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Reflection

Graduation process

The graduation project started with the existing research project “Future Adaptive Facades and Components” with the question from “Rollecate” Facade Construction Company about the direction the facade industry is heading to. According to the Sustainable Design Graduation Studio, every research project has to fit within two of the four tracks of the Master Building Technology: Façade, Structural, Climate and Computational design. The chosen tracks for this graduation project were Facade and Climate design. In terms of Facade Design, the graduation project delivers a detailed facade system, which can be applied to new buildings or retrofitting projects. In terms of Climate design, the focus lays on sustainability, since the aim of the proposed facade system is to improve energy efficiency of office buildings while providing thermal comfort to the users.

For the current research project an innovative adaptive facade system for offices was developed, which delivers different functions at the same time and can be applied in different climate conditions. This Multi-functional Facade Module (MFM) consists of different units, being multi-functional as a whole, an aspect which is achieved by making a selection of modules to be used according to each project and its context. In addition, the proposed design is modular, which gives the possibility to be altered easily throughout its lifecycle, thus being also adaptive to future innovations. In order to evaluate it, this facade system is tested for an office building in Amsterdam, Netherlands with the main objective of providing thermal comfort to the occupants, whilst minimizing the energy consumption.

The method used in order to define the type of units proposed and their materials was to research the existing adaptive methods applied in the construction industry and define the state-of-the-art. It needs to be emphasized that the chosen reference projects are representative and focus was put on variety in order to show the different potentials that adaptive facades have. In terms of specific time restrictions when the classification was made, it may be possible that examples of the same value were excluded. Through this research, knowledge was gained on the systems used, their functions and materialisation. Consequently, the future trends were defined in the near and far future according to their current level of development and application extent.

All decisions for the design of the façade system were based on the results of this research. In addition, the decision-making process was facilitated by evaluating the most relevant case studies and the conclusions they reached from simulations or if already demonstrated and tested. The products and projects that were studied led to the definition of the design principles that needed to be followed

and also to the selection of materials and their position in the modules. This method appeared to be efficient because the whole scope of adaptive innovative systems were taken into consideration, both ready products already in the market as well as research projects with future potential. Nevertheless, it is important to be mentioned that not all case studies mention extensively how exactly they work or the exact materials used and thus it is possible that parameters and materials of similar importance and efficiency as of the ones chosen, were not considered. The selection was based not only on the conclusions of these research projects but also taking into consideration the feasibility of their application in the near future as defined together with "Rollecate".

As far as the testing is concerned, both hand calculations and simulations were conducted. The hand calculations preceded the simulations for three reasons; first to ensure that the specifications of each module reach the official requirements in terms of thermal insulation quality level for office buildings in the Netherlands, second to have an indication which modules are more effective in terms of providing the thermal comfort and third to have a first evaluation of the modules performance, ensuring that the approach is logical. Then the simulations would give more accurate results of the overall performance since there are materials tested, which behavior is very difficult to calculate by hand. Nevertheless, even in the simulations some simplifications are involved, since these materials are adaptive and thus almost impossible to be simulated by a software as they would act in reality. The composition of the chosen units materials were all possible to be made with a small difference just for one of them, which is considered negligible to be able to influence the results. However, the only aspect which was not included to the simulations was the heat provided by the natural ventilation modes because of software restrictions and thus calculated by hand and added later to the results. If simulated, the results would be more accurate although the current calculations are considered to give a good approximation.

The results obtained were beneficial and showed a much better energy performance in comparison to that of a typical office construction, which were also the desired resuts. In addition, the logic of the design with modules delivering different functions and performing better as a whole was validated to be working since the more modules were combined and simulated, the better results of energy performance and comfort were achieved.

ii. Societal impact

Nowadays, most offices facades are a typical, usually fully-glazed curtain wall, a quite standardized solution which leads to the creation of similar buildings although constructed in different countries with different climates. The proposed Multi-functional Facade Module (MFM) offers an adaptive solution for this standardized practice lowering the energy consumption, improving the indoor environment and offering more aesthetical variety. An additional advantage is that the facade system is not only applied for new projects but could also be used for retrofitting with the use of an additional substructure, leading to substantial improvements of the building's performance. Nevertheless, it should be mentioned that a higher level of complexity is involved in comparison to a widely used common curtain wall system, not in terms of the facade type used but of the materials and layers applied.

It is certain that the proposed project is applicable in practice for two main reasons; first there are quite a few similar projects currently under development as presented in the research framework of this report, which have reached positive conclusions, promising great potential in terms of energy performance and second the results of this research project also prove that MFMs are performing well offering considerable energy savings. Besides, the proposed design is incorporated in a unitized facade system, which is already widely applied. Furthermore, this design leads to a much better and more efficient management of the indoor environment, since less energy is required in order to reach the official standards and requirements, which is undeniably a big advantage especially concerning the 2020 zero-energy buildings regulations.

Except for the climate considerations, in terms of technical benefits, the proposed system is modular, an aspect which offers several advantages. First of all, the units of the facade system are demountable offering flexibility in component reuse. Moreover, they are transportable by truck, since they are small in size and relatively lightweight. In addition, a single element can be easily replaced with another one offering the advantage of upgradeability. This is extremely beneficial because it gives the possibility of improving the facade even more in the future according to new innovations and developments of the system or to the changing wishes of the building's users. In addition, unitized facades are composed out of individual off-site prefabricated elements leading to a fast and economic installation with limited use of resources in manpower and tooling compared to traditional curtain walls. Last but not least, maintenance is also easy to be performed since the system used is unitized.

In conclusion, taking all these factors into consideration, it is obvious that the Multi-functional Facade Module is a promising facade concept for future applications. MFMs offer not only an adaptive but also a sustainable solution to the construction of office buildings ensuring the new EU building regulations are met, which impose that by 2020 all new buildings should reach nearly zero-energy levels.