

Digital Workflows

Seamless digital workflows in architecture

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The shift towards digital design and construction in architecture seems to be omnipresent and irreversible. The opportunities that come along with this digital evolution appear to be vast but still sub optimally used by different stakeholders within the realisation of architecture. This opens the opportunity to connect the data these specialists create in one single, digital seamless flow of data describing the complete lifecycle of a real estate project. It seems that architects could play a pivotal role in this shift. There may be a central role and as such the opportunity to add extra value in the creation of a streamlined digital workflow while touching a more fundamental issue, namely how architects can strengthen their position from which they can claim and protect their creativity and aesthetic concerns under the ever expanding growth of specialists within the AEC industry. In this article these thoughts are excavated and discussed by introducing some of the work of Studio RAP.

Key words: Digital workflow, architecture, AEC industry, digital fabrication, parametric design, 3d-printing

1 Introduction

Rapidly evolving digital technology brought endless new possibilities to the way we envision, design and construct the built environment in the last few decades. Many specialists within the AEC industry adopted digital tools to manage, organize and execute construction tasks. They digitized previously analog tasks which substantially improved workforce productivity and extended their technical capabilities to make the impossible possible. This opens the opportunity to connect the data these specialists create in one single, digital seamless flow of data describing the complete lifecycle of a real estate project. The promise of such digital workflow is to set project-specific objectives as early as the initializing stage and keep track of them during the design, engineering, construction,

maintenance, dismounting and remounting stage. This potentially enables a truly holistic approach to a circular life cycle of a building with a new set of contemporary aesthetics. In this article some thoughts are explored on how to come closer to this idea by introducing some of the work of Studio RAP.

2 The creation of data

Since the rise of digital computers, stakeholders within the AEC industry started to digitize the data they created. This started the transition from a purely analog building process to a semi-digital supply chain. Semi-digital, as most contemporary building processes can be framed as digitally scattered, where many specialists combine analog tasks with digital tasks for different clients with different needs, responsibilities and interests. Without a transcending idea about how digital data should be exchanged between stakeholders of a building process, the unique benefits of a completely digital workflow are not taken to an advantage. Most of the time there's no stakeholder within a contemporary building process that takes full responsibility on this matter for the complete life cycle of a building. The key in realising this is to follow a streamlined protocol on how to exchange purely digital data to communicate and execute project-specific objectives from the very beginning of a project till the very end of a project. In such a digital lifecycle everything that's digital needs to stay digital, from early project-specific objectives till the reuse of every building part.

The digital road from the initiative phase of a building project till the demounting and reconfiguration of building components still needs to be constructed and will be fairly complicated. To realise this still many different specialists are needed to fulfill all building regulatory and client-specific requirements. Tender laws in Europe make this scattered building process even more profound. This matter asks for a stakeholder that sets up a protocol for the digital workflow of a project, but for which stakeholder could this be an opportunity?

3 The digital caretaker

Most of the time there's no digital caretaker appointed during the building process as most clients are not familiar with the broad opportunities a complete digital process can deliver. These days most consultants are adopting digital tools, but there's one consultant that has

a historically close relationship with the initiator and the end user of a project which is connected to a project from an early development stage, the architect. As most architects are digital-native these days, it's obvious that streamlining this digital workflow could be an opportunity for this specialist. Also in the light of the eroded role of most architects which have lost much ground in recent years this can be fairly interesting. In the publication *Why Architects Matter*, Flora Samuel explains this diminishing role. Where project objectives related to costs and benefits took over the more subjective approach to the design of the built environment which includes matters like social, cultural, contextual and aesthetic considerations. This thinning role of architects doesn't stop at the profession itself but has long lasting effects on people's life, as they undergo the outcome of the architect's work every day.

The benefits of becoming such a digital caretaker can be twofold for the architect, they can play a crucial role in creating a streamlined digital workflow and reclaim a more central role in the building process. This last benefit touches even a more fundamental issue, because it gives architects the opportunity to strengthen their position from which they can claim and protect their creativity and aesthetic concerns.

In this perspective Studio RAP is explicitly aiming at reclaiming such a significant role for the architect in the designing and realisation process of the built environment. To show how such a central role in the designing and realisation in a building process could work, two case studies are discussed where the role of the architect went beyond their traditional responsibilities. These two case studies are the Main Concert Hall of Theatre Zuidplein (Rotterdam, NL) and Poortmeesters | New Delft Blue (Delft, NL).

