"CANOPÉE DES HALLES DE PARIS": CASE STUDY FOR AN INNOVATIVE DIGITAL APPROACH TO TENDER COMPETITION

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ABSTRACT

The traditional tender competition procedure embeds a series of negative aspects, linked to the use of 2D technical drawings that describe geometries and technological solutions of which an architectural project is composed.

The technical language linked to orthogonal projections is no longer a good medium to describe contemporary architectural concepts: during the tender a potential incoherence generated by 2D representation may lead to a not accurate evaluation of costs, risks, and time. The goal of this study is to introduce an innovative concept of digital tendering, integrating the traditional set of 2D technical drawings into a 3D interoperable model based on the widely diffused IFC format, detached from specific commercial approaches. This implemented documentation will help construction societies to better comprehend the complexity of the technical solutions, through a pedagogic 3D model which contains all the information needed for economical evaluation and a series of direct links to the whole project documentation.

"Canopée des Halles" project was approached during the PRO phase, which preceded the tender competition. During this period the company DECODE played an intermediary role, developing a 3D master model based on technical information and made it evolve through a verification and correction process. Once the model was completed, DECODE acquired the documentation for the tender and started to fill the 3D model with semantic information useful during the calculation phase. Then the geometries were linked to their specific 2D technical documentation and the whole master model was exported into an IFC interoperable format. Construction companies received from the Paris City Hall a dvd, containing the 4D model (3D geometry + information), the pdf documentation attached to this and the eveBIM viewer. Into this innovative approach eveBIM represented the pedagogical instrument able to increase the comprehension of the project and provide a technical support to the calculation process through a paper-less approach.

Keywords: Digital tender competition, IFC, Interoperability, Master model, ICT strategies.

1. INTRODUCTION

In many countries of European Union the tender process represents a standard and consolidated procedure through which construction companies receive and evaluate a series of documents related to a public project, in order to define an economical offer for its realization. This kind of process, which hasn't sill been affected by innovative digital technologies, embeds a series of negative aspects, linked to the use of 2D technical drawings that describe the series of geometries and technological solutions of which an architectural project is composed.

The main problem is defined by the potential incoherence existing between a traditional 2D representation and a complex 3D geometry, also considering contractual responsibilities linked to tendering technical documentation. Since the diffusion of Computer Aided Design (CAD) in the construction industry, technical languages linked to traditional orthogonal projections cannot be considered anymore a good medium to describe the complexity of contemporary architectural concepts. During the tender process a potential incoherence generated interpreting a project through traditional 2D representation may lead to a non accurate evaluation of the construction costs, a worse comprehension of the risks related to specific construction techniques and a false perception of the quantity of time needed in order to develop the solutions required (Smith and Tarif 2009).

While the first problem is identified by the formal complexity of a project, a second obstacle is determined by the complexity of relationships which occur into a large scale project, such as “Canopée des Halles” in Paris. In this case potential incoherencies may appear in the areas where different lots of the project, designed by different specialists, meet together (Gallaher et al. 2009).

The main goal of this study is to introduce an innovative concept of digital tendering, which integrates the traditional set of technical 2D drawings, produced by different specialists, into a 3D interoperable model based on Industry Foundation Classes (IFC) platform.

Moreover, a second goal of the study is to analyze and describe the advantages associated to the adoption of a collaborative approach for the development of a large scale project, together with the development of a single master model for the reduction of potential incoherencies existing between complementary technological solutions.

2. DIFFERENT TYPOLOGIES OF INITIAL TECHNICAL DOCUMENTATION

“Les Halles” area represents the heart of the French capital, both considering economic aspects and the infrastructural system. In the wide urban area, the most important part of the underground and RER systems converge together, providing highly diffused connections. Above the multimodal node, there is one of the largest shopping mall of Europe, which strongly contributes to the Parisian economy. Moreover, at the ground level, a green area completes the system, presenting a potential higher than its current utilization.

Figure 1: Physical model of the project “Canopée des Halles”. Author of the image: Patrick Berger & Jeacques Anziutti Architectes, and Arnaud Rinuccini.

