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**Key words:** Parametric design, Grasshopper, Productivity.

**Summary.** This paper focuses on the use of modern parametric design and modelling tools to accelerate the challenging and difficult large design projects. The methodology is also suitable in dealing with renovation and/or modification in the existing structures. Two project examples are presented here namely, construction of membrane façade to existing structure of football stadium Metz, France and renovation of the roof of main train station Dresden, Germany. The structures have deformations with the passage of time and the renovation is more complicated as compared to the theoretical form. Parametrization makes the tasks feasible with enhanced productivity, efficiency and accuracy.

## 1 INTRODUCTION

With the recent advancement of parametric tools, there is now much more space and potential to expedite and make the modelling, construction of drawings or generation of final model files to use them in workshop production. This way is not only efficient and fast but also reliable and accurate and can avoid the errors occurred during manual formulation of such items.

This paper emphasizes on to describe the workflow of parametric design, its practical application in real time projects and to remove the reluctance to adopt such tools which mostly comes to switch from conventional to modern techniques.

## 2 DESIGN WORKFLOW

The basic workflow starts from initial geometry which can be a model, a part or some sort of system line geometry. This is the input for further work. This input is imported in Rhino and based on the requirements, some small modifications can be done directly with rhino commands. After this, a parametric design tool from Rhino called Grasshopper, is invoked. This is a visual programming language tool. Its canvas provides a wide range of commands and further plugins to parameterize the model.

After running the grasshopper script, the data is send to Rhino and eventually back to the initiating software if needed for later usage. Figure 1 shows the workflow used in this paper.

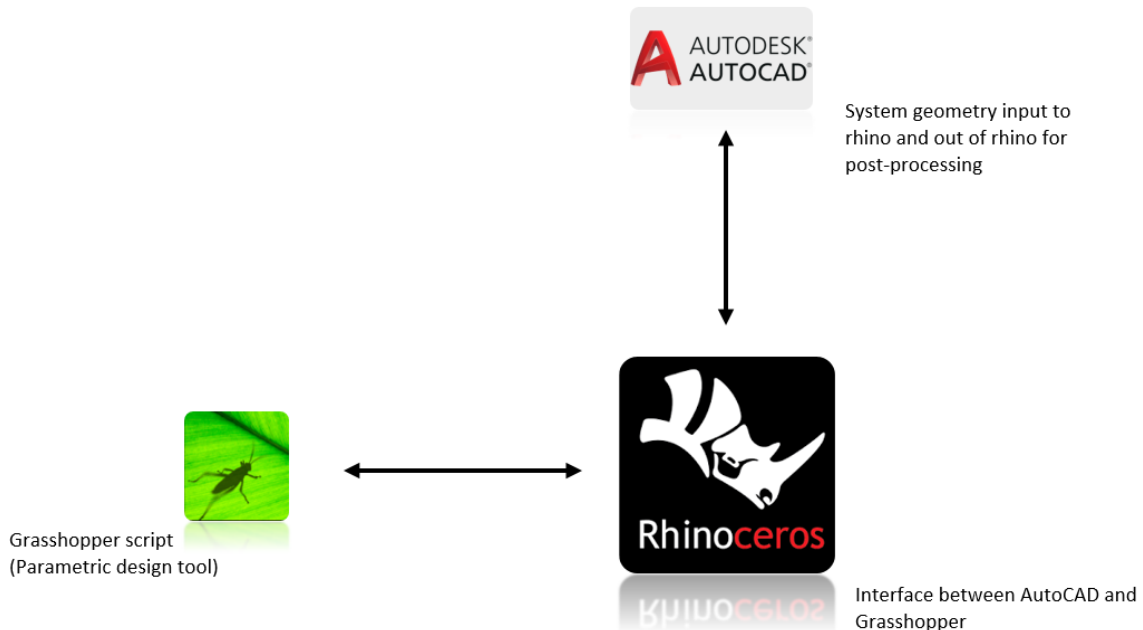


Figure 1: Parametric design workflow, input geometry is transferred to Rhino and subsequently processed in Grasshopper and the results are transferred back to AutoCAD

Two project examples are presented here to show the exact workflow and subsequent final results namely, construction of membrane façade to existing structure of football stadium Metz, France and renovation of the roof of main train station Dresden, Germany.

