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Sustainability in Façade Design: Approaches and Outlooks from Design Practitioners

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Abstract

The concept of sustainability has risen in the last three decades, as a vehicle to guide our efforts to overcome major environmental and societal challenges such as global warming and environmental degradation. The built environment is responsible for about 40% of the global CO2 emissions, a fact that has led to countless debates, approaches, and new technologies for the design of our buildings, and especially, the building envelope. The goal of this paper is to explore the current role and the impact that sustainability has in the design of the building façade, based on the insights from practicing architects with relevant experience in the field. While we know of countless theoretical approaches and design theories to deal with sustainability, the point of view from practitioners has hardly been in the spotlight. So, the input for the assessment was obtained through a series of interviews with designers, representing 34 different architectural firms in the Netherlands, between January and April of 2020. The 34 interviews followed a semi-structured questionnaire comprising open-ended questions, structured around different themes concerning their façade design process. The present document showcases and discusses the results from the following questions: what is the role of sustainability in your façade design process? How does it influence the result?

The exploration of the gathered information shows that within the broader scope of sustainability, circularity is the most mentioned set of aspects that currently have a clear impact on façade design, closely followed by energy related aspects, and further below issues related to the user, nature inclusion, and val. Furthermore, it is possible to identify different and sometimes clashing approaches derived from different notions of sustainability: some interviewees believe in permanence and timeless buildings, which leads to massive structures and detailing focused on ageing and durability; while for others it mainly revolves around using less raw materials and re-use/recycling potential of building components; which leads to light structures, with focus on connections aiming for total disassembly and material recovery. These, among others, should be regarded as possibilities to choose from a set of potential approaches, whose suitability should be carefully assessed to match each project brief, under the larger aim to design and build sustainable façades, buildings and cities.

Keywords

Façade design, sustainability, design process

1 INTRODUCTION

The concept of sustainability has risen in the last three decades, as a vehicle to guide our efforts to overcome major environmental and societal challenges such as global warming and environmental degradation. The built environment is responsible for 39% of the global CO₂ emissions (UNEP, 2019), a fact that has led to countless debates, approaches, and new technologies for the design of our buildings, and especially, the building envelope. The façade is arguably the most complex system in any building, having to deal with a myriad of requirements ranging from technical to symbolic, in its dual condition of interface between inside and outside and literal face and expression of the building. Therefore, it is there where said approaches and technologies collide during the design process. Nevertheless, while we know of countless theoretical approaches and design theories to tackle the issue, the point of view from practitioners has hardly been in the spotlight.

Architects are the main professionals in charge of putting sustainable measures in place within our built environment, adding them to the inherent complexity behind the design of our buildings and their façades. Understanding how they deal with these challenges in their design process is regarded as a key issue if we seriously strive to make a sustainable built environment a reality. New challenges will undoubtedly impact the design choices of said architects, thus indirectly defining the performance, construction and aesthetics of building façades. However, it is not always clear what these challenges entail, nor what is exactly being asked from a sustainable design. So, what do architects understand under the broad term of sustainability when it comes to façade design? How do they apply this in their practice?

The goal of this paper is to explore the role and the impact that sustainability has in the design of the building façade, based on the insights from practicing architects with relevant experience in the field. This entails a dual purpose, aiming to identify certain concepts underlying the notions of sustainability that are currently understood by a sample of practitioners; while aiming to understand their façade design choices and the approaches they currently follow in the name of sustainability. Hopefully this knowledge will provide relevant insights to the practical application of sustainable measures in façade design, from the perspective of architectural designers.

2 METHODOLOGY

The study follows the qualitative evaluation of primary information by means of content analysis techniques. The input for the assessment was obtained through a series of interviews with designers, representing 34 different architectural firms in the Netherlands (based in Amsterdam, Rotterdam, The Hague and Delft), between January and April of 2020. The 34 interviews followed a semi-structured questionnaire comprising open-ended questions, structured around four themes: (I) General design approach, (II) Façade design elements and intentions (III) Aesthetic perception of façades, and (IV) Sustainability in façade design. The present document focuses on the results from the last theme, which circled around two related questions: What is the role of sustainability in your façade design process? How does it influence the result?

