Lessons learned from a BIM-based lighting design project

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Introduction

Until now, most lighting design projects start when architects, structural engineers, and in some cases mechanical engineers, have finished their jobs. In such projects, there are therefore a number of limitations and restrictions when the lighting designer starts his/her job. On the other hand, most of the time, in order to achieve a successful lighting design project, good collaboration between the architects, lighting designers, electrical engineers and installers is needed from the beginning to the end of the project. The graph below, known as the MacLeamy curve (Fig. 1), shows the importance of having the possibility of making changes in the project and the costs incurred at different levels of the design process. As shown, by involving all engineers and designers in the project from a very early stage, everyone has significantly more influence on the project and can collaborate more effectively, making reaching the main goal easier.
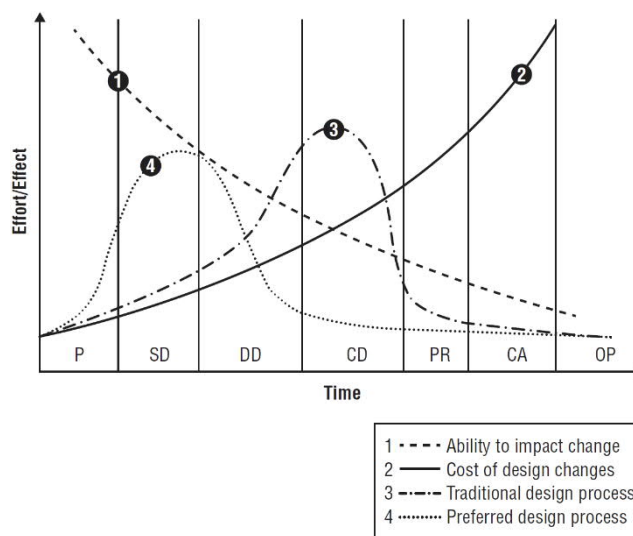

Fig. 1: "The effort curves in the design and construction industry" (Marcus, Kirby & Krygiel, 2017).

Moreover, a successful project also needs to satisfy all other disciplines, such as acoustic, structural and mechanical engineering. Therefore, to be able to collaborate with one other, we need to have a core platform where each group can easily upload their work to the model and be updated with the latest changes on the model. Nowadays, working with BIM-based 3D modelling software is very common in architectural firms. Architects and structural engineers around the world have adopted such 3D programs. However, such software has not been widely used by lighting designers, electrical or mechanical engineers. Two of the most important reasons why they have not started using the software is because they do not have enough knowledge about working with BIM models, and because of the weakness of the software used by other experts to communicate with BIM-based modelling software. We have had the opportunity to test a BIM-based model and in this paper, we will share our experiences and the lessons learnt. Our aim is to explore whether this method of working is more convenient and efficient than traditional CAD-based workflow. If so, we hope this paper will guide and inspire more people to embrace this seemingly revolutionary method of working.

Case study project

We have recently been working on an Interrail project. Our task as lighting designers for this project has been to renovate the platform areas. We have been working through different project stages, from an early design proposal to a construction document. The project has involved many consultants with different expertise, since it is an extensive project with many complexities that must also be carried out in a short time. One of the most important, and maybe unusual, conditions for this project is that as many professionals as possible have been using 3D-based software: Autodesk Revit BIM-based 3D modelling software.

Throughout this project we have gained an extensive amount of new knowledge and it is crucial to mention that we are in the development phase and all discussions in this paper are based on our current experience.

Fig. 2: An illustration of our new proposal for one of the platforms for the Stockholm Central Station project.

Building Information Modelling (BIM)

In ISO/TS12911, Building (Construction) Information Modelling is defined as a "shared digital representation of physical and functional characteristics of any built object, including buildings, bridges, roads, process plant". In a traditional CAD-based workflow, the model is based on creating stand-alone drawings and objects, while generally the main concept of a BIM-based model is to work in 3D rather than 2D models. That said, it should still be able to produce 2D models easily. (Marcus, Kirby & Krygiel, 2017). Moreover, in BIM-based 3D modelling software, in addition to information about geometry and placement, each individual element carries some non-graphical information relevant to that object. Therefore, in an ideal world, there is no need to define any additional information to make any simulation or documentation.