### 3 FOOTBALL STADIUM METZ, FRANCE

#### 3.1 Introduction

As a modification measure, membrane façade is proposed for football stadium Metz, France. The existing steel structure is made of pipes (Figure 2) and the proposed membrane covering is designed with a secondary steel structure which in turn is supported by the main existing steel structure (Figure 3). The conceptual view of the membrane façade is shown in Figure 4.



Figure 2: Membrane covering is proposed on west side existing steel structure (source: formTL)

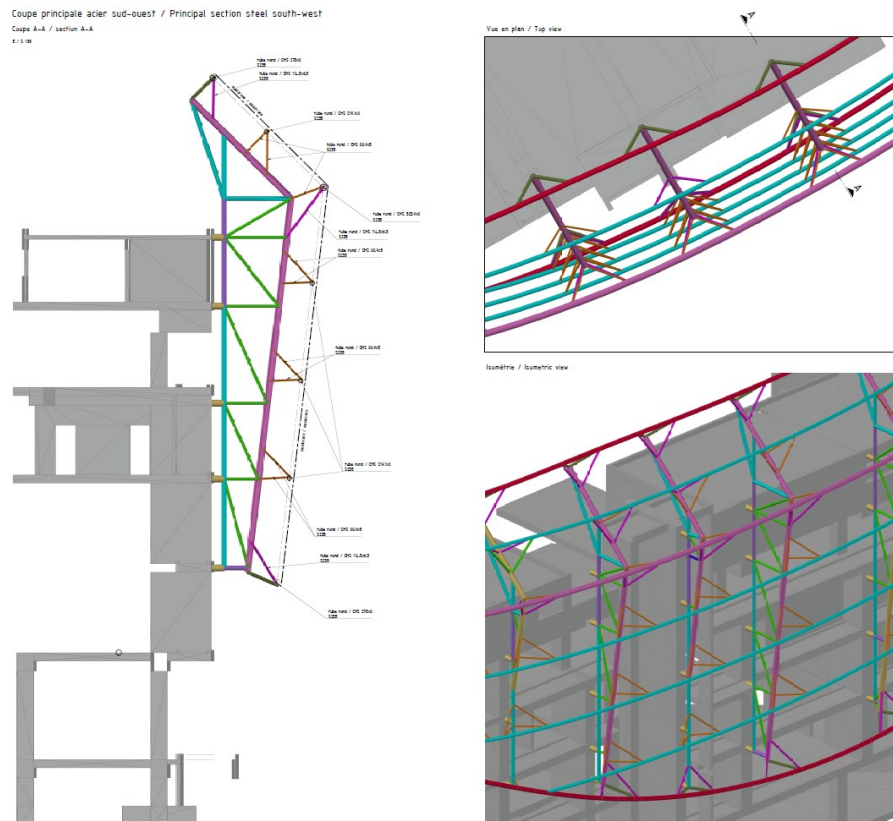


Figure 3: CAD model showing existing steel structure and secondary steel structure for the membrane covering (source: formTL)

