Ecological Construction and Intelligent Control

Ar. Pallavi Sharma
Research Scholar, Amity School of Architecture and Planning, Amity University, Haryana, India

ABSTRACT

Eco-friendly, or ecological, construction is building a structure that is beneficial or non-harmful to the environment, and resource efficient. Otherwise known A Green building, this type of construction is efficient in its use of local and renewable materials, and in the energy required to build it, and the energy generated while being within it. Eco-friendly construction has developed in response to the knowledge that buildings have an often negative impact upon our environment and our natural resources. This includes transporting materials hundreds or thousands of miles, which has a negative impact in the energy required to transport them, and also in emissions of hazardous chemical from a poorly designed building that creates and traps them.

An intelligent building starts with an environmentally friendly design. Creating a project that is environmentally friendly and energy efficient ties in closely with many of the intelligent attributes. Intelligent buildings are designed for long-term sustainability and minimal environmental impact through the selection of recycled and recyclable materials, construction, maintenance and operations procedures. Providing the ability to integrate building controls, optimize operations, and enterprise level management results in a significant enhancement in energy efficiency, lowering both cost and energy usage compared to non-intelligent projects.

Intelligent buildings are intended to be the preferred environment for occupants. This requires focused attention to environmental factors that affect occupants' perception, comfort, and productivity. An intelligent design finds the balance, providing a superior indoor environment and minimizing energy usage and operating labor. This is where the technology becomes valuable. Using integration and automation we are able to implement solutions that both provide a superior environment and minimize energy.

Keywords: Automation Systems, Green Building, Energy efficient, Control theory.

1. INTRODUCTION

An intelligent building is one in which the building fabric, space, services and information systems can respond in an efficient manner. An intelligent building system concept recognizes that the true cost of the building is not its cost of construction; it must include the operating and maintenance costs over the structure's life span. Intelligent building yield cost reductions over all these areas by

optimizing energy use through automated control, communication and management systems. They also guard against repair costs, employee time, productivity loss, revenue loss. An intelligent building is an essence one that integrates various systems (such as lighting, heating, air conditioning, voice and data communication and other building functions) to effectively manage resources in a coordinated mode to maximize occupant performance, investment and operating cost, savings and flexibility.

2. BUILDING AUTOMATION SYSTEM (BAS)

Building automation describes the advanced functionally provided by the control system of a building. A building automation system is an example of a distributed control system. The control system is a computerized, intelligent network of electronic devices to monitor and control the mechanical electronics and lighting systems in a building.

The building automation system functionally reduces building energy and maintenance costs when compared to a non-controlled building. A building controlled by a building automation system is often referred to as **an intelligent building system** or **a smart home**.

3. INTELLIGENT BUILDING DESIGNS AND BUILDING MANAGEMENT SYSTEMS

The field of Intelligent Buildings, Intelligent Homes, and Building Management Systems encompasses an enormous variety of technologies, across commercial, industrial, institutional and domestic buildings, including energy management systems and building controls. The function of Building Management Systems is central to "Intelligent Buildings" concept; its purpose is to control, monitor and optimize building services, e.g., lighting; heating; security, CCTV and alarm systems; access control; audio-visual and entertainment systems; ventilation, filtration and climate control, etc.; even time & attendance control and reporting.

4. INTELLIGENT BUILDINGS – CONTROL THEORY

The use of these technologies allows the optimization of various site and building services, often yielding significant cost reductions and large energy savings. There are numerous methods by which building services within buildings can be controlled, falling broadly into two method types:

- **Time based** - providing heating or lighting services, etc., only when required, and
- **Optimizer Parameter based -** often utilizing a representative aspect of the service, such as temperature for space heating or illuminance for lighting.

HEATING – Time-Based Control

Time-based controls can be used to turn on and off the heating system (and/or water heating) at pre-selected periods (of the day, of the week, etc). Optimizer Parameters: whatever the conditions, the controls make sure the building reaches the desired temperature when occupancy starts.