Once the architectural concept was defined, the French design procedure presents a phase called PRO, focused on the demonstration of the feasibility of all the technological solutions adopted into the project, through the definition of technical specifications and constraints, also linked to the materials used for each element. The first approach of the company DECODE to the PRO phase consisted into the reception of the entire technical documentation useful for the first version of the 3D model. The different actors participating to the project prepared and delivered different typologies of technical documents, considering the specific level of implication and the contractual responsibilities associated to the different lots of the project.

The input documentation delivered by Patrick Berger & Jacques Anziutti Architects for the realization of the master model was composed of three main categories: the first input consisted of a 3D model, through which global constraints were assigned. These constraints were considered as mandatory and were developed in order to preserve the architectural concept during the feasibility verification process. The constraint model, which previously led the work of the engineers and the façade specialists, was accompanied by a series of plans, sections and details describing the main logic of the project, the organization of different areas and functions, and the architectural aspects associated to the most important technological solutions. The third category of documentation is related to those lots, considering the huge amount of geometries and their complexity, weren't represented through 2D technical details. In this case architects provided a "Logigramme", a structured set of rules useful during the generation of huge quantities of elements, in association to specific constraints.

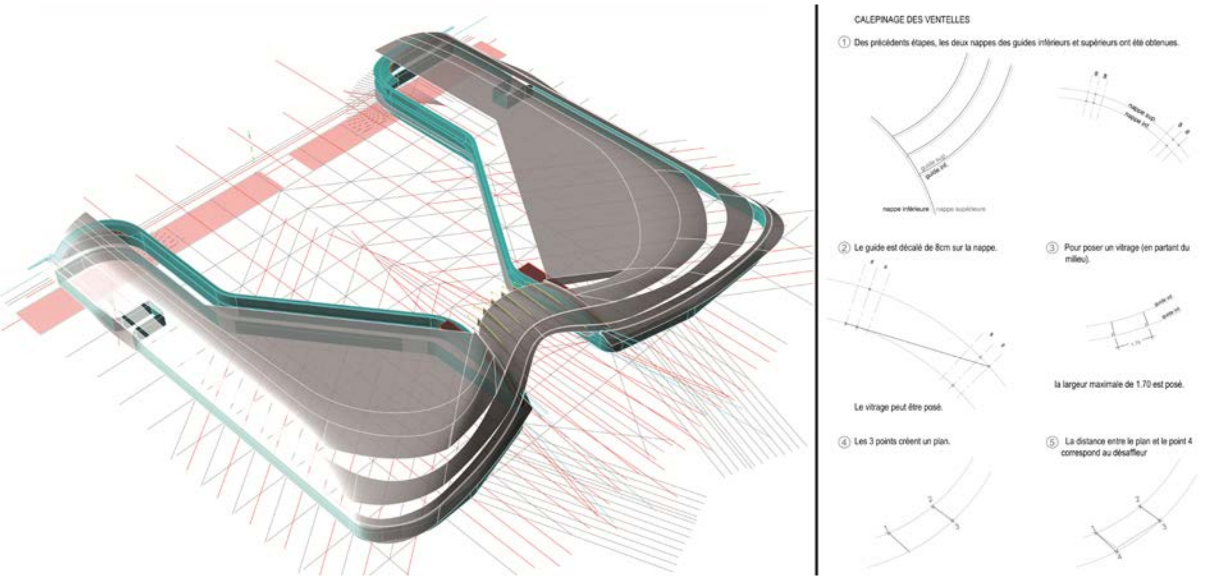

Figure 2: 3D architectural model (left) and an example extracted from "Logigramme" (right). Author of the technical documentation: Patrick Berger & Jacques Anziutti Architectes.

Separately distance from the architect, the engineering company Ingérop provided a full series of plans, sections and details describing every technological solution related to the primary structure. The necessity of detailing each area of the structure was closely linked to the analysis and dimensioning of structural elements. Moreover, the documents produced by Ingérop were directly integrated into the tender documentation, unlike the architectural 3D model or the "Logigramme".