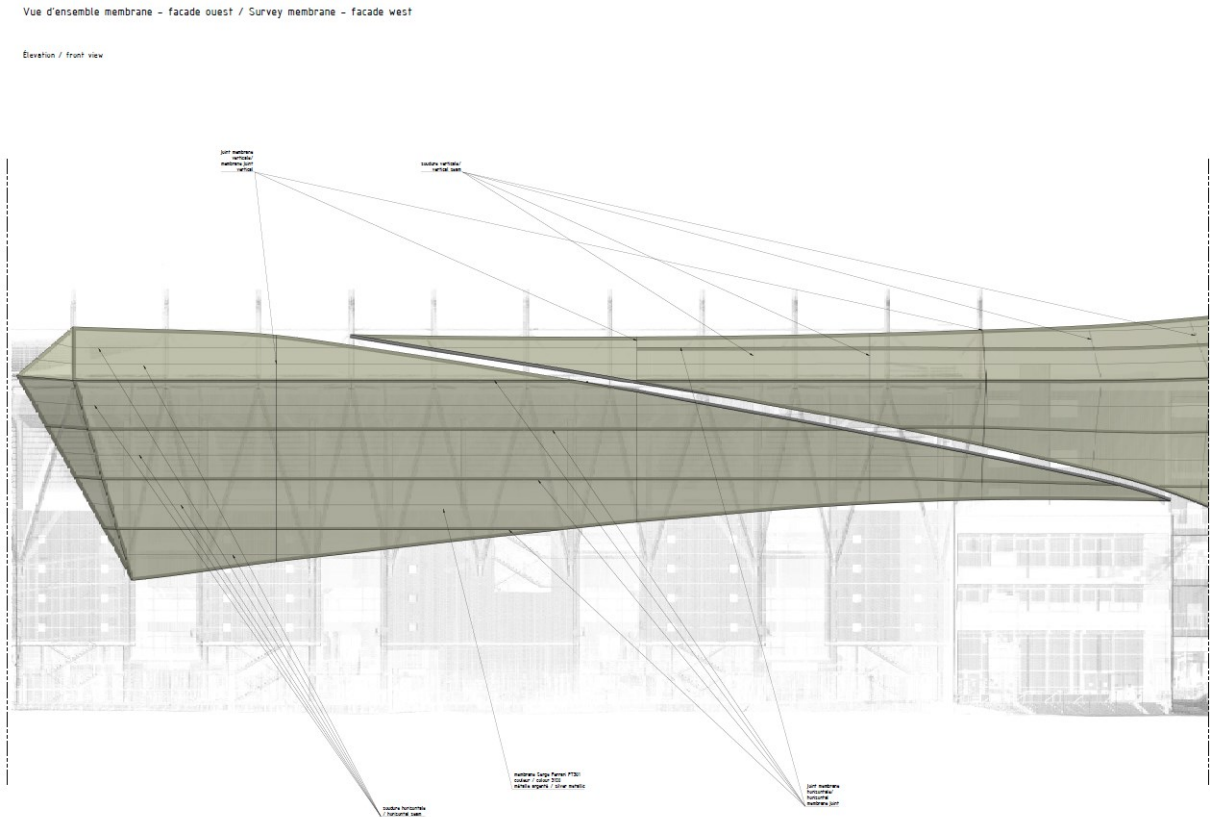


Figure 4: Membrane covering is proposed on existing steel structure (source: formTL)

### 3.2 Parametric system points generation

The secondary steel structure with connection on existing steel structure require definite system points. The system points should be made available in 3d CAD model and this will be given to the client. Due to the challenging and always different corresponding angle at which the secondary steel meets to primary steel, the manual generation of system points was quite cumbersome. Therefore, the parametric approach comes here to make that process efficient as well as accurate with relatively enhanced productivity.

Figure 5 shows a typical connection detail where two secondary steel struts are connecting together to transfer the forces to the primary steel. The marked system points are different for almost all the locations. Grasshopper script is used to parameterize the task.

The workflow is same as shown in Figure 1. The system lines of the structure are prepared in the AutoCAD and exported to Rhino. Here in Rhino, the grasshopper script is prepared to get the system points as small 3d spheres along with their respective layers. This involves finding the middle curve of the two secondary steel struts based on the half of the angle between them. This middle curve is then having intersection at two different pipe diameters

shown in Figure 5. After doing this for all the connections, the information in the form of points exported in *dwg* format to incorporate the data in complete model in AutoCAD. This model will shall be used with the client for their execution work.

