ADVANCED MATERIALS AND TECHNOGIES FOR ENERGY EFFICIENT BUILDINGS

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Construction of buildings has been responsible for at least 35% of energy use in many countries. The high demand for energy usage with global standards of living is ascending, these results to several challenges on resources and capacity. It is necessary to improve the construction techniques and approaches and engineers are tasked with finding solutions to this problem. Advanced materials have been developed to for construction of energy efficient buildings to accommodate the need reduce energy consumption and to preserve the environment.

KEYWORDS: advanced materials, technologies, energy efficient buildings, durable building materials.

Many years ago, researchers have been studying the finest technique for achieving optimal energy efficiency. Now engineers possess an enormous selection of materials, components, usage and techniques. The quality effort in energy efficiency produced good materials, which have always been trademark of a well-built structure. Understanding of how the structural system of energy efficient building is vital, knowing the appropriate way to integrate all of the structural elements and understanding the network and interaction is indispensable in order to produce a high performance building.

Advanced materials and technology in construction is an alternative to the existing building techniques. This minimizes the environmental impact in such a way that it saves energy, water, and lessens pollution emissions. The building technology uses a system of approach which has an overall environmental impact on the structure. These materials are produced using environmentally friendly processes which include: recovered products, recycled materials, certified wood products, products from renewable materials, materials that don't release harmful pollutants, and especially durable building materials.

Various energy efficient materials have been researched however, discussion will be based on: cool roofs structural insulated panels, and insulating concrete forms.

1) Cool Roofs. These are roofs that are designed to maintain a lower roof temperature than traditional roofs while the sun is shining. Sunlight is the fundamental factor that causes roofs to become very hot. Cool roofs have surfaces that reflect sunlight and emit heat more efficiently than hot or dark roofs, keeping them cooler in the sun. In other words, hot roofs absorb much more solar energy than cool roofs, making them hotter. Since most dark roofs absorb 90% or more of the incoming solar energy, the roof can reach temperatures higher than 66º C when it's warm and sunny. Higher roof temperatures increase the heat flow into the building, causing the air conditioning system to work harder and use more energy in summertime. However, light-coloured roofs absorb less

than 50% of the solar energy, reducing the roof temperature and decreasing air conditioning energy use.

A cool roof is also advantageous to a house owner in numerous ways. Cool roofs can reduce energy bills by decreasing air conditioning needs, improve indoor thermal comfort for spaces that are not air conditioned, and decrease roof operating temperature, which may extend roof service life.

Fig.1. Source: fullcover-roofing.com

In various circumstance, cool roofs cost about the same as non-cool alternatives. The energy cost savings you can realize from a cool roof depends on various considerations, including local climate; the amount of insulation in the roof; how the building is used; energy prices; and the type and efficiency of the heating and cooling systems.

Cool roofs can also be valuable to the environment and lawmakers; this can provide solution to environmental issues that will benefit to society. Cool roofs can lower the local air temperature, which improves the air quality and slows smog formation; reduce peak electric power demand, which can help prevent power outages.

The installation of cool roofs depend on several factors, including its type, size, complexity, method of attachment, and building location. Nevertheless, in situation where new roofs are required for installation, cool roof alternatives are usually more costly or slightly more expensive than similar non-cool alternatives. It is often required to have feasibility studies of the region and conduct material test before installing cool roofs, which may lead to raise in cost of construction.

Fig.2. Source: fullcover-roofing.com

The maintenance of cool roof is comparable to non-cool roofs. Over time, dirt accumulation on the roof may reduce solar reflectance. The manufacturer's cleaning recommendations should be followed in other to avoid improper cleaning (e.g., power washing, harsh chemicals) could damage your roof.

In warm climates, moist locations, cool roof surfaces can be easily affected by algae or mould growth than hot roofs. This is not a major problem, but it can look bad and reduce the roof's reflectance. Some roof coatings (fig. 2) include special chemicals that prevent mould or algae growth, and these can last for a few years.

In cold climates, roofs can accumulate moisture through condensation, and this may eventually lead to material degradation. Moisture control in cold climates is an important part of any roof's design. It is possible, though not yet proven, that cool roofs might be more susceptible to accumulating moisture than dark roofs of the same design. This can be avoided using proper design techniques.

