Green Future, Clean Future

Energy Efficient Buildings

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BEFORE you start reading this piece, allow me to ask you some questions.

1. *In the morning when you open your curtains and windows, do you feel the fresh air and breeze or are you forced to look at the concrete structures around and sulk for a view?*
2. *While working from home do you need to keep your air conditioner and lights permanently on or can you sustain without them?*
3. *Do you have the privilege of installing solar panels and rainwater harvesting or you just see the sun, the rain and curse or enjoy them on respective days?*
4. *Do you apply the concepts of recycle and reuse in your day to day life or you just think about segregating and reducing the waste...endlessly?*
5. *Lastly, do you ever calculate the energy needs of your house/home or just focus on earning more to pay those inflated bills?*

If your answers to all the above questions are No or Yes, in that order, then spend a few minutes reading this article.

A dream house...with a beautiful structure, grand exteriors and exquisite interiors is everyone's fantasy. But this home becomes a smart structure if it is future-proofed. A future-proofed building is also called an Energy Efficient Building, Green Building or Sustainable Building.

Energy efficiency arises from using technology that requires less energy to perform the same function. For example, using a Light-emitting Diode (LED) light bulb or a Compact Fluorescent Light (CFL) bulb that requires less energy than an incandescent light bulb to produce the same amount of light.

Architect Speak

Three well-known architects Mr Sanjay Prakash, Mr Ashok B. Lall and Mr Praveen P. Patel with decades of experience in constructing energy-efficient buildings share their responses to three questions.

Which is the best design/structure for an energy-efficient building?

- The simple criteria to choose the best design/structure depends on two factors: the energy or resources used to make it, called embodied energy (capital) and/or the energy or resources required to run the facility (operations).
- An energy-efficient building should use minimum energy, water and topsoil to produce and less of these to operate.
- It should keep the heat out. This is achieved by keeping the glass area just enough for good daylight, shading the glass against the sun from outside, building external walls using insulating materials, and insulating the roof.
- These buildings may also employ passive cooling like shading, insulation, colour and orientation, or even non-passive measures like better or more energy-efficient mechanical devices and systems.
- Use natural materials like secondary soil (not topsoil) and secondary timber (not valuable tropical hardwood species), or bamboo (grown in waste-water so as to reduce its water footprint), or rubble (stone), and avoid or minimize high-energy industrially processed materials like aluminum, glass, steel, cement and fired bricks.

How to differentiate between an energy-efficient building and a normal building?

For owners, who focus on energy in operation, the easiest measure would be the running energy bill for operations and comparing those with another similar building. Because these things are hard to do, and definitely not possible before buying a space, various NGOs have set up independent voluntary certification for "green" buildings. The Indian Government has evolved Green Rating for Integrated Habitat Assessment (GRIHA) system. Besides these voluntary rating systems, there are also mandatory standards, like the Energy Conservation Building Code (ECBC) designed by the Ministry of Power, through its Bureau of Energy Efficiency (BEE).

How to modify an existing building into an energy-efficient building?

It is generally more difficult but possible to build an energy-efficient building afresh than modify one. There is no one size fits all. To modify an existing building into an efficient building, we have to minimize its energy use by various methods. This includes energy-efficient materials, openings, insulations, use of electrical fixtures, local climatic conditions, etc. Also the envelope - external walls, windows and roof - can be modified. A layer of insulation to walls can be added, leaky windows can be replaced with good windows that close well. All glass from the sun can be shaded during the hot season.

Simply put, an energy-efficient building is a building designed to consume minimum amount of energy during its construction and operation. Ms Mili Majumdar, Managing Director, Green Business Certification Inc. India (GBCI India), says that primarily energy is used in a building for cooling or heating of space, for lighting it up and for powering the appliances, equipments like your computer or water heating, etc.

She says, "When we talk about an energy-efficient building, the first principle is to design it as per the climate. In India, there are five different climate zones. So what we will essentially build in the cold climate of Shimla will not be the same that we build for a composite climate as in Delhi. Similarly, the orientation of a building plays a major role. In Shimla, we will need to orient the building appropriately to have maximum daylight. But in a hot climate, we will try to avoid maximum amount of sun that comes inside the building so that the building remains cool and there is less of external heat coming in. Since we are in the Northern hemisphere, we design buildings to be mostly south-facing but from south also a lot of heat comes in. So we have to ensure minimum glass areas which are appropriately shaded to allow the daylight to come in but not the heat. Traditionally in some places, there is a courtyard or we need to especially focus on ventilation, particularly in a humid climate like in Kerala. There we will try to take advantage of the blowing wind by orienting the building in a way that maximum amount of ventilation is facilitated."

There are some more principles that energy-efficient buildings need to satisfy:

- Should have minimum negative impact on the environment.
- Should utilise all natural resources efficiently.
- Should prevent destruction of the local natural habitat and biodiversity.
- Should reduce the energy and water demands of the building.
- Should reduce air and water pollution.
- Should reuse the construction waste material.
- Should increase occupant productivity.

Experts count the benefits in numbers as well:

- 30-50% reduction in energy consumption
- 40% reduction in freshwater demand
- 40-65% reduction in water consumption
- 30-40% reduction in operational cost

The Secret Recipe

The practice of designing and operating energy-efficient buildings has been in vogue since very early times. But, even in the 21st century, technology should only be considered the last resort in the effort to minimize the efficiency of a building. There are two major aspects that contribute towards the "green-ness" of a building:

1. The active measures are those that require the consumption of energy, like efficient air conditioning, solar-powered lighting and interventions of that nature. Technology plays a major role in these active strategies - the

3D Printing: Key to affordable housing?