The complexity of this project required the presence of a specialist façade engineering company called ARCORA. Its activity was focused on a structural analysis and technological design for vertical façades and glass covering. The technical information provided consisted of a series of 2D representation of typical details, which had to be subsequently adapted to the complex geometry determined by the architects. The details related to the complex covering systems just described the family of secondary structural elements, removed from the representative logic adopted by Ingérop. Complex façade details were more focused in determining the logical rules necessary to develop thousands of different geometries belonging to the same topology.

The majority of the documents adopted as input for the generation of the digital model also belong to the data-base of contractual documentation delivered during the tendering phase. In this sense is interesting to observe how construction methods aren't completely defined for all the lots and areas of the project. In some cases this lack of description generates the possibility, for the construction industries, to choose their own approach for the construction of specific technological components.

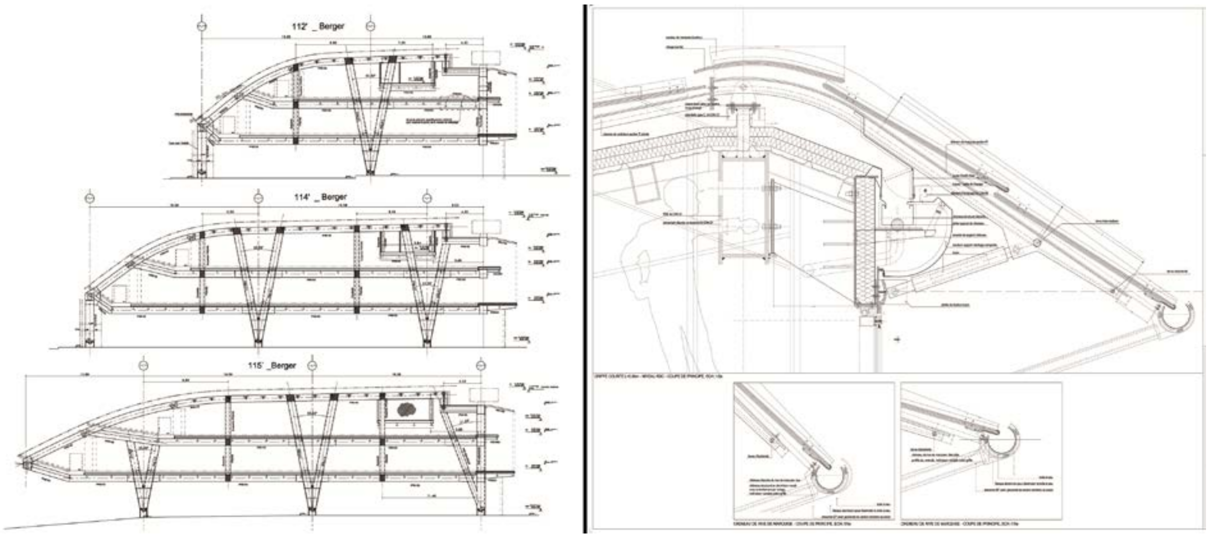

Figure 3: Main sections for primary structure (left) and typical detail for secondary structure (right). Authors of the technical documentation: Ingérop, ARCORA.

3. MIXED APPROACH FOR ACCURATE MODELING STRATEGIES

Once that DECODE had received all the documentation describing the project, they started a preliminary study aiming at comprehending the best approach to digital modeling in order to respect time and accuracy constraints (Ferries 2004, Moum 2008). During this process the characteristics of the PRO phase played a fundamental role in the decision process, because the development of the 3D master model required a high level of accuracy just in some areas and lots of the building.

This gradient of variation was firstly related to the possibility, for construction industries, to modify the project during the tender competition, in order to propose a cheaper and more optimized solution. The eventual modification of technological solutions developed during the PRO phase, focused on specific aspects of the project, leaded all the actors to accurately calibrate the level of detail and also influenced the definition of DECODE approach, finally directed to an adaptive level of detailing.