4 Main Concert Hall of Theatre Zuidplein

4.1 Introduction

The main concert hall is part of the interior of Theatre Zuidplein built on the South bank of Rotterdam (NL) and was delivered in May 2020 (Fig. 1 and 2). The acoustic walls which in one fluid movement embrace the audience and the artist were designed and realised using a complete digital workflow. The project was designed with the use of algorithms, which resulted in a rippling ocean of thousands of triangles, creating the perfect acoustics possible for this venue. Studio RAP functioned in this project as a digital

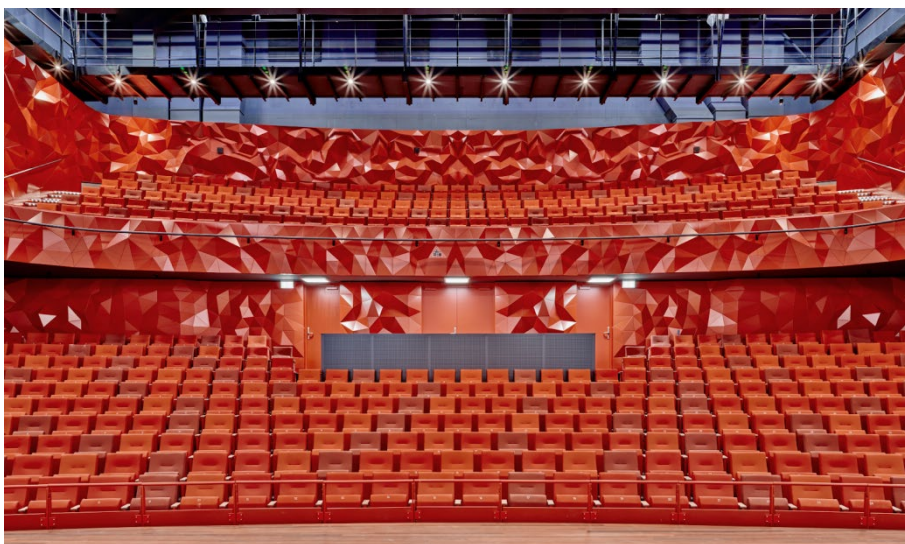


Figure 1. View from the podium, main concert hall Theatre Zuidplein, ©Studio RAP

caretaker and initiated a team of (digital) specialists, set up the protocol for exchanging digital data, digitally designed the acoustic walls, generated digital production data and ensured a digital database with the realised building parts for future maintenance and reuse. Creating this streamlined flow of digital data gave the opportunity to claim a certain artistic freedom to realise an eye-catching design. Like a beautifully stylized cliff face, the acoustic walls enclose the main auditorium with 600 seats of the new theater. It's an enormous aluminum-composite puzzle, consisting of 6.000 uniquely shaped triangles.

4.2 The client

The City of Rotterdam commissioned Studio RAP to design and realise the interior of the main theatre hall within a tight budget and tight schedule. Because the original tender phase did not give a solution that could be realised within time and budget the client was looking for a different approach. For that reason the municipality came across the Rotterdam-based architecture firm that is pioneering the integration of digital techniques in the construction process, aiming to realise projects with a complete digital workflow. With this innovative approach, by digitizing the wall design from start to finish with self-developed algorithms, the project was realized within budget and planning.



Figure 2. Flat areas of triangles and areas of triangles that form a folded surface, main concert hall Theatre Zuidplein, ©Studio RAP

4.3 *Digital workflow*

All the phases of this project have been realized fully digitally and parametrically, from design to realization (Fig. 3, 4, 5 and 6). As the theatre was almost built the project could start from a digital point cloud. Through the algorithmic design of Studio RAP, engineering firm Arup made its acoustic and structural calculations and RAP generated only digital production data for the contractor Aldowa. The advantage of this method is that everything remains digital and therefore variable till the production and execution phase. This opened up the possibility to make changes without any problems until late in the realisation process. In this way, different design scenarios can easily be tested for planning, technical and financial feasibility. Studio RAP functioned as the digital caretaker in this project ensuring the right digital data was created, used and exchanged.

