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# Integration Of Bim In The Design Co-Ordination Of Sustainable Residential Building

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***Abstract***

*The rapid increase in worldwide energy consumption has raised a global concern about the future of energy use and its impact on the surrounding environment. Such impact is causing resource degradation, increased carbon emissions, depletion of the ozone layer, and global warming. As the building sector is considered one of the main energy-consuming sectors, the trend of sustainable designs, green projects, energy optimization and reduction policies are many countries' recent focus.*

*The digital revolution has begun to the next stage. BIM is changing the way we plan; build maintain and use our social and economic infrastructure. This enables to plan new infrastructure more effectively, build it at lower cost and operate and maintain it more efficiently. Above all, it will enable citizens to make better use of the existing infrastructure. BIM holds large amounts of information about its design, operation and current condition. This enables engineers, contractors and suppliers to integrate complex components cutting out waste and reducing the risk of errors. This provides the customers with real-time information about available services and with accurate assessments of the condition of assets.*

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***Keywords:*** *Building Information Modeling**,** Digital revolution, Energy optimization, efficiency, sustainable designs,*

## Introduction

### Background

The construction industry is ever evolving with increasing performance demand. Project hand



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over deadlines are shorter, costs are tighter, regulation more stringent, project briefs are more complex, construction procurement methods more varied, Technology forever developing, parallel to technology quality more difficult to achieve and maintain. Managing site is a process that consists of the building or assembling of infrastructure. Far from being a single activity, large scale construction is a feat of human multitasking. For the successful management and execution of a construction project, effective planning and technical supports are essential. (Garber, 2014).

Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. For the professionals involved in a project, BIM enables a virtual information model to be handed from the design team (architects, surveyors, civil, structural and building services engineers, etc.) to the main contractor and subcontractors and then on to the owner/operator; each professional adds discipline-specific knowledge to the single shared model. This reduces information losses that traditionally occurred when a new team takes 'ownership' of the project, and provides more extensive information to owners of complex structures. (Eastman et. al, 2008)

**Problem Definition**

The problem with the conventional method of construction is that the architects and engineers make a lot of decisions, and sometimes it goes wrong, which is usually based on too little or too much information and mostly because of the information that is not integrated. Also, we are making too many cumulative mistakes and wasting resources using cautious approaches. The federal government has predicted savings of over $15.8 billion annually from integrated processes. Projects today save 5-12% when BIM is properly used (*Jernigan. F.,2008*). It is quite evident that there is a need for a change in a thinking process on how we go about the construction process in order to obtain the best practice.

BIM can be used to demonstrate the entire building life cycle, supporting processes including cost management, construction management, project management and facility operation. BIM also prevents errors by enabling conflict or 'clash detection' whereby the computer model visually highlights to the team where parts of the building (e.g.: structural frame and building services pipes or ducts) may wrongly intersect.

**Present scenario in India**

“Implementation of BIM in India faces the problems concerning cost of software, new hardware and training employees. Adequate training required in the firms is one of the biggest obstacles to BIM adoption, followed by senior management buy-in. Since most of the architectural firms in India still use 2D drafting software like Autodesk AutoCAD, they are not keen on investing time in training the staff or investing money in new technologies involving BIM culture that permeates a new way of thinking about building design in the industry” (Bedrick, 2005). Also, very few owners are ready to pay the extra cost for digital models of their project which offer expanded services in the future (Scheer, 2008).

The Government of India has announced its vision on implementing smart cities and 97 cities are name under this list for future development (Smart Cities Mission, 2015). In order to manage such huge projects, BIM plays an important role. BIM can be used for digital and information technologies, urban planning best practices, public-private partnerships, and policy change.

**Sustainable construction**

Sustainable construction is simple words means to practice construction activities using environmentally responsible processes and natural resources efficiently throughout the life-cycle of the structure from planning, designing, executing to facility management.



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The main goals of Sustainable construction are:

- Social progress which recognizes the needs of everyone
- Effective protection of the environment
- Responsible use of natural resources
- Maintenance of high and stable levels of economic growth and employment

**Project aim**

The main aim of the project is to know the importance of advance technologies in construction industry so as to overcome the losses or failures it is facing currently, there are a lot of advancements happening everyday so it is important to be updated and utilize whichever is appropriate. Apart from that, being a responsible citizen and engineer it is our duty to reduce the environmental impacts caused by us in every possible way. Therefore, by adopting Sustainable construction we can do our bit. In this project we have implemented the ways to utilize the natural, renewable and ambient energy in order to make best use of it.

