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Classification of Adaptive Facade: An Investigation on the Potential of Shading Devices in Adaptive Facades

Adaptif Cephelerde Sınıflandırma: Adaptif Cephelerde Kullanılan Güneş Kırıcıların Potansiyeli Üzerine Bir Araştırma

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ABSTRACT

In this research, three different building facades in different climate types according to Köppen Climate Classification and where shading devices are used adaptively are analysed through a model developed by using the adaptive facade classification criteria in the literature. In the model used, the control parameters affecting the facade design, the adaptation method of the facade, the control system and technique, the visibility of the adaptation, and the time scale criteria are addressed, while the potential of using sun shades, which have been used as a traditional solar control tool for many years, in adaptive facades are evaluated. The facades of Carabanchel Social Housing (Spain), Sebrea Headquarter (Brazil), and Swisstech Convention Centre (Switzerland), which are located in different climate classes and where shading devices are used adaptively, are examined. The effects of shading devices with different materials and technological elements on user comfort when they meet with adaptive facade technology are discussed. In addition to the aim of optimizing user comfort, the contribution of adaptive facades, which have the additional aim of reducing structural energy costs by conserving energy, to the energy efficiency and sustainability goals of the building is also addressed, along with its effect on indoor comfort when designed using shading devices. This study emphasizes that shading devices have an important potential not only in terms of aesthetics but also in terms of sustainability goals.

Keywords: Classification of Adaptive Facade, Carabanchel Social Housing, Shading Device, Sebrea Headquarter, Swisstech Convention Centre

ÖZ

Bu araştırmada, Köppen İklim Sınıflandırması'na göre farklı iklim tiplerinde bulunan ve güneş kırıcıların adaptif olarak kullanıldığı üç farklı yapı cephesi literatürde yer alan adaptif cephe sınıflandırma kriterlerinden yararlanarak geliştirilen bir sınıflandırma modeli üzerinden incelenmiştir. Kullanılan modelde; cephe tasarımını etkileyen kontrol parametreleri, cephenin adaptasyon yöntemi, kontrol sistemi ve tekniği, adaptasyonun görünürlüğü ve zaman ölçeği kriterleri ele alınırken geleneksel bir güneş kontrol aracı olarak uzun yıllardır kullanılan güneş kırıcıların adaptif cephelerdeki kullanım potansiyeli değerlendirilmiştir. Farklı iklim sınıflarında bulunan ve güneş kırıcıların adaptif özellikte kullanıldığı ve Carabanchel Social Housing (İspanya), Sebrea Headquarter (Brezilya) ve Swisstech Convention Centre (İsviçre) yapılarına ait cepheler incelenerek farklı malzeme ve teknolojik unsurlarla donatılmış güneş kırıcıların adaptif cephe teknolojisi ile buluştuğunda kullanıcı konforuna etkileri ele alınmıştır. Kullanıcı konforunu optimize etme amacına ek olarak diğer bir amacı da enerji korunumu yaparak yapısal kaynaklı enerji giderlerini azaltmak olan adaptif cephelerin, güneş kırıcılar kullanılarak tasarlandığı durumda iç ortam konforuna etkisiyle birlikte, yapının enerji etkinlik ve sürdürülebilirlik hedeflerine olan katkısına da değinilmektedir. Bu çalışma; güneş kırıcıların sadece estetik açıdan değil, sürdürülebilirlik hedefleri açısından da önemli bir potansiyele sahip olduğunu vurgulamaktadır.

Anahtar Kelimeler: Adaptif Cephe Sınıflandırması, Carabanchel Sosyal Evleri, Güneş Kırıcı, Sebrea Binası, Swisstech Convention Merkezi

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INTRODUCTION:

