1. INTRODUCTION

1.1 Purpose of Study

The development of new technologies, new processing methods and new materials in contemporary society has exerted influence not only on the space creation of architecture itself, but also on the realization of design concepts. As convergence and fusion are becoming more important than ever, the existing boundaries of architecture have been expanded, enabling the expression of unlimited possibilities. Especially, the architecture surface has been re-evaluated as a starting point for the manifestation of the concepts and characteristics of buildings. Furthermore, continuously developing materials and systems in contemporary architectural surface design are narrowing down the disparity between the architects’ imagination and reality, in terms of the expression and highlighting of the program and the nature of each building.

Since the surface of a building is regarded as a factor in the expression of its identity, it is like an individual’s clothing, which expresses their personality and forms a cultural and social connection between them and others. This common feature has led architecture and fashion to agree on the similarities between them, and their boundaries have been broken down to expand the horizons of design.

Fabric is the oldest material in clothing design, and is widely used in contemporary fashion, due to the development of new design techniques and the ability to combine different materials. The continuous development of fabrics has given inspiration to architectural surface design, and has created a crossing point between fashion and architecture design.

This study redefines the essential expression properties of fabrics, and examines a system which applies these features to architectural surface design. Also, this study classified the expression methods to incorporate fabric effects (which, historically, is the oldest characteristics expressed by clothing) into architectural surfaces according to their materials, and investigated specific systems and detail effects.

1.2 Study Method and Procedure

This study examined the correlation between architectural surfaces and fabric, through a comprehensive theoretical review of them. This study explains the general definitions of fabric in clothing design within contemporary society and culture, and of modern architectural surface as well as their meaning changes, and found a cross-point between the two expression tools (architecture surface and fabric, expressing design through...
understanding of the definition of fabric and its meaning extension). This study specifically classifies the expression properties of fabric based on this, and investigates its potential for application to architectural design and development, exploring systems and details to actually realize fabric effects through case study. Furthermore, we analyzed construction methods, and their effects, through case-study according to material and classification.

2. GENERAL REVIEW OF CONTEMPORARY ARCHITECTURAL SURFACE AND FABRIC

2.1 Understanding of Surface
The surface is an element that surrounds a living organism or an inanimate object, to ensure its existence as an independent entity that can form a relationship with its surroundings through change or protection. This element is not only perceived as the features of the thing's appearance, but also plays a crucial role in defining the characteristics of the subject.

Clothing (as a surface) goes beyond the purpose of protecting the human body, to show decorative meaning and to incorporate social and cultural concepts. Textiles (or materials) are the basic component unit of clothing, and also play the most important role in producing various changes and dramatic effects. The sensory experience of the clothing's surface can be strengthened by highlighting and modifying the distinctive and unique features of the materials, and its limitations can be overcome to create more a creative and artistic appearance by borrowing a material used in a specific field and developing a new processing method.

2.2 Understanding and Meaning Changes of Contemporary Architectural Surfaces
The surface is defined in architecture as 'the outer part of a building enclosing the interior volume' and in geometry as 'covering a solid material with a thin and flexible material,' and is often used as a meaning of outer covering or 'skin.' Due to the industrialization in the 19th century, the development of new construction materials (such as concrete, steel, and glass) and technology has divided the surface from the structural system and offered possibilities for expressing it as a design concept. The definition of 'surface', as it pertains to construction, broke away from being a passive concept of the past to become generalized as an independent factor in the late 19th century, and has gone beyond the functions of being the first layer to form a partition between a building and the outside environment and being a visual effect that acts as a window for communication with society. 'Architectural surface' is regarded as an important factor in the recognition and the expression of the identity of a building, and its meaning has been extended to respond to situational changes that are the result of periodical paradigm shifts, commercialization, and technology advances.

Construction communicates with the urban environment and expresses its existence through the surface; through this process, the recent changes in architectural surface have had a significant influence on social concepts like informatization, multiculturalism, and consumption culture. Thanks to these ramifications, architectural surface design has acquired the nature of delivering the design concept of an architect and realizing sensory images, and projects the sense and sensitivity of the architects and observers by applying a creative facade-system construction method, or by converging it with various materials.

2.3 Definition and Meaning Extension of Fabric
Fabric is a basic component unit of clothing, and has a meaning as a material, which is also called as woven, textile or cloth. The word 'fabric' also derives from the Latin 'fabricare' which means 'building' 'fabricating,' or 'producing' and which indicates the structural bonding comprising textile tissues instead of a material aspect of cloth. Fabrics may have varying degrees of tension, luster and water-repellency, depending on the threads' material, and the weaving and processing methods, and are used in many different fields as various design factors, the diverse characteristics of fabric.

