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Sound absorbing textile surfaces in the urban landscape – collaborative research in textile and architectural design

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Abstract

The design of woven and knitted structures can be compared with the formation of buildings' facades and constructions. However, textile designers do not generally participate when the exterior structure and facades of a building take shape, but rather when textiles and materials for the indoor environment are chosen, often with the intention of enhancing the acoustic qualities of spaces. In this research project, two architects and a textile designer collaborate, the latter focusing particularly on sound design. Incorporating textile designers in the early stages of building projects can lead to benefits of exploring and improving sound landscapes in outdoor environments.

In order to search for and develop new approaches, methods and techniques in the field described as textile architecture, textile facade modules were designed and produced, and the design process was examined and evaluated from the points of departure of the two design fields. Questions such as 'who is actually prototyping?' arose, as well as the search for finding common references and concepts, both historical and contemporary, to strengthen the collaborative work.

A practice-based experimental approach was important for the project and the merger of the two design fields, not least to put different textile techniques and materials to the test to examine how they can affect the sound landscape and experiences of space. The key activities in the laboratory work were technique, method, perception, stage-setting and context, which connected both to textile design and architecture. The different textile materials were chosen to comply with the requirements of external climate impact and rough outdoor environments. In groups of demarcated design experiments, the textile techniques of weaving and hand tufting were explored, and the modules were tested acoustically.

Key words: textile architecture, acoustics, urban soundscape, facade modules, Japanese architecture.

Introduction

This research project belongs to the research field of textile architecture, and its overall purpose and aim is to build a joint interdisciplinary research platform for textile architecture, involving collaboration between textile design, architecture and acoustics, to explore the design possibilities this cooperation can generate. The project is called 'Urban Materiality – Towards New Collaborations in Textile and Architectural Design' and is ongoing from 2016 to 2019 with funding from the Swedish Research Council / Artistic Research. The project focuses on outdoor environments, and the issues that are interconnected include examining and improving the sound environment in urban spaces, problems linked to unwanted noise, and exploring the visually 'non-perfect' with connections to the use, view and approach to materials and perspectives on sustainability. We want to develop new ways of thinking by bringing textile designers into the work with outdoor environments, thus focusing not only on visual aspects but also on acoustic qualities when designing facades. The focus shifts from interior to exterior, and the perspectives are widened in order to think about textiles on a larger scale outdoors, which can broaden the field for where textile designers can introduce their skills.

The collaboration is based on that the methods, techniques and tools – digital as well as analogue – used for building structures, textile as well as architectural, show similarities. The three participants' fields of competence are textile design and architecture, including sound design, interior architecture and the sustainable transformation of the built environment. One member of the team has Japanese traditional and contemporary architecture as a specific research field.

The layer between outside and inside, the building's facade, is central in the project and various methods and techniques have been tested based on both fields, textile design and architecture, with connections to spatial context, staging, and experiences and perceptions of space. The key activities for the laboratory and experimental work have been context, method, technique, perception and stage-setting, which connect to both textile design and architecture.

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Textile architecture

The initial phase of the project started with a study and discussion of what textile architecture is, can and could be, while we also explored real architectural projects. The project was initiated by acquiring common references on textile architecture and conceptions of space – we needed to discuss and reason about textile architecture in order to be able to identify differences and similarities in approaches and mindsets. This work continued parallel to the empirical work with prototypes and samples, and included interpretations from the different design fields.

What then is textile architecture? In a special issue of the journal *Architectural Design* on the theme ‘Architextiles’, the guest editor Mark Garcia describes the field, the history and the theory of the relationship between architecture and textiles:

> *This survey considers the architecture–textiles relationship across four of its most frequently occurring forms: when a textile or textile-based process is used as a metaphor, when a textile-like spatial structure (such as weave) is produced in architecture, when textiles (or textile composites) are used as a real material in a real building, and where textiles appear in architectural theory and texts. (Garcia 2006: 13)*

This became a useful model for how our study of textile architecture was organised and developed. With regard to ‘theory and texts’, one of the starting points was the book *Textile Architecture*, where the author, Sylvie Krüger defines and divides textile architecture in different groups, among others ‘Vertical Space Definer’, including ‘Exterior Curtain’ and ‘Curtain Wall’, which led us to the metaphor of ‘Curtain’ (Krüger 2009). Regarding the group ‘Exterior Curtain’, Krüger (2009) connects to Japanese architecture and the traditional wooden town house *machiya*, showing a facade from the Shinbashi-dori area in Gion, Kyoto (figure 1). In *machiya*, various, vertical and movable layers, resembling curtains, appear and interact. Interpretations of this tradition of ‘exterior curtain’ can be seen in contemporary Japanese architecture, for example in projects by the architect Kengo Kuma and his architectural office Kengo Kuma and Associates, whose designs feature spatial structures connecting to textile techniques and methods.