Since the 3D model with all its information is saved in one central file placed in either a local or a cloud server, we need to make fundamental changes in our conventional 2D-based workflow in order to be able to apply BIM-based software successfully.

BIM-based design workflow

In a CAD-based design workflow, each of the different professions involved in the project work almost separately and in different drawing files. Therefore, because of the nature of such a working method, the level of collaboration between different disciplines is quite low. More importantly, in the 3D BIM-based method everyone working on the same file can interact through geometry and information. This in turn makes the workflow easier and faster.

However, in this type of work, the users must develop a 3D model with an acceptable level of detail before producing any 2D drawings. Therefore, it will take more time to produce a single plan in comparison to a CAD-based workflow. Once such a model has been produced, many drawing sheets or schedule-based documents can be made with less effort.

Generally, every BIM-based 3D model requires some geometrical and object information:

- a full 3D model of the project with all elements including all needed architectural, structural, mechanical, electrical objects
- all geometrical information required (thickness, material types, placements) for each object (windows, floors, walls, ceiling, architectural or structural columns, beams)
- all information required for each specific type of family

However, a BIM-based workflow doesn't necessarily mean a higher level of expertise or quality than a CAD-based project. Rather, it requires thorough planning and management. Regarding time and accuracy, extracting data from the

model and quantifying each type of element is more convenient in a BIM-based model. Moreover, creating final 2D drawings, plans, sections or elevations can mostly be done automatically in a BIM-based model, while in a CAD-based model every single drawing has to be created separately (Marcus, Kirby & Krygiel, 2017).

BIM-based workflow advantages

Therefore, regarding the nature of BIM-based modelling, we have divided the advantages of using a BIM-based workflow in comparison with a CAD-based one into two categories. The first category shows the benefits obtained if we have one central file including all elements from different disciplines. The second category shows all advantages related to all information in each element.

- Benefits from working solely with one central file including all elements from different disciplines:
    - close collaboration between all designers (architects, landscape designers, lighting designers) to achieve a better design quality
    - better coordination between all disciplines during the entire design process
    - work can be reviewed easily and continuously from different perspectives by different experts
    - provision of a more realistic overview and checks to avoid interference from different elements
    - generation of realistic virtual, static or interactive rendering images by including all elements existing in the space, such as pipes, fixtures and equipment, for better communication with the client
    - avoidance of collisions between different elements, and solving detected clashes during collaboration meetings
    - 2D drawings and sheets can be created more easily and faster.
- Benefits of including all information required in each element or in the model:
    - analyses of energy, light, and daylight can be carried out more easily and faster by applying existing add-ons or plugins.
    - different elements can be filtered conveniently (show/hide or highlight) by applying different logical functions for each element. As lighting designers, we use the schedule tool in Revit. By assigning relevant parameters, such as name of manufacturer, image of a product, efficiency, wattage, light distribution, product specific name, article number, CCT, CRI, lumen output, colour of housing, and even price, it is far easier to create specification sheets, including the number of luminaires required
    - schedules or other documents can be created faster and more easily.

Challenges

Besides all the benefits mentioned above, there are some areas that need to be considered when working on BIM-based projects as they can be more or less challenging. Some of them apply to any type of BIM-based workflow, while others are specifically linked to Autodesk Revit.