HEATING – Optimizer Parameter (Temperature Control Examples)

- **Temperature control**: protection against freezing or frost protection generally involves running heating system pumps and boilers when external temperature reaches a set level (0°C).
- **Compensated systems:** will control flow temperature in the heating circuit relative to external temperature. This will give a rise in the circuit flow temperature when outside temperature drops.
- **Thermostatic radiator valves:** these sense space temperature in a room and throttle the flow accordingly through the radiator or convector to which they are fitted.
- **Proportional control**: involves switching equipment on and off automatically to regulate output.
- Other methods can include thermostats, occupancy sensing PIR's (passive infra-red sensors), and manual user control.

5. LIGHTING CONTROL METHODS

Different control systems exist, again time-based control and optimizer parameter-based where a level of illuminance or particular use of lighting is required.

- **Zones:** lights are switched on corresponding to the use and layout of the lit areas, in order to avoid lighting a large area if only a small part of it needs light.
- **Time control:** to switch on and off automatically in each zone to a preset schedule for light use.
- **Passive Infra-Red (PIR) Occupancy sensing: In** areas which are occupied intermittently, occupancy sensors can be used to indicate whether or not anybody is present and switch the light on or off accordingly.
- Light level monitoring: this consists of switching or dimming artificial lighting to maintain a light level measured by a photocell.

6. BUILDING MANAGEMENT SYSTEMS AND INTELLIGENT BUILDINGS:

1. Energy Savings

Until recent years, energy efficiency has been a relatively low priority and low perceived opportunity to building owners and investors. However, with the dramatic increase and awareness of energy use concerns, and the advances in cost-effective technologies, energy efficiency is fast becoming part of real estate management, facilities management and operations strategy. The concepts are also now making significant inroads into the domestic residential house building sectors.

For lighting, energy savings can be up to 75% of the original circuit load, which represents 5% of the total energy consumption of the residential and commercial sectors.

Energy savings potential from water heating, cooling, or hot water production, can be up to 10%, which represents up to 7% of the total energy consumption of the domestic residential and commercial sectors.

2. Environmental and Greenhouse Gas Benefits

Greenhouse gas emission reductions depend on and correlate to reductions in energy use.

Intelligent Buildings and Building Management Systems technologies contribute directly to the reduction in energy use, in commercial, industrial, institutional and domestic residential sectors.

In short, Intelligent Buildings and suitably applied Building Management Systems are good for the environment.

Legislation and environmental standards; health and safety regulations; and global trends towards improving indoor air quality standards are all significant drivers of - and provide a continuous endorsement of the need for - Building Management Systems and the Intelligent Buildings technologies.

3. Market Trends

Careful interpretation is required. In the UK, adoption of controls technologies into the new build and major refurbishment sectors is relatively high: Estimates a few years ago of the UK market for Building Management **Control Systems** for new build and major refurbishment, all sectors, suggest market adoption of (as at 1994 - Source UK1 An Appraisal of UK Energy RTD, ETSU - 1994):

- Heating controls 70%.
- Hot water system controls 90%.
- Air conditioning controls 80%.

However according to European Commission as many as 90% of all **existing buildings** have **inapplicable or ineffective** controls, many of which require complete refurbishment of control systems.

Moreover conventional control systems stop short of automated Intelligent Buildings full capabilities. A significant human element is required for optimal effective operation even if control systems correctly specified and installed.

4. Practical Benefits

Energy-effective systems balance a building's electric light, daylight and mechanical systems for maximum benefit. Enhanced lighting design is more than an electrical layout. It must consider the

needs and schedules of occupants, seasonal and climatic daylight changes, and its impact on the building's mechanical systems.