**Objectives**

The objectives of the project are as follow:

- To examine strengths and limitations of Building Information Modeling
- To reduce the risk, minimize overall cost and enhance lifecycle involved of the project
- To provide sustainability to reduce environmental impacts
- Feasibility, Smart Health and Security through Home Automation

**Methods**

The quantitative method used in the research, the data collection and data analysis tools are as follow:

**Proposed Site**

The proposed site is located in **Byramangala**, Bidadi; which is in the outskirts of city Bengaluru (Bangalore), the capital city of Karnataka state, India. Bengaluru is known as garden city for its greenery. Since last few years, the land price is increasing (Venkataraman, 2013) and also air pollution is raising like never before. This has caused a new trend of housing such as green-houses or sustainable houses. So, it will be a good idea for the Client to invest in these residences to gain better health, cost of construction is also reasonable. The site plot size is 40 feet North-South x 60 feet East-West.

The primary data and external guidance for the execution of the project was given by Mr. Kaushik Manjunath, Managing Director, Secured Walls. Secured Walls is a conglomerate of Engineers, Project managers, architects & subsequent construction professionals who strive to make sure that your dream project is built, exactly the same way you dreamt it, if not better. They attempt to deliver your project in the most advanced, orderly and systematic way. They also strive in impending modern integrated BIM methods and inclined towards sustainable approach.

The company is handled by Mr. Kaushik Manjunath as Managing Director; Mr. Sachin R Burli as Director Execution & Procurement and Mr. Samsath O S as Director Finance & Operation. The vision of the company is “To be pre-eminent establishment that entirely involves our individuals, passionately embrace new concepts, seeks out transforming technologies and functions with unbending ethical standards.”

**Client’s requirement**

**Ground Floor** - 1 Hall, 1 Kitchen, 1 Dining area, 1 Pooja room, 1 Store room, Staircase, 1 Master



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Bedroom with attached bathroom, 1 common room with attached bathroom, 1 Toilet.

**First Floor –** 2 Bedrooms with attached bathroom, Balcony/sit-out area

**Common Utilities –** 2 car parks, 10,000 liters capacity sump tank, 4,000 liters capacity Rain Water Harvesting tank, lawn/garden area, home automation.

**Methodology**

- The required primary data is collected from the source.
- Architectural Plan is made in order to meet the clients demand.
- The design, planning and analyzing is done using two methods in order to understand the difference between them.
    - By using Conventional Method
    - By using BIM method
    - The difference between them is interpreted.

**By using Conventional Method**

- **Software Used**
    - AutoCAD 2020
    - STAAD.Pro v8i
    - Microsoft Excel

- **Procedure**
    - Understanding the requirements
    - Architectural planning using Auto desk AutoCAD version 2020
    - Design calculations using Microsoft Excel and STAAD.Pro v8i as per IS Codes
    - Structural analysis with the aid of STAAD.Pro v8i
    - Interpretation of results and derivation of conclusions.

**By using BIM Method**

- **Software Used**
    - REVIT 2020

- **Procedure**
    - Understanding the requirements
    - Architectural planning using REVIT Architecture 2020
    - Design calculations and Structural Analysis using REVIT Structure 2020