BIM-based workflow challenges

- In any BIM-based project, there is usually a need to have a BIM coordinator who can assist and solve issues related to BIM-based 3D modelling software, further educate the team, create 2D and 3D delivery outputs, and head 3D coordination meetings.
- The BIM program is not fully ready to be used by professions than other architects and structural engineers. This means that all other groups face several challenges in the course of the project.
- Including all objects from all disciplines involved in the project makes the model quite heavy and difficult to work with. One solution might be to work in different model files for each discipline and then link them together by switching every layer on and off whenever needed.
- Problems can occur when different people with different Revit skills are working in the same file, since they have limited knowledge about how to handle the program (i.e. deleting some element by mistake). The solution could be to make a backup once in a while, or to lock the objects.
- When creating 2D drawings automatically, we should be aware that some of the fixtures can be invisible in a 2D plan or section. When the fixtures are placed in the 3D spaces some of them may be hidden by other objects if the cutting plane and the depth of view are not correctly adjusted. This will require some manual work.
- Clearly defining the task and area that each person in each group and department is responsible for, and trying not to overlap the work and mix responsibilities. Since we are working in one central file, parts or elements that someone else is working on can easy accidentally be altered without informing him/her.

Revit tool workflow challenges

In general, although Revit is quite powerful and an extremely useful tool for all stages of any architectural project, we have found some limitations and have faced some challenges during our work in this BIM-based project that have

forced us to find alternative solutions. Some of the problems may well be solved in the near future, but others are more complicated. The problems we have encountered during our work:

- Revit itself is not fully equipped to do the job required by different professions, and some specialists from different disciplines are not fully ready to apply it in their everyday work. It is therefore advisable to hold coordination meetings at regular intervals to determine any potential interference between elements in the model.
- In a BIM-based workflow, everyone works on their own local file, but every now and then they will need to synchronise with each other in order to update the local file as well as the central model. However, as soon as the central model increases in size, synchronisation between local and central files slows down. It works better when using a cloud-based central model file, but that can be an issue for clients who save their model in a public, semi-public or private cloud.
- If the luminaire range includes an IES file, the photometric diagram is converted into a 3D object when exporting the model in an object-oriented IFC file format. When using Dialux Evo as our lighting calculation software, import statements regarding lighting fixture families are ignored. However, if we use ReluxDesktop, instead of importing the family from their database, ReluxCad (a plugin to communicate between Revit and ReluxDesktop) will replace each lighting fixture family with a relevant lighting fixture with the same photometric file in the same place as it exists in Revit.
- If we are using lighting fixtures with illuminating surfaces, such as linear or square-shaped fixtures, some rendering programs (such as Enscape or Revit) cannot appropriately simulate the light distribution from light fixtures that include photometric files.
- Problems in exporting the fixtures' orientation and their relevant photometric file when they are not aligned to a horizontal or vertical plane.
- When adding photometric files (in our case IES files) to the fixture family, it converts the photometric diagram to a 3D object. Therefore, the model will be quite heavy, making further work with the model more difficult.
- Face-based luminaires are sometimes removed if we move the host surface. However, if the fixtures are kept in their positions while their hosts are moved, we can mark/filter those unhosted elements and highlight the changes in the model.

BIM-based tools to help lighting designers

To assure high-quality lighting design solutions can be achieved, it is important that lighting designers are involved in the project from an early stage and can collaborate with architects from the start. In the Interrail project our first task was to decide which luminaires were to remain in the building and where, and which fixtures were to be replaced. The second step was to analyse different spaces using different tools and software to assess their problems, strengths, weaknesses and potential. A study of the existing light quality in the space enabled us to make better decisions when embarking on the design process. We began by analysing the existing conditions in indoor and semi-outdoor spaces by day and night.
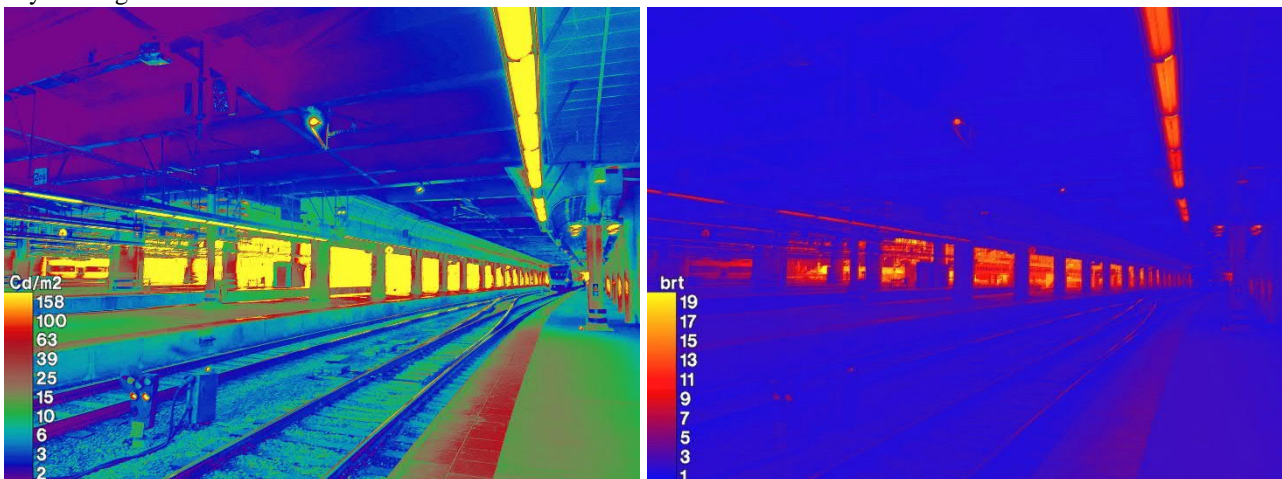