Studies show that buildings demand 34% of the world's energy, which is even higher than the energy demands of industry and transportation (Shakouri, et al., 2012). Energy problems have made energy saving and sustainability principles in buildings a necessity of architectural design. In fact, the "form follows function" approach adopted by many designers in the 20th century has fallen behind the "form follows environment", "form follows performance" and "form follows sustainability" approaches in the 21st century (Hensel and Menges, 2008). Architectural structures should provide many different functions together in terms of efficient use of natural resources and energy saving, and should adapt to the environmental conditions as much as possible. In this sense, the concept of 'responsive architecture', which can adapt to environmental conditions, was put forward by Negroponte in 1970 (Negroponte, 1975). Responsive architecture not only emphasizes the dynamic nature of architectural design but also provides a framework for structures to align with the ever-changing needs of communities and the environment. This adaptability to environmental conditions is crucial, and it has laid the foundation for the emergence of the 'adaptive architecture' concept (Altın and Orhon, 2014). In the pursuit of the highest building quality, adaptive architecture offers solutions to address dynamic factors (Mésároš et al., 2021). It encompasses the design and construction of buildings capable of dynamically adapting to environmental changes and enhancing energy efficiency (Jäger, 2017). Thus, the adaptability of architecture is not only about responding to immediate needs but is also essential for the long-term resilience of social-ecological systems and effective management of environmental change (Kamara and Dejaco, 2017). In this regard, the key aspect of adaptive architecture lies in its ability to provide structures with the flexibility to evolve alongside societal and environmental shifts. By embracing an innovative and flexible approach throughout the design and construction phases, adaptive architecture ensures that buildings are not static entities but dynamic entities capable of continuous transformation.

Loonen et al. (2010) stated that a climate-adapted building envelope CABS (Climate Adaptived Building Skin) possesses the capability to modify its functions, properties, or behavior in a repetitive and reversible manner, aligning with evolving performance requirements and varying boundary conditions. This adaptability allows the building envelope to enhance overall building performance, specifically in terms of primary energy consumption, while preserving the desired levels of thermal and visual comfort. Adaptive facades, also known as responsive facades, enable buildings to adapt to changing external conditions through movable elements and smart materials (Schmidt and Austin, 2016). As environmental factors such as wind and sun are variable, the facade needs to have the flexibility to adapt to changing environmental conditions (Looman, 2017). Using climate-adaptable building envelopes (CABS) instead of traditional building envelopes in the building prevents the negative effects of existing external environmental changes around the building and allows "mediated" indoor conditions instead of "generated" (Addington, 2009). Research initiatives such as COST ActionTU1403[3], FACET-Project[4] , and IEA ECBCS Annex 44[5] aim to increase awareness and understanding of adaptive facades through systematic classification models and investigation of optimized design approaches for different climatic conditions. These projects seek to integrate environmentally sensitive building elements into structures and develop components that enhance building comfort conditions (Başarır and Altun, 2017).

[3] COST Action TU1403, also known as the Adaptive Facades Network, is a European-funded networking program focused on the development, education, and exchange of knowledge in the field of adaptive facades. See Knaack, et al., 2015, and Bedon et al., 2018 for further information.

[4] In the FACET project, the 'reverse modelling' approach is used and optimized for different climatic conditions in various time transitions (seasons, day-night, instantaneous) where realistic building envelope and possibilities are being investigated (de Boer, et al., 2011).

[5] IEA ECBCS Annex 44 is an international collaboration focused on the research and development of responsive building systems. It involves researchers from various countries and aims to collect information about the performance of buildings that utilize environmentally responsive elements. For additional information, consult to Heiselberg, 2012.

1. METHOD OF THE STUDY

Table 1: Method of the Study

Literature survey on the classification models developed for adaptive facades →	Determination of the criterias in the available daptive facade classification models →	Developing a classification model by using the classification criteria in the literature →	Using the developed classification model on 3 adaptive façades with sun shades
Step 1	Step 2	Step 3	Step 4

Although adaptive facades equipped with the latest technology provide positive conditions for the interior and energy conservation, they move away from sustainability targets due to their high economic cost (Aelenei et al., 2018). Designers looking for effective and economical solutions have built many buildings in which shading elements such as shading devices, blinds, light shelves and shutters are equipped with adaptive features on the facade. This analysis may reveal the potential of shading devices to increase the energy efficiency of structures, improve indoor comfort and reduce their environmental impact, contributing to the wider adoption of such solutions in future building design. Besides shading devices are not only used to improve visual comfort but also have an impact on thermal comfort, acoustic comfort and indoor air quality.