The architectural firms that participated in the study mostly comprise small-sized companies, having between 10 and 49 employees (47%); being followed by medium ones (41%). Within the latter, a sub-distinction is made, between medium-sized companies with less than 100 employees (10 firms / 29%) and medium-large-sized companies employing 100-250 people (4 firms / 12%). Lastly, 4 micro-sized companies (less than 10 employees) also took part in the study (12%). About the interviewees, the vast majority holds a Partner position in the firm (85%, considering 9 Partners and 20 Founding Partners); while roughly a third of the group has had between 10 to 19 years of

experience in architectural design (32%), and another third has been designing for 30-39 years (32%). The remaining third is composed of professionals with 20-29 years of experience (18%) and others with more than 40 years in design (15%).

Figure 1 shows the complete sample in terms of their declared years of experience and the size of the firm they represent. The graph shows a high dispersion in the years of experience declared by the interviewees, evidencing an heterogeneous sample. Furthermore, this wide range of experience is reflected across the different categories of company sizes. Moreover, the graph distinguishes between the interviewees who stated to have more experience working on residential projects (housing and mixed-use buildings), and who declared to have more experience with non-residential buildings (commercial, cultural, educational and public buildings, among others).

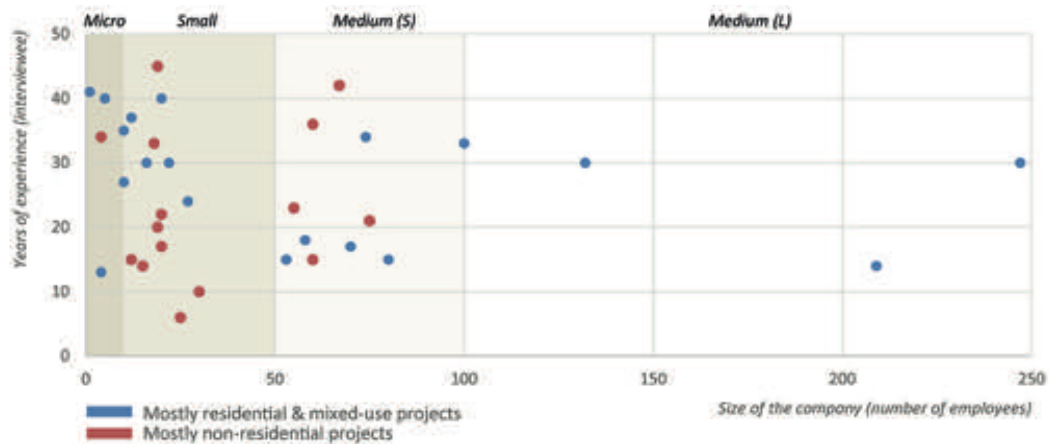


FIG. 1 Years of experience declared by the interviewees vs. the size of the company they represent

3 RESEARCH

3.1 CONTENT ANALYSIS AND CODING OF THE RESPONSES

The interviews were recorded and transcribed; to be then coded for the assessment using the software ATLAS.ti, resulting in a database in Microsoft Excel to allow for the qualitative and quantitative analysis of the gathered information. By coding the responses, it was possible to identify 27 distinctive keywords, depicted in a word cloud in Figure 2. The word sizes reflect the frequency of each keyword within the pool of responses.



FIG. 2 Word cloud of identified aspects (keywords)

An initial exploration of the keywords showed that the consideration of passive strategies is the aspect most mentioned by the sample (n=14), being addressed by almost half of the interviewees; followed by material durability (n=12); permanence (n=12); and recycling & reuse (n=10). As a second step in the assessment, the keywords were grouped into larger themes, categorising the gathered information for a better understanding of the responses. Based on the 27 keywords, 5 main themes were identified: (I) energy, (II) circularity, (III) user, (IV) nature and (V) value (Fig. 3).

