These examples generally are not environmental but they have some types and applications that is compatible with environment, and those are the examples which will be explained widely in this study.

Key words: Environmental Forces, Innovative Materials, Nano Materials, Smart Materials.

Introduction

"The building envelope is more than a façade–it is the poetic mediation between an internal spatial realm and the outside world."

Successful building envelope design requires more than aesthetic qualities on the outside. Keeping water out, heat or cooled air in, and resisting the impact of wind, blast, heat gain. Many of the most important building envelope design elements, such as performance criteria and building system components, are hidden from view. As far as building envelope trends, sustainability, moisture intrusion, energy efficiency, solar control, enhanced use of glass, new technology, along with high performance composite materials, products, and systems, are likely to remain important product concepts in the building envelope marketplace. If the present is any indication, these products will be constantly changing and updated, to meet the next challenge, capture the next trend, and provide architects with even more exciting design opportunities. For these reasons, and the desire to promote sound professional design standards, a thorough understanding of building envelope design methods and construction techniques are critical aspects of architectural practice. This article will address the impact of using Innovative Compatible Materials that comprise the building envelope, and explore innovative qualities, trends, and characteristics.

The Innovative Environmentally Compatible Materials

Innovative environmentally compatible materials are products using new developed technology to produce materials with environmentally compatible properties. In this paper there are two selected examples for innovative environmentally compatible materials: Smart materials and nano-materials. These examples generally are not environmental but they have some types and applications that is compatible with environment, and those are the examples which will be explained widely. We can use the following points to address the performance of the Innovative Compatible Materials:

1. Evaluate the latest innovative materials, technology, architectural components, and related systems that comprise the building envelope.
2. Identify performance characteristics and qualities that are important considerations during building envelope design, specification, and construction.
3. Explain how to minimize risk and liability when approaching design, specification, and selection of building envelope products and systems.
4. Analyze the sustainability benefits and attributes of various building envelope innovative products.

Smart Materials

Smart materials are those that change in response to changing conditions (moist, heat, light, pressure and electricity) by changing their properties (mechanical, electrical, appearance), their structure, composition, and functions according to the environmental stimuli.

Elements and Characteristics of Smart Materials

in an integrated way in a smart building system: sensors; actuators[1]; and importantly the backbone or nervous system. The physical characteristics of smart materials are determined by these energy fields and the mechanism through which this energy input to a material is converted.

- If the mechanism affects on the internal energy of the material by altering either the material's molecular structure (microstructure) then the input results in a property change of the material.
- If the mechanism changes the energy state of the material composition, but does not alter the material, then the input results in an exchange of energy from one to another.

Smart Materials and Sustainability

The terms 'smart' and 'sustainable' are frequently used together in the context buildings. Smart is often used to refer more to the responsiveness of the building, in particular through the use of information technology and control systems than to use

[1] **Sensors**: Sensors are detection devices for responding to changes in the environment and warn accordingly. (Integrated information management system and performance models). **Actuators:** Actuators make things happen. They are control devices that close or open an electrical circuit or close or open a pipe. For example, they may perform a dual role extracting heat from low grade sources like ground water or geothermal reservoirs and serve it as mechanical pumps to deliver the warmed water to the heating system of a building.

materials and design in 'smart' ways. To understand green features of smart materials, first the convergence of smartness and sustainability has to be explained.

The convergence of smartness and sustainability have been showed by defining some aspects of smart technology which have delivered specific ideas and technologies to obtain sustainable outcomes. The environmental assessment for some smart materials can be summarized in the impact of material on controlling on the environmental forces (e.g. thermal and lighting forces)

Applications for Using Smart Sustainable Materials

Smart technology supporting the goals of sustainability, by understanding large scale use of smart technology.

Building Integrated Photovoltaics (BIPV) System is the integration of photovoltaics (PV) into the building envelope.

Incorporating photovoltaics into the façade of a building: Complementing or replacing traditional view or spandrel glass. Often, these installations are vertical, reducing access to available solar resources, but the large surface area of buildings can help compensate for the reduced power.(Figure 1)

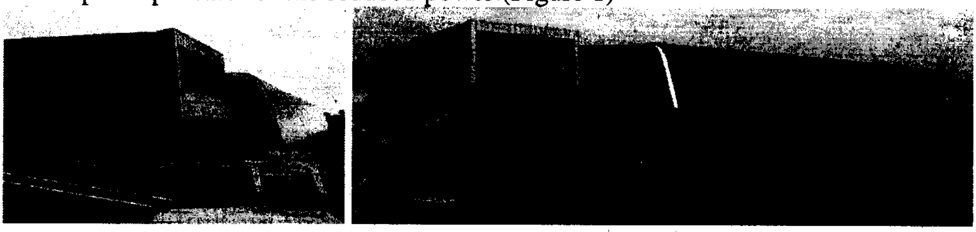


Figure 1 : The photovoltaic panels are fully integrated into the building design - the government training center in Germany.
Source: http://www.designbuild-network.com/features/feature315/feature315-4.html