Since the fabric's thickness shows depth and three-dimensionality, they can be draped and placed on a certain object, or they can be intentionally cut and patched together, to cover and wrap something. Also, if the fabric is cut, torn, or draped, both their dynamic aspect and three-dimensional effect can be realized and expressed as a formative factor. If a sculpture is draped with a fabric, the soft texture of the fabric will be revealed. Given this, fabrics have been the most familiar material to humans throughout the history of humanity, and are used in various fields like construction, aviation and medicine; also, some fabrics are produced by mixing new materials, or are developed by combining them with metal and industrial materials, and high-tech fabrics fabricated using bio- and nano-technologies have opened up a new chapter.

2.4 Relationship between Contemporary Architectural Surface and Fabrics
If we equate buildings to humans, clothing is the outermost surface of humans and is a tool for protecting the body and expressing the identity. Recently, architecture and fashion have begun to share each other's possibilities and limitations, and to give inspiration to each other.

The recently held [Skin+Bones] Exhibition was an event that confirmed the connection points between fashion and construction, and to check the attempts to apply each other's techniques and surface designs. The exhibition opened in November 2006, and lasted for one year; it displayed important designs and events that have made significant contributions to cultural changes in the architecture and fashion fields since the early 1980s. Through this exhibition their similarity, in terms of the aesthetic pursuit tendency, theoretical backgrounds, and technological innovation, demonstrated their mutual influence. The SKIN+BONES works by Architect Meejin Yoon rested between concept and reality, but they were on a small scale. Even if they become scaled up, most of them will still have the possibility for realistic changes. The white-colored woolen Möbius dress (Figure 1) got a motive from Möbius strips, and had a loop shape obtained by taking a rectangular strip of fabric, twisting one end through 180°, and then joining the ends. This work presumed the human body as a single structure and expressed the fabric entwining the human body as the surface, and the fabric strip in the shape of a Möbius strip had the same hierarchy both on the inside and outside.
In order to determine the close correlation between architecture and fashion, Architect Peter Testa conducted an experiment on how to apply new fiber materials (such as carbon fiber and Prepreg tape) to various surface designs, in which he incorporated existing fabric manufacturing techniques—such as braiding, weaving and knitting—as structural methods. (Figure 2)

In this meaningful experiment, he reversely applied the volume and shape of textiles to architectural designs. Thus, fabric is the common denominator in the relationship of materials between the architectural surface design and the skin of clothing, and becomes a mediating tool to push forward the horizons of architectural design.

3. UNDERSTANDING OF FABRIC EXPRESSION IN CONTEMPORARY ARCHITECTURAL SURFACE

3.1 Classification of Fabric Expression Properties

As mentioned above, if we look into the results of case-studies conducted on the correlation between fabric and contemporary architectural surfaces, we can determine the morphological characteristics of a unique skin, including a streamlined shape and an independent and close relationship. This can be interpreted as the common features that fashion and architectural design agree upon when accepting fabric as a material. This study selected those features which could be applied to architectural surface design from among the various characteristics of fabric, and classified them according to their material and surface features in order to provide clues for the fabric expression effects realized by material-specific expression methods; in addition, we look at case studies, which will be discussed later in the paper.

3.1.1 Material Properties

A. Flexibility

Fabric has the flexibility to allow for free stretching and movement, and the lightness of fabric itself enables these movements to create various delicate dynamics (Figure 3,4). The flexibility of fabric gives visual and tactile softness, and the unrestricted application of the fabric material can push back the limits of the producers.

b. Lightness

Fabric is a material which is lighter, relative to its volume, compared to other materials; since it can be moved by a light breeze or contact with humans, unexpected reactions can take place (Figure 5,6). Lightness, lexically, means lightweight; thanks to this feature, nomads are able to use fabric to produce their portable dwellings.

c. Adhesion

Fabric does not have a rigid shape, so when it comes in contact with a certain object, the unique natural and soft nature of the fabric can form enough adhesion to the surface to reveal the shape of the object (Figure 7). Without additional techniques, a new morphological attempt can be done by overlapping an object, which can subsequently lead to the occurrence of ambiguity and variation in the domain. (Figure 8)
3.1.2 Surface Properties

a. Irregularity
Fabric has more diverse shapes than any other materials. Regardless of which field designers belong to, they can create various shapes or sizes with it, depending on their plans and intentions (Figure 9). Due to this feature, they can create design vocabularies by resorting to simple coincidence, or with minimal rules and frames (Figure 10).

b. Variability
Variability, lexically, refers to an intrinsic ability to change shape and tissue while maintaining the stability of other properties, and to adapt to the changes. In this sense, fabric has unspecific natures that allow for various patterns, textures and transparency, depending on the properties of the raw materials and processing methods. (Figure 11,12)

The properties of fabric can be classified in various ways, depending on the classification criteria, but this paper classified only those properties which can be applied to architectural surface designs. The classification of the above fabric properties can be summarized as seen in the following table.

