Material Considerations in Architectural Design: A Study of the Aspects Identified by Architects for Selecting Materials

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Material Considerations in Architectural Design:

A Study of the Aspects Identified by Architects for Selecting Materials

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Abstract

Material selection in architecture is not only about choosing the strongest, cheapest, or most obvious materials available. Architects also choose warm, formal, functional, or local materials for buildings. And the material options are not limited by only these considerations. The material selection process is a complex process that is influenced and determined by numerous preconditions, decisions and considerations. The current material selection tools, however, focus mainly on the technical aspects of materials. In order to make well-considered and justifiable material choices, architects have a need for information on the whole spectrum of aspects considered during the design and selection process.

Earlier work presented a framework, based on a literature study and the analysis of in-depth interviews, in which the different attributes of materials that contribute to a design project were identified and organized. To refine this framework and make it available for architects during the material selection process, a group of architects was selected and assembled into a focus group.

This study presents how the focus group identified, classified and commented on the considerations that are made by architects while selecting materials for a project. The evaluation of the collected data, and the discussion within the group, permitted the formulation of comments and resulted in a revised framework of material considerations, useful during the design and selection process of a material. Material properties (1), Experience (2), Manufacturing process (3), and Context (4) were identified as the different elements that are related to the material selection process. The four groups are presented here in detail.

Keywords

Material Selection; Design Aspects; Architectural Experience; Material Attributes; Focus Group; Design Process

Every architecture project has its personal and individual character due to the many variable facets it is built from; building materials are one of these facets. Numerous architecture projects (think of work by Kengo Kuma, Herzog and Demeuron, or MVRDV) illustrate that the material choice does not only determine what *can* be built, but also determines the character of the building.

Nowadays, an increasing diversity of materials is available for the buildings that architects design. To choose among this large number of materials, the architect has to take into account several design criteria. In general, every material selection process is employed to fulfill a simple need, identifying the best material for a particular application. (Fernandez, 2006) In order to identify what a "best" material can be, it is important to understand what aspects are at play while architects are choosing materials. Moreover, to facilitate a constructive material selection process, the architects are in need of the proper information on materials (guiding them in taking decisions). Focusing on materials, this paper aims to identify the different elements contributing to the material selection process for buildings, and generate a schematic of basic material selection considerations for an architectural design project.

The paper consists of three parts. The first part briefly situates the research context. The second part presents the results of a focus group study. The last part discusses the similarities and differences of these results with a previous study in order to present a refined framework for selecting materials for an architecture project.

Research context

Lack of information

Designers do not only design for function and use but also for experience. In architecture, the materials that shape an environment will largely influence the user's perception of that environment. Choosing materials for an architecture project is not only about meeting technical requirements, the material's appearance and sensory behaviour play an equally important role while designing (Ashby & Johnson, 2002; Fernandez, 2006; Malnar & Vodvarka, 2004; Pallasmaa, 2005). While selecting a material, the architect considers performance related characteristics, such as the material's durability or compression strength, but also looks into aspects that concern the user experience or sensory stimulation, such as the material's color or texture. Moreover the architect might have a certain atmosphere in mind that will be reflected through the feeling the materials evoke, as a `formal' feeling for a lawyer's lobby or a `trendy' feeling for a lounge bar. Architects are responsible for selecting appropriate materials for our living environments, and should thus take into consideration these varying aspects.

The current material selection tools and material data sheets provide extensive information on the technical aspects of materials, useful for specifying a material's technical performance. These material sources, however, lack the considerations or descriptions to evaluate the sensorial and intangible aspects which are important to architects. Ashby and Johnson (2002) introduce `aesthetic attributes' in the material properties list for product designers when describing material aspects such as the transparency, warmth, or softness. Within the field of product design several studies focus on the definition or description of sensorial, expressive or emotive qualities of products (Desmet & Hekkert, 2007; Schifferstein & Cleiren, 2005; Sonneveld, 2007) or more specifically materials (Bergmann Tiest & Kappers, 2007; Karana, Hekkert, & Kandachar, 2008; van Kesteren, 2008).