Figure 1: Town house *machiya*, showing a facade from the Shinbashi-dori area in Kyoto, photography by Kristina Fridh.

On the same theme, ‘theory and texts’, the architect Gottfried Semper is a well-known historical reference for connections between textile art and architecture. In his comprehensive book *Style in the Technical and Tectonic Arts; or, Practical Aesthetics* from 1860, these links are described, not least through detailed references to various textile techniques and methods (Semper 2004). The book shows an illustration of the Caribbean hut from Trinidad that was included in the Great Exhibition of 1851 in London, where the enclosure is wickerwork and resembles vertically positioned carpets (Semper 2004: 666). Semper (2010) detaches the load-bearing elements, that is, the supporting structure, from the division of space and the boundaries for space, which he instead means are textile walls, and he states that carpets were the original space dividers and visually represent the wall. This leads to the notion of ‘Carpet’ as a metaphor, but also Semper’s ‘the Principle of “Bekleidung” (Dressing)’ (Semper 2010: 246–253), since the textiles were separated from the tectonics and could cover the load-bearing structure.

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Another important historical reference is the architect Adolf Loos, once a student of Gottfried Semper. His villas exhibit discreet, white facades outwardly, but the ‘carpet’ as a metaphor was important for the spaces created inside – the interiors were dressed in carpets and tapestries and clad with wooden panels and different kinds of stone material such as marble tiles, which resulted in a clear division into interior and exterior. The carpet was necessary to form spaces possible to live in, ‘…to provide a warm and livable space’ (Loos 2011: 241). Loos (2011) was influenced by Semper’s ‘Principle of “Bekleidung” (Dressing)’, as is reflected in Loos’s essay ‘The Principle of Cladding’, and ‘Dressing’ has developed into an obvious metaphor for architects and textile designers and also for us in the project.

The carpet as an important part of a building is also found in traditional Japanese architecture, in the *tatami* mat, which forms a building module and is used both horizontally and vertically. The module has different designs and is made of various materials, and by repeating and adding the module, larger structures can be built (Locher 2010; Itoh 1969) (figure 2). The structure is reminiscent of the Caribbean hut, but the big difference is that there are no fixed interior and exterior. The inside and the outside of the building are instead continuously changing – the interior interacts with the garden and the landscape through the modules, which form several movable vertical layers, and the load-bearing structure, a post-and-beam system, is not covered or ‘dressed’.

Figure 2: The Nishimura Villa in Kyoto, photography by Kristina Fridh.

The interaction between outside and inside in Japanese architecture lead us back to the ‘curtain’ as metaphor and Krüger’s ‘Curtain Wall’ and then further on to textile designer Petra Blaisse’s curtains (Krüger 2009). Blaisse also uses the ‘curtain’ as a metaphor, stating that the curtain can add functions and qualities to space that the architecture itself cannot meet alone, such as solving problems of acoustics, light and climate (Blaisse 2011b). She argues that the curtain has its own personality, and her design office’s webpage features a large number of design projects, showing different characteristics of transparency and impermeability. The textiles disappear and reappear and catch our attention, and obviously have something to say (Blaisse 2017). The projects of Blaisse and her design office Inside Outside, for example the Chazen Museum of Art (2008-2011), the Kunsthal in Rotterdam (1999) and the ETH Zurich exhibition space (2016) (Blaisse 1999; 2011a; 2016), are interesting to compare with the architectural projects of Kengo Kuma and Associates.