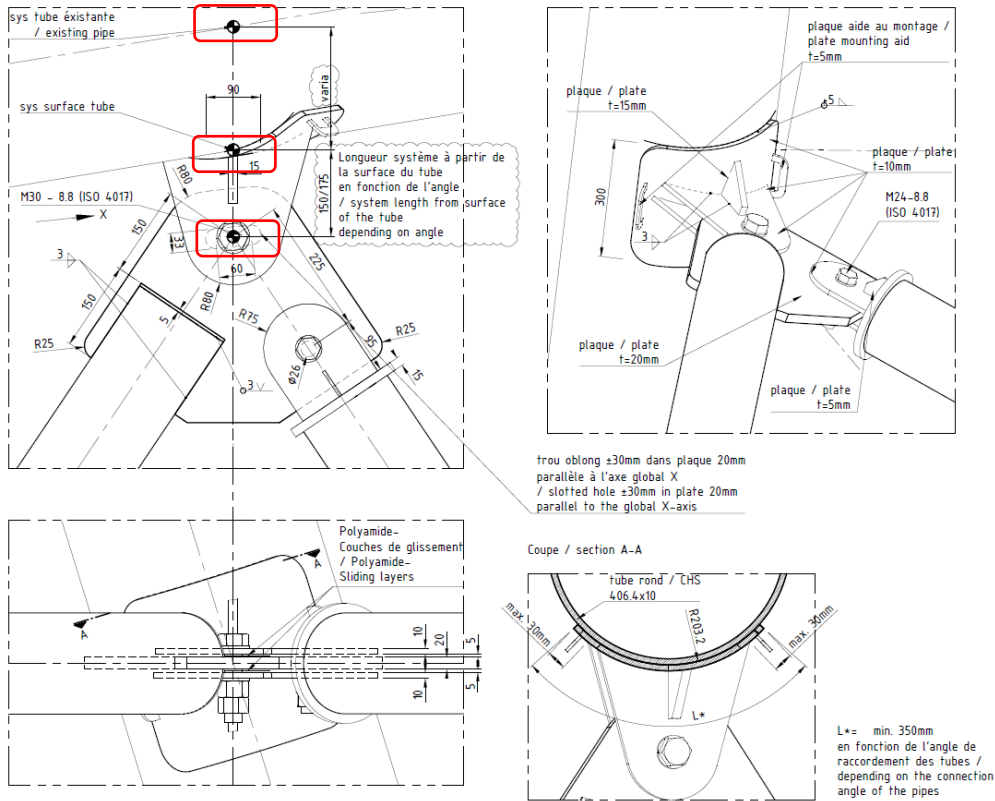


Figure 5: Typical connection detail showing the desired system points marked with red rectangles