Within the discipline of architecture, however, the intangible qualities of materials are not described and mapped within the current design models. Even though an increasing amount of books attribute attention to these intangible aspects of materials (Addington & Schodek, 2005; Beylerian, Dent, & Moryadas, 2005; Keuning et al, 2004), this interest is limited to an occasional description of the phenomena without providing a clear and comprehensive overview that might be useful to architect-designers. There is a need for a more structured description of these aspects in order to ease the architect's material selection process.

Understanding the selection process

Before investigating the descriptions of such 'intangible' parameters of materials within the field of architecture, the authors believe that the overall material selection process should be mapped in detail. Fernandez (2006) argues that the contemporary architect mainly makes choices that result in "fabricated assemblies of standardized performance attributes", implying that they do not choose for materials but rather for 'material systems'. He continues that limiting the assembly of buildings to the specification of systems would impede the discovery of design opportunities inherent in materials themselves. The development of a material selection model will frame the aspects that contain these opportunities.

Van Kesteren, Stappers, and Kandachar (2005) present a material selection considerations model for product design where product-personality, use, function, material characteristics, shape, and manufacturing processes are represented as the elements that are considered by the industrial designer during the material selection process. It is however doubtful that this model will be valid in architecture as well. Architecture is not only concerned with a larger scale, also the interaction with the user is different for architecture and product design.

This research aims to identify, organize, map, and describe the different aspects considered during the material selection process in a more comprehensive way, in order to provide this information to architects for use during their material selection process and to allow a less ambiguous discussion of these aspects amongst architects and with their clients.

Focus group study

In a previous study (Wastiels, Wouters, & Lindekens, 2007), in-depth interviews revealed how the choice for a particular material influences a project and how it contributes to create a certain expression for the building or space. A framework was presented based on the analysis of the data (presented in figure 1).

In the following study the material selection process is approached from the architect's point of view, investigating all the aspects that occupy architects while choosing materials. In order to improve and refine the developed framework into a comprehensive overview of material selection considerations for architecture projects, a focus group study with five professional architects was conducted.

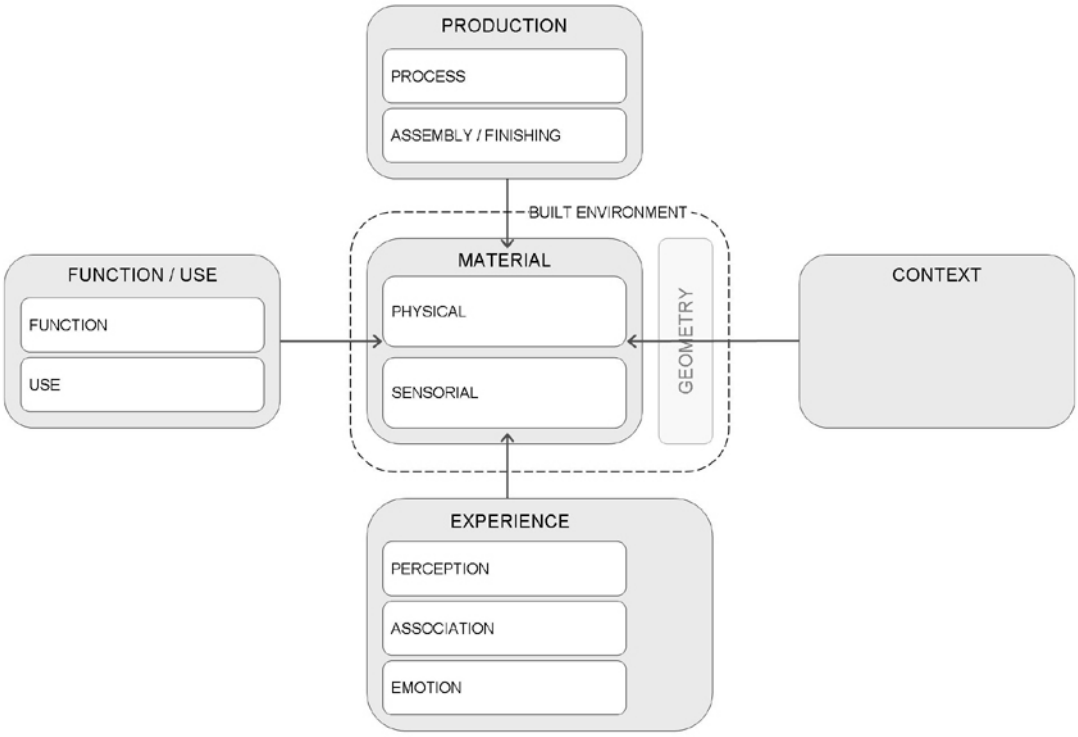

Fig 1. Framework that represents the different aspects that relate to the material choice in architectural projects.