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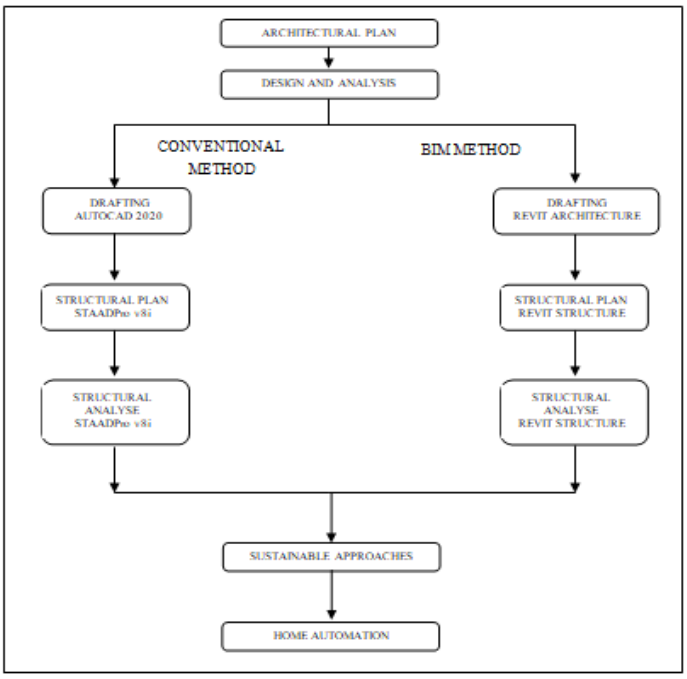


**Figure 1: Methodology of the project**

- Site Dimension considered was 60’ X 80’
- Built up area dimension is 55’ X 29’
- No. Of Floors ‘G+1’
- Total Built-up area 2345 sqft
- Total Carpet Area 1970 sqft

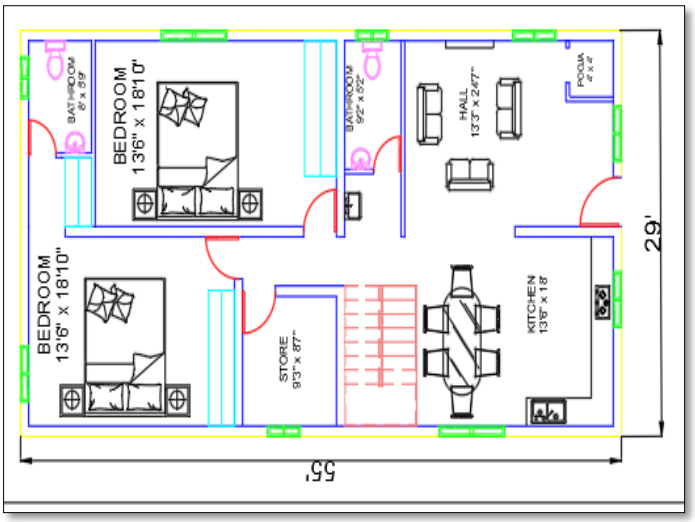


**Figure 2: Ground Floor Architectural Plan**



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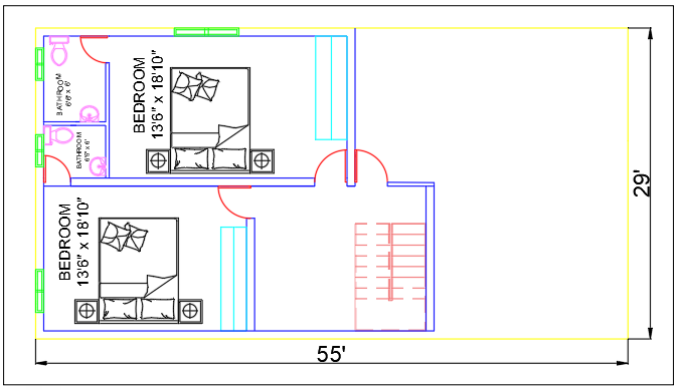