Fig. 3: These images are based on converting luminance values (cd/m2) to brightness values with an exponent of 1/3 (DiLaura, Houser, et. al. 2011). Such analyses are useful when considering uniformity and contrast.

When the architects prepared a 3D model in Revit, the first step for us was to perform contrast and lighting comfort analyses. Using Aftab Alpha Windows-based software and an Aftab Luminance iPhone app, we made physically-based HDR photos of different places of the area. By creating luminance/brightness-based false-colour images, we could better understand the lighting conditions during the day and night. The next step was to classify each area as daylit, partially daylit or non-daylit with the help of a newly developed Revit add-in called Aftab Rad. Alternatively, we could use another Revit add-in called ElumTools, or Autodesk Insight 360. The difference between these two and Aftab Rad is that Aftab Rad enables the Revit 3D model to communicate directly with Radiance and Daysim, which are well-

known validated open-source lighting simulation software. The latter provide users with much more flexibility, while ElumTools and Insight 360, are confined to what they offer.
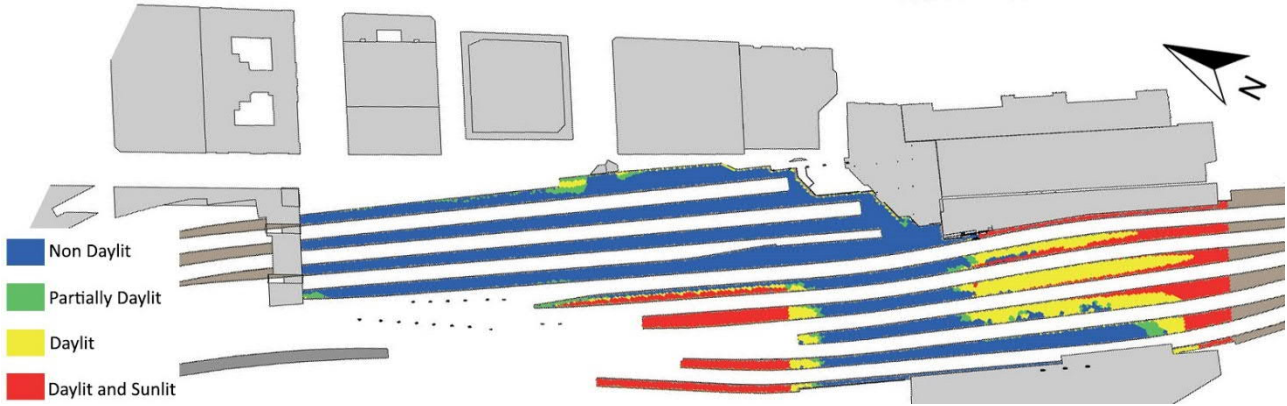

Fig. 4: With reference to the definition of a daylit or sunlit area in IES LM-82-12, we classified the different areas of the semi-closed platforms as sunlit, daylit, partially daylit and non-daylit. This helped us propose different lighting design scenarios for each of these spaces.