4.4 *The perfect sound*

Together with Arup over 10.000 virtual theatre hall variants were simulated. The hall was, as it were, digitally kneaded after which the best variant was chosen. Using advanced software, calculations were made to measure the effect of a certain curvature in the design on the reflection of the sound of a speaker or musician on the stage. Afterwards this main

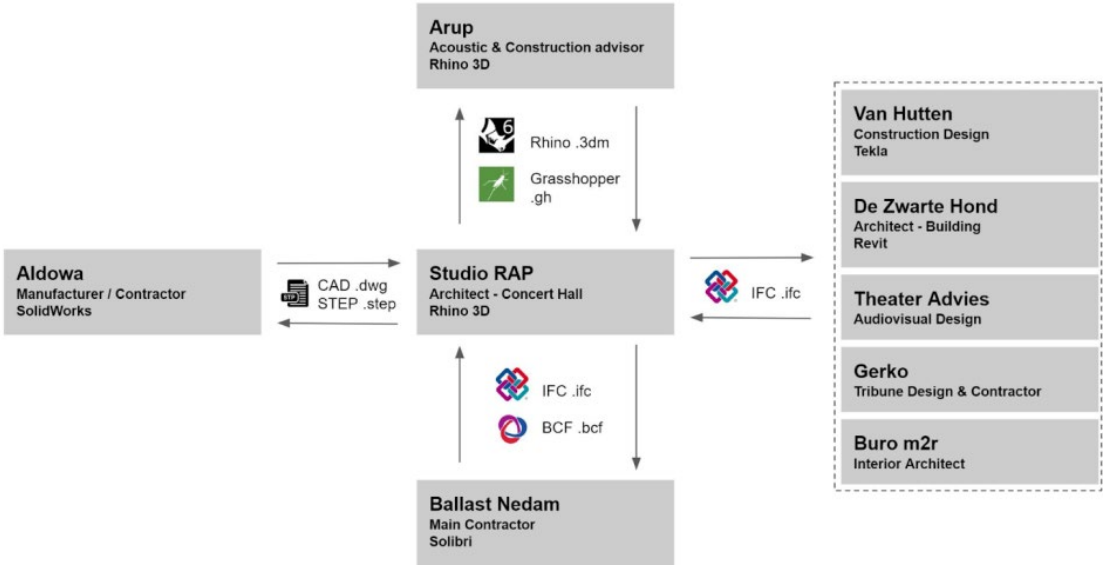


Figure 3. Stakeholders as part of the realisation process of the main concert hall of theatre Zuidplein, ©Studio RAP

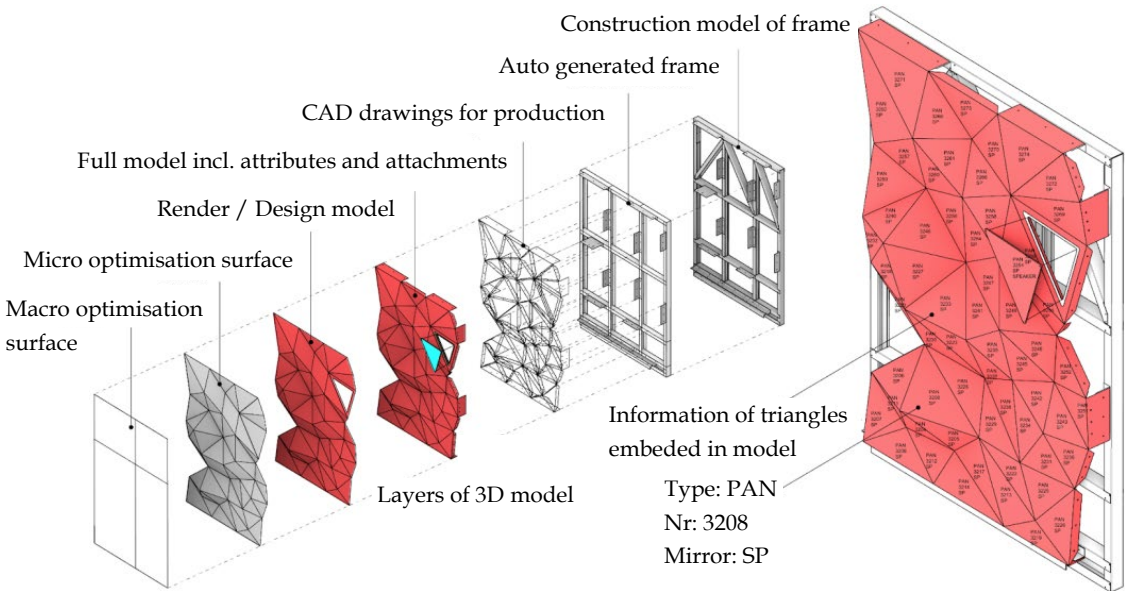


Figure 4. The parametric model explained of the main concert hall of theatre Zuidplein, ©Studio RAP