**Figure 3: First Floor Architectural Plan**

## ARCHITECTURAL PLAN USING REVIT ARCHITECTURE 2020

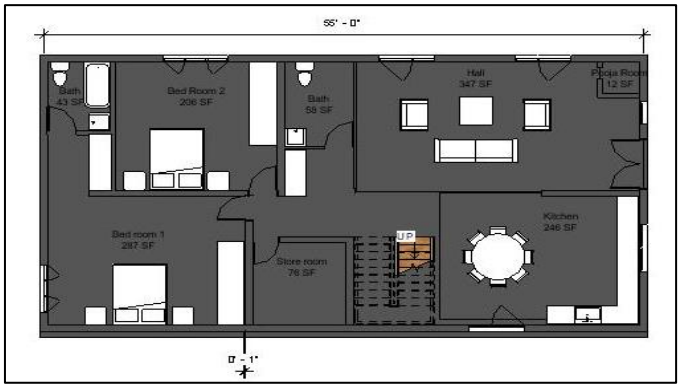


**Figure 4: Ground Floor Architectural Plan**

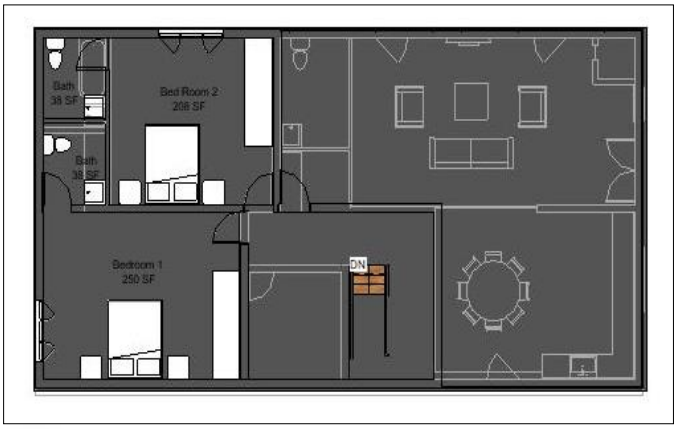


**Figure 5: Ground Floor Architectural Plan**



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**Figure 6: Elevation of the building**

## STRUCTURAL PLAN DETAILS

- Soil Bearing Capacity is 150 kN/m$^2$
- Thickness of wall 9” (230 mm)
- Dimensions provided for Beam 9” X 18”
- Dimensions provided for Column 9” X 18”
- Dimensions for Plinth Beam 9” X 18”
- Thickness of Slab 6” (Two way Slab)
- Type of Walls
  - Main Wall – 230 mm Concrete
  - Partition Wall – 100 mm Partition wall
- Loads Considered
- Dead Load
- Live Load
- Factored Load
- Unfactored Load

## PLAN FOR PLINTH BEAM

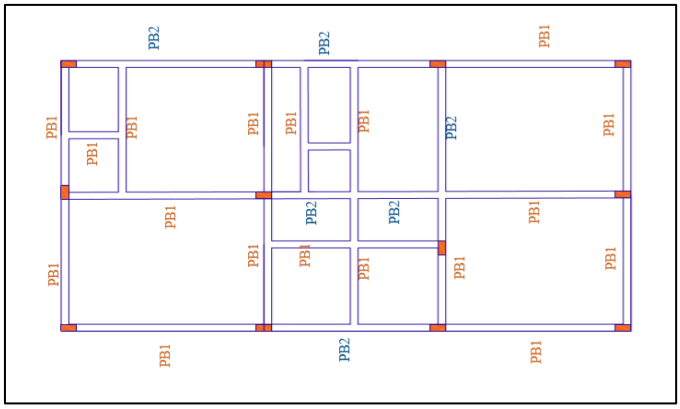


**Figure 7: Plan for Plinth Beam**



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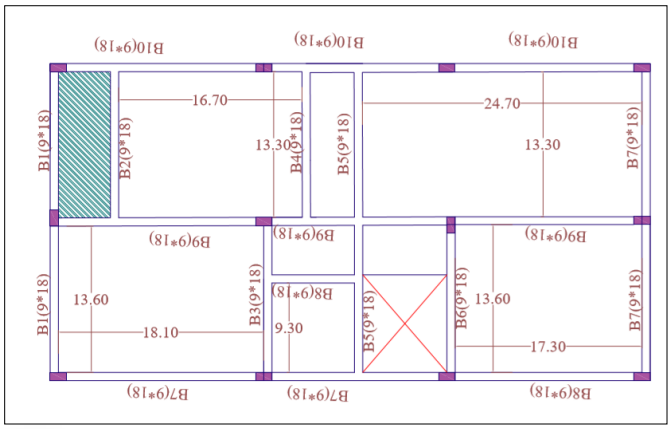