One of Kengo Kuma and Associates’ projects was dressed in pleats of aluminium mesh, and ‘dressing’ was used as a metaphor and translated into a real spatial structure. The Hongkou SOHO project (2015) is located in Shanghai (figure 3, 4), and the facade is described on the architectural office’s website: ‘…like woven lace, which forms a soft dress for women’ (Kuma 2015). The way of thinking facades in

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different layers with empty spaces in-between from the Japanese tradition is included, since the facade's layer has a distance to the underlying building glass, but the load-bearing structure has been dressed here. Instead of real textile materials, hard building materials have been used, that is, aluminium strips have been braided to a weave that forms modules which are then added. Another project in Shanghai, Shipyard 1862 (2017), has an 'exterior curtain' as a weave where the warp is stainless steel wire and has mounted ceramic bricks (figure 5). Kengo Kuma's way of thinking and his working methods show similarities with textile techniques, both regarding facade layers and building constructions. In the project Sunny Hills in Tokyo (2013), the wooden lattice that forms the building structure can be compared to a knitted structure with interlacing loops locked and hooked into each other (figure 6). Other examples are found where spatial textile structures have been erected; however, the materials are not textile but hard building materials.

Figure 3: Hongkou SOHO in Shanghai, designed by Kengo Kuma and Associates. Photography by Kristina Fridh.

Figure 4: Detail of the facade, Hongkou SOHO. Photography by Kristina Fridh.

Figure 5. Facade Shipyard 1862 in Shanghai, designed by Kengo Kuma and Associates. Photography by Kristina Fridh.

Figure 6: Sunny Hills in Tokyo, designed by Kengo Kuma and Associates. Photography by Kristina Fridh.

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Wonder

In addition to thinking of the facade in layers, we want to use textile materials outside to change the perspectives, since real textile materials are rarely used outdoors in urban architecture. The textiles must, of course, meet different technical building regulations such as durability and resistance to fire and moisture, but textile architecture can be much more and can change our views on materials and materiality. Today, aesthetic ideals of perfection often result in premature and unnecessary replacement of facade materials and building components, which needs to be challenged from a sustainability perspective. Sustainability is a perspective encompassed by the competence of one of the project's participants whose focus is on renovation. We want to explore the potentials of textile modules to dress an existing facade, as a sustainable alternative, and we also want to examine the possibility of their being parts of new facades. Thus, one starting point in the project was to design 'disturbances' in the form of the textile facade modules. These modules can give rise to positive spatial experiences of something 'non-perfect' and uncompleted, but also something unexpected, not least by using textile materials outdoors, which can evoke wonder.

The stage-setting of surprising experiences of wonder creates prerequisites for being involved in mental processes, which can build bridges between consciousness and matter, and building, human being and landscape that can prevent buildings from being perceived and conceived as objects (Fridh 2017; Kuma 2008). This positive approach to the imperfect and incomplete and to the unexpected experience of materiality is connected to traditional Japanese aesthetic ideals, originating from the tea culture. Soetsu Yanagi describes this as a hidden, subjective beauty to be found, for example, in the 'non-perfect' tea bowls used in the Japanese tea ceremony (Yanagi 1989: 119–126). Here, the observer may wonder about the rough, uneven ceramic surface and unsymmetrical form of the tea bowl, and be tempted to complete this incomplete object mentally. The experience of wonder is also found in contemporary Japanese architecture, such as that of Kengo Kuma. Two examples by Kuma's architectural office can be mentioned here: the Community Market Yusuhara (2010), where, in a facade, modules of straw are surprisingly applied in another context (figure 7), and LVMH Osaka (2004), where 4 mm-thin slices of onyx stone are used, which, even if it is stone, turns out to be transparent (figure 8) (interior see Kuma 2004).

Figure 7: The Community Market Yusuhara, designed by Kengo Kuma and Associates. Photography by Kristina Fridh.

Figure 8: LVMH Osaka, designed by Kengo Kuma and Associates. Photography by Kristina Fridh.

Sound acoustics in urban environments

The method of making a soundscape map was tested in the project to identify different sounds that can occur in an urban environment. The method is a way to find the sonic identity of an urban place, and the soundscape map and study were developed by the composer and researcher Murray Schafer (Schafer 1977a; 1977b). The term soundscape embraces a person's entire perception of sound in an environment and comprises so-called natural sound, such as from wind and rain as well as people's conversations, cars, buses and other modern technology. A specific place was selected in Gothenburg along the street Södra Vägen, which met the criteria of being burdened by traffic noise with low sound frequencies but also other high frequency sounds. If textile acoustic modules had been applied in this area, they would have needed the capacity to absorb both the low and high frequency sounds in order to be able to affect and change the soundscape – knowledge that also can be used in other urban environments with a similar sonic identity. A soundscape map was made with notes for sounds that were heard on specific occasions during one day – observations were made repeatedly during a twelve hour period.