Then, as soon as architects made a new design for parts of the area, we started to do our lighting simulation study by exporting the 3D model from Revit to Dialux Evo with the help of IFC files. Here it is worth mentioning that when exporting the model to light simulation programs we usually need to detach and simplify the model and only exporting the elements and areas required in order to be able to work more efficiently and accurately. Other alternatives for lighting simulation would have been to use the ReluxCAD add-on or the Revit ElumTools add-in. ReluxCAD has a feature that helps its users to import ranges of fixtures from around 100 manufactures directly to Revit. By exporting the 3D model from Revit to ReluxDesktop, all the fixtures are exported together with the model. Thus, unlike DIALux evo, we do not need to place them manually, and we can import the placement of the fixtures together with their relevant families into Revit. However, since DIALux evo uses the Photon-mapping algorithm for its lighting calculations, it is faster and more efficient when working with more complex models. In this BIM-based project, from the schematic design phase onwards, we were required to place the right fixture families inside the BIM 3D model. That was to help architects and other disciplines to review luminaire placements and their interference with other elements in the model. When reviewing the project, we used both Revit and Navisworks. However, in our routine coordination meeting, only Navisworks was used since it works better for importing different types of 3D model files. Regarding the rendering tools, we used Revit Enscape plugin to create fast and good rendering images. This also enables you to make 360° virtual reality images. Other alternatives to be used are the Revit V-Ray plugin and Autodesk Rendering in the Cloud. To create a more professional visualization of high-end quality we used a Corona Renderer for 3ds Max.
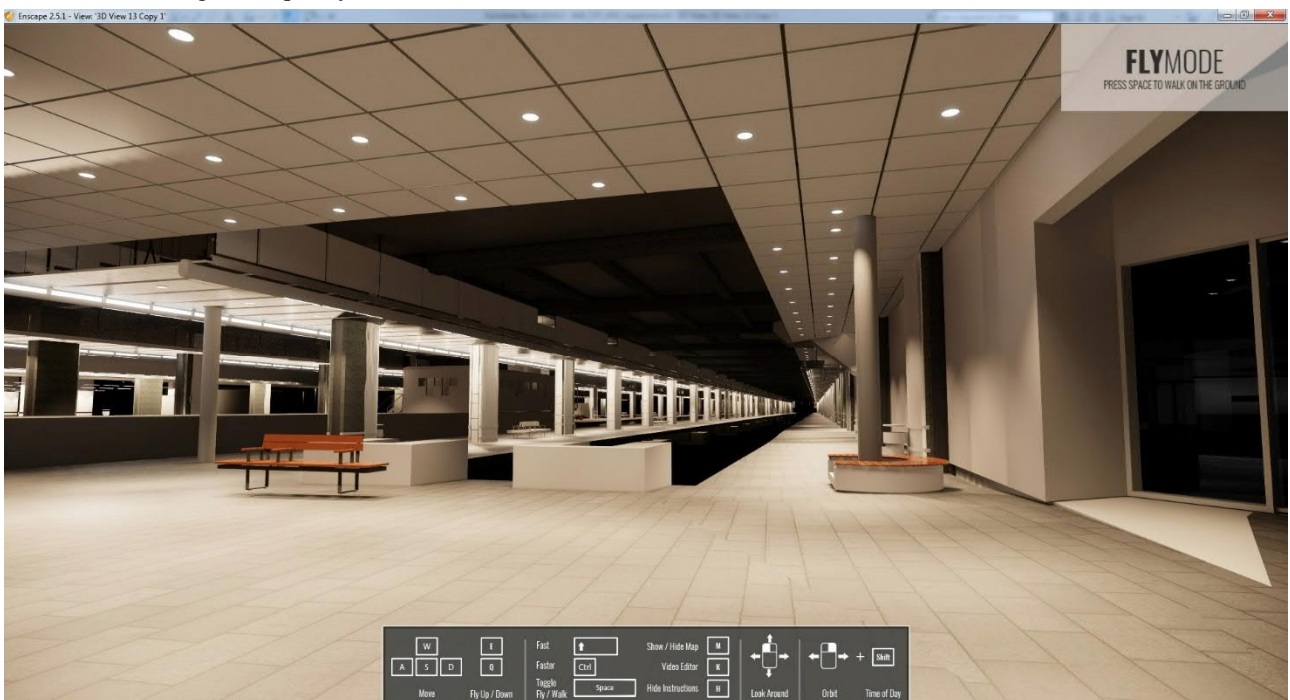