The method of this study involves four main components, as outlined and elucidated in Table 1. First, the literature review encompasses along with an examination of classification models devised for adaptive facades. This phase provides essential contextual understanding and theoretical framework for the subsequent phases. Second, classification phases of the available models and priority criteria clarifying. Third, to compose a review model that utilizes existing classification criteria and expands some of these criteria. The adaptive facade classification criteria to be used in the model in Table 2 are the comfort parameter provided by the system (Loonen et al., 2013), adaptation method of shading devices (Aelenei et al., 2018), the type of movement of the shading devices (Moloney, 2011), the control technique (Ramzy and Fayed, 2011), the control system (Voigt et al., 2023), the sustainability potential of the building (Belek and Yamaçlı, 2023), the visibility of the adaptation (Loonen et al., 2015; Voigt et al., 2023), the time scale (Loonen et al., 2013) and the type of material used on the shading component (Fox and Yeh, 2000). The sustainability criterion used in adaptive facade classification systems has been expanded and the sustainability potential of the building has been analysed by dividing it into three dimensions of sustainability: environmental, social, and economic aspects (Gök and Yiğit, 2017). Besides, the examination includes the presence of features contributing to system sustainability, such as the use of natural materials, the use of recyclable materials, energy generation, energy efficiency, water and waste management. Finally, in this study, it is aimed to examine building facades where shading devices, one of the traditional solar control elements, gain adaptive properties by combining them with modern technology. These features can enable structures to adapt to environmental conditions and contribute to structural sustainability goals. In the study, three different building examples in different climate types according to Köppen Climate Classification were considered (Figure 1). These examples aim to evaluate the working principle of the adaptability features of sunshades in different climatic conditions and their sustainability contributions through different structures.

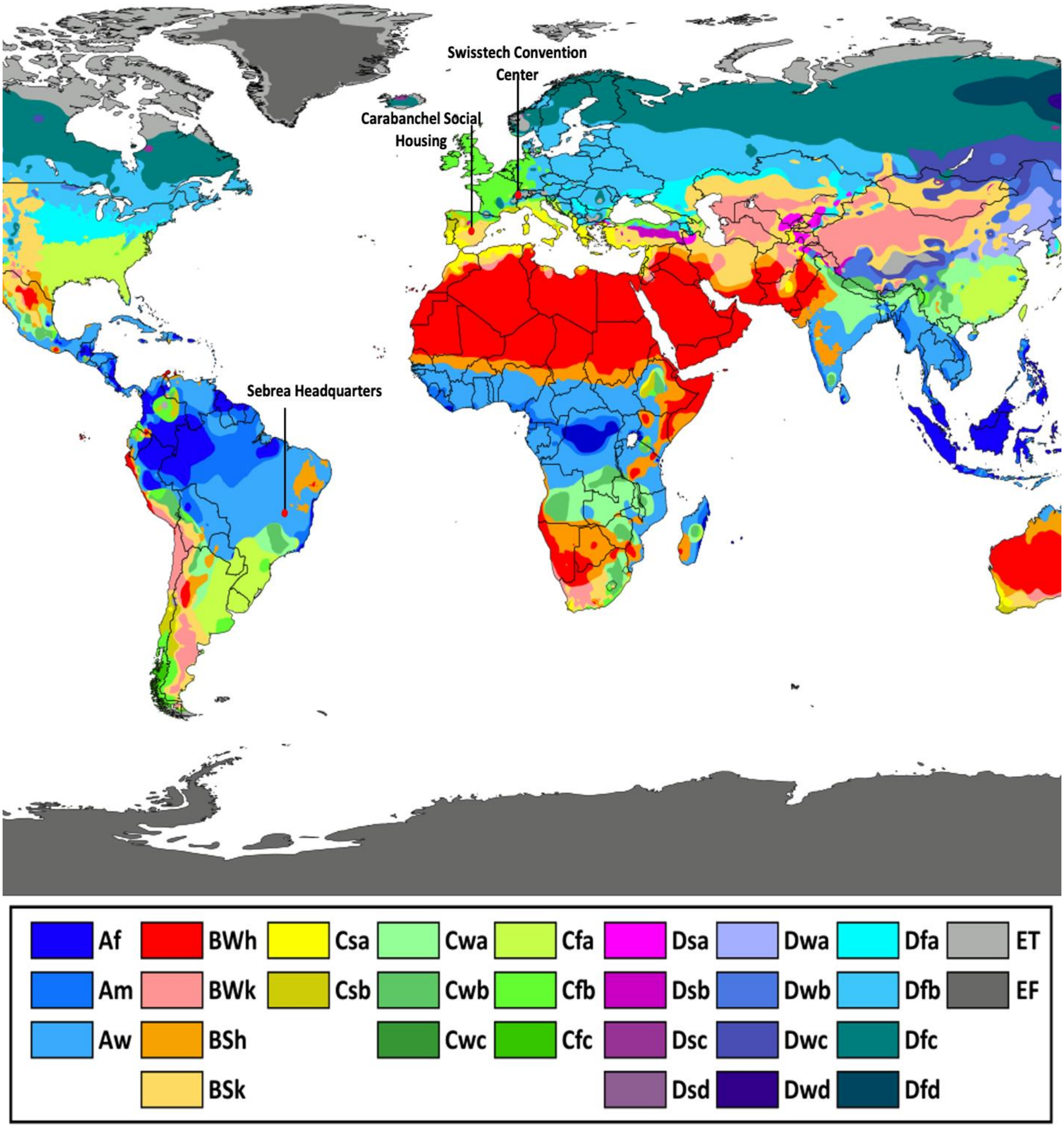
Table 2: Classification Model Approach of the Research (Developed by utilising Fox and Yeh, 2000; Moloney, 2011; Ramzy and Fayed, 2011; Loonen et al., 2013; Loonen et al., 2015; Başarır and Altun, 2017; Aelenei et al., 2018; Belek and Yamaçlı, 2023; Voigt et al., 2023).