Participants

Five subjects, three male and two female Belgian architects, between 23 and 46 years of age (average age 39), participated in the group discussion. All of them work in practice and their professional experience varies between 6 months and 20 years, with an average of 15 years. One subject arrived late, and joined the group at the start of the second phase of the test. They were not informed on the subject of the discussion.

Procedure

A small pilot study was conducted with two architects to verify the setup and procedure, in order to make small adjustments where necessary. The results from this pilot study were not considered. The final course of the study was as follows.

The focus group study consisted of three phases. First, participants were asked to individually list the aspects they consider while selecting a material for a project. They were given some examples of specific material selection cases, extracted from interviews in a previous study (Wastiels, Wouters, & Lindekens, 2007). These extracts covered a variety of aspects, ranging from function to technical aspects, but were kept minimal in order not to influence or limit their thoughts. Words were written down for 20 minutes on separate post-it notes. Each participant read out their aspects to the others and they were given the opportunity to add extra aspects if they were not already mentioned by the others.

Then, the respondents were requested to perform a free classification task, categorize all notes and ascribe matching headings. They were invited to

organize the aspects into groups in any way that seemed reasonable to them, without any constraints on the number or size of classes. It was up to them to decide the appropriate number of classes and their content. When they reached a classification (after 26 minutes), they were asked to verify the content of the different groups and make adjustments where necessary. A final categorization was established after about one hour. The complete discussion was videotaped for further reference during the analysis.

To end, after a short brake, the framework (fig. 1) (Wastiels, Wouters, & Lindekens, 2007) was presented by the researcher and the respondents were asked to compare and discuss the two frameworks.

Analysis

The focus group discussion concentrated on the identification of overarching themes being significant during the material selection process. The results from the study were analyzed at the level of the creation of the groups, using the content of the groups (the actual notes) only as guides to clarify the decisions or the nature of the groups. The actual words listed by the participants are thus only illustrative of the groups and are not intended to give a comprehensive overview of the content of these groups.

Where the previous study investigated how particular material aspects influence the overall perception of a building, the new study explores which aspects are used by architects to translate their concept and meet the given or formulated set of preconditions. Both issues reflect on the design process and complement each other. The study presented here, thus allows to perfect the earlier developed framework.

The next section describes the results from the focus group study and compares them to the previous framework. In combination with the discussion of the presented framework, a refined model of considerations concerning materials in architecture is presented as a result.

Categories suggested by focus group

The focus group created seven different categories of aspects that are considered while selecting a material: (1) physical aspects, (2) appearance, (3) subjective, (4) cultural context, (5) physical context, (6) time, and (7) money. The final organization is represented in figure 2, and the content of the categories according to the focus group is described next.

‘Physical aspects’ relate to the technical characteristics, which can be found on a technical material data sheet, or are directly related to it (strength, porosity, acoustics, weight). The respondents refer to them as straight engineering aspects. ‘Appearance’ covers the material’s visual or tactual aspects (color, texture, gloss, softness). In the category ‘subjective’ the material choice is related to intuition and is personally influenced (memory, aesthetically pleasing, character, atmosphere). Aspects such as quality, style, and expression, are grouped together under the name ‘cultural context’. Within this group, a subgroup ‘ethics’ is created (ecological, durable, availability, re-use). ‘Physical context’ classes considerations such as location, use, application, and orientation of the building.

A separate meaning was attached to the clusters 'time' (adaptability, flexibility, temporality) and 'money' (cost, time of delivery). Even though the participants were not explicitly asked to organize the notes according to the time process of the material selection, they made an explicit statement about it for these last two groups as opposed to the others. Time and money aspects are seen as matters that are considered throughout the process, constantly feeding the other decisions. These groups were placed crosswise in their organization scheme (see groups 6 and 7 in figure 2).