A second aspect that deeply influenced the choice of an appropriate level of detailing was related to the future integration of 2D technical documentation into the 3D master model. 2D plans, sections and details always represent a contractual documentation, which have to be included into the tendering. This legal aspect allowed the development of a 3D master model characterized by an accurate detailing just in those lots which weren't described into the 2D drawings developed by architects, engineers, façade specialists, etc. Considering the documentation received for the "Canopée des Halles" project, the most accurate detailing level was assigned to those areas described in the "Logigramme" and in topological details produced by ARCORA. In this sense is possible to conclude that the level of detailing and accuracy of the 3D master model was directly related to the level of complexity which characterized each lot of the project. The more complex a lot was, the higher level of detailing was required.

Different typologies of software were analyzed, in order to define the best set of instruments to adopt during the development of the master model. This process took into consideration products like Autodesk® Revit®, Nemetschek AllPlan, Tekla® Structures, GT Digital Project™, etc. Different characteristics were compared together, analyzing the ability of the products to easily manage complex geometries, the quality of import/export files (for interoperability purposes) and the possibility to integrate different sets of attributes into the geometries (Nour 2009). At the end of this process DECODE chose the 3D accurate modeler McNeel Rhinoceros®, considering its attitude to easily generate and manage extremely complex geometries, the ability to structure a parametric/generative approach through the plug-in Grasshopper®, and the possibility to increase the software potential through a series of plug-ins dedicated to the implementation of Building Information Modeling (BIM).