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The soundscape study showed that the most dominant sounds consisted of low sound frequencies and originated from traffic (cars, buses and trams). When the sound level from the traffic noise decreased, other sounds became more dominant such as sounds from birds and people (speech and footsteps) and the rustling of trees in the wind. As a reference for the soundscape map, a noise map made by the Gothenburg Environmental Administration Office was studied (Holmes 2015). The noise map shows the sound pressure levels measured in decibels, and the areas analysed are accorded colours matching different intervals on the decibel scale. The noise map points at a more simplified understanding, but confirmed the perceptions and experiences from the soundscape study: along Södra Vägen, large areas were marked in red, which indicates high decibel levels.

To be able to analyse the sonic experiences from the soundscape study at Södra Vägen, we used a number of 'sonic effects', a concept developed by the French research institute CRESSON (Augoyard and Torgue 2005). Six groups of sonic effects have been formed to include in total sixty-six sonic effects, and these act as tools that the listener can use to describe, analyse and understand the experiences of everyday sounds in architectural and urban spaces (ibid). Each of the six groups describes different relations between the environment and the human listener. Two of the groups of sonic effects were found to be appropriate to apply in the analysis of the soundscape at Södra Vägen. The first group was 'elementary effects', which are tools for the sound material in itself, for example, reverberation and echo, and the second group was 'memo-perceptive effects' that are linked to memory and perceptive organisation, and to how a person perceives the sounds in an actual situation. Some of the other groups can be mentioned such as 'psychomotor effects', which embrace how sounds have an impact on a listener psychologically, and 'semantic effects' that demonstrate the meaning of sounds to a listener. The group of 'memo-perceptive effects' comprises 'metabolic' and 'ubiquitous' sonic effects which were used, and the group of 'elementary effects' was applied since descriptions of sounds echoing were part of the notes from the soundscape study.

The urban soundscape at Södra Vägen can be described as 'metabolic' since sudden, specific sounds were heard during a period of time against a background of more monotonous, subdued sounds. Later, these sounds were no longer heard and other sounds caught the attention. Thus, to define a sound as 'metabolic', the experience has to be based on two fundamental criteria: the instability of the sonic structure and the way sounds vary between foreground and background over time (ibid). The soundscape at Södra Vägen was also experienced as 'ubiquitous', and this effect concerns the difficulty or the impossibility of locating a sound source, that is, the sounds seems to come from everywhere and nowhere at the same time. Hence, the effect of 'ubiquity' is characterised by the instability of references in space, and when exposed to a multitude of surrounding sources – standing in the focal point of sounds – one cannot identify where the sounds emanate from (ibid). From the group of 'elementary effects', as mentioned before, the echo effect was

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used in the study: sounds were echoed at Södra Vägen during a long period of time, mixed in a sound chaos (ibid).

The challenge and the potential of a sound environment such as Södra Vägen, with big acoustic variations, are that textile modules applied to facades could be designed to absorb low frequency sounds and short-lived, high frequency and intrusive sounds. The modules could also subdue the echo effect and make it possible to identify from which direction specific sounds come. This would make it easier to navigate in the urban landscape and achieve a more stable sound environment. A future study of how a number of people perceive the soundscape at Södra Vägen would also give valuable data concerning sounds perceived as negative, that should be dampened, and sounds perceived as positive to be enhanced. This would inform us further concerning the required sound-affecting properties in the design work with textile facade modules.

Real material

The 'exterior curtain', the 'carpet' and 'dressing' recur as metaphors in the design work with the textile modules in real materials, and through using textile materials outdoors, we create and stage 'wonder' – the interior perspective has moved outside. We chose to work with different layers in the modules and add those, which affect the sound absorbing qualities positively, especially when there is a distance, empty space, between the different textile materials. This way of thinking in layers relates to the references of the projects in Japanese architecture, both traditional and contemporary. The visual appearance of the textile modules is 'general', although they evoke experiences of the 'non-perfect' and 'wonder', thus, they can be applied in various environments. However, they have different acoustic qualities and therefore they will be applied in different sound landscapes at certain places, to interplay with and affect the acoustics. The design modules can dress the facades and be applied both in renovation projects and in new buildings and bring the positive outcome to improve acoustic qualities in urban environments.