5. Lighting systems:

Adding daylight to a building is one way to achieve an energy-effective design. Natural daylight 'harvesting' can make people happier, healthier, and more productive. And with the reduced need for electric light, a great deal of money can be saved on energy. Nearly every commercial building is a potential energy saving project, where the electric lighting systems can be designed to be dimmed with the availability of daylight. **Up to 75% of lighting energy consumption can be saved.** In addition, by reducing electric lighting and minimizing solar heat gain, controlled lighting can also reduce a building's air conditioning load.

6. Mechanical systems:

The HVAC system and controls, including the distribution system of air into the workspaces, are the mechanical parts of buildings that affect thermal comfort. These systems must work together to provide building comfort. While not usually a part of the aesthetics of a building, they are critical to its operations and occupant satisfaction.

The number one office complaint is that the workplace is too hot. Number two is that it's too cold.

Many people cope by adding fans, space heaters, covering up vents, complaining, conducting 'thermostat wars' with their co-workers, or simply leaving the office. Occupants can be driven to distraction trying to adjust the comfort in their space. Improper temperature, humidity, ventilation, and indoor air quality can also have significant impacts on productivity and health. When we are thermally comfortable we work better, shop longer, relax, breathe easier, focus our attention better.

In order to provide a comfortable and healthy indoor environment the building mechanical system must:

- Provide an acceptable level of temperature and humidity and safe guard against odours and indoor air pollutants.
- Create a sense of habitability through air movement, ventilation and slight temperature variation.
- Allow the occupant to control and modify conditions to suit individual preferences.

7. ENVIRONMENTAL DESIGN

An intelligent building starts with an environmentally friendly design. Creating a project that is environmentally friendly and energy efficient ties in closely with many of the intelligent attributes. Intelligent buildings are designed for long-term sustainability and minimal environmental impact

through the selection of recycled and recyclable materials, construction, maintenance and operations procedures. Providing the ability to integrate building controls, optimize operations, and enterprise level management results in a significant enhancement in energy efficiency, lowering both cost and energy usage compared to non-intelligent projects.

Intelligent buildings are intended to be the preferred environment for occupants. This requires focused attention to environmental factors that affect occupants' perception, comfort, and productivity. An intelligent design finds the balance, providing a superior indoor environment and minimizing energy usage and operating labor. This is where the technology becomes valuable. Using integration and automation we are able to implement solutions that both provide a superior environment and minimize energy.

8. BUILDING MODELING

An intelligent design needs to start with a complete model. This modeling begins early on with CAD designs that evolve into project renderings. Using new standards such as AEC-XML and GB-XML, this information can readily be shared with HVAC and other system models. Modeling of an intelligent building will be used not just in design, but will continue into construction and operation.

In the past, building modeling has been widely used as a design tool and often for construction as well. In an intelligent building we would expect that this model will be used by new sophisticated tools that will actually be able to use the original modeling information to make decisions about optimization and continuous recommissioning of critical building systems. Ideally, the model will follow through the lifespan of the building, be updated as necessary and serve as a digital document of the building.

9. BUILDING CIRCULATION AND NETWORKING

Buildings exist to enable collaboration, allowing occupants to be productive, efficient, and creative. Intelligent buildings provide for improved occupant circulation, interaction, and collaboration. From a design perspective this means attention to how the occupants will circulate through the building. How will they enter the space? How will they move efficiently vertically and horizontally through the space? Can we incorporate digital signage to improve navigation and circulation?

Collaboration can also be improved through the use of design elements to encourage networking in both formal and informal spaces. Formal collaboration spaces are conference rooms, break rooms, classrooms, and seminar rooms. Informal collaboration spaces include niches and seating spaces in corridors, coffee shops, outdoor seating areas, and other places where building occupants can get together for brief planned or unplanned interactions.

10. CONCLUSION

The goal of having an intelligent building only starts with early planning in the design stage. In many ways, this mirrors the design and fulfillment of many green or LEED projects today, but it uses technology to provide for a superior space. There are enormous benefits to be gained by creating intelligent buildings. We need to continue to work as an industry to quantify these benefits, educate owners and consultants, and to deliver a superior product to the market.

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