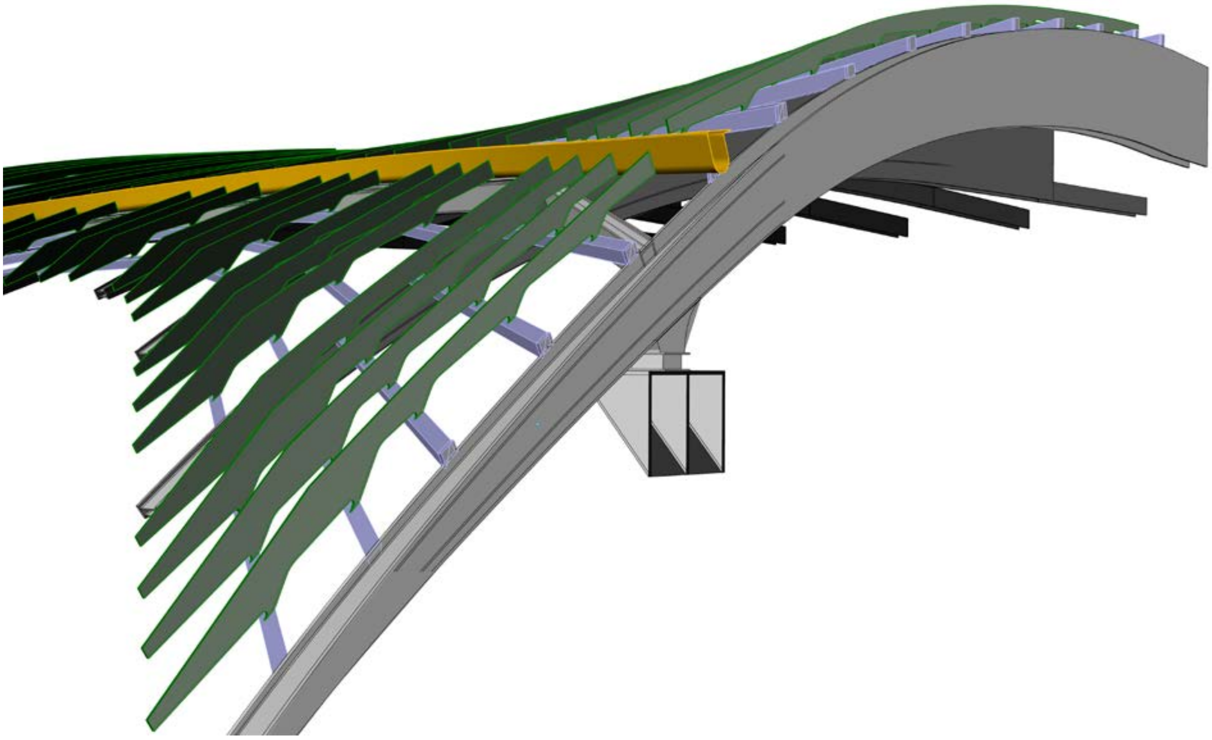

Figure 4: Level of precision required for the development of a complex part of the project, considering the PRO phase characteristics.

A second study, linked to the software, was focused on the relationship between traditional modeling and a parametric/generative approach. Considering the complexity of “Canopée des Halles” project, and the presence of standard and customized elements, the software adopted also allowed approaches for different lots, following an adaptive strategy. The plug-in Grasshopper was adopted for those areas which specifically needed a generative/parametric process, while other less intricate areas were developed through a cheaper and faster 3D modeling process. This decision differed from those fully parametric logics that govern other software products and allowed DECODE to optimize the workflow and the quality of results considering the PRO phase deadlines.

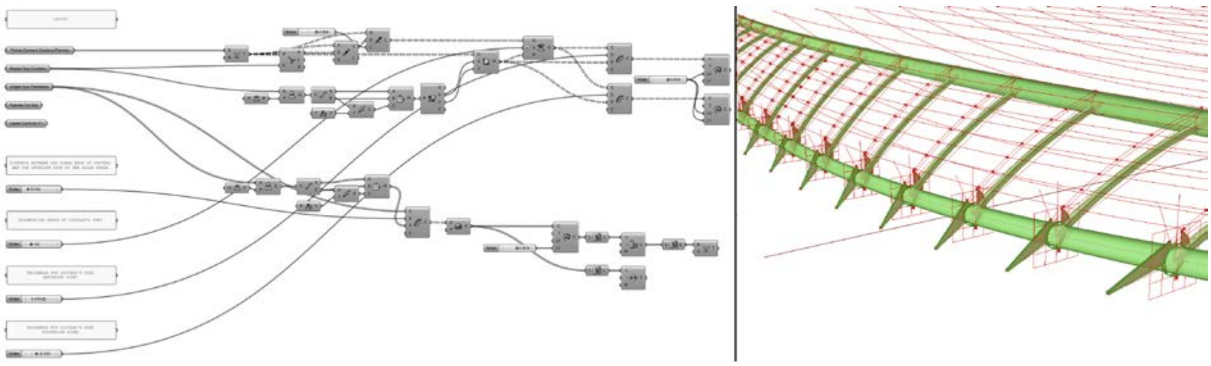

Figure 5: Example of a Grasshopper diagram (left) embedding a set of rules and parameters necessary to create complex geometries (right).

4. CLASH DETECTION AND COLLABORATIVE EVOLUTION OF THE MODEL

The development of the model was characterized by an evolutive process, which took into consideration analyses and comparisons of different technological solutions, the individualization of clashes, the communication of those incoherencies to the different actors concerned and the update of the model based on more suitable solutions. Once the first version of the model was concluded, several clashes emerged from a semi-automatic detection procedure. The majority of those incoherencies were due to the relationships between different lots and their relative interfaces. This kind of result shows a high level of quality reached during the development of specific technical solutions from each company and specialist, but a deep lack of communication and verification on the eventual relationships problems between different lots (Gallaher et al. 2009). The methodology applied by DECODE for quality control reviews differed from the most diffused automatic collision detection procedures and approached the problem through a mixed solution: manual quality reviews were operated on those lots generated through a traditional 3D modeling process, while automatic control strategies were specifically developed for complex lots, extending the field of quality review beyond the classical collision detection. This mixed approach allowed a simplification of the quality control for standard areas of the project and led to an extremely accurate verification of those technical constraints that influenced the generation of complex lots.

