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Performance Evaluation of Dynamic Facades

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Abstract
Dynamic facades have a significant role in reducing building energy use while improving the comfort of the occupants. Also, dynamic facades can increase energy efficiency and the use of renewable energy while maintaining high levels of indoor environmental quality. This study explores advantages, disadvantages and future expectations considering the dynamic facades. The objective of this study is to gain an understanding of how experts currently define the major strengths, weaknesses, opportunities and treats of dynamic façades, key performance indicators they use and their vision for the future of dynamic facades. A qualitative study design was performed, using semi-structured interviews. Seven interviewees working in academia and practice were selected who represented the range of possible dynamic façade professionals, from researchers and designers considered performance in the assessment of dynamic facades. Our findings emphasize the challenges and the gaps for further development of effective facade control for high-performance operation of dynamic facades.

Keywords
Facade experts, semi-structured interviews, key performance indicators

1. Introduction

The main purpose of an envelope is to protect the structure and its contents from exposure to the environment effects (extreme temperatures, solar radiation, humidity, wind, rain, snow, etc.). Other considerations are generally user comfort such as acoustics, indoor air quality, etc.), aesthetics, durability, sustainability and energy performance (Moghtadernejad, 2013). During the past decade, façades are one of the most important contributing elements in reducing energy consumption. Material selection and design of façade components get more complex because of the increase in performance demands. Dynamic facades are made of different subsystems and different dynamic façade technologies and solutions have different interactions with the HVAC system, occupant comfort expectation and other building subsystems. This results into very complex systems and subsystems with very hard to predict controls and interactions. Therefore,

assessment of dynamic facades has many challenges and we are willing to address those challenges and identify the gaps according to experts' opinions.

2. Scope and Method

This paper attempts to investigate the performance of dynamic facades from the view of dynamic facade experts who have minimum 6 years experiences. For this purpose, a questionnaire was prepared and seven dynamic facade experts including academicians, architects, facade subcontractors and facade consultant were interviewed.

2.1 Interview Set-Up and Background Information

Before the interviews, the authors set up a pilot study to test and improve the questionnaire's consistency. Peer reviewers were asked to comment and revise the questionnaire to provide critical feedback in order to optimize the clarity and relevance of the questions. After interviews, verbatim transcriptions were prepared, and the authors asked interviewees for approval of their answers or to include the necessary revisions.
The interview structure consisted of five main sections. In the first section, we identified the background information of the interviewees and their professional experience. In the second section, the definition and interpretation of a dynamic facade was discussed with the experts. In the third section of the interview, participants were asked about the advantages of dynamic facades. On the contrary, in section 4, the participants were asked about the perceived disadvantages of dynamic facades. Finally, in section 5, their thoughts about the future of dynamic facades were recorded.
Most of the interviewed experts represented façade engineers, façade contractors and architects. Experts were selected to cover a wide range of different actors involved in the processes of façade construction, inspection, operation and maintenance. All interviewed experts had an experience ranging from 6 to 10 years and have worked at least on one project with dynamic facades.

2.2 Interview Results

2.2.1 Definition of dynamic facades

Most interviewees associated AFs with their dynamic nature and ability to react to outdoor or indoor conditions. Solar radiation and light transmittance control were frequently mentioned as examples of useful dynamic facades' characteristics, followed by ventilation. However, no particular key performance indicator was cited when interviewees were asked how they assess the performance of a dynamic façade. Structural stability was found to be the most commonly discussed performance criterion during project commissioning and inspection.

2.2.2 Advantages and disadvantages of dynamic facades

When interviewees were asked to rank cost, energy and occupant satisfaction in order of importance for dynamic facades. The results list occupant satisfaction, cost and energy in the theoretically ideal order of importance. However, all interviewees had a different ranking about the order of importance of dynamic facades in reality. They mentioned that in real construction

projects, the cost is considered to be the most important variable followed by energy and finally occupant satisfaction. For most projects they participated in, there was no feedback loop regarding occupant satisfaction. Only few interviewees had been involved in a soft-landing stage and performed post-occupancy evaluation for their designed and constructed dynamic facades.

The strengths of dynamic facades involved providing dynamic operation for optimal daylighting, solar control and natural ventilation and the optimization of heating and cooling loads. Also, interviewees identified the empowerment of users to control the indoor climate as a powerful benefit leading to higher occupant satisfaction and productivity. In parallel, there is an opportunity to increase dynamic facades in the market due to mass customization and the advancement of building controls. On the other hand, the high investment cost and the need for tailor-made solutions for dynamic facades were identified as weaknesses. The largest risk associated with dynamic facades was the operational and construction stage and the weak management of the maintenance and long-term performance and occupant control.

2.2.3 Dynamic characteristics of the projects

Interviewees were asked that the dynamic characteristics in their projects. According to the answers there are various dynamic project characteristics, such as operable windows, shadings, wind speed and water sensor, light transmittance as well as ventilation systems (Figure 1).