<table>
<thead>
<tr>
<th>Material Properties</th>
<th>Surface Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>Irregularity</td>
</tr>
<tr>
<td>- enables free movement</td>
<td></td>
</tr>
<tr>
<td>- soft and tactile</td>
<td>- designs in free shapes</td>
</tr>
<tr>
<td>- various shapes and sizes</td>
<td></td>
</tr>
<tr>
<td>- enable the expression of irregular curves and geometric shapes</td>
<td></td>
</tr>
<tr>
<td>Lightness</td>
<td>Variability</td>
</tr>
<tr>
<td>- light weight relative to volume</td>
<td></td>
</tr>
<tr>
<td>- convenient to move</td>
<td></td>
</tr>
<tr>
<td>- possible to generate unintended situations</td>
<td></td>
</tr>
<tr>
<td>- alterations depending on processing methods</td>
<td></td>
</tr>
<tr>
<td>- broaden the range of expression of designs while maintaining the properties of fabric</td>
<td></td>
</tr>
<tr>
<td>Adhesiveness</td>
<td></td>
</tr>
<tr>
<td>- possible to guess the shape</td>
<td></td>
</tr>
<tr>
<td>- enable morphological attempts through overlapping with an object</td>
<td></td>
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<tr>
<td>- ambiguity and variability of the domain</td>
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</tbody>
</table>

3.2 Expression Patterns of Fabric Properties on Contemporary Architectural Surfaces
The above classified properties of fabric are those physical properties which are visually and perceptually perceived as fabric, and the patterns of contemporary architectural surfaces which express the unique and distinctive features of fabric can be divided into several categories.

3.2.1 Draped
Draped fabric expression technique with irregular wrinkles that reflect the weightiness of the fabric as it is. In contemporary
architectural surface, being draped by natural wrinkles is the most important element in realizing the draped expression pattern of fabric. Through this, the architectural surface can acquire the flexibility and irregularity from among the properties of fabric. Aichinger House, designed by the Austrian design studio Hertl Architects, is a two-story house in which a curtain effect is created by using frames and latches differentiated from the entire building structure in order to apply the patterns of contemporary architectural surfaces (Figure 13).

3.2.2 Crinkled
Fabric is an easy material whose shape can be easily altered with weak force and which can be created into various shapes for experiment. ‘Crinkled’ is to utilize this property of fabric to create surfaces using various techniques including folding, cutting and bending. Continuous and irregular effects need to be realized to express ‘Crinkled,’ and through this, the architectural surface acquires ‘irregularity’ and ‘lightness.’ ‘Dear Ginza’ of Amano Design Office located in Giza, Tokyo, embodies an irregular and crinkled surface design by using the double skin consisting of curtain walls and systematically-connected digital printed punching metal. (Figure 14)

3.2.3 Softened
Fabric not only has visual effects but also provokes tactile stimuli with its softness. The surface treatment is the most important to express ‘Softened’ in contemporary architectural surface, and when a softened surface in a concrete curvy shape is realized, the surface will acquire ‘flexibility’ and ‘variation.’ Designed by Magma Architecture, the Olympic Shooting Venue has a facade consisting of curved space, and small and large openings, in order to give visual stimuli to the audience who visit the site to watch shooting games. To express natural softness, phthalate PVC was used and, as the shooting game has a unique characteristic in that there are no limits to the openings, these circular shaped openings also function as ventilation and entrances.

3.2.4 Wrapped
The ‘Wrapped’ expression pattern of fabric can create a new space by overlapping ones whose shapes can be guessed with others which are completely heterogeneous. For the expression of ‘wrapped,’ the surface must acquire such fabric properties as flexibility, which is manifested in the tense physical property, and adhesion, which is related to object.

The Kukje Gallery in Seoul, which was completed in April 2012, is a building that is rapped with about 500,000 welded meshes made of stainless steel fabric with flexibility and high strength, in order to reveal the non-linear geometric shape of the entire structure. The accurate calculation of the surface shape, area size, and number of mesh rings was implemented through a modeling technique by utilizing digital technology.

4. FABRIC EXPRESSION EFFECTS THROUGH ARCHITECTURAL SURFACE MATERIALS

Construction materials have been the most important selective requirement, from the past up until now. The new exploration of architectural surface makes architects’ attitude toward materials creative and pushes back the limits. This study classified those materials which are commonly used in architecture, and examined the expression properties and patterns of the applied fabrics to analyze the fabric effects that are expressed in architectural surfaces.