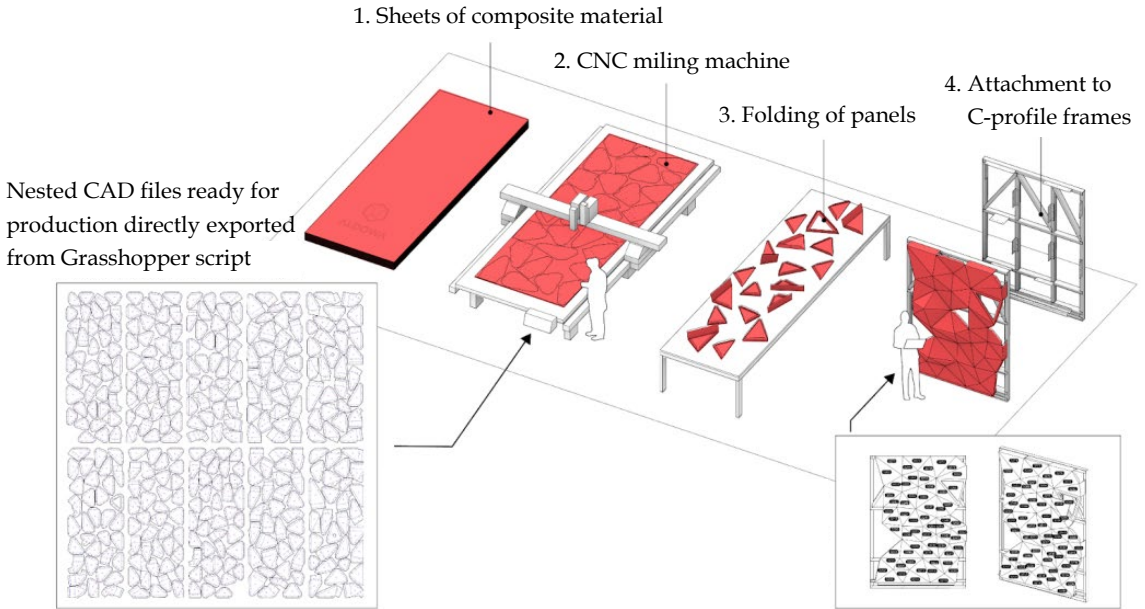


Figure 5. Overview of the production process and the production data visualised for the production of the 6.000 unique triangles of the main concert hall of theatre Zuidplein, ©Studio RAP

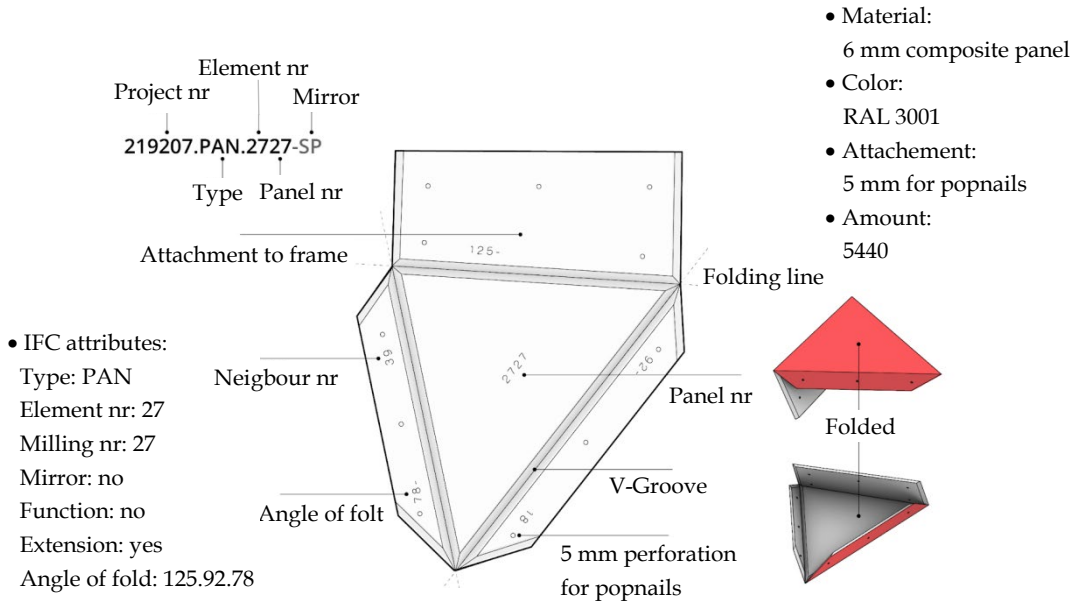


Figure 6. The digital data that comes along with every triangle of the main concert hall of theatre Zuidplein, ©Studio RAP

shape is translated into smaller triangles which in turn are adjusted. Where so-called ‘pure reflections’ are desired, the area of triangles is flat. Where diffuse reflections are desired, the area of triangles form a folded surface. The result is an even distribution of sound across the entire auditorium, so that every member of the audience can fully enjoy the show or concert they came to see.