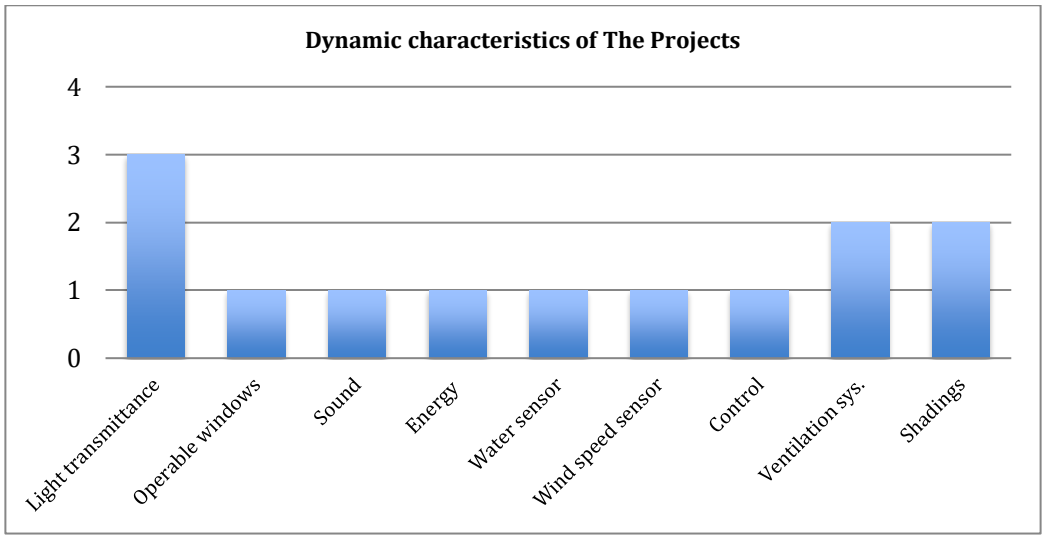

Figure 1. Dynamic characteristics in the projects

2.2.4 Key performance indicators of dynamic facades

Authors asked the interviewees the key performance indicators that they use in the performance assessment of dynamic facades and some of the answer were stability and robustness, water and air tightness, annual energy consumption, performance of structure, interaction between components as shown in Figure 2.

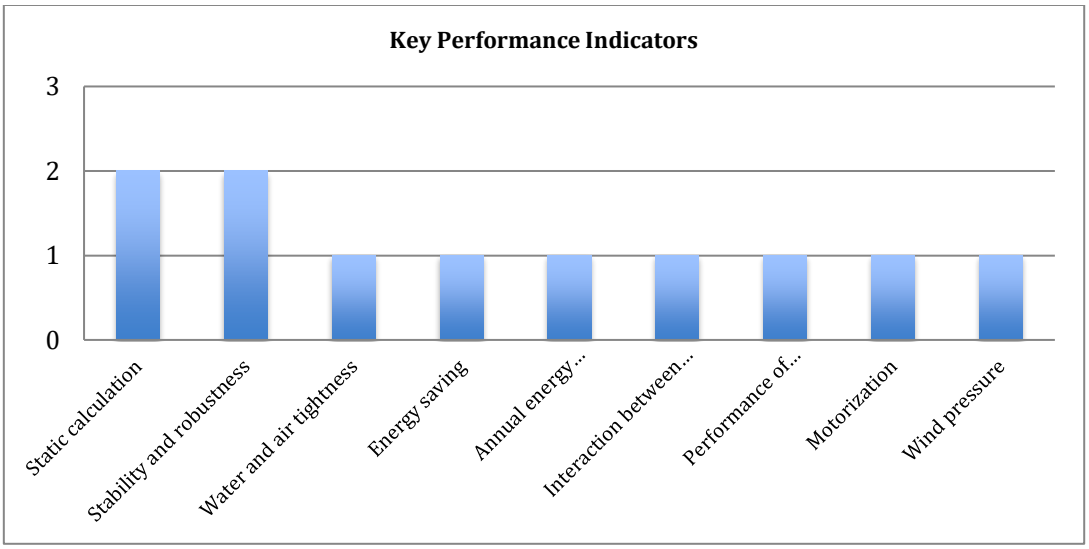

Figure 2. Key performance indicators in the projects

2.2.5 Future of dynamic facades

Interviewees described their expectations and future ideas that dynamic facades should integrate. Three major questions shaped the responses and are structured under the following paragraphs:

What needs to be done for a better dynamic façades' design process and performance quality?

- Develop a framework of KPIs that are user-centric and that address occupants' well-being and productivity in relation to dynamic facades.
- Determine universal user satisfaction indicators and standards and associate them with dynamic facades environmental performance.
- Develop better tools to predict AF performance while taking into account users and their behavioral variability and the dynamic nature of the facades.

What features would you expect to find in future dynamic facades?

- User-driven façade technologies using smartphones or individualized preset occupant operation preferences.
- Real-time personalized and individualized control.
- Intelligent feedback mechanisms to visualize outdoor and indoor conditions in real-time.

Who should be responsible for maintaining the dynamic façade performance after construction?

- Performance contracts can be used to maintain the performance of AFs as part of the whole building level performance.
- By developing holistic guarantees for AFs' maintenance, operation and continuous commissioning, it will become a common practice resulting in a robust facade performance.

3. Conclusions

The aim of the study was to analyze the expert opinions in order to identify the gaps in dynamic facades performance. The methodology used in the study was based on semi-structured interviews. The interviewed experts could not form a statistically representative sample.

However, they provide a snapshot that was elaborated on by the authors in terms of current challenges in dynamic facades performance assessment.

Dynamic facades must function in relation to occupant comfort and different KPIs. Product-based facades should be designed, constructed and operated as integrated systems. Quality assurance and holistic assessment can only be guaranteed by long-term monitoring and by coupling performance to their operations. The authors are expecting that the assessment of dynamic facades and performance evaluation will increase its market penetration. However, this needs to be coupled to mass customization and personalized occupant control. Smart and predictive maintenance can assure dynamic facades robust performance and their liability.

References

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