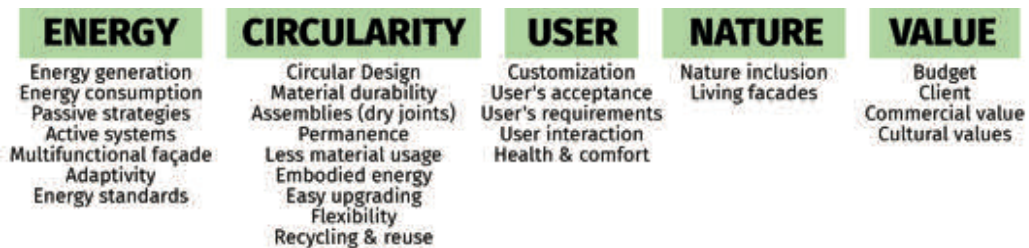


FIG. 3 Identified themes across the mentioned aspects

The keywords grouped under energy consist of aspects related to the energy flows required for the successful operation of our buildings. The mentions by the interviewees consider energy consumption (n=8) and energy generation (n=9), as central aspects for the design of nearly zero energy buildings (NZEB), establishing demands and limitations for the design of their envelopes. Likewise, in this group belong mentions of passive strategies (n=14) that may be applied as part of the design of the envelope, such as the use of louvres or insulation; or the potential integration of active systems and new technologies (n=6) to improve the energy efficiency of the overall building, such as heat storage components or decentral ventilation units. The explicit mentions of the multiple functions that façades need to increasingly accommodate were gathered within the keyword multifunctional façade (n=2), making a distinction against mentions for the need for adaptive façades (n=5), understood as façade systems that are “able to change its functions, features, or behaviour over time in response to transient performance requirements and boundary conditions, with the aim of improving the overall building performances” (Loonen et al., 2015). Lastly, this group also considers mentions of energy standards and building regulations, due to their direct impact on design decisions (n=7).

The second group, dubbed circularity, considers first of all general mentions of circular design (n=6), plus other aspects related to the efficient use of material flows and resources in the building construction. Among them, there is a relevant number of mentions of material durability (n=12) and overall material usage (n=4), alongside concerns for the embodied energy of materials and components (n=9). Regarding the direct impact of these concerns on the design of façades, the group gathers diverging approaches on the matter. On the one hand, it is possible to identify permanence (n=12) as a relevant concept posed by interviewees advocating for long-lasting buildings that can pass the test of time, by means of durable materials and a timeless design. On the other hand, the conception of buildings as assemblies was posed by a section of the sample, with emphasis on the design of construction details under dry connections (n=9), which allow for the easy disassembly of the building and/or its components. Other mentions in the group refer to the recycling & reuse of building components (n=10), either allowing the reuse of new components by ensuring an easy disassembly, or incorporating reclaimed materials into a new design. Lastly, the ability of the façade to accommodate changes during the lifetime of the building was reflected in mentions of the need for more flexibility (n=7) and the easy upgrading of its components (n=5).

The third identified theme revolves around the user and groups aspects that were declared to have a role in the design of sustainable façades, such as users' requirements in general (n=3), where health & comfort requirements were identified as distinctive aspects (n=4); and users' acceptance (n=2) was explicitly mentioned in a couple of cases. Here the distinction refers to the pragmatic nature of answering to general and various functional requirements stated during the design process, while acceptance speaks of the approval of the result, appealing to personal preferences. Single mentions within the theme referred to user interaction (n=1), and the potential for customisation (n=1).

The fourth theme, nature, focuses on the use of nature-based solutions as a resource for the design of façades, with the aim to benefit biodiversity in our cities. Within this theme, two keywords were grouped: living façades (n=7) and nature inclusion (n=4). The former refers to the integration of greenery in the building envelope, either as green façades, where climbers are attached to building surfaces; or living walls, where plants directly grow on fertile modular panels (Perini et al., 2011). Nature inclusion is a broader concept that explicitly tackles the aim of restoring the urban ecosystem, which not also includes the use of vegetation, but also promotes biodiversity by actively attracting bees and birds into urban areas.

