

## Basic research on interaction design of environmentally friendly building envelopes using natural elements

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**Abstract.** With the emergence of new building materials and the development of construction techniques, the lines between architecture and building envelope have been blurred. As such, the building envelope is no longer just a fixed element, but is an element that is subject to change depending on the surrounding environment. Moreover, with environmentally friendly buildings increasingly in the spotlight, there have been environmentally friendly construction approaches that aim to reduce energy consumption and preserve the natural environment. This study, therefore, aims to build basic data on interaction design of building envelopes that apply natural elements by considering examples of Ned Kahn's works using natural elements.

**Keywords:** Interface Design, Interaction, Building Façade (Skin), Sustainable

### 1 Introduction

In the past, the building envelope was defined as an integrated concept identified with the building structure itself, rather than through an independent concept of a building envelope. However, with the emergence of new building materials and the development of construction techniques, the lines between architecture and building envelope have been blurred. As such, the building envelope is no longer just a fixed element, but an element that is subject to change depending on the surrounding environment. As well, with many countries aggressively pursuing energy-saving policies, there have been enthusiastic attempts to save energy in the building envelope, which consumes a great deal of energy. Thus, there have been environmentally friendly approaches in the area of building envelopes, such as by reducing energy consumption and preserving the natural environment.

Thus, this study aims to build basic data on interaction design of building envelopes that apply natural elements by examining examples of Ned Kahn's works using natural elements.

## 2 Concepts and types of building envelopes and interaction design

### 2.1 Concepts of envelopes and interaction design

The dictionary definition of a building envelope is the 'outer shell of a building that covers the inner volume', indicating the façade of a building in today's architecture with the main entrance for the building [1]. Interaction design refers to a mutual interaction between humans and products or services, mostly designing the interaction between humans and computers. Human-centered design as well as usability and accessibility are the main goals of interaction design.

With the application of interaction design in the field of building envelopes, the building envelope has become an active agent, in contrast with its previous role as a passive separator. In other words, the envelope is developing from one-way and fixed expressions toward two-way communication that perceives and responds to the surrounding environment.

Building envelopes applying interaction can be categorized into three types: graphic element, media façade, and phenomenological element.

**Table 1.** Types of building envelopes applying interaction design

Type	Feature	
Building envelope as a graphic element [2]	Method that enables users to experience various façades of the building by adding graphic elements to the formerly fixed building envelope, and creating a visual façade without physically changing the exterior	
Building envelope as a media façade	Method that enables mutual communication among human desires, buildings and the surrounding environment by breaking away from the fixed architecture of the past, using new media to program electronic, acoustic and visual events into aesthetic concretization with the electronic device acting as the main lexicon of architecture	
Building envelope as a phenomenological element	Method of building envelope that changes while enabling practical expressions by surrounding environment or context, classified into artificial and natural elements	
	Artificial elements	Method in which the envelope responds to the external environment by programming the inner sensor according to the changing weather of the outdoor environment and the indoor environment of the building

	Natural elements	Method in which it is possible to elicit infinite responses of the envelope toward the external environment, with the envelope infinitely responding to the external environment immediately
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### 3 Interaction design case analysis of environmentally friendly building envelopes applying natural elements

In terms of interaction, building envelopes no longer just emphasize aesthetic elements, but fundamentally approach the aspect of saving energy and thus satisfy both human desires and energy saving at the same time. This study will analyze the interaction design of environmentally friendly building envelopes through a case analysis of building envelopes applying natural elements by focusing on the works of Ned Kahn, an environmentally friendly architect and writer.

**Table 2.** Interaction design case analysis of environmentally friendly building envelopes through Ned Kahn's works

Ned Khan's works	Image	Feature
Mare Indurum		This is a double-skin structure that forms the building envelope using the natural environment, and reflective shapes of each module appear due to the influence of the reflection of light and wind on thousands of mirrors arranged between glass layers on the envelope.
Kinetic artwork for Brisbane airport		It is a façade of the short-stay car parking lot that shows different forms of envelope depending on the reflection of sunlight, as the aluminum panels sway in the natural element of wind.
Vertical canal		Thousands of small and clear plastic panels are hanging on minimized thin stainless steel cables to endure the wind in order to express a transparent, horizontal and flat water-shaped plate. In this way, light is reflected depending on the movements caused by the wind, diversifying the expression of colors on the façade.
Wind silos		Steel disks that respond to the wind are hanging and moving up and down by inserting a metal screen on the exterior wall of the parking lot, inducing external reactions through the changes of the façade.
Fragmented dunes		Panels moved individually by the wind are perceived differently according to the direction of the wind and the visible distance, and the shadows created by the sun as it passes through the screen are projected on the floor and bottle, enabling the interior and exterior to interact with each other.

As shown in Table 2, this study analyzed cases of building envelopes applying natural elements by focusing on the works of Ned Kahn, environmentally friendly architect and writer. The results showed that the composition of building envelopes are in the double-skin form, with the envelope on the outside expressed as various facades due to the effects of natural elements. Wind and light were the main natural elements that exerted an influence. The envelope structure of the buildings was also becoming more lightweight, minimizing the effects of the outdoor environment on the indoor areas due to the double-skin envelope.

## 4 Conclusion

This study was conducted to build basic data on interaction design of building envelopes that applied natural elements by examining examples of Ned Kahn's works using natural elements, and the conclusions are as follows. In terms of interaction, building envelopes no longer just emphasize aesthetic elements, but fundamentally approach the aspect of saving energy and thus satisfy both human desires and the need for energy saving at the same time. Moreover, the composition of building envelopes with natural elements takes a double-skin form, with the envelope on the outside expressed as various facades due to the effects of natural elements. Wind and light were the main natural elements that exerted an influence, and envelope structure of the buildings was also becoming more lightweight, minimizing the effects of the outdoor environment on the indoor areas due to the double-skin envelope. Accordingly, this study aimed to build basic data for future research by analyzing technological elements for interaction design of envelopes through a case analysis of environmentally friendly envelope technology in Ned Kahn's works applying natural elements.

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