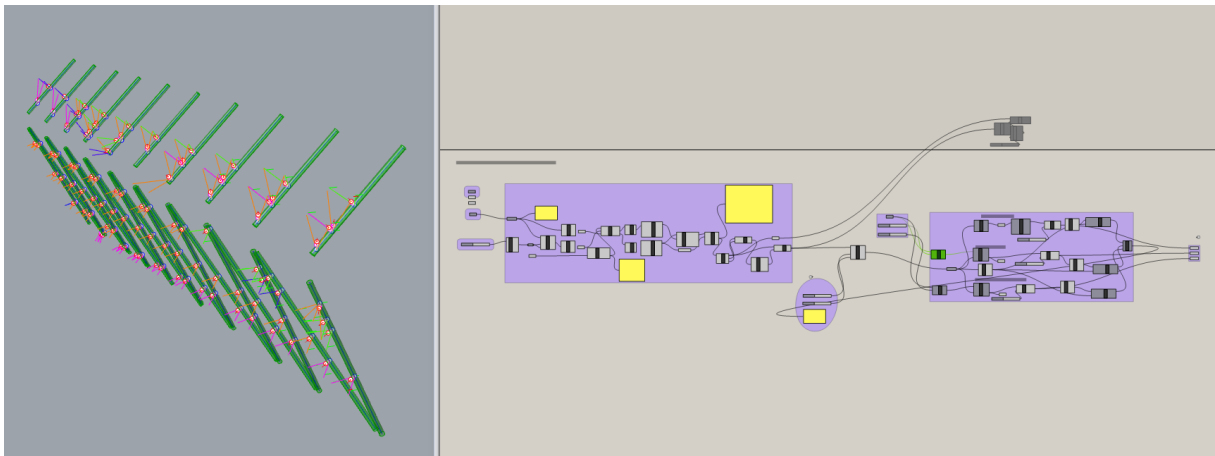


Figure 6: Grasshopper script(right) showing the preview of marked command green in Rhino (left)

A screenshot showing Rhino and Grasshopper script is depicted in Figure 6. The right

windows show the grasshopper script whereas left window shows the preview during grasshopper script execution.

## 4 MAIN TRAIN STATION DRESDEN, GERMANY

### 4.1 Introduction

The main train station Dresden is being covered with a new membrane. There were challenges as of the volume of the work as well as the existing structure is also deformed to some degree with the passage of time. Hence the existing structural form should be considered for the planning and design of membrane replacement.

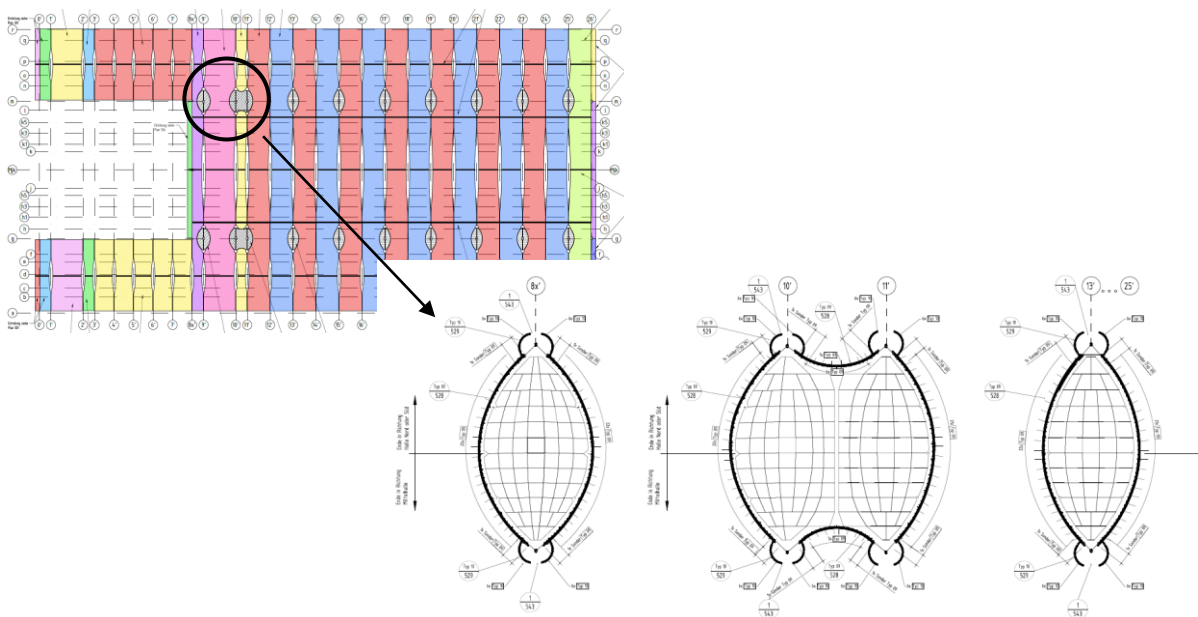


Figure 7: Dresden main train station roof plan view(left) showing the location of skylights (source: **if\_group & EHS**)

This makes the design process quite complex. Placing of the aluminium keder profile to work as a clamping part is of primary importance in membrane construction. Therefore, one area of its application is explained here along with the parametric approach to make the placing and workshop design efficient.