Fig. 5: This image shows a screenshot from the Enscape Revit add-in interface to quickly understand the architectural and lighting design of the space.

The tools and software used in the design development stage was more or less the same as in the other stages, but since we also needed to produce electrical documentation, we used MagiCAD, which has a large library of 2D-symbols and electrical objects. Using smart tools for connecting cables to objects was immensely helpful.

Figure 6 shows what tools and software were used during which part of the design process. Although the table is based on our experience in this renovation project, we may well use it as a simple tool box for future BIM-based projects.
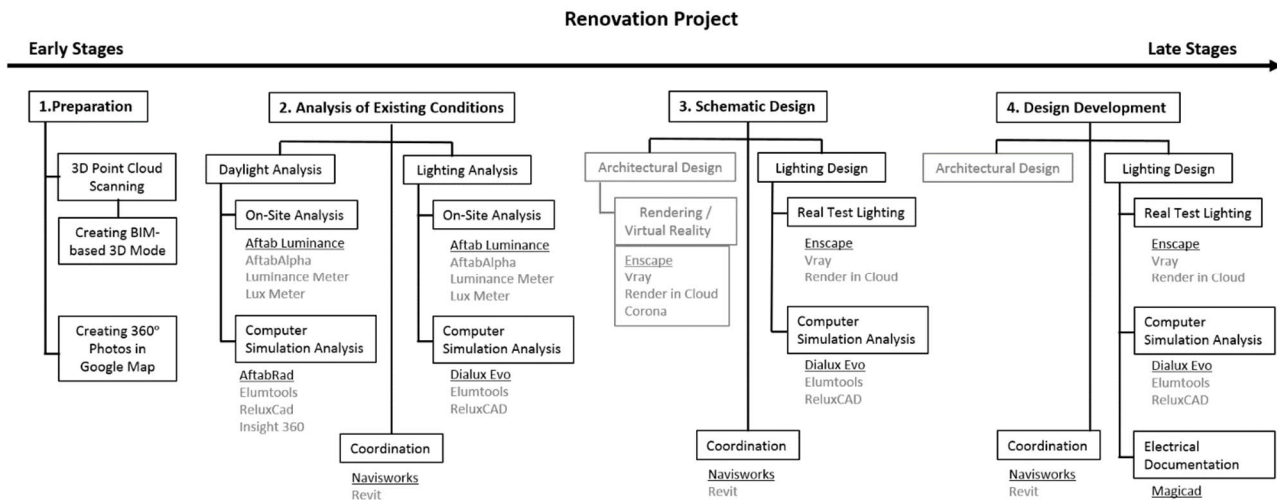
Fig. 6: Diagram showing the BIM-based auxiliary lighting design tools applied during the BIM-based architectural design process for the renovation project.

Conclusion

Using BIM-based modelling and workflow has meant a shift in the way our projects are accomplished. Not only has it proven to improve communication between architects and other professions, it has also allowed us as lighting designers to enter the process at an earlier stage in the project, which enhances the chances of realizing a better final solution. However, since this was our first BIM-based project, we had little or no knowledge about this method, which meant that a lot of time was invested in learning, facing challenges, and solving problems.

Throughout this project we have realized that the model consists of information about the objects that can easily be exported to analyses and other documentation. This has proved to be a great advantage. Together with everything mentioned above, it has made us eager to continue using this method as well as digging deeper into what it has to offer.

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