Each clash detection campaign was always followed by a series of technical workshops, which saw the participation of at least two different actors, between architects, engineers, façade specialists, etc. During each workshop problems were discussed and analyzed, aiming at finding a feasible solution. The problem of responsibility and decision represented an interesting aspect of the problem solving process: the relationship between different lots often determine the adaptation of multiple technical solutions linked to the problem. In this case decisions were shared between the specialists responsible for the adaptation of the details and, moreover, the society Ingérop, which leaded the whole PRO phase (Klinc et al. 2009, Ku et al. 2008).

During this process DECODE mainly worked on the analysis of the project, the identification of eventual incoherence, their communication, and the updating of the master model. Though the development of technical solutions was assigned to the pool of technical specialists, the expertise level and the deeper knowledge/comprehension of the master model allowed DECODE to quickly and autonomously develop alternative solutions to the incoherencies highlighted during the clash detection process. This active approach, adopted by the model manager, accelerated the resolution of problems linked to some extremely complex areas, like the “Petite Canopée”.

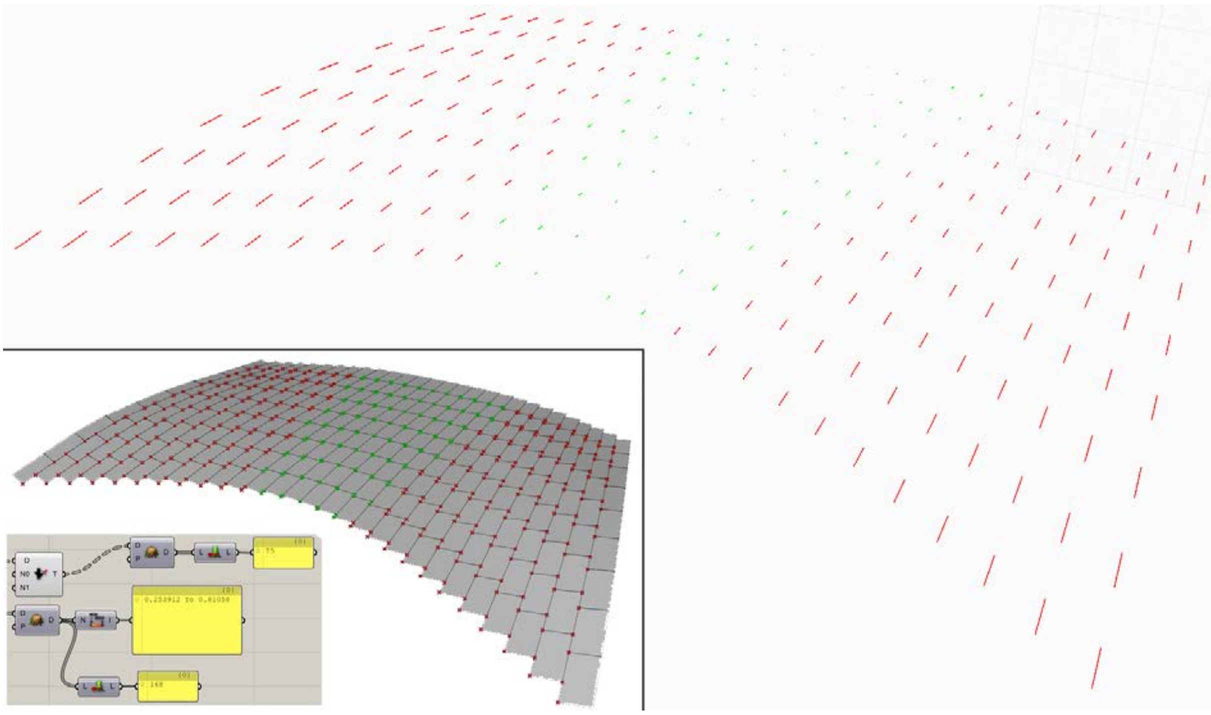

Figure 6: Example of geometrical analysis, showing a problem of lag between the glass panels that compose the “Petite Canopée”, a lightweight structure belonging to the project.