**Figure 8: Framing Layout of First Floor**

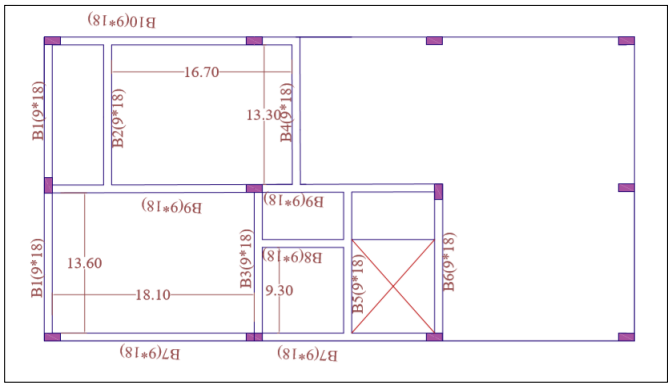


**Figure 9: Framing Layout of Second Floor**

## STRUCTURAL PLAN USING REVIT STRUCTURE 2020

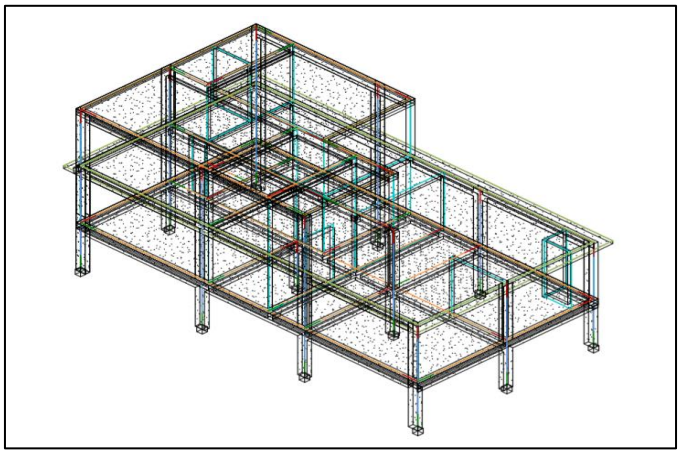

**Figure 10: Structural Plan using Revit Structure 2020**

## SUSTAINABLE APPROACH

- **Use of sustainable construction materials**



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Considering global scenario at present, construction industry is the major contributor for $CO_2$ emission to the atmosphere; it contributes about 50%. This is majorly imparted from materials such as cement, bricks used for construction and also some of the manufacturing process (Roux and Alexander, 2007). The better way to absorb sustainable design is by cautious selection of eco-friendly materials. Some of the key features for sustainable construction are shown below.

Table 1: Key to the green features of sustainable building materials (Kim and Rigdon, 1998)

| GREEN FEATURES | | |
|---|---|---|
| **MANUFACTURING PROCESS** | **BUILDING OPERATIONS (BO)** | **WASTE MANAGEMENT (WM)** |
| Waste Reduction (WR) | Energy Efficiency (EE) | Biodegradable (B) |
| Pollution Prevention (P2) | Water Treatment and Conservation (WTC) | Recyclable (R) |
| Recycled (RC) | Non Toxic (NT) | Reusable (RU) |
| Embodied Energy Reduction(EER) | Renewable Energy Sources (RES) | Others (O) |
| Natural Materials (NM) | Longer Life (LL) | |

## Execution

Green construction can help in reducing the energy requirement, such as cooling, by adopting sustainable techniques. This can help in reflecting healthier indoor environment, with more natural light and clean air entering the building, GI doors are used for main doors instead of Teak wood, WPC/PVC doors are used for toilets, Flush doors are used for room, UPVC windows are used, reused steel is used for grills. So, this way timber consumption is reduced, which intern leads to less deforestation.