The building is designed to be self-efficient in energy. The roof and façade incorporate 10,000 m² of PV cells integrated with glazed panels. Two types of solar module were employed: mono-crystalline cells with a peak efficiency of 16% and lower density polycrystalline cells at 12.5%. The power generated greatly exceeds the needs of the building at 750,000kWh per year [**Hata! Yer işareti tanımlanmamış.**].

Incorporating Photovoltaics into awnings and saw-tooth designs on a building façade: They increase access to direct sunlight while providing additional architectural benefits such as passive shading.

Using PVs in roofing systems: This system can provide a direct replacement for batten and seam metal roofing and traditional 3-tab asphalt shingles.
E.g.: Using PVs on roofs, the PV colonnade of Cambridge USHER project. One purpose of the colonnade is to provide a platform for electricity production which in turn would provide a zero emissions transport link with the center of the city. The roof of the colonnade will accommodate 3500m² of cadmium telluride photovoltaic cells with a peak output of 300 kW and will generate over 260,000kW h of DC current per year. Additionally the PVs at both sites will be dedicated to producing hydrogen to power fuel cell buses [**Hata! Yer işareti tanımlanmamış.**].

Using PV for skylight systems: It is an economical use of PV and an exciting design feature water into hydrogen and oxygen.

Ricoh Stadium: Coventry City Football Club: (Lighting control and energy management) Within the Ricoh Arena a networked lighting control system has been installed throughout the building to control the operations of the pitch and concourse amenity lighting as well as the entertainment suites dimming and scene control requirements. The system provides lighting control with added power saving efficiencies by the use of a centralized control system being networked to intelligent relay modules throughout the building and external areas. The system has been set-up to be fully automatic, although the user can control various functions of the lighting from the touch screen controllers, which have been provided in the security room and in match control.

Nano-materials

Nano-materials relates to the use of nano structures to generate and improve the material properties. Innovative motivator of this century – the biggest secret in the smallest possible dimension. Nanotechnology ("nano" – Greek: dwarf) is a comparatively young technology. Nanotechnologies are the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale. A motivation in nano-science is to try to understand how materials behave when sample sizes are close to atomic dimensions.
Scale: One nanometer (nm) is one billionth, or 10-9, of a meter. In comparison to a human hair which is ca. 80,000 nm in diameter, the nano-fibers are 1,000 times smaller in diameter.
In a simplest form, nanotechnology conceptually offers the potential to build "bottom-up", creating materials and structures with no detects and with novel properties (nano-materials).

Properties of Nano-materials

The main reasons why materials at the nano-scale can have different properties are:

- An increase of surface area: Nano-materials have a much greater surface area to volume ratio than their conventional forms, which can lead to greater chemical reactivity and affect their strength.
- Quantum effects occur: At the nano scale, quantum effects can become much more important in determining the material's properties and characteristics, leading to novel optical, electrical and magnetic behaviors.

Categories of Nano-materials:

Nano-materials have three main categories:

- Materials that have one dimension in the nano-scale (and are extended in the other two dimensions) are layers, such as a thin films or surface coatings.
- Materials that are nano-scale in two dimensions (and extended in one dimension).
- Materials that are nano-scale in three dimensions are particles, such as precipitates, colloids and quantum dots (tiny particles of semiconductor materials). All conventional materials like metals, semiconductors, glass, ceramic or polymers can in principle be obtained with a nano-scale dimension.

Green features of Nano-materials:

Nanotechnology, the manipulation of matter at the molecular scale, is opening new possibilities in green building through products like solar energy collecting paints, nanogel high-insulating translucent panels (aerogel), and heat-absorbing windows. Even more dramatic breakthroughs are in development such as paint-on lasers that could one day allow materials to send information to each other, windows that shift from transparent to opaque with the flip of a switch, and environmentally friendly biocides for preserving wood.

These breakthrough materials are opening new frontiers in green building, offering unprecedented performance in energy efficiency, durability, economy and sustainability. The nanotechnology applications for green building emphasize on the energy conservation capabilities of architectural nano-materials and the role of nano-sensors in green building. Ubiquitous sensing is likely to bring a host of benefits including customized temperature settings in buildings, light-sensitive photochromic windows, and user-aware appliances. The nanotechnology concept can be achieved by using nano-materials.