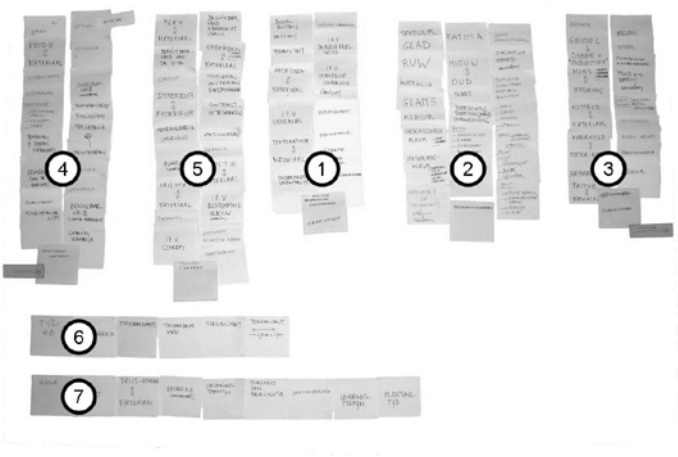

Fig 2. Groups organized by the focus group. (1) physical aspects, (2) appearance, (3) subjective, (4) cultural context, (5) physical context, (6) time, (7) money.

Refining the framework

The framework represented in figure 1 was the result of a literature study in combination with the analysis of in-depth interviews with architects. Five domains describing the material impact in a design and material selection process were identified: 'physical attributes', 'user experiences', 'manufacturing process', 'function/use' and 'context'. In the following discussion, the similarities and difference between the framework and the results from the focus group will be discussed, in order to perfect the framework where necessary.

Context

The physical context was the first category to be suggested by the focus group. The environment in which a project is physically located will usually create the first set of preconditions for the design choices. One participant argues that choosing materials for a renovation project in a five-story building where the construction site can only be accessed by a small elevator will be different from considerations made for a newly built project where the site is easily accessible. Another subject continues that when building in the woods, material considerations might be guided by the fact that mosses will grow on the façade. A smooth coat of plaster might thus not be the best choice, but for a building erected in rough recycled bricks it might be acceptable to be covered with mosses. All these considerations are unambiguously grouped as relating to the physical context.

In contrast, the categorization of cultural aspects troubles the focus group throughout the discussion. One of the subjects would place almost any aspect in the culture group because he believes that everything is culturally influenced. The group argues that culture covers so much, that they could indeed put every aspect into that group if they would like. They agree to organize considerations into other categories where possible, and only retain aspects that are directly related to the culture. Aspects such as quality, style, ecology, and durability can be found as considerations emerging from a cultural context.

In the original framework (fig. 1), all the aspects described above were situated within one general context group. Because the differences between cultural considerations and those emerging from the physical context are significant, both context categories suggested by the focus group (cultural context and physical context) are maintained and integrated as two sub-groups within the overarching theme 'Context'.

During their discussion the focus group created a separate category for aspects related to the context of use. They argued that the differences in material choices largely depend on the nature of the design project, for example designing for a public or a private building. The character of the assignment determines the materialization: a kindergarten, a city hall, or a hospital will each require a different kind of materialization. More specifically the material is related to the function it has to perform; the extreme example that one will not construct a bunker out of glass is given. Even though this cluster relating to the nature of the project was classified within the physical context at the end of their discussion, the final discussion of the framework revealed that aspects related to the function or use are significant during the material selection process and could form their own group of considerations. One would never specify a carpet for use in a bathroom because of the specific function and use of that room. The context of use can thus be seen as different from the physical context because it influences the material choice in a different way. On the other hand, participants agree that the representation of the group 'function/use' in the previous framework (fig. 1) overvalues the group compared to the other aspects of the context, and should definitely not be placed opposite of it. Because the use or function of a building also relates to the project context (and more specifically its program), an additional group 'context of use' is created within the context field.

To conclude, *CONTEXT* has been defined as a group of considerations concerning the existing context of the design project: culturally, physically as well as in terms of use. These are all the aspects that are either defined in the design program, or are the existing conditions of the environment the project is situated in. The *physical context* is defined as aspects concerning the project location (orientation, accessibility) and the immediate environment (adjacent materials and buildings). The *context of use* describes the context in which the material is applied (interior/exterior, renovation/newly built) or the function the material will have to accommodate (building's use, building element).The *cultural context* includes all consideration that concern cultural values (ethics, style, ecology).