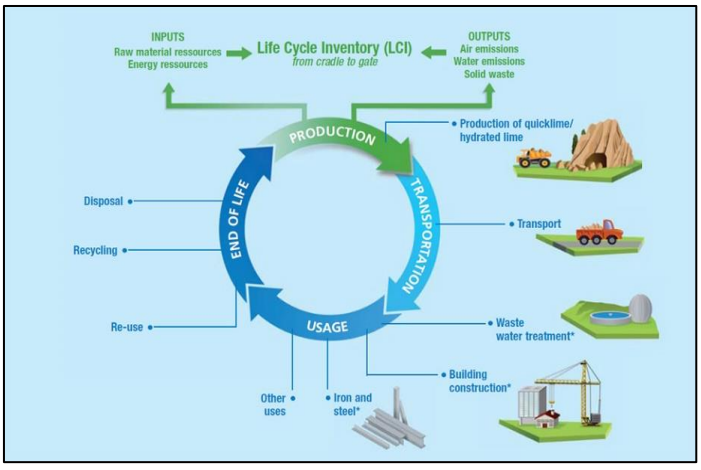


**Figure 11: Lifecycle assessment of construction materials (EuLA, 2014)**

Limitations

- High initial cost
- Higher cost of Flats
- Possible lack of indoor air quality

- **Achieving Sustainable Water Conservation**



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Scarcity of water is one of the major concerns in Bengaluru. Providing sufficient water for an apartment can be a challenge. This shortage of water is caused by insufficient rain and limited groundwater source. To meet this demand, rainwater harvesting or sewage treatment can be used on site. These are the most common practice in areas with water deficiency but treating grey water can prove to be expensive as well (the economist, 2010).

**Execution**

Small Decentralized systems are recommended for producing recycled water for domestic use, watering gardens (Russo et. al, 2014). Permeable pavements can be used within site premises to collect rainwater or run-off water along with design pipeline systems. These pavement types are suitable for regular use and allow water on its surface to percolate directly and collect in underlying infiltration chambers. Provision for trapping oil and other pollutants can be made. Similar provisions can be made underneath garden area and other parts of site for recharging groundwater level.

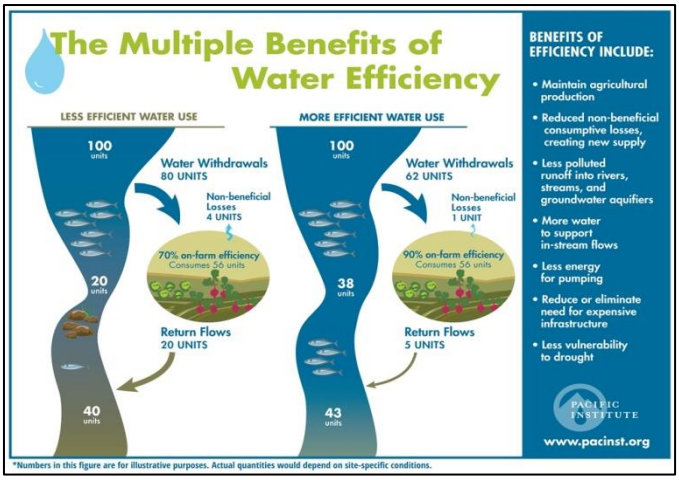


**Figure 12: Sustainable Water Conservation (Coolie, 2014)**

**Limitations**

- Initial investment is high
- Water obtained can't be used for drinking purpose
- Regular maintenance should be carried out.

- **Generating sustainable energy**

The major problem in Bengaluru is power cuts during summer. The scarcity of electricity in India still exists. Instead of depending on backup power supply like Generators or UPS, a step towards natural and renewable sources can be made. The Carbon Trust (2016) reported that 40% of a building's electricity is used by lighting system. By generating electricity, the buildings can self-dependent and also share the excess generation with the Electricity Department (KPTCL).



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**Figure 13: Sustainable energy (Alexander, 2016)**

**Execution**

Solar panels are popular in India, it can be adopted in this project in order to generate electricity and heat water (Intelligent energy, 2007).

Piezoelectric materials like Quartz or Barium Titanate can be installed on the staircase of the building for power generation. Small amount of energy is generated but can be sufficient for service lightings in the building (Duan, Wang and Quek, 2010). It is relatively cheaper and energy can be generated dude to impact load easily.

**Limitations**

- High initial investment
- Lack of technical knowledge
- Better conditions to work
- Wind mill can be noisy
- Piezoelectric materials generate very less amount of electricity.

- **Encouraging Efficient Waste Disposal**

Waste can be rubbish, garbage, refuse or junk. Waste management may comprise of many types of wastes such as construction waste, domestic waste, kitchen waste, garden waste, electronic waste etc (Annepu, 2012).

**Execution**

Firstly, these wastes are collected and stored separately. Separate containers are provided in particular area; the residents are requested to dump their wastes in the specific containers. The best practice to dispose waste is by landfill, incineration and recycles and reuses methods.