4.5 *Warm & dynamic play of colors*

The walls do not just affect the auditorium’s soundscape: they also break the light in countless color tones inside the theater to create a warm and dynamic play of colors. Because each triangle is unique and folded at a unique angle, the light is refracted in different shades of red.

5 **Poortmeesters | New Delft Blue**

5.1 *Introduction*

Another project where Studio RAP played a central role within the realisation is Poortmeesters | New Delft Blue, a pioneering project in the historic Dutch city Delft (Fig. 7 and 8). Also for this project Studio RAP executed tasks that go beyond the traditional architects’ consultancy, as they were also responsible for the contracting and 3d-printing of this unique project. This project reinterprets the world-famous decorative qualities and design vocabulary of Delft Blue porcelain. By fusing 3D clay printing, computational



Figure 7. Artist impression of the project Poortmeesters with the New Delft Blue gates designed by Studio RAP, ©Studio RAP + Beeldenfabriek

design, and artisanal glazing, New Delft Blue hopes to unfold a new architectural potential of ceramic ornamentation of the 21st century.

5.2 *Design vocabulary*

The lush communal courtyard of the Poortmeesters building block, which is part of the large-scale redevelopment Nieuw Delft, is framed by two large entry gates. These refer to Delft as a medieval trading city with its many city gates and provide passers-by with a glimpse of the idyllic life going on inside. The New Delft Blue gates take their inspiration from traditional Delft Blue porcelain plates. The design vocabulary of these plates has changed radically over the centuries from copying Chinese and Japanese Oriental designs to making contemporary Dutch designs. The differentiation between a decorative, abstracted frame and picturesque scene, however, has been a recurring trait. As such, this division is the starting point for the New Delft Blue design, where the scene is the ever-changing courtyard life while the gates stand as a three-dimensional frame that focuses the view.



Figure 8. Artist impression of the project Poortmeesters with the New Delft Blue gates designed by Studio RAP, ©Studio RAP + Beeldenfabriek

5.3 *New Delft Blue*

The gates, four meters wide, eight meters high and twelve meters deep, cover a large public staircase. The ceramic cladding is designed to balance the two functions of the gates: indicating a separation between public space and communal space, while also guiding one's attention to the courtyard. The deep blue color reflects the connection to Delft Blue porcelain and the surrounding canals, and it provides a pleasing contrast to the earth-toned brickwork of the building. A serpentine line in the ornamental pattern guides viewers' eyes past the straight lines of the staircase and the gate toward the welcoming scene at its center.



Figure 9. A series of 3d-printed tiles for the New Delft Blue gates using a robotic arm the workshop at Studio RAP, ©Studio RAP

The approximately 3.000 tiles that will eventually cover the two gates are being 3D printed, allowing for the creation of contemporary ceramics that are both rich and unique. Using an algorithmic approach to 3D pattern design, certain manufacturing constraints— maximum overhang, width, height and depth, shrinkage constraints, and internal support structure— were taken into account when the geometry of the tiles was generated. Because the tiles are being 3D printed, applying variations to their shapes allow for poetic ways of “ painting with shapes.” This is done, for example, by applying a transparent blue runny glaze on the convex portions of the tiles (the hills) while allowing for deep blue glaze pools in the concave (valley) areas of the tiles (Fig. 9). This allows for smooth transitions between hues of blue that are impossible to produce otherwise.

3d-printed-ceramic is a high-quality cladding material that offers low maintenance and high durability in even the most corrosive environments i.e. deserts and coastal areas. As such, the potential for 3D-printed ceramics goes far beyond the applications within Delft and for this reason it will also be applied in a design by Studio RAP for two residential highrise projects at this moment (Fig. 10).



Figure 10. Close up photo of a 3d-printed ceramic tile showing the 3d-printed layers and the transparent blue glaze, ©Studio RAP

6 New added values of the architect

For both case studies the client was specifically looking for a different approach to realise something extraordinary and was open and willing to adopt a new digital workflow to realise it. The two discussed projects show an opportunity on how architects could play a crucial role in creating a streamlined digital workflow and reclaim a more central role within the building process. This could strengthen their position from which they can claim and protect their creativity and aesthetic concerns to improve the built environment that affects people's life, as they undergo the outcome of the architect's work every day.

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