BUILDING NAME, Country (Type of Köppen Climate Classification)						
Facade			**Facade Detail**			
Facade Image Example			**Detailed Facade Image**			
Comfort Parameters						
Visual Comfort	Thermal Comfort	Acoustic Comfort	Indoor Air Quality			
Material of the Shading Device						
Wood	Plastic	Metal	Glass	Other: Specific		
Adaptation Method of Shading Device						
Dynamic	Folding	Static				
	Sliding					
	Rotation					
	Scale					
Control System						
Pneumatic	Hydraulic	Mechanic	Chemical	Electromagnetic		
Control Type						
Internal Control	External Control					
Time of Adaptation						
Seconds	Minutes	Hours	Days	Weeks	Months	Years
Visibility of Adaptation						
Yes	Form	No				
	Angle					
	Color					
	Texture					
Impact of the Shading Devices on Sustainability						
Social	Environmental	Economics				
Contribution of Shading Devices to System Sustainability.						
Materials		Energy		Water and Waste Management		
Natural Materials	Recyclable Materials	Energy Efficiency	Energy Generation	Waste Management	Water Management	

This research focuses on examining structures located in three different geographical regions to understand how shading devices can be optimized in various climatic conditions. The *Swisstech Convention Centre* selected for the study, is located in Lausanne, Switzerland, where the Köppen climate classification indicates a Dfb climate type. The most distinctive feature of this climate is its continental characteristics, with long winters, short summers, and precipitation occurring throughout the year (Köppen, 1930). The primary reason for selecting a structure in this climate type is to investigate the reasons for using sun shading devices in a region where the summer season is short. The second selected structure is the *Carabanchel Social Housing* building in Madrid, Spain, which is situated in a region dominated by the Csb climate type according to the Köppen classification (Köppen, 1930). The main characteristic of this climate type is hot and dry summers, along with short winters.

The reason for selecting the *Carabanchel* structure for examination is to highlight the positive effects of sun shading devices in a climate where summers are particularly hot. The third structure chosen for the study is the *Sebrea* Headquarter building in the capital of Brazil, which falls under the Aw climate type according to the Köppen Climate Classification. This climate zone exhibits tropical climate characteristics, with the region receiving more solar radiation compared to the other selected locations. The primary reason for selecting this structure is to emphasize the advantages of using sun shading devices in a region near the equator.

Figure 1: Marking the Locations of the Selected Buildings on the Köppen Climate Classification Map, (Peel et al., 2016).