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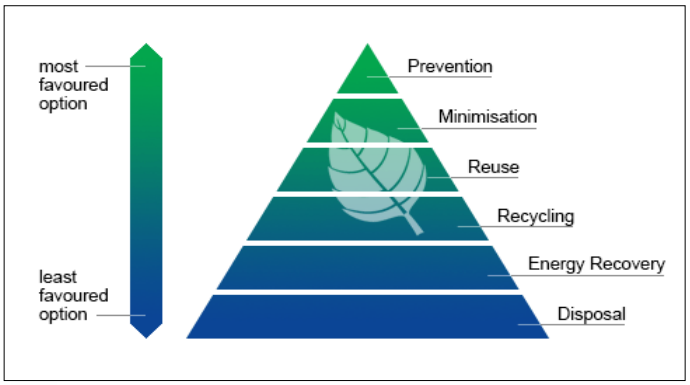


**Figure 14: Efficient waste disposal (ChemWaste, 2016)**

## Limitations

- High initial investment
- High maintenance cost
- Proper disposal mechanism is required.

## Home Automation

- It is an application of smart technology within one's home, in creating a comfortable home and effective lifestyle.
- It improves automation control and monitors house hold device
- Connects via standard means of communication for its operation

## Features of smart home

- Home security systems
- Controlled exterior & interior lightings
- Automatic window & curtains
- Automatic garage door
- Distributed entertainment systems
- Home energy management system
- Smart AC & temperature system
- Smart home appliances syncing
- Automated control through phone

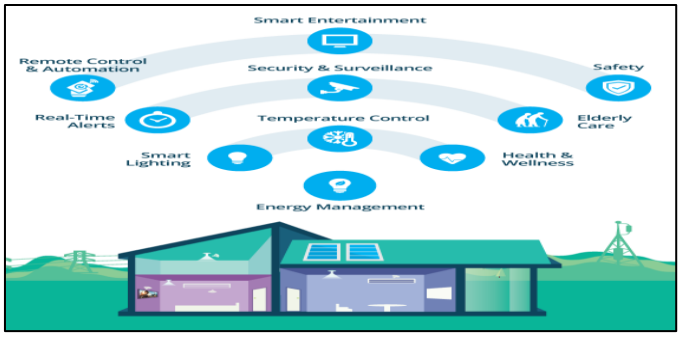


**Figure 14: Efficient waste disposal (ChemWaste, 2016)**



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**Why smart home?**

Smart home is applicable in various aspects of our home. Office and environment to suit our different preferences

- **Comfort & ease of control**

Smart homes offer ease of controlling device around the home. This is one of its outstanding features.

These features offer automation & remote control of the device around the home from any location such as:

- Automatic control of doors and gates
- Automatic shutdown of appliances when not in use

Smart homes offer ease of controlling device around the home. This is one of its outstanding features.

These features offer automation & remote control of the device around the home from any location such as:

- Automatic control of doors and gates
- Automatic shutdown of appliances when not in use
- Automatic setting & maintenance of right temperature at house
- Automatically adjust or regulate light intensity based on room luminosity.

- **Entertainment**

Smart home offers multi room entertainment network which enables listening to music and watching videos from any part of the house

- Easy control – Parental control features on TV & computers for children to watch only certain videos.
- Digital access - Access favorite channels from any music system or TV around the home
- Digital storage – system automatic plays favorite songs or videos based on moods.

**Figure 15: Applications of Home Automation**

**Results and Discussion**



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**Table 2 Differences between conventional and BIM method**

| CONVENTIONAL METHOD | BIM METHOD |
|---|---|
| • Requires various software, for the preconstruction process. | • Can be done using any one software. |
| • The results obtained are not so accurate as data is transferred through different software. | • The results obtained are more accurate. |
| • The time required is more. | • Time required is less. |
| • Cannot be accessed by everyone at same time. | • Anyone with authentic identity can access it at any time. |

## ADVANTAGES AND DISADVANTAGES OF BIM

### Advantages of BIM

- Development of design is consistent across all the teams; design would be more efficient and reliable.
- Data stored at single centralised place, all authenticated users could access the information and would be on same page.
- Efficient usage of the resources for design results in reduction of man hours and raw materials which indeed improves the economy of the project.
- Better communication – Same information is published across all the layers of the engineering teams, with this there would be smooth business functioning enhancing organisation image.
- Due to reduced misunderstandings there will not be much of rework and also the overall risk is reduced.