Lastly, mentions of budget constraints (n=5), the relation with the client (n=4), and the commercial value of the façade (n=2) were grouped under a theme labelled value. These mentions mostly tackle practical aspects and difficulties of implementing sustainable measures in the design of the building envelope, asking the designers for inventive solutions to keep projects on the agreed budget; and constantly advocating for these measures in talks with the clients, trying to convince them by means of quantifying the potential returns that these could have in the long run. Also within this group it was considered a mention for cultural values (n=1), in the case of the renovation of heritage buildings, broadening the scope of what value refers to in the application of sustainable measures. The fact that these practical aspects appeared in the study shows the relevance of considering practitioners' point of view, being the ones dealing with practical matters in the name of sustainability.

4 RESULTS AND DISCUSSION

4.1 FREQUENCY OF MENTIONS AND IDENTIFICATION OF RELEVANT ASPECTS AND THEMES

The frequency of the mentions per identified aspect, and the total amount of mentions per theme/group are shown in figure 4, arranged from higher to lower frequency for an easier understanding. It is important to point out that the quantitative assessment of the responses serves an illustrative purpose, to discuss the relative perceived relevance of these aspects within the interviewed sample. Hence, these results must be understood as merely referential, needing further research to unequivocally judge their overall importance. With this in mind, passive design strategies have the higher mentions, their application being regarded as the most clear impact that concerns for sustainability have in the design of the building envelope. Nonetheless, the energy group comes second after the circularity group, which gathers most mentions, by being addressed by 30 out of the 34 interviewed professionals (88% of the sample). These two themes (energy and circularity) were by far the most associated to sustainability in façade design by the interviewees, not just by the number of mentions, but also by the number of distinguishable aspects identified in their responses and their level of detail, which will be discussed in the following paragraphs.

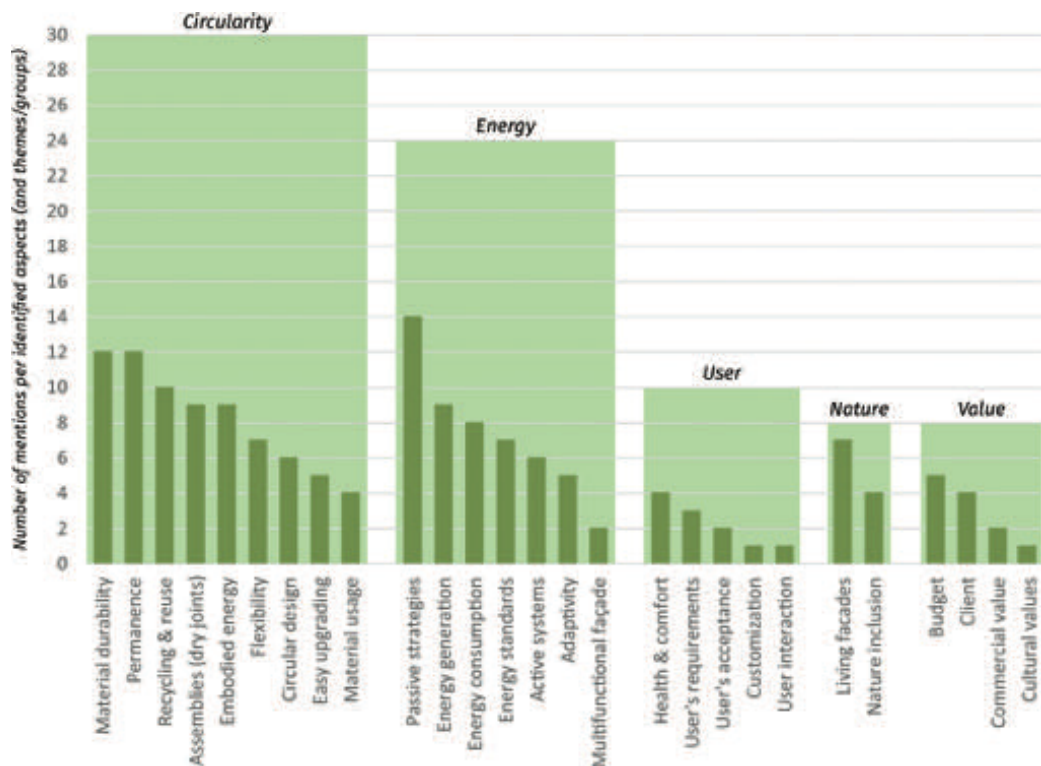


FIG. 4 Frequency of mentions for each identified aspect and total mentions per theme

