ADVANCED INTEGRATED FAÇADES: AN OVERVIEW

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Advanced Integrated Façades (AIF) are one type of RBE and can be considered as the actual development of what started with passive architecture concepts and evolved into the intelligent skins (or façades) concept.

**ADVANCED**: dynamic, adaptive and intelligent

**INTEGRATED**: interaction between building components interaction between building components and the building systems (including HVAC systems)

These concepts have been strongly developed in **TRANSPARENT FAÇADES**.
ADVANCED INTEGRATED FAÇADES

New comfort concepts improve upon the “simple” thermal approach including the overall well-being of occupants.

Such concepts lead to more transparent buildings, mainly in the services area - **Transparency** means:

- strong visual connection between the building interior and the surroundings, as if the building itself could be part of it
- the otherwise separated indoor and outdoor environments can “merge”
- the view to the outdoors is not limited (an atmosphere that is better appreciated by occupants)

A **transparent façade**:

- has a pleasant appearance
- evokes high-tech images
- transforms the façade in a landmark in the urban landscape.
The first realizations of these concept used single glazed façades ⇒ drawbacks concerning indoor thermal comfort and energy consumption.

Innovative glazing systems with solar shading devices improved performance (cold seasons)

A real breakthrough was the adoption of double skin façades (DSF), i.e. an arrangement with a glazed skin on the exterior of the main glazed façade, forming a cavity between the outermost layers. Solar control devices are placed within the cavity, where they are protected from weather and air pollution.

It did not take long to evidence the advantages that resulted from allowing air to flow in the cavity.
A further advancement was achieved when the idea of "intelligence" was included in DSF, introducing the intelligent skin/façade/glass-façade concept. An intelligent façade may be defined as a composition of construction elements confined to the outer, weather-protecting zone of a building, which performs functions that can be individually or cumulatively adjusted to respond predictably to environment variations, to maintain comfort with the least use of energy.

The introduction of "intelligence" associated with DSF represents a change from a static envelope to one with a dynamic behaviour and from a single-function element to a multi-function integrated system. In order to build an actual AIF its conception must result from an "intelligent design" rather than just from an assembly of "intelligent components".

This implies that the design process should be integrated in order to achieve interior comfort through efficient, energy-saving measures and then it requires new approaches and procedures.
ADVANCED INTEGRATED FAÇADES

CONSTRUCTIVE AND FUNCTIONAL ELEMENTS

- glazing
- shading device
- air flow (type of ventilation, flow path)
- interface with HVAC systems
- control systems

- Natural Ventilation (NV)
- Mechanical Ventilation (MV)
- Hybrid Ventilation (HV)

Exhaust Air (EA)  
Supply Air (SA)  
Reversible Air Flow (RAF)  
Outdoor Air Curtain (OAC)  
Indoor Air Curtain (IAC)
AIF classification is not a straightforward task due to the number of different and cumulative aspects to be considered. However DSF classification criteria can be used as a basis.

Within Annex 44 an updated classification of the most common criteria will be followed and established definitions will be used, with some added definitions that correspond to the work carried out by the present task:

- Type of ventilation
- Flow path
- Façade config.
CLIMATE WALL [CW]

Climate façade

Climate window
DOUBLE SKIN FAÇADE [DSF]

Buffer

Box window

Shaft box

Corridor

Multi-storey Louvers
DSF: BOX WINDOW [BW]
DSF: SHAFT BOX [SB]
DSF: CORRIDOR FAÇADE [C]
DSF: MULTI-STOREY [MS]

Elevation | Section | Plan
--- | --- | ---

Interfacial layer
Outer facade layer

Rooms 1
Rooms 2
Rooms 3

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DSF: MULTI-STOREY LOUVERED [MS]
dominant fraction is located in Continental/Northern European countries (56.7%) – Germany, Switzerland, Finland, France and Belgium. Japan also contributes a large percentage of about 13.0%.
Natural ventilation (58.1%) and Multi Storey (47%) config. are the most common solutions.
YEAR OF CONSTRUCTION/RETROFIT

Nr. of buildings (sample: 215 buildings)
APPLICATION FIELD

less than 20 buildings (~10%) are not of the office type.

Among them it was possible to identify:

• airports (2),
• malls (3),
• schools (5),
• Courts of Justice (2),
• libraries (2),

and

• hotel, hospital and demonstration and science building with one example each.
AIF MAIN FUNCTIONS

- to recover heat during cold season and/or preheat ventilation air
- to improve the thermal insulation of the glazed systems during both hot and cold season
- to reduce solar loads and enhance natural light control without the drawback of the overheating of a solar shading device located in the indoor environment
- to extend the use of natural ventilation, particularly in the case of high rise buildings

When connected to the building energy system, all of these features, thanks to a dynamic “adjustment” of the system so that it can adapt to the working conditions, contribute to the reduction of energy consumption and the improvement of thermal comfort.

HOWEVER EXPECTED RESULTS ARE OFTEN NOT FILLED
<table>
<thead>
<tr>
<th>BENEFITS</th>
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</thead>
<tbody>
<tr>
<td>Acoustics</td>
</tr>
<tr>
<td>Energy</td>
</tr>
<tr>
<td>Ventilation</td>
</tr>
<tr>
<td>LIMITATIONS</td>
</tr>
</tbody>
</table>

**Acoustics**
- Offers better acoustical insulation against outdoor noise.

**Energy**
- May act as a static or dynamic thermal buffer, thus reducing heating/cooling energy needs.

**Ventilation**
- Improves the use of natural ventilation.
- Operable windows are allowed.
- Reduces cavity condensation.