5. FROM RHINOCEROS TO AN INTEROPERABLE IFC MASTER MODEL

The most important and interesting passage developed during the PRO phase was focused on the translation of a Rhino based 3D model into an interoperable IFC based master model (Nour 2009). The attitude of Rhinoceros differs from standard BIM software, being oriented on accurate 3D modeling of complex geometries, without specific attributes. Currently some plug-ins allow the conversion of 3D geometries into BIM objects, but none of them were useful in order to support the whole process of conversion. Moreover, another problem was linked to customization of attributes quantities and typologies: the complexity of the project and the gradient of technological elements designed required an extremely flexible and customizable conversion system, able to offer optimized configurations of attributes accordingly with specific needs of each single lot (Froese 2003, Parinaud 2008).

These two fundamental aspects led DECODE to develop specific integration and conversion tools, collected into a plug-in which was adopted during the whole development phase of the IFC master model. The plug-in was modified and tested for a long period, while the technical documentation was collected and prepared for its implementation within the geometry. Once the collection of documentation was concluded and attributes associated to the geometries were optimized, DECODE translated the Rhino 3D model into its IFC interoperable version.

The development of the Rhino plug-in and the production of the IFC master model required a constant interaction with the CSTB – Centre Scientifique et Technique du Bâtiment, in order to verify the interaction between the master model and eveBIM, the instrument proposed to the construction industry for the exploration and the navigation through the project, availing the IFC format. During this phase DECODE worked as beta-tester for the evolution of eveBIM, deeply influencing its growth and the characteristics of the final product. At the same time, the output of the Rhino plug-in was tuned aiming at corresponding to the standards used into eveBIM. This control procedure didn’t exclude the possibility to export the same model into totally different software, but just optimized the dialog with one specific instrument. The IFC model was also tested in different BIM software and viewers, aiming at preserving the vocation to interoperability (Pazlar and Turk 2008).