The textile materials that we have chosen to work with in the project must meet different technical building requirements for fire, moisture and durability in a tough outdoor environment, where the materials are exposed to UV light, air pollution, rain and both low and high temperatures. The materials must also be able to withstand wind forces, which makes demands on the construction itself and how the modules are attached to the facade. The selection of yarns was discussed with the textile engineer researchers at the Swedish School of Textiles and current fire properties were discussed with experts at the Swedish research institute RISE. In the first experiments, we chose to work with Pemotex yarn, a fire-resistant polyester yarn mixed with a thin melting thread that shrinks when the yarn is exposed to hot steam (Heinrich and Kuhnhoff 1998), and cotton yarn and polypropylene yarn, which will be replaced later in the process by the fire-resistant Trevira CS yarn, which ignites first

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at 500 degrees (Zhao and Wang 2017). By using Pemotex yarn, a three-dimensional surface can be created that dampens sound better than a flat surface, since the energy of the sound waves is then both diffused and absorbed (Cox and D’Antonio 2016). We also chose to proceed with basalt fibre yarn made of volcanic stone, characterised by good resistance to low and high temperatures and heat, that is, by thermal stability and effective insulation (Overkamp et al. 2016). Glass fibre yarn, which is incombustible, turned out to be an appropriate material to combine with other yarns for some of the designs (Kadolph 2014). It was proposed that the inner layers of the textile modules should consist of nonwoven textiles to form a thick layer – nonwoven fabrics can be tailor-made by choice of fibres and manufacturing process, which makes it possible to affect the sound absorbing capacity. Thick and compact nonwoven fabrics of wool have good properties seen from the perspectives of fire requirements.

In addition to a three-dimensional surface, the sound absorbing properties are improved through the use of heavy materials, but it is also important to control the density and permeability of the textile. This is explained by the fact that sound can be described as a wave induced by a vibration and transmitted by, for example, air or water. When sound waves reach a dense material, such as a concrete wall, they will be reflected without any energy loss, that is, there is no sound absorption. If instead sound waves reach a material that allows them to pass through it, part of the energy in the sound waves will be converted into heat, and it is heard as absorption of the sound. When the sound waves meet a three-dimensional surface, their energy will be diffused due to their being spread in all directions, and this is also heard as absorption of the sound.

The proposed model module shows a ‘vertical space definer’, according to Krüger’s definitions, which is meant to be mounted at a distance from the facade, and consists of various textile materials organised in different layers (figure 9). The distance from the facade, that is, the empty space in-between, improves the reflections of the sound waves and contributes to the energy loss, which means better absorption.

Figure 9: The proposed model module consists of various textile materials organised in different layers, illustrated by Margareta Zetterblom.

The exterior curtain and the carpet

The designs of the modules form two main groups, the first group where the textile technique weaving is used for the outer layer and where the metaphor of the ‘exterior curtain’ is applied, and the second group where the textile technique hand tufting is used and the metaphor applied is the ‘carpet’. Thus, the two groups differ in the outer layers of the modules, whereas the inner layers could be designed as

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previously described in figure 9 to achieve a high level of sound absorption. For the 'exterior curtain', we decided to use the weaving technique, since we wanted to design a non-elastic and stable textile. The module has an outer three-dimensional, textured surface that will be able to diffuse and absorb high frequency sounds. It also allows low frequency sounds to pass through the material to reach the separate, underlying, thick, nonwoven layer that absorbs low frequency sounds. Consequently, the outer layer of the textile should not be too dense and the level of density could be experimented with through the shrinking of the Pemotex yarn.

The focus of the first series of design experiments was to create a woven three-dimensional structure, a prototype, by using Pemotex yarn and then explore the relationship between density and the desired transmission of sound (Cox and D'Antonio 2016). The outcome of these experiments was knowledge of how the weft density could restrict or support the shrinkage of a material (figure10). The second series of prototypes were focused on the degree of shrinkage, which is dependent on the time period of exposure to heat and the degree of temperature. The prototypes exposed here are double cloth constructions before they have been exposed to heat and the same samples when exposed to exactly 68 degrees for three minutes (figure 11). For these prototypes of the 'exterior curtain', we combined the use of Pemotex yarn with basalt fibre yarn and glass fibre yarn (figure 12).

