OPTIMISING THE BUILDING MANAGEMENT SYSTEM IN SMART PASSIVE BUILDINGS

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REFLECTION

The main objective of this research is to show how a building management system can help to extend the passive period of a smart passive building in order to limit the total energy consumption while increasing the comfort conditions. For this research, the MOR prototype was used as a case study for doing measurements and a model was built in Grasshopper to provide simulations. It was then intended to use this model in modeFRONTIER to run optimisations. Unfortunately, when comparing the results from the simulation to the measurements, it turned out that the model was not able to provide accurate results. Therefore, the existing DesignBuilder model was used to run the optimisation, despite the limited options. Considering all results an intervention is proposed.

This research combines energy efficiency and comfort conditions with digital optimisation of a full-size prototype. It creates a deeper understanding of the HVAC systems inside the prototype and new insights into standards for thermal comfort, indoor air quality and visual comfort. Using different systems, both passive and active, and automating those using a building management system. It is therefore positioned in the sustainable graduation design studio with the aspects of climate design and design informatics.

1. Graduation process

Because the prototype was still in the process of being rebuilt in the Netherlands, a lot of its functionalities were not up and running yet. Especially the electrical work was running behind due to limited capacity. Since this is a student project no one was available to work on it full time. With multiple schedules and needing help from professionals, the work was not done in time for the measurements.

Eventually, all work on the prototype had to stop due to the coronavirus. The Green Village did not allow for students to continue research on site. A remote connection to the prototypes building management system was set up so measurements could be collected. Unfortunately, this did mean that the windows were not properly tested, the shading motors were not connected to power and the weather station was not positioned properly. And most importantly the building was not airtight yet. Next to that this meant that all measurements taken of the prototypes were of an empty building that was not being used. It was also not possible to check up on the prototype to see if at some point people entered the prototype and opened windows or left open doors for example.

The intention was to use the existing DesignBuilder model for the simulations. After the decision was made to use modeFRONTIER for the optimisations it turned out that DesignBuilder could not work with modeFRONTIER optimisation, therefore a new model had to be created. During a discussion with PhD candidate Berk Ekici, who has experience with energy optimisations, he suggested that making a model in Grasshopper using the Ladybug, Honeybee and Ironbug plugins would be the best solution. After comparison of the simulation to the measurements, it turned out that this model was unable to accurately simulate the prototype. Therefore, it was decided to use the DesignBuilder model and the built-in optimisation engine of DesignBuilder for the optimisations. The results could still be processed by the modeFRONTIER design space.

Because Ironbug is a fairly new plugin, it is not widely used yet. This means that the amount of documentation was limited. Where for Honeybee multiple tutorials are available, for Ironbug only a limited number of example files could be found without a thorough explanation. Piecing all the systems of the prototype together, it was hard to understand how the different systems had to be connected. The plugin allows for a quite detailed set of parameters to be set, but due to the limited explanations, it was hard to filter all the possibilities and find the right ones for the settings. Not being able to fully understand the workings of the plugin, it produced a lot of error messages which eventually got solved with the help of the Ladybug Discourse forum

page. When finally, a working model was produced, not all aspects of the prototype could be modelled due to limitations of the applications.

Since the DesignBuilder model was pre-existing some settings had to be changed to resemble the prototype as built. The model was setup with a simple HVAC template. Since already a lot of time was put into the Grasshopper model, there was not enough time to set up a detailed HVAC system. This could have made it possible to look deeper into all the different systems as had been set up in the Grasshopper model. Furthermore the DesignBuilder optimisation engine is very limited since it will only allow for certain objectives, constraints and design variables to be picked from a list. It is also only possible to choose between two optimisation algorithms. Whereas modeFRONTIER has more elaborate options.

Concluding, there is still a lot of work that could be done on both the models. While running simulations and comparing those to the measurements it was found that the Grasshopper model did not supply accurate results. While trying to change settings in the model to see what caused the discrepancies between measured and simulated data, it turned out that the HVAC system was not performing as expected. The DesignBuilder model was able to supply more accurate results but was very limited in optimisation options. Because the prototype did not have working windows and shades, was not airtight yet and the measurements made by the weather station were not an accurate representation of the local climate, it could be discussed if it is possible to fully verify the model made when comparing it to the measurements.

2. Societal impact

During the competition, the systems in the prototype were set to function in the Hungarian climate (warm-summer humid continental climate according to the Köppen climate classification) whereas the Netherlands has a temperate oceanic climate (MOR Team, 2019). Showing that it is possible for the MOR prototype to function efficiently in both Hungarian and Dutch climates with only changing the settings of the building management system proves that it will also be able to function efficiently when the local climate will change.

Another part of the MOR project is to show the adaptability of buildings. The prototype is based on a section of the Marconi towers, which are three office towers located in Rotterdam. The prototype shows how these towers can be transformed into apartments with the possibility to transform back to offices if the demand from the market changes. Because the building management system can be used in residential buildings as well as offices or other functions, this can also show that the building could change its function and still perform at the most efficient level for that function (Priva, 2019).

The proposed interventions still have to be tested in the prototype in order to verify that they actually lead to a lower energy consumption and increased comfort conditions. Only then the prototype can become an example of the benefits of using building management systems is residential apartments. These systems will allow for many other possibilities that are not discussed yet.

Ethical issues

Ethical issues that could be encountered could consist of taking all decisions away from the residents. Should it be allowed for the residents to be able to change the settings of the system like turning up the thermostat or opening the windows themselves? Should we be able to let a system make all those decisions for them? When are these systems reliable enough?

When looking at the Adaptive Temperature Limits Guideline, type Alpha only allows for higher temperatures if the residents are able to open the windows themselves. This because people like to feel in control. Only knowing that they are able to adjust the climate makes them feel more comfortable. If we eliminate that, will they become less satisfied with these buildings?

3. Conclusion

In hindsight, I was very optimistic about the whole process. As we have found multiple times before, rebuilding the prototype cost more time than we planned. While we had the re-opening planned for the 6th of February, we still needed to finish things way after that.

When it turned out that I was going to make a new model I did not realise the enormous time it would cost me to build the model while learning the applications. When I finally did finish it I did not account for what would happen if the model could not accurately simulate what I already had found in the measurements of the prototype. Building the model did help me gain more understanding of the way the building and the building management system works. It even showed me other possibilities that the system currently does not have. And with the model that I have made it should be possible to continue the workflow that I have planned for after the existing issues in the prototype and model are fixed to the extent where it is better able to match new measurements. A better understanding of the Ironbug plugin is necessary to be able to find the causes of the current issues.

Switching to using the DesignBuilder model this late in the process left me with very little time to fully improve the model. If I would have had the time that I now put into building the Grasshopper model I probably would have been able to set up the detailed HVAC system and I would have been able to optimise more setpoints with this software. Due to the problems with the Grasshopper model I also started too late with the optimisation process. I see now that taking more time for the optimisations could have led to more accurate results. Running a initial optimisation to analyse the results and using these insights to run the actual optimisation could have lead to less excluded results.

Due to the coronavirus, a lot of things changed. I think it, in the end, had the most effect on the working conditions. I am able to focus better on my work at the BT studio than at home. It took me a while to find a good routine but I still feel the productivity was lower. Working at the studio it is much easier to talk to fellow students and ask them for help.