Applications for using environmental Nano-materials

In Architecture Nano-materials can achieve the environmental concept in their technology like antireflective glass, insulation & coating materials.

Anti reflective glass:

This technology is based on the expertise in synthesizing nano-particles with precisely controlled size, physical, chemical, and electronic properties.

a) Photovoltaics
Photovoltaic modules equipped with antireflective glass, show significant performance benefits compared to conventional modules. In addition to the technical advantages, modules with antireflective glass exhibit a distinct reduced glare and pleasant optical appearance.
b) Solar thermal collectors
In solar thermal collectors generating hot water for domestic use. Antireflective glass as cover sheet for the collector also results in a beneficial thermal yield.
c) Greenhouses
Antireflective glazing can be advantageously used in other fields of high demand on light and energy transmittance. In the last decade of twentieth century, Europe exhibited a growing rate of vegetables and flowers which are grown in greenhouses. A transmittance of 6% increase results in a 6% higher crop yield.
d) Protection of glazing
The antireflective glass can be used as a tailored system for protecting historical facades and ancient glazing. For this application, color neutrality is of crucial importance since the optical appearance of the building should not be influenced. This antireflective glass can easily be adjusted in its reflectance color by varying the coating thickness.
e) Displays
Antireflective glass is not only ideal for typical antireflective uses such as museums and displays, but a practical choice for retail storefronts, showrooms, and a host of applications where an anti-reflective product was never an option.

Insulation materials (aerogel)

Nano-crystalline materials synthesized by the sol-gel technique result in foam like structures called "aerogel" or " frozen smoke" or "blue smoke". Applications for using aerogel as insulation materials are:

a) Aerogel Pipes Insulation
Aerogel insulation stops pipe heat loss by eliminating heat dispersion from the piping into the surrounding hall which improves safety in tight spaces.
b) Aerogel Interior Wall Insulation
Aerogel interior wall insulation reduces U-Values by 44% and lowers energy use and carbon emissions.

c) Aerogel Insulation for Slim Solar Panels

The aerogel solution provided the required thermal performance while minimizing insulation thickness (fig. 2. 54), meeting the key criteria. Advantages of Insulation for Slim Solar Panels are:

- The panel was required to be super slim (25 mm) to replace existing roofing tiles.
- The very low conductive heat generated savings over conventional insulating materials during night hours.
- Slim solar panels generate no negative VOCs 2 through the operating temperature range of 65°– 200°C.

d) Aerogel Windows (Airglass Windows)

A large number of aerogel glazing prototypes have been made with partly evacuated aerogel in between two layers of low iron and anti-reflection treated glass panes with an airtight edge seal solution based on multi-layered plastic foil developed for vacuum insulation purposes.

Coatings of Materials

Coating surfaces with nano-materials is allowable to many different types of surfaces.

a) Superhydrophobic wood:

"Lotus Spray"--using principles involving surface contact and adhesion discovered in the leaves of the lotus plant, as well as a combination of nano-particles and very hydrophobic polymers-makes a wood surface such as that shown here extremely water-repellent and self-cleaning.

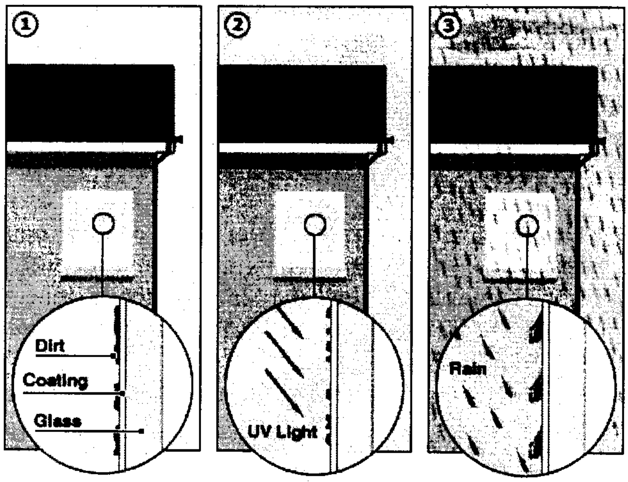
b) Photo-catalytic Ceramic Tile

Photo-catalytic[2] ceramic tiles are coated with nano-sized photo-catalyst, with particle size around 7nm4. The transparent thin film of photo-catalyst exhibits the air purification, anti-bacterial and self cleaning properties. Photo-catalytic ceramic tile could be used on to the interior and exterior surfaces of buildings, toilet, etc.

c) Glass coatings

Self-cleaning glass: Self-Cleaning Glass uses the forces of nature to maintain its clear appearance without leaving unsightly streaks (Figure 2). In a dual-action process organic dirt is broken down by daylight and is then washed away by rain, thus making it environmentally friendly and very easy to maintain.