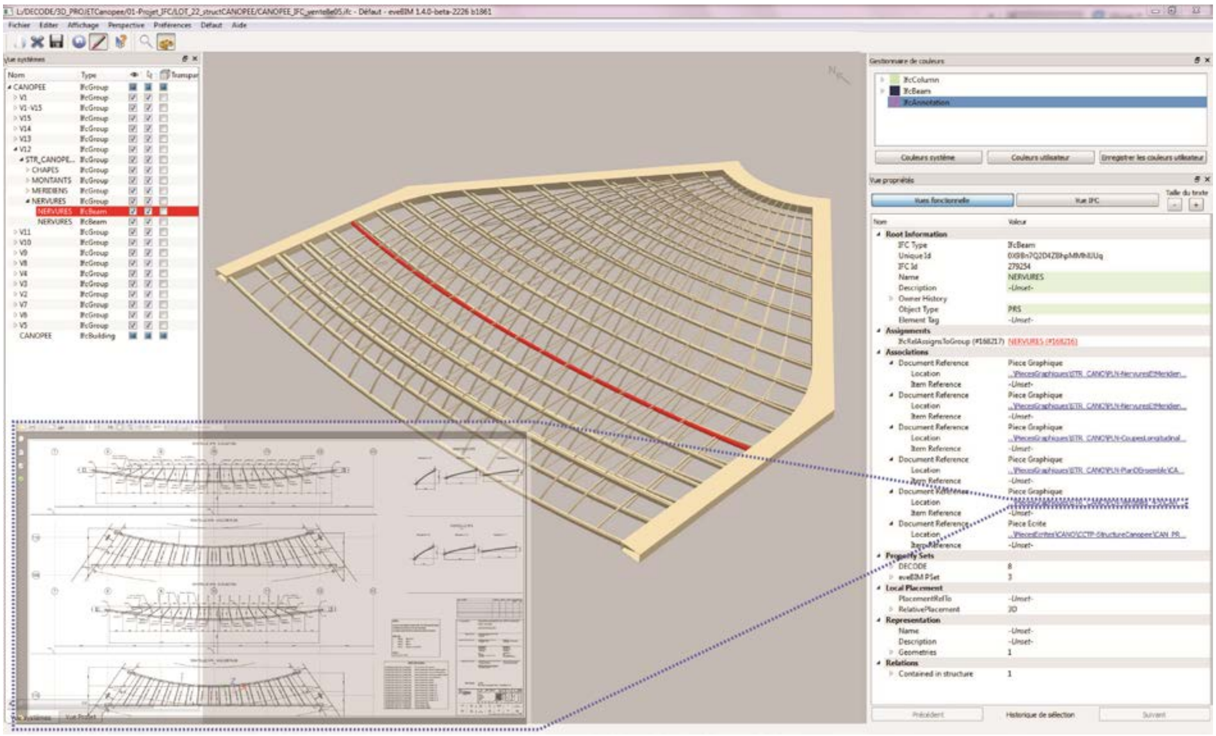

Figure 7: eveBIM environment, which allows the user to navigate into the model, access semantic information and technical documentation linked to the geometries.

The last passage of the translation process, from the Rhino 3D model to the IFC master model, was dedicated to analysis and verification of the delivery package for tender process. It was mandatory to optimize the full model in order to reduce its size and check the workflow quality, considering the hardware available at the construction companies. The whole model, complete with attachments, software installer and guides, was optimized until it was contained in a single dvd. This passage represented the conclusion of the PRO phase and the start-up for the tender process.

6. DELIVERY AND CONCLUSIONS

« Canopée des Halles » project represents a unique opportunity to test innovative interoperability procedures for complex architectures. The development of the PRO phase demonstrated the possibility to develop an interoperable model, based on IFC platform, working with a simple, flexible and accurate 3D modeler, implemented with specific plug-ins. This experience also showed the utility of a master model during the evolution of multiple technical solutions focused on demonstrating the project feasibility. By contrast, considering the timeline originally previewed for the development and conclusion of this phase, based on a six months period, the adoption of this innovative process required an additional three months, necessary for the development of the IFC master model prototype.

The conclusion of this innovative procedure, associated to the PRO phase, led us to extract a series of lessons, useful for next experiences. The first lesson is focused on the typology of incoherencies which may appear during the development of a 3D model incorporating different actors' information: in this case the majority of incoherencies emerged lead us to focus more attention on the connections between complementary components, designed by different actors. There connections always represented critical points, more difficult to analyze than single quality reviews on single lots. The second lesson can be individuated into the advantages due to a mixed approach, which combines together classical 3D modeling and parametric/generative design: this double potential led to an optimization of each task, selecting the better procedure according to the complexity of the lot treated. The third lesson is focused on BIM approach: this case study demonstrated the possibility to generate an interoperable BIM model even when working with an accurate 3D modeling software, availing of specific plug-ins for the implementation of semantic information and subsequent format conversion. This possibility simplified the generation of the model on one side and allowed to achieve a rich and high quality result accordingly to the typical standards of Building Information Modeling approach.

Construction companies expressed their genuine interest in participating to this digital tender process, which represented an absolute innovation in France. The development of a 3D model, associated with the contractual documentation, demonstrated its utility twice: firstly by reducing risks through the resolution of clashes and incoherencies; and secondarily by supporting construction companies in the comprehension of such complex architecture.

The last expected result, which will appear at the end of the tender competition process, is a reduction of the price previewed before the PRO phase, and fixed to 180M€. This reduction will demonstrate the quality and the pertinence of a non-conventional interoperable approach, as conceived and structured by the company DECODE during this case study.

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- Client: SemPariSeine (Ville de Paris)
- Architectural project: Patrick Berger & Jacques Anzitutti Architectes
- Responsible for the PRO phase: Ingérop
- Development of the master model: DECODE – Development Complex Design

Consultants:

- ACV – Ingénieur Acoustique
- ARCORA – Ingénierie structures et façades
- BASE CONSULTANTS – Conseiller environnemental
- EPPAG – Emmer Pfenninger Partner AG
- INGELUX – Conseiller éclairage

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