2. EXISTING CLASSIFICATION METHODS OF ADAPTIVE FACADES

Researchers have employed various approaches in the development of classification methods for adaptive facades, with an apparent focus on three common stages. Loonen et al. (2015) emphasized three key stages observed in these classification methods as: first, gathering information from the environment; second, perceiving the information obtained from the environment; and third, creating a response. Fox and Yeh (2000) focused on material, facade typology, and control mechanisms in their classification study. The movement type of the facade elements, the method facilitating this movement, and the control system of the facade stood out in their model. Addington and Shodeck (2005) worked on a classification method reduced to smart materials, where the properties and energy exchange of smart materials formed the subcategories providing physical and chemical consequences for the facade. In 2009, a classification scheme concentrating on building elements was developed by IEA ECBCS Annex 44[6]. This model categorized elements based on their location in the structure, examining performance characteristics, functionality, physical behavior, and HVAC[7] relationship (Heiselberg, 2012). This system allows for an analysis of the correct design of facade elements during the design phase (Ayçam, 2011).

Table 3: Classification Methods for Adaptive Facades

Year	Authors	Criteria
2000	Fox and Yeh	Material, Facade Typology, Control Mechanisms
2005	Addington and Shodeck	Smart Material Properties, Energy Exchange
2009	IEA ECBCS Annex 44	Performance Characteristics, Function, Physical Behavior, HVAC Relationship
2011	Ramzy and Fayed	Movement System, Degree of Mobility, Control Technique, System Configuration, Cost
2013	Loonen et al.	Comfort Parameter, Time Scale, Scale Adaptation, Control Type, Facade Typology
2015	Loonen et al.	Purpose of Design, Sensitivity Function of Facade, Visibility
2017	Başarır and Altun	Trigger Environment Conditions, Adaptive Element, Adaptation Factor, Response to Adaptation, Movement Type, Adaptation Scale, Movement Limit, Structure System
2018	Aelenei et al.	Technology Level of System, Type of Facade, Purpose of Adaptation, Type of Material, Type of Adaptation Devices, Adaptation Type, Actuator Type, Type of Trigger, Adaptation Element Scale, Time, Adaptation Degree, Visibility
2023	Belek and Yamaçlı	Adaptive Facade Typology, Adaptive Facade System, Class of Adaptive Facade, Adaptive Facade Sustainable Design Goals
2023	Voigt et al.	Control System, Purpose of Adaptation, Sensor, Adaptation Type, Actuator Type, Input Driving Facade, Adaptation Element Scale, Time, Adaptation Degree, Visibility, Adaptation Function, HVAC Relationship, Integration of Adaptive Elements

As seen in Table 3, classification methods for adaptive facades have evolved over time, with various approaches focusing on different aspects of facade design and functionality. Loonen et al. (2015) highlighted three essential stages in these methods: gathering information from the environment,

[6] IEA ECBCS Annex 44 is an international collaboration focused on the research and development of responsive building systems. It involves researchers from various countries and aims to collect information about the performance of buildings that utilize environmentally responsive elements. For additional information, consult to Heiselberg, 2012.

[7] Acronym for Heating, Ventilation, and Air Conditioning.