[2] **Photo-catalytic:** material has properties to decompose various kinds of contaminants and suppress the growth of bacteria.



1 - Dirt, glass, Nano-scale Active coating containing microcrystalline titanium dioxide
2 - Sun shines on window. The UV rays trigger a chemical reaction in Active coating, called a photo-catalytic process, which breaks down dirt
3 - When water hits glass, a hydrophilic effect is created. Water spreads evenly over the surface, instead of droplets, so runs off and takes dirt with it

Figure 2 : Phases of self cleaning glass.
Source: http://news.bbc.co.uk/2/hi/technology/3770353.stm

UV-Attenuating Coatings: The incorporation of nano-materials in surface coatings can provide long-term protection from harmful UV radiation in harsh environments without significantly effecting optical clarity, gloss, color or physical properties.

Abrasion-Resistant Coatings: These coatings are especially well-suited for incorporation into coating systems, greatly enhancing abrasion resistance with minimal effects on clarity, gloss and physical properties of the coatings.

The Advantage and Disadvantage of Using Innovative Materials from an Economic View

The study assessed the use of innovative environmentally compatible products, which the report defined as those having less of a negative environmental impact than standard building materials. The drivers behind the trend were many: shifting attitudes among builders and consumers, government mandates, and the higher prices that green buildings often search on the market. The study didn't consider the prices for green materials relative to their conventional competitors, but considered the cost savings — from recycling waste materials and using less energy-intensive manufacturing processes — in making greener products will often offset higher costs elsewhere in their production.

Cement is a good example. Chemical reactions during its creation emit large amounts of CO^2, and energy is needed to heat and dry its constituent products. Many cement manufacturers still rely on coal-fired kilns, and for every ton of cement made, about a ton of CO^2 is released. Established cement makers currently aren't focused on developing new products to replace conventional cement. Instead, they are searching for ways to reduce the energy intensity of their manufacturing processes and adopting cleaner sources of energy.

As governments increasingly place limits and prices on carbon emissions, they may stop tinkering with its manufacturing processes and start looking more seriously at innovative ways to use innovative environmentally compatible materials.

Commercial office buildings, new residential buildings and home improvements will likely present the biggest opportunities in innovative environmentally compatible products. We expect green materials to take an especially strong hold in commercial and residential rebuilds and retrofits.

Conclusion

As this roundup of innovative products, concepts, and trends has demonstrated, architects have many options when reviewing building envelope products, related components, and systems. Increasingly, these new products and systems offer various features that are designed to enhance performance and potentially reduce risk to architects and owners. Installation, warranties, the nature of the labor force, and product delivery schedules are other considerations that can streamline, or complicate, project schedules and budgets. Many types of Innovative Compatible Materials can be used on the building envelope to address different owner needs, code requirements, and design challenges. From the above mentioned clarifications of innovative green features, a conclusion could be drawn in the following points:

- Materials can be grouped to conventional materials (using earlier or less developed technology), and innovative materials (using new developed technology). Environmentally compatible materials can be grouped the same grouping.
- Green features of smart materials are shown by the description of inputs and outputs of each smart material and assessment of its available environmental

applications. In other meaning green features of smart materials appears from the convergence between smartness and sustainability. From this assessment we can determine smart materials that can be considered environmentally compatible materials.

- Green feature of nano-materials are shown by the description of the environmental applications for some nano-materials.

References

1. Antoine Predock Architect, PC, Albuquerque, NM
2. Peter F. Smith, Sustainability at the cutting edge, Architectural press, 2003.
3. http://www.nicnas.gov.au/Current_Issues/Nanotechnology/What_Are_Nanomaterials.asp
4. John Ewins, Nanotechnology – the challenge to occupational health and hygiene, First International Symposium on Occupational Health Implications of Nano-materials. 12 – 14 October 2004.
5. Michelle Addington, Smart materials and technologies in architecture, 2005.
6. www.nicnas.gov.au/Current_Issues/Nanotechnology/What_Are_Nanomaterials.asp
7. www.nanowerk.com/nanotechnology/introduction/introduction_to_nanotechnology_3.html
8. G. Elvin, Building Green with Nanotechnology, Green Technology Forum, US. 2007.
9. www.azom.com/details.asp?ArticleID=1066
10. www.aerogel.com/markets/c_solarpanel.html
11. www.nanophase.com/applications/uv-attenuating_coatings.asp