Would you like to live in a house that has come out of a printer - a 3D printed house? The journey of such a house starts from a computer and ends up in a concrete structure.

India's first 3D printed house is situated in the IIT Madras campus. It is a 600-sq ft unit converted into a single-storey house. Such houses can be built in just five days, but due to the COVID lockdown, it took 21 days to complete this first 3D printed house. Of course, Tvasta Manufacturing Solutions that made the house, confirms that in normal situation such houses can be built in just five days.

Now, what is the science behind the innovation of 3D printed houses? The technique utilizes a Concrete 3D Printer that accepts a computerised two-dimensional design file from the user and fabricates a 3D structure in a layer-by-layer manner. Ingredients required include the 3D printer, software, material in the right composition, design for your dream structure, application-specific printing strategies and above all the zest of creating something distinctive.

It is much easier to transport and move a 3D Printer than it is to move a precast factory. 3D Printing technology can also be used as an off-site production facility to produce modules that can be then assembled into a much larger structure.

Expert in developing such technology, Tvasta group Co-founder and Chief Executive Officer Mr V.S. Adithya points out that the technology is flexible and can enable the construction of precast structures for even smaller projects. It enables customized construction according to land plots available. The 3D Printing Precast factory is movable from location to location and quickly as well.

However, says Mr Adithya, there is a need for indigenous development and validation of the technology. The technology also needs to be imparted to the wider construction industry so that it can penetrate the construction market beyond Tier 1 cities such as Mumbai, Chennai, Delhi, etc. The technology developed should also be validated for Sustainability, Productivity and Structural Stability so that it can be used widely for multi-storey construction projects.

Mr Suraj Sonwalkar, a 3DCP Researcher and Entrepreneur opines, "I see that 3D concrete printing technology is a natural fit for the construction industry. It exactly matches the challenges, demands, and required skills of the construction industry. Such as tailor-made designs, pressure to speed up the delivery and reduce cost, increase in automation as contractors face skilled labour shortage, accurate production, etc. All these requirements can be satisfied using 3D concrete printing."

Benefits

- Optimized structure
- User friendly
- Application specific design
- Uncompromised aesthetic appeal
- Use of local materials
- Reduced material usage
- More durable/long-lasting
- Adaptable
- Feasible with latest trends
- Environment-friendly
- Energy efficient
- Less time taking for construction
- Less investment/ economical/affordable
- No need to transport concrete over long distances
- Minimum to no waste generation

Image credit (a to d): "Tvasta Manufacturing Solutions"


(c)


(d)

3D concrete printing material is not everyday used concrete mix design. It's a special mixture, and each concrete printing company has its own mix design. The 3DConcrete Printing material is 1.5 to 2 times expensive than the normal concrete. So, efforts need to be made to make the material cheaper, sustainable, and open-source in the 3DConcrete Printing Sector for faster adoption in the industry.

The houses can be built in any shape and size as per choice - a hut or dome-shaped head of the house, curved stairs or round windows, anything and everything is possible. Even multi-storeyed buildings, 2-3-4 BHK can be achieved with this technology. You can get these houses painted with your favourite colour paint or use wallpapers.

The 3D printed houses can be constructed at any place and under any circumstances, be it hot or cold, dry or snowy, windy or stormy and can be regulated as per weather requirements. The houses are environment friendly, forward-looking, energy-efficient, durable and affordable. The fire in the kitchen to the lights in your room, all can be modified as you want and need. Moreover, the technology creates only 1/3rd of the waste generated using conventional building methods.

There are two types of printers - Robotic arm and Gantry printers - that are popularly used in the construction industry. Robot printers have the advantage of being more mobile/movable than gantry printers and of being able to print certain complex prints due to the 6-axis movement that gantry printers would have difficulties with. Gantry printers on the other hand have cost and stability advantages. They offer the ability to make larger prints and even print entire buildings in one go, as opposed to the more limited prints of robot printers.

Mr Phanisri Pradeep Pratapa, Assistant Professor in Department of Civil Engineering at Indian Institute of Technology, Madras, says, "3D printing or Additive Manufacturing techniques are evolving rapidly and are revolutionising the way structures and components are fabricated in various fields like mechanical, aerospace, and biomedical engineering. In recent years, there have also been significant developments that lead to the application of 3D printing ideas for construction in civil engineering."

The motivation to use 3D printing to construct structures comes from its ability to realize complex shapes, says Pratapa. While complex shapes and geometries may have a good architectural appeal, they can also lead to structures that are efficient in terms of cost and function. Further motivation comes from the fact that the 3D printing processes can be substantially automated to enable rapid and high-quality construction.

Technologies developed within India currently are cheaper than the ones that are being offered from American and European companies where cost of construction is not the primary constraint in projects. 3D Printing is uniquely suited to meet the challenges of India for affordable housing with 2 crore houses to be built by 2022 and 10 crore houses to be built by 2030.

This doesn't seem to be a distant dream. If this technology can produce houses at five days per house, building 10 crore houses would not be a big challenge. According to the World Economic Forum, by 2030, three billion people will need improved housing. That means building 96,000 new homes every day. All this and much more depends on how early this housing technology can become a common practice in our country.