### Disadvantages of BIM

- Cost of software: BIM software requires a considerate investment in new technology. The advantages usually make the investment worthwhile, but only if the software is used efficiently.
- Lack of experts: The relative newness of BIM, meaning that there are limited numbers of experts working in the field. The software purchase may require an additional investment in training and education.

## OUTCOMES OF SUSTAINABLE APPROACH

## SUSTAINABILITY TO REDUCE ENVIRONMENTAL IMPACT

- By applying rain water harvesting technique and using permeable pavement wherever possible, run off can be collected. Apart, from this small decentralised units are installed to recycle water for domestic and garden purpose.
- By using natural and renewable source of light, basic required electricity is generated. Energy is also generated due to impact load.
- By disposing off the waste materials responsibly, we can help in maintaining environmental cleanliness and also see that hazardous materials are disposed off properly.

## BENEFITS AND LIMITATIONS OF HOME AUTOMATION

## BENEFITS OF HOME AUTOMATION



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- **Energy Saving**: Home systems have definitely proven themselves in the arena of energy efficiency. Automated thermostats allow you to pre set, based on the time of day and the day of the week. And some even adjust to your behaviors, learning and adapting automation to your temperature preferences without your ever inputting a pre-selected schedule. Traditional or behavior-based automation can also be applied to virtually every gadget that can be remotely controlled – from sprinkler systems to coffee makers. Actual energy savings ultimately depend on the type of device you select and its automation capabilities. But on average, product manufacturers estimate the systems can help consumers save anywhere from 10 to 15 percent off of heating and cooling bills.
- **Convenience**: In today's fast-paced society, the less you have to worry about, the better. Right? Convenience is another primary selling point of home automation devices, which virtually eliminate small hassles such as turning the lights off before you go to bed or adjusting the thermostat when you wake up in the morning. Many systems come with remote dashboard capabilities, so forgetting to turn off that coffee pot before you leave no longer requires a trip back to the house. Simply pull up the dashboard on a smart device or computer, and turn the coffee pot off in a matter of seconds.

### 4.3.1 LIMITATIONS OF HOME AUTOMATION

- Installation Depending on the complexity of the system, installing a home automation device can be a significant burden on the homeowner. It can either cost you money if you hire an outside contractor or cost you time if you venture to do it yourself.
- Complex Technology Automating everything in life may sound extremely appealing, but sometimes a good old-fashioned flip of the switch is a lot easier than reaching for your smart phone to turn lights on and off. Before you decide which system is right for you, think about how far you really want to take home automation in your household.
- System Compatibility controlling all aspects of home automation from one centralized platform is important, but not all systems are compatible with one another. Your security system, for example, may require you to log in to one location to manage settings, while your smart thermostat may require you to log in to another platform to turn the air conditioner on and off. To truly leverage the convenience of home automation, you may need to invest in centralized platform technology to control all systems and devices from one location.
- Cost: Even though the price of home automation systems has become much more affordable in recent years, the cost to purchase and install a device can still add up. Consumer Reports offers a wide range of information and insights – including costs – on the best home automation systems on the market.

**Conclusion**

In this report, various guiding principles towards sustainable approach that are relevant to the site is discussed. There can't be sole drivers for development; it needs immense planning, polices and also support from the users as well. The whole idea of the report was to develop sustainable resources which are suitable for the end users and environment. Also, to influence the future projects to concentrate on this aspect to reduce pollution. The aim is to set up an example to sustainable neighborhood and create awareness to the people to look into advantages of sustainability particularly in India. The government also has to address these issues as soon as possible for the better living of mankind. The involvement of public sector along with private sector through NGO's could play important role in waste management.

The digital revolution has begun to the next stage. BIM is changing the way we plan, build maintain and use our social and economic infrastructure. This enables to plan new infrastructure more effectively, build it at lower cost and operate and maintain it more efficiently. Above all, it will enable citizens to make better use of the existing infrastructure. BIM holds large amounts of information



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- IS 875.2.1987 – CODE OF PRACTICE FOR DESIGN LOADS (OTHER THAN EARTHQUAKE) FOR BUILDINGS AND STRUCTURES – IMPOSED LOAD
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