### 4.2 Placing of aluminium keder clamping profile in existing skylight

The plan view of the roof and the location of skylights are shown in Figure 7. Figure 8 shows the two small steel pipes along with the main steel pipe where the keder profile should be connected with straps to the small steel pipes. The as built 3d model of skylight was made available. The new design of the membrane is done and the new system membrane geometry boundary should be considered while placing the keder profile on existing structure. In order

to achieve this, Grasshopper script and Rhino commands are used and the workflow is similar as in Figure 1.

The system line of the existing steel pipe structure and the new membrane design are transferred from AutoCAD to Rhino. In Rhino, the membrane system line is divided approximately in the middle and then it is further divided in equal segments according to the system length of the keder profile.

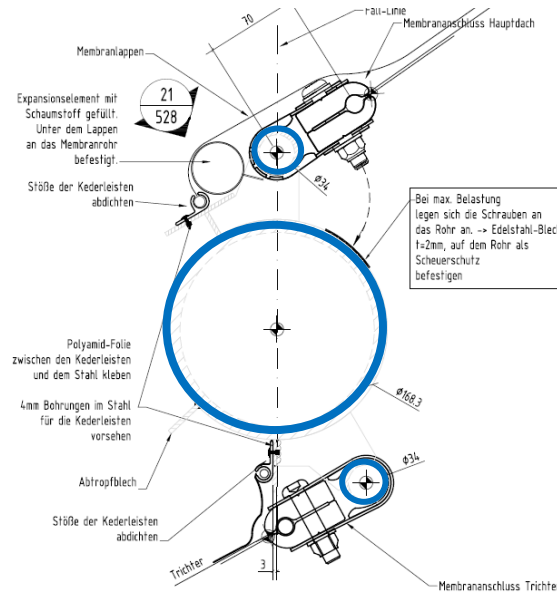


Figure 8: Excerpt from the keder clamp detail of skylight along with the existing steel structure which is shown in blue (source: if\_group & EHS)

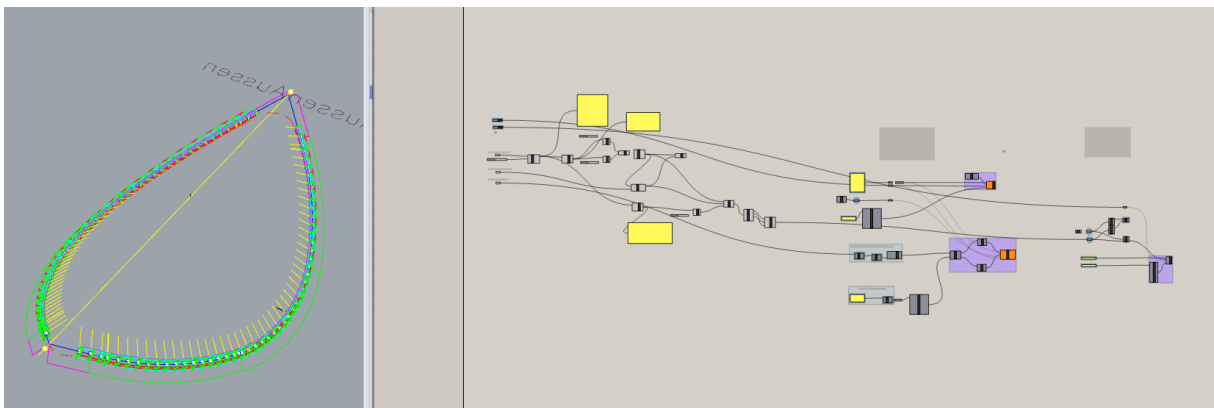


Figure 9: Grasshopper script(right) and the reference model in Rhino (left)

After having the basis prepared, the Grasshopper script is used (Figure 9). A dummy block consisting of 2 lines is placed considering that the existing structure and the design membrane



Figure 10: Principle of placing keder profile: steel pipe system line(cyan) and membrane system line(light green). A set of two lines(dark green) orient themselves with the end points on membrane divided segments and third point perpendicular on steel pipe system line.