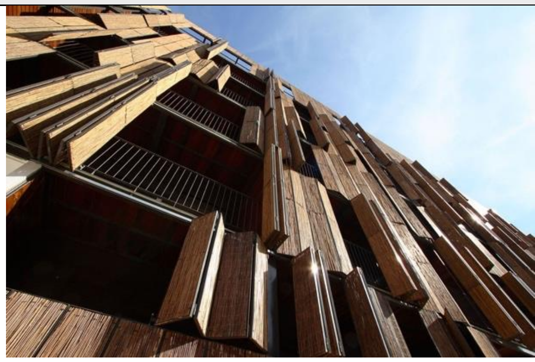
perceiving this information, and creating a response. Fox and Yeh (2000) emphasized material, facade typology, and control mechanisms, while Addington and Shodeck (2005) narrowed their focus to smart materials and their physical and chemical consequences for facades. IEA ECBCS Annex 44 developed a classification scheme based on building elements' location, performance characteristics, functionality, physical behavior, and HVAC relationship (Ayçam, 2011; Heiselberg, 2012). Ramzy and Fayed (2011) classified adaptive facade systems based on movement system, degree of mobility, control technique, system configuration, control limit, and cost. Loonen et al. (2013) emphasized the importance of climate-sensitive adaptive facades being able to change properties over time and return to their original state. Their approach considered factors such as comfort parameters, time scale, scale adaptation, control type, and facade typology. Başarır and Altun (2017) proposed a classification model addressing design parameters lacking in previous methods and tested it on structures with different adaptation features. Belek and Yamaçlı (2023) included the sustainability goals of the system such as energy efficiency, thermal comfort, air quality comfort and visual comfort in the adaptive facade classification table they use. Aelenei et al. (2018) classified adaptive facade systems according to technology level of system, type of facade, purpose of adaptation, type of material, type of adaptation devices, adaptation type, actuator type, type of trigger, adaptation element scale, time, adaptation degree, visibility. Voigt et al. (2023) focused on facade design parameters in their classification systems, examining buildings based on control system, purpose of adaptation, sensor, adaptation type, actuator type, triggering input, scale of adaptation, time, degree of adaptation, visibility, function of adaptation, HVAC relationship, and integration of adaptive elements. These diverse classification models contribute to a comprehensive understanding of adaptive facade design and functionality.

3. FINDINGS

3.1 Carabanchel Social Housing

The Carabanchel Social Housing project, located on the outskirts of Madrid, Spain, is a social housing development designed by Foreign Office Architects (FOA) and completed in 2007. This project is part of a regeneration area, bordered by a new urban park to the west and similar housing blocks to the north, east, and south (URL 1). The complex is a compact structure designed to accommodate private gardens for the units on the eastern side and double-aspect units facing both gardens. The units are organized as elongated "tubes" connecting both facades, which are fully glazed. These glazed facades feature 1.5-meter-wide terraces enclosed with bamboo screens mounted on folding frames, offering residents shading, privacy, and flexibility (URL 1). Thus, sunshades made from bamboo material, installed on all facades of the building, contribute to optimizing indoor comfort conditions (Aelenei et al., 2018). Bamboo, a natural building material, is not very commonly cultivated in Spain except for a few special types. However, when used as a building material, it offers many advantages. Being a natural and renewable material, it causes minimal environmental pollution.

Table 4: Adaptive Facade Features of Carabanchel Social Housing

Carabanchel Social Housing, Switzerland (Csb Climate Type)	
Facade	**Facade Detail**
 URL 2	 URL 3

Comfort Parameters			
Visual Comfort	***Thermal Comfort***	***Acoustic Comfort***	Indoor Air Quality

Material of the Shading Device				
Wood	Plastic	Metal	Glass	***Other: Bamboo***

Adaptation Method of Shading Device		
Dynamic	***Folding***	Static
	Sliding	
	Rotation	
	Scale	

Control System				
Pneumatic	Hydraulic	***Mechanic***	Chemical	Electromagnetic

Control Type	
Internal Control	***External Control***

Time of Adaptation						
Seconds	Minutes	Hours	Days	Weeks	Months	Years

Visibility of Adaptation		
Yes	Form	No
	Angle	
	Color	
	Texture	

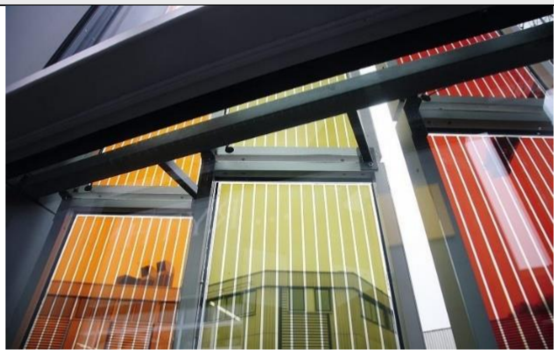
Impact of the Shading Devices on Sustainability		
Social	***Environmental***	***Economics***

Contribution of Shading Devices to System Sustainability.					
Materials		***Energy***		***Water and Waste Management***	
Natural Materials	***Recyclable Materials***	***Energy Efficiency***	Energy Generation	***Waste Management***	Water Management

3. 2. Swisstech Convention Centre

In this building constructed in Switzerland in 2014, unlike most sun-shading elements on the west facade, transparent daylight control elements were used. Thanks to the photovoltaic cells placed on the glass shading devices, approximately 8,000 kWh of energy can be generated throughout the year, which is twice the amount of energy the building requires (Barraud, 2013). The adaptive facade elements, which provide visual comfort conditions indoors, follow the sun with a rotational movement, and their colored structure allows for color changes inside the building.