The fact that circularity, as a group, scored the highest comes as no surprise, given the current attention and interest around such concepts. Notwithstanding, it is refreshing to see how embedded it already is in Dutch designers' practice and their concerns about the future. When answering, several interviewees stated concerns about the lack of information and validated tools to assess the impact of circularity on building construction. Moreover, and directly related to the previous

statement, there does not seem to be a unified strategy to incorporate these concerns into architectural design. Hence, based on the gathered responses, it is possible to see that the firms have adopted particular approaches that suit their work flow and design views, as a way to wrap their heads around circularity themes, aiming to stay ahead of regulations on the matter that they know will come sooner rather than later. This issue will be expanded upon in section 4.2.

After circularity, energy appears as a major issue, although it is the authors' opinion that the fact that energy appears second might be explained by the early internalisation of energy requirements in their daily practice. Thus, it seems to be taken for granted, skewing the number of mentions and making it seem like it is a secondary issue (although the number of mentions correctly reflect the fact that right now, circularity seems to be the major issue that Dutch architects are trying to wrap their heads around). This statement is backed by the tone of some responses when stating that "obviously, one aspect is the technical one. If you have to make an energy neutral building there will be a lot of let's say limitation or demands on the façade", or "it starts always with insulation and sun and all of that, in order to try and make sure it (the building) performs energetically as well as we can".

One of the major concerns declared in relation to energy aspects, refers to the impact stringent regulations have on the final design, mostly regarding daylight availability and the decrease of transparency in buildings. Thus, some interviewees stated as a relevant issue in their daily practice, to find the balance between energy performance and daylight access when it comes to defining window-to-wall ratios and window position in their façade projects. Moreover, some interviewees expressed concern about the impact that increasing temperatures will have on Dutch buildings, which is not considered in current regulations and building guidelines ("there is a sort of strange contradiction between the fact that we insulate like hell and the climate is becoming warmer"). Another relevant concern expressed within this theme was related to energy generation and its role in energy neutral buildings. It was explicitly stated by some interviewees that the need for energy neutrality in the built environment will make the integration of PV panels in façades more common over time, due to the lack of roof space, which will bring completely different aesthetics. While some interviewees merely referred to PV integration in buildings (BIPV) as a fact that architects will have to increasingly deal with, others took a strong stand against the need for building integration, arguing "why should architecture be defined by PV panels?! Come on! We should find another way and take it away from the buildings. What do we do with all this technical stuff in about 10-20 years?"

The user and nature groups, while less mentioned, are regarded as emerging themes. About a third of the sample mentioned at least one user-related aspect, and several aspects were distinguished within the group, which shows the multiple facets of an issue that is nowadays getting increasing attention. Similarly, the application of nature-based solutions in the built environment has been heavily promoted by the European Union in the last years, being defined as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions" (European Commission, 2015). When it comes to the building façade, nature-based solutions mostly refer to green façades or living walls, as the responses showed; however other strategies for nature inclusion are also attracting attention, evidenced by the integration of "bee hotels" and nesting zones in projects declared by the interviewees. The fact that about a fourth of the sample mentioned these aspects is regarded as a promising sign of their ongoing application, which is expected to increase in the coming years based on their active promotion.