**LIMITATIONS**
- External pane openings may reduce noise insulation but usually not in a significant way.
- Room to room sound transmission (“telephone” effect) is possible.
- High internal loads may require extra cooling energy, thus compensating the benefit of energy reduction.
- Sensitive to components change from design specification.
- Mechanical ventilation HVAC systems may be needed to ensure thermal comfort.
- Pollutant dissemination is possible.
### AIF “CLAIMED” BENEFITS AND POSSIBLE LIMITATIONS - 2

<table>
<thead>
<tr>
<th>Category</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shading</td>
<td>Various types of solar shading device are possible due to the weather;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pollution protection is offered by the external pane</td>
<td></td>
</tr>
<tr>
<td>Wind pressure</td>
<td>Protects the inner pane from gusting and reduces static pressure in</td>
<td>Cavity wind induced pressure depends on DSF/AIF configuration;</td>
</tr>
<tr>
<td></td>
<td>high-rise buildings;</td>
<td>Certain zones of the façade may not be protective;</td>
</tr>
<tr>
<td></td>
<td>Reduces the difficulty of operating windows/doors and the risk for</td>
<td>Heavy wind loading is possible</td>
</tr>
<tr>
<td></td>
<td>maintenance staff</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>Enables the installation of light redirecting elements;</td>
<td>Reduces the amount of daylight entering the building in comparison with</td>
</tr>
<tr>
<td></td>
<td>Improves the use of natural lighting with no thermal discomfort</td>
<td>single glazed façades</td>
</tr>
</tbody>
</table>
## AIF “CLAIMED” BENEFITS AND POSSIBLE LIMITATIONS - 3

<table>
<thead>
<tr>
<th>Fire Safety</th>
<th>Reduced the ability for smoke ventilation; risk of fire/smoke spreading among floors or rooms; Reduces the ability of fire fighters to reach the inner façade; Increases the risk of broken glass hitting the ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Lowers operation costs and may reduce overall costs, resulting in a more cost effective solution</td>
</tr>
<tr>
<td></td>
<td>Higher investment costs and maintenance costs; May increase overall costs, resulting in a less cost effective solution</td>
</tr>
<tr>
<td>Sustainability</td>
<td>May significantly reduce energy consumption; Higher lifecycle of weather protected elements, reducing waste;</td>
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<tr>
<td></td>
<td>Higher materials input; Environmental impact depends on used materials; Improper design may significantly increase energy consumption</td>
</tr>
</tbody>
</table>
the main reason for adopting AIF solutions is the improvement in energy management towards consumption reduction that maintains optimal indoor comfort levels.

To prepare for the future, the building sector has to be much less energy demanding.

It also has to be fully adaptive to the local climate and, of course, be environmentally sustainable and cost effective.

Within this framework, the façade will be one of the principal elements in the buildings of the future.

there is a need for teamwork from the onset of building design.
In order for AIF solutions to be conveyed, designers need:

- guidelines in the form of simplified tools,
- standards
- regulations,
- updated and more reliable tools for more advanced design stages,
- specific benchmarks

The confidence on simulation results will become more and more essential as contractors demand that cost effectiveness and claimed comfort conditions be evaluated in post occupancy and be included in “warranty”.

The lack of specific models for AIF behaviour may therefore slow the use of those kinds of solutions.
They must be able to consider the effects of:

- the outdoor climate (for naturally ventilated façades the variability of the wind in space and time should be modelled)
- the façade (glazed panes, shading devices, ventilation strategy, thermal properties)
- the building (physics, occupancy schedule, HVAC systems)
- the control system

So far few simulation tools are available for an accurate assessment, due to the complexity of interactions and no tools are yet available in a form ready for designers to use.
SIMULATION TOOLS

Component simulation tools:
- WIS (www.windat.org)
- BISCO/TRISCO/VOLTRA (www.physibel.be)
- OPTICS 5 (www.eetd.lbl.gov/btp/software.html)
- FRAME (www.frameplus.net)

Building simulation tools:
useful for the analysis of the energy implication due to the use of a AIF, not so effective to study and design the component itself

More than 240 software packages are available (www.eere.energy.gov/buildings/tools_directory: TRNSYS, ESP-r, ENERGYPLUS, CAPSOL, ECOTECT, TAS,……)

Commercial CFD software (Fluent, Flovent, StarCd,…)

Developed by Research centers (Numerical models and data based models,…)

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No standardized procedure to certify performance and to test the façades

mainly in laboratory (research activities in test facilities)

few in real buildings

lack of complete, organic and systematic set of experimental data

Lack of classification and certification standards
CONCLUSIONS

- R&D activity is still required to assure efficient solutions and a widespread application of AIFs, that are one of the key elements in the buildings of the future
- A wide variety of solutions has been and will be developed

However

- designers need guidelines in the form of simplified tools, standards and regulations; updated and more reliable tools for more advanced design stages and specific benchmark
- architects and engineers must educate investors and owners for decision making and occupants for use
- validation of the simulation tools and post-occupancy monitoring in real buildings is necessary
GLAZING