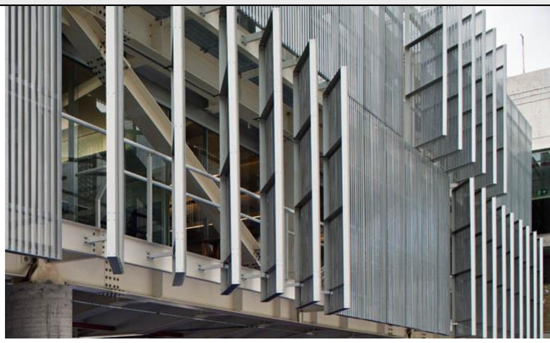
Table 5: Adaptive Facade Features of Swisstech Convention Centre

<table>
<tr><th colspan="7">Swisstech Convention Centre, Switzerland (Dfb Climate Type)</th></tr>
<tr><th colspan="3">Facade</th><th colspan="4">Facade Detail</th></tr>
<tr><td colspan="3">
(Bisquert, 2014)</td><td colspan="4">
(Barraud, 2013)</td></tr>
<tr><th colspan="7">Comfort Parameters</th></tr>
<tr><td>Visual Comfort</td><td>Thermal Comfort</td><td>Acoustic Comfort</td><td>Indoor Air Quality</td></tr>
<tr><th colspan="7">Material of the Shading Device</th></tr>
<tr><td>Wood</td><td>Plastic</td><td>Metal</td><td>Glass</td><td>Other: PV Cells</td></tr>
<tr><th colspan="7">Adaptation Method of Shading Device</th></tr>
<tr><td rowspan="4">Dynamic</td><td>Folding</td><td rowspan="4">Static</td></tr>
<tr><td>Sliding</td></tr>
<tr><td>Rotation</td></tr>
<tr><td>Scale</td></tr>
<tr><th colspan="7">Control System</th></tr>
<tr><td>Pneumatic</td><td>Hydraulic</td><td>Mechanic</td><td>Chemical</td><td>Electromagnetic</td></tr>
<tr><th colspan="7">Control Type</th></tr>
<tr><td>Internal Control</td><td>External Control</td></tr>
<tr><th colspan="7">Time of Adaptation</th></tr>
<tr><td>Seconds</td><td>Minutes</td><td>Hours</td><td>Days</td><td>Weeks</td><td>Months</td><td>Years</td></tr>
<tr><th colspan="7">Visibility of Adaptation</th></tr>
<tr><td rowspan="4">Yes</td><td>Form</td><td rowspan="4">No</td></tr>
<tr><td>Angle</td></tr>
<tr><td>Color</td></tr>
<tr><td>Texture</td></tr>
<tr><th colspan="7">Impact of the Shading Devices on Sustainability</th></tr>
<tr><td colspan="2">Social</td><td colspan="2">Environmental</td><td colspan="2">Economics</td></tr>
<tr><th colspan="7">Contribution of Shading Devices to System Sustainability.</th></tr>
<tr><td colspan="2">Materials</td><td colspan="2">Energy</td><td colspan="2">Water and Waste Management</td></tr>
<tr><td>Natural Materials</td><td>Recyclable Materials</td><td>Energy Efficiency</td><td>Energy Generation</td><td>Waste Management</td><td>Water Management</td></tr>
</table>

3. 3. Sebrea Headquarter

In 2010, the office building constructed in Brazil features shading devices made of metal on its facade. These facade elements, which can rotate around their axis depending on the position of the sun, help prevent overheating issues in the building and contribute to reducing cooling expenses (Kızılörenli and Maden, 2021). Additionally, the shading devices assist in controlling the amount of air and sound entering the interior space.