Lastly, value related aspects were mentioned as the most practical impact derived from the application of sustainable measures, evidenced by statements referring to the return of initial investments ("budget versus how much money the building can generate once it's finished"), or maintenance costs associated to complex measures ("we had a complex double façade with solar shades in between, ventilation and openable windows... the maintenance costs were constantly a discussion"). Nonetheless, while budget issues are of course central for the implementation of sustainable measures, the same interviewees that declared this also stated that they have seen an ongoing change on the clients' wishes and willingness to implement sustainable measures, which greatly facilitates the process.

4.2 RELATION BETWEEN THEMES/ASPECTS AND IDENTIFICATION OF TRENDS

Sustainability is a multi-variable concept, which tackles multiple areas of knowledge and practical applications. Thus, the responses of the interviewees usually considered mentions of multiple aspects, touching upon more than one of the previously discussed themes. The average number of identified mentions per interviewee was 4.8; divided across 2.4 themes in average. Because of that, these cross-mentions were explored as a second part of the assessment, aiming to show the interviewees' understanding of sustainability in façade design, not only considering isolated mentions of certain aspects but also potential relations between them.

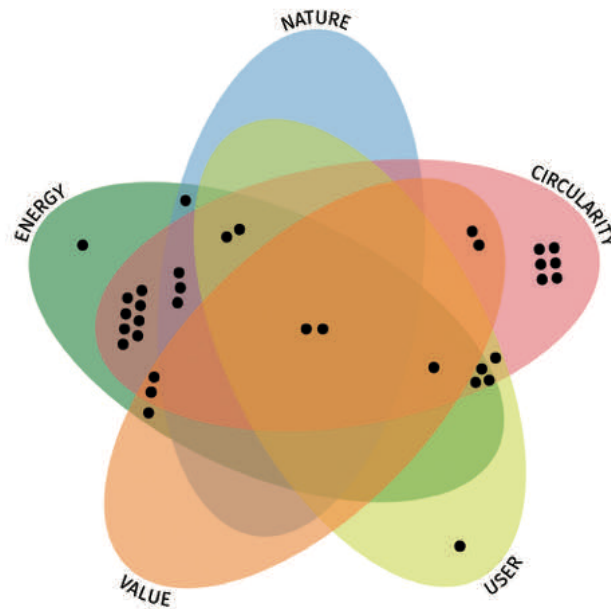


FIG. 5 Position of the interviewees' responses based on the themes they tackled

Figure 5 shows a 5-way Venn graph showing all responses in relation to the themes they tackled (using the online tool developed by Bardou et al., 2014). So, each dot represents a different interviewee, and its position shows which themes shape their understanding of sustainability. As discussed earlier in the text, circularity aspects were mentioned by 88% of the sample, while energy aspects were mentioned by 71%. Moreover, interviewees that mention aspects contained in either one or both of them add up to almost the total sample (97%); cementing their position as the themes most commonly associated to sustainability when it comes to façade design. Only one interviewee did not explicitly mention any aspect within those themes, placing the focus on users' behaviour and their interaction with the building envelope in order to control or at least modify their

comfort. Nonetheless, this posture does not negate the relevance of the aforementioned themes, but simply chooses to actively place the focus somewhere else (the user).

As another layer in the assessment of the responses, an effort was made to identify trends based on potentially distinguishable relations between groups of aspects, that would allow to identify different approaches to the topic of sustainability; and then compare these trends against basic characteristics of the surveyed sample, in an attempt to check for the existence of potential designers' profiles when it comes to following these approaches. This, of course, as an exploratory exercise constrained within the boundaries of the sample size considered in the study.

Given the multi-variable nature of the overall concept of sustainability, in general there were no discernible patterns or trends. Nonetheless, two clashing approaches were distinguished when it comes to circularity: (a) permanence; and (b) design for disassembly. Figure 6 shows a 4-way Venn diagram depicting the relations between these aspects from the interviewees' responses; where it is possible to see on the one hand that mentions of permanence and material durability are highly correlated; while on the other hand, fairly distinct from the first group, there is also some correlation between mentions of assembly and material usage.