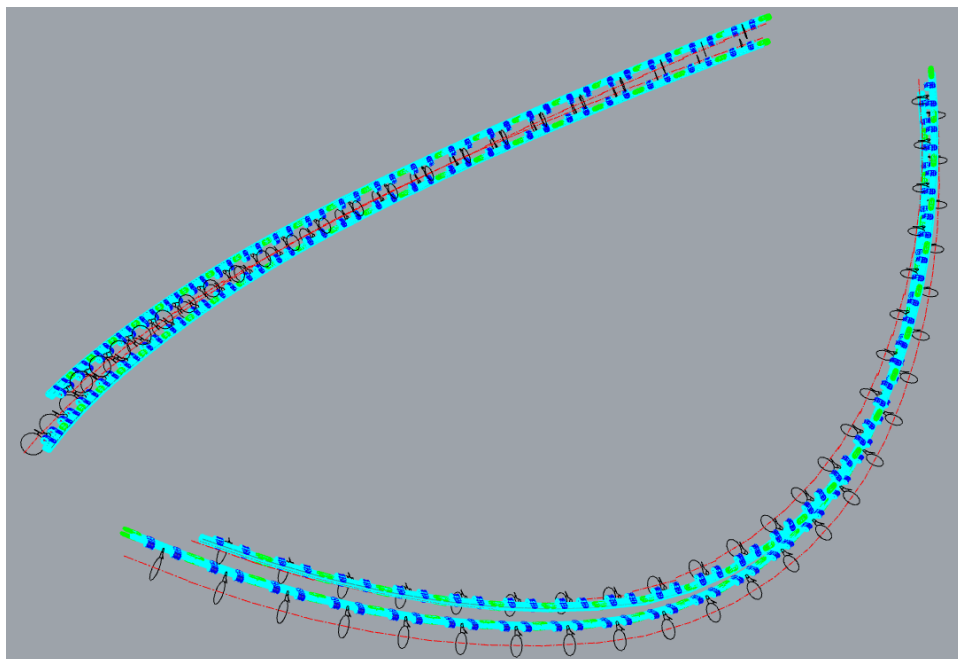


Figure 11: Result after exporting the data to AutoCAD (total 92 keder elements are placed in one skylight)

boundary meeting perpendicularly (Figure 10). In this way the complex as-built geometry is take into account to place the dummy block accurately in each small segment of the keder



profile. Later this is exported to AutoCAD and the replaced with original keder 3d profile in the complete model. In this way, the keder profiles are placed with accuracy and minimum effort. The final model after export is shown in Figure 11.

## 12 CONCLUSIONS

- The parametric approach in the field of construction is the right tool to deal with the large volume of work in an efficient and accurate way. Also, in the cases where there are repetitive tasks, same strategy would also serve the purpose.
- To elaborate it in detail, two examples of the membrane construction are presented. In both of them, it is quite clear that parametrization played an important in solving and handling the challenging problems without compromising accuracy and efficiency.

## CREDITS

### **Football stadium Metz, France:**

Client: FC Metz

Architect: F\*Fiebiger GmbH Architekten+Ingenieure, Kaiserslautern

Façade contractor: PFEIFER Seil- und Hebetchnik GmbH, Memmingen

Structural design façade: formTL ingenieure für tragwerk und leichtbau gmbh, Radolfzell

Membrane material: SergeFerrari FT 381

### **Main train station Dresden, Germany**

Client: DB Station&Service AG, Dresden

Main contractor: PFEIFER Seil- und Hebetchnik GmbH, Memmingen

Structural design: IF-Ingenieure für Flächentragwerke GmbH, Reichenau-Waldsiedlung and

EHS beratende Ingenieure für Bauwesen GmbH, Braunschweig

Workshop engineering: formTL ingenieure für tragwerk und leichtbau gmbh, Radolfzell

Membrane material: Verseidag GF 7000