Figure 10: In the first series of design experiments a woven three-dimensional structure was created by using Pemotex yarn. Photography by Margareta Zetterblom.

Figure 11: The first group of prototypes (the 'exterior curtain'): double cloth samples before and after they have been exposed to heat. Photography by Margareta Zetterblom.

Figure 12: For the prototypes of the 'exterior curtain', we combined the use of Pemotex yarn with basalt fibre yarn and glass fibre yarn. Photography by Margareta Zetterblom.

In the second group of prototypes, where the textile technique of hand tufting was used, the connection to the metaphor of the 'carpet' as well as 'dressing' is obvious (figure 13). Basalt fibre yarn and glass fibre yarn were used and combined, and some of the prototypes were tested outdoors for approximately a year, being mounted on a facade. The samples which were tufted using basalt yarn were not significantly affected by climate or pollution, while the samples made of glass fibre yarn showed small colour changes (figure 14). At this stage of the project, this points to good prospects for using these yarns in outdoor environments.

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Figure 13: The second group of prototypes (the ‘carpet’): hand tufted samples made of basalt fibre yarn and glass fibre yarn. Photography by Margareta Zetterblom.

Figure14: Prototype of glass fibre yarn tested outdoors showing small colour changes. Photography by Margareta Zetterblom.

A variety of nonwoven materials were selected for the inner layers of the modules, and sound absorbing tests were conducted to find appropriate nonwoven materials suitable for absorbing low frequency sounds. Since the nonwoven textile should be resistant to fire, compact wool was found to be an appropriate material. However, there is a relationship between density and sound absorbing capacity as mentioned before, but one of the samples of dense wool showed good results in absorbing low frequency sounds.

Parallel to the designing and making of the prototypes, samples were tested acoustically to obtain information on the materials’ sound absorbing properties in relation to different sound frequencies. To measure sound absorbing properties, an air-flow resistance instrument was used. Small samples, ten cm in diameter, were inserted, and the results gave information about air-flow resistance and how the sample absorbed a range of sound frequencies from low frequency to high frequency sound. In the diagram, the x-axis shows sound frequencies from low 20 Hz to high 20 000 Hz, and the y-axis indicates the absorption coefficient, equivalent to how much the textile sample absorbs each sound frequency, varying between 0 and 1. For one of the double cloth prototypes that was tested, the diagram demonstrates that it absorbed middle frequency sounds but high frequency sounds best (figure 15). One of the hand tufted samples displayed the result of absorbing low frequencies slightly better than the woven textile (figure 16). The proposed model module is made of several different textile layers, of which the innermost consists of nonwoven textile, and a number of nonwoven textiles were tested. The results showed that especially heavy nonwoven materials made of wool absorbed low frequency sounds best (figure 17). The idea of using a combination of various textile layers could then result in the absorption of several different sound frequencies; a need which was indicated through the soundscape study at Södra Vägen. More samples will be tested continuously in the process of designing the prototypes, to find differences and to improve the sound absorbing capacity for the required sound frequencies.

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Figure 15: Test: double cloth prototype. Method of measurement and diagram, http://www.acousticmodelling.com/.

Figure 16: Test: hand tufted prototype. Method of measurement and diagram, http://www.acousticmodelling.com/.

Figure 17: Test: nonwoven textile made of wool. Method of measurement and diagram, http://www.acousticmodelling.com/.

At this stage of the project, three prototypes of double cloth samples were selected according to their acoustic test results and their distinct three-dimensional surface structure on both sides of the textiles, which makes them reversible for the use of both sides as outside structure (figure 18, 19, 20). These prototypes will be woven as larger samples in black, and they and the hand tufted prototypes could be combined with layers of nonwoven material for future tests in full scale. One step further would be to conduct tests of the full-scale prototypes in urban environments.

Figure 18: Prototype of double cloth no. 1. All three of the selected samples are reversible for the use of both sides as outside structure. Photography by Margareta Zetterblom.

Figure 19: Prototype of double cloth no. 2. Photography by Margareta Zetterblom.

Figure 20: Prototype of double cloth no. 3. Photography by Margareta Zetterblom.