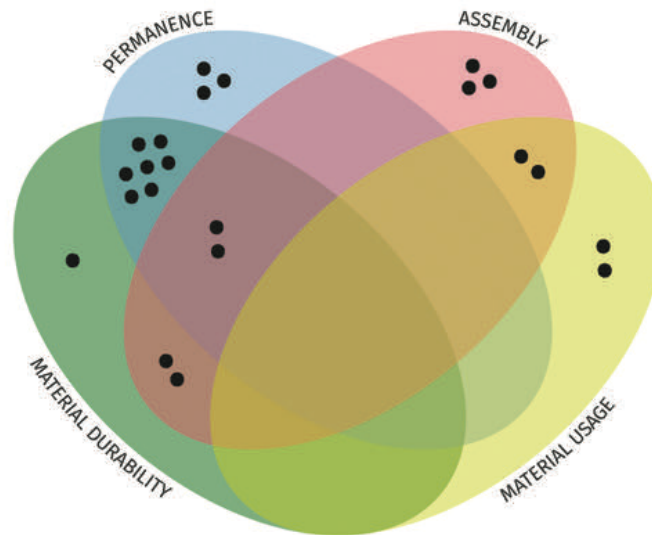


FIG. 6 Interviewees' responses related to selected aspects within the circularity theme

A more detailed overview of the responses effectively shows that designers who declared permanence as one of the aspects related to sustainability, also mentioned to strive for timeless buildings; besides a predilection for the use of "real" materials such as natural stone or concrete, over steel or aluminium, based on how well the former sustain the passage of time. Therefore, in these cases, the design of the envelope follows massiveness as a guide, with façade detailing focused on improving the durability and aesthetics of the building surfaces over time. The reasoning behind this approach entails that long-lasting buildings make a more efficient use of the material and energy resources embedded into their design and construction, aiming to keep these on-site by prolonging the operation phase for as long as possible (Foster, 2020). Consequently, besides massiveness and the use of materials that do not require major maintenance; a key aspect in the design of façades within this approach is an embedded flexibility and resilience, that allows the façade – and the building behind it – to accommodate to changes that will occur along its lifetime.

On the other hand, reviewing the responses that contain mentions of façade design as an assembly of components, it is possible to see assembly-related aspects along concerns for the recycling and reuse of such components and materials. Moreover, the responses also referred to the need to use less raw materials; which of course circles back to the reuse of already processed building materials and components, but also entails the design of slender structures and lightweight façades, where material usage has been optimised for their particular performance. If the first approach was based on permanence and usage flexibility to achieve a 'never-ending building'; thinking of buildings in terms of assemblies focuses instead on their components' lifecycle, under the assumption that buildings do not need to last forever, but their parts and components need to be designed to allow for their reuse in other buildings under a smart output approach (Heesbeen & Prieto, 2020). Consequently, a key aspect in this is the design of the interfaces between components, based on dry connections and mono-material components, striving for total disassembly and material recovery.

When comparing the mention of these approaches against other responses from the interviewees, no clear correlations were found. This means that the predilection for either approach does not seem to follow any discernible pattern that could help defining designers' profiles. This holds true when comparing the responses against basic sample descriptors such as their declared years of experience, the size of the firms they represented, or their particular expertise in either newly built projects or renovations; and also other responses from the questionnaire such as their understanding of the main role of façades, the role of façade design within their building design workflow, or aesthetic preferences when it comes to façades. The only exception to this, would be a faint relation encountered between the mention of these approaches and the declared main experience of the interviewees in terms of either residential or non-residential projects. Hence, it was found that designers who mentioned permanence and durability as aspects related to sustainability, tended to be the ones who declared to have more experience with residential projects; while the mentions for assembly were almost equally divided among the ones who declared to have mostly worked in residential and non-residential projects, slightly favouring the latter (Fig.7). This fact seems to make sense, considering the different nature of both types of projects (arguably, housing is generally meant to last and blend with the urban layout; while the usually iconic aspect of non-residential buildings means that they are subjected to more changes during their lifetime); nevertheless, although this fact is worth mentioning within the exploratory aims of the study, further research activities with a larger sample are needed in order to test and fully corroborate this finding.