Manufacturing process

Even though the manufacturing process and its implications were not mentioned by the focus group during their grouping task, during the discussion of the framework they acknowledged that these aspects can be of major importance while selecting a material. One of the architects mentioned that a mould would not be fabricated if it were for an element only to be used once throughout the construction process. He continues that in a project where a large number of identical elements are required, the production process would definitely influence the material selection process. Based on the fact that the manufacturing process is an important factor for material selection according to several material sources (Ashby & Johnson, 2002; van Kesteren, 2008), as well as based on the findings of the previous work (Wastiels, Wouters, & Lindekens, 2007) the class 'Manufacturing process' was retained as a separate element of consideration during the material selection process.

MANUFACTURING PROCESSES are defined as the aspects that relate to the *production process* (poured, pre-fabricated, hand-formed), *assembly* (dry connection, columns and beams, seamless) and *finishing technique* (polished, varnished, colored).

Experiences

The 'subjective' category was the second one (after the context) to be constructed during the focus group discussion. At that moment these grouped aspects were named 'gut feelings', or 'intuition'. Aspects that determine the character of a building, or how a material application can contribute to the overall atmosphere of a project are discussed. One of the participants mentions that 'hard' can relate to the different associations people make, and that each of them would compose a different palette of materials when they would be asked to design a 'hard volume'. Aluminum cladding might not be very hard in technical terms, but it might feel or seem hard. According to the focus group, intuition relates to how people anticipate on the appearance. All these aspects correspond to the 'Experience' category defined in the framework.

EXPERIENCES are defined as the perception of the (material) environment by an individual, and can thus be referred to as the 'intangible characteristics' of a material. The choice of materials will largely influence the observer's experience of a building or room. Within the considerations on experiences, we discern perceptions, associations and emotions (Karana & van Kesteren, 2006 ; Wastiels, Wouters & Lindekens, 2007). The *perceptive aspects* describe a meaning that is attached to the materials in the form of material characteristics (tough, warm, rough) or human characteristics (friendly, formal, strict). *Associative meanings* are fed by the associations people make with aspects, objects or situations they know (hospital-like, cheap-looking, Swiss-cabin material). *Emotive aspects* are personal emotional reactions of the user to the material (beautiful, repulsive, pleasant). These reactions differ from person to person and can be influenced by mood, preference and culture.

Material properties

Within two minutes after creating the experience group, the focus group constructed the categories 'appearance' and 'physical aspects' as being different. This indicates that architects make a clear distinction between tangible and non-tangible aspects while choosing materials. In terms of their content the groups 'physical aspects' and 'appearance' correspond to the subgroups 'physical aspects' and 'sensorial aspects' suggested in the framework. Both groups are merged under the heading 'Material properties'. After all, the appearance of a material is also a rather objective parameter that depends almost solely on the physical form and performance of the material.

MATERIAL PROPERTIES are defined as the tangible aspects, or actual measurable properties, of the chosen material. These aspects are directly related to the (physical) behaviour of the material and the production technique. A distinction can be made between aspects relating to the technical performance (the physical aspects) and those relating to our senses (the sensorial aspects). *Physical aspects* refer to the different aspects that concern the engineering, like stiffness, strength, porosity, density, thermal absorption coefficient etc. These properties are organized according to their mechanical, technical, physical, optical, thermal nature. *Sensorial aspects* are qualities that we experience through our senses. These aspects could thus be organized according to the different senses into visual (color, gloss, texture), tactile (roughness, warmth), and auditory aspects (dampness, pitch). The olfactory aspects are less obvious to be described but also the smell of a material was mentioned as an aspect that might influence the experience of the final project and thus the choice of materials. Where taste might be of importance in the field of product design, it will have no immediate significance in architecture.