Table 6: Adaptive Facade Features of Sebrea Headquarter

Sebrea Headquarter, Brazil (Aw Climate Type)	
Facade	**Facade Detail**
 (Kon, 2011)	 (Kon, 2011)

Comfort Parameters			
Visual Comfort	***Thermal Comfort***	***Acoustic Comfort***	***Indoor Air Quality***

Material of the Shading Device				
Wood	Plastic	**Metal**	Glass	Other: PV Cells

Adaptation Method of Shading Device		
Dynamic	Folding	Static
	Sliding	
	Rotation	
	Scale	

Control System				
Pneumatic	Hydraulic	***Mechanic***	Chemical	Electromagnetic

Control Type	
Internal Control	***External Control***

Time of Adaptation						
Seconds	Minutes	Hours	Days	Weeks	Months	Years

Visibility of Adaptation		
Yes	Form	No
	Angle	
	Color	
	Texture	

Impact of the Shading Devices on Sustainability		
Social	***Environmental***	Economics

Contribution of Shading Devices to System Sustainability.					
Materials		***Energy***		***Water and Waste Management***	
Natural Materials	***Recyclable Materials***	***Energy Efficiency***	Energy Generation	***Waste Management***	Water Management

EVALUATION AND CONCLUSION:

Obviously, the concept of 'adaptive architecture' underlines the dynamic nature of architectural design, offering a framework for structures to harmonize with the evolving needs of communities and the environment. The historical development of adaptive architecture has culminated in a contemporary approach that emphasizes living in harmony with the natural environment while constructing sustainable and environmentally friendly buildings, placing a significant responsibility on architects. By leveraging technology and scientific advancements, architects can construct structures that align with adaptive architectural principles, demonstrating a commitment to sustainable design. Similarly, the evolution of adaptive facades, also referred to as responsive facades, mirrors a transition towards environmentally conscious architecture, advanced technologies to enhance building energy efficiency and performance. These facades possess the capacity to adapt to fluctuating environmental conditions through the integration of movable elements and smart materials. Vital to this adaptivity is the presence of a control system, which intervenes in the energy flow between indoor and outdoor environments, ensuring necessary comfort within the indoor space. The synergy between adaptive architecture and facades showcases a commitment to creating structures that respond to environmental dynamics, paving the way for a sustainable and responsive built environment. The ability to control aspects such as energy production, energy conservation, ensuring necessary comfort conditions, waste management, through architectural structures can be a step towards sustainability by contributing to the reduction of natural resource consumption. Adaptive facades, while expanding their application area with technological advancements, aim to increase their visibility through examination studies conducted on existing facade systems.

The use of shading devices, a common comfort tool, in adaptive facades is more practical and economical compared to complex facade solutions. When examining the integration of shading devices into structures in adaptive facades, it can be observed that there are examples applicable in various climate types. *The Carabanchel Social Housing* structure offers a quite different perspective on adaptive facade design. By integrating natural and traditional materials with innovative construction methods and technology, the production cost of the facade is reduced while enhancing user comfort. Situated in a warm climate region, the building is exposed to sunlight for much of the year, emphasizing the significant importance of shading devices integrated into the facade. *The Swisstech Convention Centre* is situated in a climate region where the summer months are short. Therefore, the facade is designed to not only mitigate the adverse effects of sunlight indoors but also to harness the potential of renewable energy sources by equipping shading devices with photovoltaic cells. In Switzerland, where the annual sunlight duration is relatively low, maximizing efficiency from the sun and meeting the energy needs of the structure are the primary objectives behind the design of the west facade. Considering the cost and maintenance of photovoltaic cells, the facade may not be economical. However, it achieves economic and environmental sustainability goals by reducing energy expenses to zero and avoiding waste production from energy consumption. Since the *Sebrea Headquarter* is located in a tropical region, sunlight reaches the area at a steep angle. To prevent adverse effects on visual comfort conditions due to this situation, metal sunshades were designed to be highly durable. However, the region's frequent rainfall throughout the year can lead to wear and tear issues. Despite the maintenance and refurbishment costs, the metal material's ability to be 100% recyclable contributes to environmental sustainability by eliminating the potential for shading devices, once their useful life ends, to become environmental waste.

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