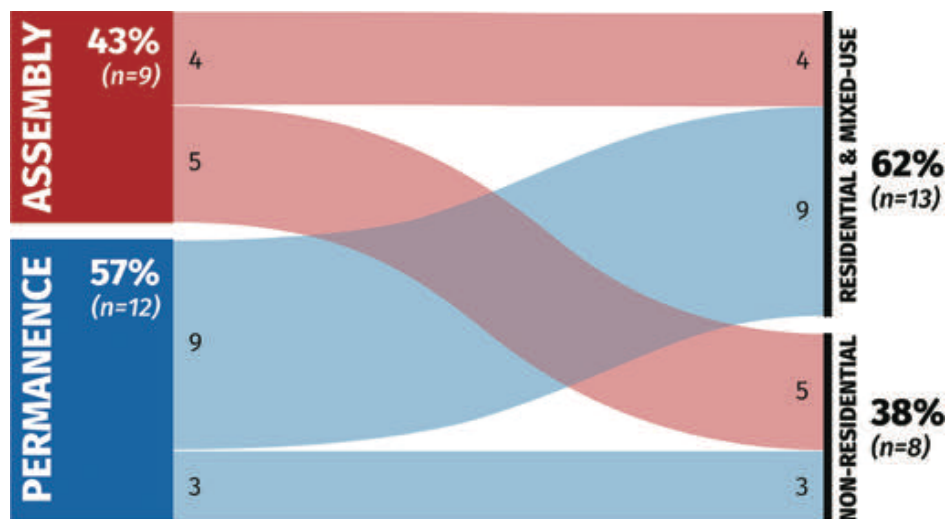


FIG. 7 Relation between mentions of the identified approaches and the main experience of the interviewees

5 CONCLUSIONS

The paper aimed to explore the role and the impact that sustainability has in façade design, through the analysis of gathered responses from several interviews with experienced architects, from 34 architectural firms based in The Netherlands. Based on the responses, it was possible to identify several aspects that have an impact on the design process, which were categorised in 5 distinct themes: energy, circularity, user, nature and value. Energy and circularity themes clustered most aspects, and received the highest amount of total mentions. As an isolated aspect, the integration of passive design strategies was singled out to be the most mentioned; while the highest total mentions of the circularity theme are regarded as evidence of the current interest around these issues in architectural design.

The fact that the interviewees mentioned multiple aspects across different themes within their responses; perfectly shows the multi-variable nature behind the concept of sustainability, tackling multiple challenges that respond to diverse areas of knowledge and practical applications. It is this multitude of aspects, that need to be considered at once, which makes the application of sustainable measures a complex matter. The interviewees acknowledged the fact that more information and tools for a comprehensive evaluation of these measures are needed, to assist them throughout the design process. Also, particularly in the case of circularity, it was possible to identify certain approaches that architects have adopted to navigate through these issues, aiming to incorporate them in their daily practice.

Therefore, when it comes to circular design, it was found that some believe in permanence and timeless buildings, which leads to massive structures and detailing focused on ageing and durability; while for others it mainly revolves around using less raw materials and the reuse/recycling potential of building components; which leads to light structures, with focus on connections aiming for total disassembly and material recovery. The identification of such strategies helps gathering a set of potential responses, which should of course follow the particularities of each case. Thus, it would be wrong to declare one strategy as generally better than the other; instead, they should be seen as possible approaches, whose suitability will be assessed after a careful consideration of the context and brief. This of course, circles back to the need for tools for the assessment of these or other approaches in terms of their response to a given set of requirements.

The exploration of the façade design process and the new challenges that sustainability brings to it, directly from the practitioners' experience; is regarded as a key issue to promote further application of sustainable measures in the built environment under a grounded discussion that includes both theory and practice. Hopefully the identification of diverse strategies and approaches, along with similarities and differences across various points of view; will help designing a common vocabulary for the understanding of sustainability in façade design, which enhances synergies between the different stakeholders responsible for the design and construction of a sustainable future.

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