It sounds reasonable that two distinct categories, each with a large number of aspects included, were created by the focus group because the information is used for two very different ends. Physical aspects, such as strength, stiffness, or porosity, will be consulted to meet certain technical or functional requirements. Sensorial aspects are chosen based on the intended expression and appearance the architect searches to achieve in the project. Currently architects have to consult different sources to receive information on these aspects: technical data sheets in combination with material samples and previous use. Even though sensorial aspects can be described objectively, currently they are not included in most of the material information sheets. In the refined framework we present below, the engineering and sensorial aspects are classified under one heading to emphasize that they can all be described based on the material properties and therefore should all be included in a material's technical data sheet.

Time and money

The groups 'time' and 'money' created by the focus group are integrated in the cultural context considerations because we believe these aspects might have an augmented importance to Belgian designers nowadays, even though the focus might be on another aspect within a few decennia. In the 19th century the focus was on hygiene and health, during the reconstruction

'construction speed' was a driving factor. These are all cultural aspects whose importance varies according to the spirit of the times. Also, during the discussion, time aspects, such as adaptability, modularity, or possibility of phasing, were explicitly linked to ethics and money. One of the subjects notes that in earlier days, architects aimed to design a building that would last for 300 years, rather than worry about the cost of the material. This interaction between time, money and ethics relates to the culture and these categories are thus organized within the cultural context in the presented framework.

Designer's intentions

The focus group had difficulties integrating their note 'concept' within their categorization (and so it ended up within the context group). Aspects like articulate, contrast, or integrate are intentions that still need to be applied to the existing situation and thus are no choice-aspect themselves, they are designer-specific. For example, using 'contrast' as a design intention will lead to considerations about the physical context (what materials are applied in the existing environment?) and the sensorial or expressive qualities of the existing materials (using warm materials compared to the coldness of the existing environment).

The "intentions" or "concepts" designers work with can be interpreted as a third dimension to the framework of material considerations. These aspects are designer-related and thus will have an influence on how the framework is interpreted rather than being part of it.

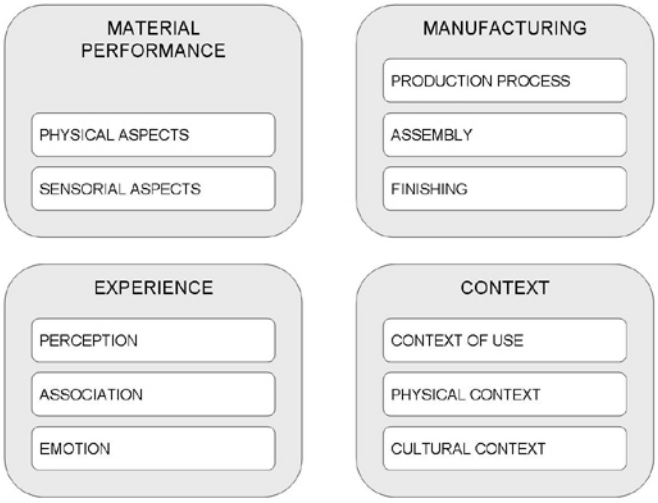

Fig 3. Refined framework of material selection considerations in architectural design.

Categories of material selection considerations

The objectives of this paper were to identify and organize the aspects considered by architects during the material selection process in order to offer a descriptive model on selecting materials for an architecture project.

Based on the comparison of the framework suggested by the focus group and that presented in figure 1, and after analyzing the interaction that took

place during the grouping task, a refined model of material selection considerations in architecture can be presented. The model is represented in figure 3. In the integrated framework four themes of material selection considerations were identified: (I) Material properties, (II) Experience, (III) Manufacturing process, and (IV) Context. The content of each of these categories was described extensively in the previous paragraphs.

In the presented framework, no pronouncement is made upon how considerations from these different categories influence each other. The different examples available from the focus group study, as well as from the in-depth interviews, however, show that the different considerations made during the material selection process are interrelated, and that the selection of a material is based on considerations from all groups rather than one. As one of the participants mentions, a design project starts to demand its own material. *"You can not dictate a material to a building. It demands its own material, from a certain logic, and from a set of preconditions, which can be contextual but also emerge from the design. And it is together that they receive their meaning."*

The framework presented here, provides an overview of the perspectives or features available to the architect while selecting materials, and can guide architects in meeting their design intentions through well-considered material choices. Moreover, it helps to understand and explain the seemingly simple but often complex, refined, and meaningful material decisions, and facilitates the communication with clients and manufacturers.

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