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Analysis of the five key activities

What are the challenges in the project and in the collaboration? Why should we cooperate? What can the two disciplines gain from collaboration? In order to discuss this, we returned to the five key activities that our experiments and laboratory work were based on: context, method, technique, stage-setting and perception. For context, the importance of finding common metaphors for textile design and space became apparent to be able to meet in new visions. It was also important to have common references and to widen the perspectives of the participants' design fields, both in theory and texts and in real applications in spatial, textile structures in architecture. Real buildings were important in the discussions, which confirms the value of practice: what has been built and designed and what is possible to build? Views of sustainability are included, since facades could be dressed by the textile modules in renovation projects to counteract unnecessary replacement of facade materials, and simultaneously, the sound landscape could be improved in urban environments burdened with unwanted noise. The model modules could be tested on existing facades first, to be further developed and also be applied to new buildings' facades. A positive side effect is that the textiles could absorb harmful air particles in polluted city air.

Who is actually prototyping in the project? Based on the methods used, we see the importance of all participants taking part in the whole design process from the start. The design process can be described as departing in the design probe, going to the design and making of the material prototypes, and then to application (Ramsgard Thomsen and Tamke 2009: 346). The design process normally starts differently for the two fields. In textile design, it means to design and make a prototype, while in architecture it means to design the facades and apply prototypes. The architect uses digital and analogue representations for this work, such as drawings and scale models, and in general the architect takes the point of departure in an existing range of products. Thus, a long period of work for the architect starts when the prototype will be applied to a building's facade with focus on the architectural design, and, during this process, it may also be necessary to modify the design of the prototype.

Our collaboration has mainly been interdisciplinary and not transdisciplinary, since the textile techniques, weaving and hand tufting, in the making of the model prototypes, require skill and experience in craftsmanship, and the digital tools of the two design fields are different to some extent. There has been some difficulty in finding common sketch tools, such as in the differences of sketching directly in the materials in textile design and with representations in architecture. However, mood boards have been used, and in the way of analysing a site's sonic identity, there are common notions of an existing concept and identity of place. Here, approaches to design and relation to place and context met in discussions about generally and site-specifically applicable designs.

In discussions about actual techniques and structures in textile design and architecture, the lack of knowledge of the other design field was revealed. Similar techniques are found in the two design fields, but, in addition, new and more advanced knowledge about techniques and tools from the other design field has been gained, not least by working in different scales, zooming in and out.

Architects often use 'hard' materials when elaborating with textile techniques in building projects, but in this project deeper knowledge from the textile field has been applied, and textile fibres and textile materials outdoors on the facades have surprisingly been found possible to use. This can result in stage-settings which can evoke wonder and create new perceptions and experiences of materials and space that can bridge between consciousness and matter, and in the project, the focus is on both visual and acoustic experiences in urban space.

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Conclusion

In the research project, we want to show the possibilities of changing the design process into something new through a joint starting point and work in parallel. The potential to shift between different scales is explored to form a comprehensive view of facade materials that not only affect visual experiences but also hearing experiences in urban spaces.

Textile designers do not normally have the experience of working on a larger scale, and architects rarely describe buildings in terms of using more advanced textile techniques, such as plain weave, double cloth (weave) or double knitting, but often only 'weaving' or 'knitting' are mentioned. Knowledge of more advanced textile materials and techniques is lacking in the architectural field, and our conclusion is that buildings and architectural work could be further developed if a scale of more advanced textile techniques were used in the sketch work, combined with, at times, shifting to a micro-level on another scale.

In the project, we recognised the necessity of making the samples and prototypes in order to measure the acoustic qualities, and to be able to describe experiential spatial qualities. Hence, we could not only work with representations in the form of drawings or digital modelling, but the actual samples needed to be tested acoustically, and the prototypes need to be evaluated in the form of workshops, which connects to valuing practice.

There are plans to organise workshops with architects and textile designers and other stakeholders, such as users and property owners, to evaluate the textile modules that have so far been designed and made. At the beginning of the project, we also established contact with two local architectural offices, one of which is working on a project with experimental housing, HSB Living Lab. Questions that have been raised are for example: How are the prototypes experienced and perceived and could the model modules be applied in different contexts and be further developed into real facade modules? How much acceptance is there for textile materials that are not usually regarded as resistant in outdoor environments? The first step will be an exhibition at the Form/Design Center in Malmö in the autumn of 2019, which will be combined with activities such as workshop and lecture. The aim of the exhibition is to evaluate the prototypes in the form of a workshop and to show the possibilities and visions that textile architecture opens, not least with the point of departure in improving the urban sound landscape and perspectives of sustainability.

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