Fig.3.Source:Normanton.co.uk

2. Structural insulated panels (SIP) are a composite building material. They consist of an insulating layer of rigid core sandwiched between two layers of structural board (fig. 3). The board can be a sheet of metal, plywood, cement or oriented strand board (OSB). They share the same structural properties as an I-beam or I-column. The rigid insulation core of the SIP acts as a web, while the sheathing fulfils the function of the flanges. SIP combine several components of conventional building, such as studs and joists, insulation, vapour barrier and air barrier. They can be used for many different applications, such as exterior wall, roof, floor and foundation systems.

Structural insulated panel is a high performance building system for residential and light commercial construction. The panels consist of an insulating foam core sandwiched between two structural facings, typically oriented strand board (OSB). SIP is produced under factory controlled conditions and can be fabricated to fit nearly any building design. The result is a building system that is extremely strong, energy efficient and cost effective.

Fig.4. Source: Buildipedia.com

Structural insulated panels have turn out to be widely used alternative to construction materials for homes and other buildings (fig 4). SIP is obtainable with a core of agriculture fibres (such as wheat straw) that offers similar thermal and structural performance. The result is an engineered panel that provides structural framing, insulation, and exterior sheathing in a solid, one-piece component.

Panel manufacturers often use a continuous lamination machines in the production of panels, which automate forming and cutting according to dimensions transferred from digital floor plans. Various dimension of panels can be easily transported to the construction site, the panels can be rapidly assembled by workers without extensive training. Structural insulated panels' construction allows builders to quickly construct an exterior building frame that is strong, airtight, and energy efficient.

The key design idea for Structural insulated panel is elegant in its simplicity, and offers several advantages for constructing walls and roofs. With the capacity to handle axial, bending, racking, and shear loads, properly designed and assembled Structural insulated panel not only replace conventional framing, but will withstand high wind, and seismic forces.

Structural insulated panels resist extreme weather condition such as: fire, tornadoes, earthquakes, and hurricanes. Regions prone such harsh weather condition often report cases of destroyed homes every year. However, houses built with structural insulated panels have survived such disaster with little-to-no structural damage. It was reported that 200 mph winds extreme tornadoes in Tennessee USA (fig.5). Homes with structural insulated panels have repeatedly withstood against the force of nature. These advanced materials guaranteed more durability and energy efficiency than found in stick built homes.

Fig.5. Source: www.acmepanel.com

In January 1995, a severe earthquake (7.2 on the Richter scale) destroyed a Japanese city of Kobe with over one million people living in the city. Elevated highways (designed to withstand earthquakes) collapsed, railways were ravaged, and the whole blocks of houses were ruined. More than 5,000 died and hundreds of thousands were left homeless. The remarkable strength of structural insulated panels were designed to withstand typical loads caused by seismic activity and high winds.

Structural insulated panel production is a very significant factor to be weighed in before obtaining the panel. The quality of its fabrication will determine how long the structural panel will last and the level of performance. It is vital to know the fabrication process of the structural panel and how the surface panel was gummed or glued to the insulation material. Improper gluing can separate and reduce its performance. The types of Structural insulated panels are:

1. Expanded Polystyrene Insulated Panels
2. Polyurethane or Polyisocyanurate Insulated Panels
3. Compressed Straw Core Insulated Panels

Structural insulated panels have the following advantages:

- Using SIP higher R-values can be obtained;
- Higher strength-to-weight ratio;
- The insulation offered by SIP is superior when compared to studs or traditional construction methods;
- SIP can offer energy savings between 12% to 14%;
- Using SIP a more air-tight unit can be build, resulting in a quieter and more comfortable structure;
- SIP are extremely strong, energy-efficient and offer a cost-effective alternative;
- SIP will save you money with a faster construction method;
- Reduced amounts of waste and labour;
- SIP will produce less expensive heating and cooling equipment inside the structure;
- SIP produces flatter surfaces to work with;
- No need to look for studs to place fasteners;
- No curvatures due to drying of the material
- Can be treated against insects;
- Structural Insulated Panels can be used in walls, ceilings, floors and roofs;
- Structural insulated panel wall systems were adopted into the International Residential Code (IRC) on May 22, 2007.