4.1. Plastic Fabric
Compared to other materials, plastic fabric allows for processing into a certain shape, yet it is basically a solid material. Therefore, it requires various construction technologies to produce the fabric effects. In particular, the light weight of plastics can make possible the expression of fabric effects that can overcome the limits of its physical properties.
4.2. Metal Fabric

The processing of a shape itself is possible, but since secondary processed materials (like chains and meshes) are widely used, they are applied to surface designs through various methods. Although the basic physical property of metal is not flexible, flexibility and adhesion can be acquired after secondary processing.

4.3. CONCRETE FABRIC

The basic properties of concrete mean that it is heavy and difficult to process, but it has the advantage of being able to be manufactured into any kind of shape if it is molded. If this advantage is to be utilized, the concrete can express a fabric-like texture and acquire irregularity.
A Study on Fabric Effects on Contemporary Architectural Surfaces, Based on the Material Characteristics

Table 4. Concrete Fabric

<table>
<thead>
<tr>
<th>Title</th>
<th>Architect</th>
<th>Location</th>
<th>Year</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanil Visitor Center / BCHO Architecture(2008)</td>
<td>BCHO Architecture</td>
<td>Korea</td>
<td>2008</td>
<td><img src="image1" alt="Fabric" /></td>
</tr>
<tr>
<td>-The building’s outer wall, which performs a structural function, was created in a curtain shape. -The outer wall, manufactured using a precast construction method, is not a simple decoration but plays a structural function. Parts at a certain interval are produced and assembled at the field sites. It shows irregularity and variation among fabric properties.</td>
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 Crushed Wall / Walter Jack Studio(2012)

- The fabric-shaped concrete block is molded at a scale of 1:1 to produce fabric effects. - As fabric is partially used to produce the frame, an extremely sleek and natural fabric effect can be manifested. This is also an outer surface design, which has undergone pre-fabrication and assembly processes.

Liverpool Vilahermosa / ñaki Echeverria (2012)

- Concrete panels, which are bent at the fixed center, are fabricated and installed on the building surface in order.
- Despite the heavy weight of concrete, a thin and pliable design is created to produce a fabric effect. The steel framed structure supports the movement of the concrete panels.

According to the results of the above design cases of architectural surfaces, we found that various fabric expressions are possible using the basic properties of the materials. In addition to the unique physical properties of the materials as used in the above cases, design methodologies that embody architectural surfaces also contribute to the diversification of expressing surface structures and to the enhancement of the morphological possibilities of buildings.

The architectural surface cases that examined the fabric expression effects according to the material, the expression properties and the patterns of fabric effects are summarized as follows.
5. CONCLUSION

This study redefined clothing and facade as being the respective surfaces of the human skin and a building through the basic meaning of ‘surface’, and examined the sensory meaning of ‘surface’ in contemporary architectural design, investigating the development of materials by expanding the definition to the skin in the fashion field, which has a close design relationship with architecture. This study examined the concrete correlation between the two fields by identifying the common features, in terms of the implementation of philosophy and shapes between clothing and architectural surfaces, and assessed the possibility of contemporary architectural surface design having a broader range and diversity.

Also, in order to attain the possibility for this diversity, this study examined the Skin+Bones exhibition and its works, the motif of which was derived from similar working methods and the close correlation between architecture and fashion. Architectural surfaces are getting more attention as an important factor in the design concept of architects, and the blurred boundary between different fields has led to the remarkable development of creative ideas and innovative designs in a contemporary society where the importance of convergence and fusion is getting more widely accepted.

In the first half of the paper, this study classified the properties of fabric, the typical material for clothing, according to their material and surface properties, or specifically into flexibility, lightness, adhesion, irregularity and variability. This study investigated the characteristics of these properties and explored those fabric expression patterns that are manifested in architectural surfaces. This study divided fabric expression patterns into four categories: Draped, Crinkled, Softened and Wrapped, and confirmed the visual and tactile fabric expressions that are actually realized by architectural designs.

Also, based on the above classified and defined properties and expression patterns of fabric, this study compared and analyzed the cases of fabric expressions by the external surface materials among the existing and commonly used materials. In addition, this study examined the detailed method of implementing the fabric expression of each construction case. Through this, this study was able to find out new possibilities for materials and to create various methodologies for surface design.

Further studies need to be conducted to identify common features, in terms of materials and effects between clothing and architectural surfaces, apart from the existing external construction materials and fabric effects as conducted by this study. Also, it is expected that a mutually complementary relationship with architectural surfaces can be formed through the integration of media facades and interactive facades to respond to social and cultural demands or through convergence with smart materials, thanks to technological advances.

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