3. Insulating concrete forms. The Insulating concrete forms (ICF) building technique was developed first in Europe following World War II as an economical and long-lasting approach to rebuild destroyed buildings. The approval of ICF construction has gradually spread since the 1970s, although it was initially hindered by lack of awareness.

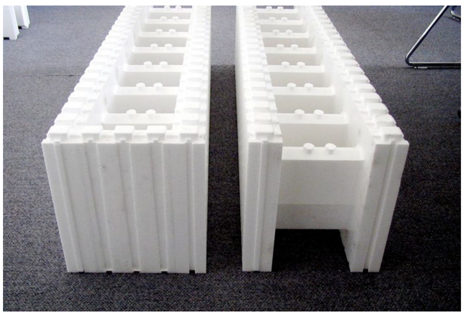
Fig.6. Source: arch tangent.com

Insulating concrete forms (fig. 6) can be constructed by cast-in-place concrete walls that are inserted between two layers of insulation material. These insulating concrete forms systems offered performance benefits like strength and energy efficiency. Common applications for this method of construction are low-rise buildings, with property uses ranging from residential, commercial and also industrial buildings. Traditional finishes are applied to interior and exterior faces, so the buildings look similar to typical construction, although the walls are usually thicker. Insulating concrete forms are forms used to hold fresh concrete that remain in place permanently to provide insulation for the structure they enclose.

Insulating concrete forms have the following benefits. They provide long-term value environment in several ways, the concrete consists of common materials that are found abundantly in many average home. Concrete gets stronger with age. The polystyrene foam does not support moisture; therefore moulds and bacteria cannot grow. The concrete will withstand a wildfire or earthquake, and will still be standing after a tornado or hurricane hurls debris at it. Its durability will keep you secure in all types of natural disasters.

Fig. 7. Source: www.quadlock.com

Installation of insulating concrete form systems is similar to masonry construction (fig. 7). Builders usually start at the corners and place a layer at a time to build up the wall. Some units, particularly those that form a “waffle” or post–and–beam concrete wall profile must be glued together or taped at the joints during assembly. Most systems today feature uniform cavities that improve flow ability of the concrete, reduce the need for adhesives during stacking, resulting in flat concrete walls of consistent thickness.

Insulating concrete form systems are compatible with concrete floors, and wood or steel floor joists. In smaller buildings, ledger assemblies for floor framing attachment mounted to the side of the formwork are common. In larger buildings or those for commercial uses, steel weld plates or bolt plates can be preinstalled within the formwork so they become embedded in the fresh concrete. This is the potential for reducing energy to heat and cool the building. Some estimates place the savings at 20 percent or more. The walls can often have high air tightness 10 to 30 percent better than frame-with compatible windows, doors, and roof.

Conclusion:

The objective for developing the specific materials used in construction, infrastructure, and manufacturing are to ensure energy efficiency. There are adequately bases on a scientific foundation that addresses advanced materials issues. The methods for solving problem from the perspective energy consumption by developing energy efficient buildings. Real life situations were sited at reference in terms of performance measurement and durability, these materials have been proven durable, to with withstand the force of mother nature, even in severe natural disasters. These are the primary goals-to improve building operations, to achieve energy efficiency, occupant comfort, and safety by clearing technical hurdles that impede widespread use of intelligent building systems.

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СОВРЕМЕННЫЕ МАТЕРИАЛЫ И ТЕХНОЛОГИИ ДЛЯ ЭНЕРГОЭФФЕКТИВНЫХ ЗДАНИЙ

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С возрастанием уровня жизни во всем мире, увеличивается потребность в энергоресурсах, что приводит к ряду проблем. Необходимо совершенствовать методы и технологии строительства, и инженеры призваны решить эти проблемы. Современные материалы были разработаны для строительства энергоэффективных зданий, которые должны решить задачу снижения потребления энергии и способствовать лучшей защите окружающей среды. В статье рассматриваются современные и материалы и технологии для решения поставленной задачи.

KEYWORDS: современные материалы, технологии, энергоэффективные здания, прочные и долговечные строительные материалы.