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Status of Residential and Commercial Buildings in India

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Abstract:
In Indian economy, construction sector accounts for approximately 40 per cent of the development investment and contributes to around 8.5 per cent of GDP. In recent times contemporary buildings are increasingly demanding and consuming more energy and resources in their construction and operation. India is a developing country with rapid growth in population, due to increased growth in population there is a heavy demand for housing infrastructure, so obviously there will be higher impact on land use. In recent times, urbanization leads to increase in horizontal land use which in deep reducing agricultural area. An order has passed from Indian government that it will be mandatory for all state governments to implement by 2017 the minimum requirements for energy efficient design and construction set by the central government to meet the challenges of depleting resources, increased urbanization and rapid construction. Today in most parts of the world, sustainable developments are slowly replacing conventional construction and building practices, in an effort to minimize the negative impacts on the environment. India too, is among the countries, which are in the vanguard of environmental protection. The main aim of this thesis is to prepare a status on residential and commercial buildings throughout India in order to provide a base line for further research and also to provide some basic recommendations for energy conservation building code framework.

Keywords: Energy efficiency buildings, energy conservation building code (ECBC), whole building performance tool.

1. INTRODUCTION

India is a developing country with rapid growth in population there is a heavy demand for housing infrastructure, so obviously there will be higher impact on land use as built up area increases vastly which will show impact on environment. In Indian economy, construction sector accounts for approximately 40 per cent of the development investment and contributes to around 8.5 per cent of GDP. An order has passed from Indian government that it will be mandatory for all state governments to implement ECBC (energy conservation building code) by 2017. The minimum requirements for energy efficient design and construction set by the central government to meet the challenges of depleting resources, increased urbanisation and rapid construction. Today in most parts of the world, sustainable developments are slowly replacing conventional construction and building practices in an effort to minimise the negative impacts on the environment as much as possible. India's accumulated primary energy demand is expected to grow by 2.5 times in the next two decades due to constant economic growth in the building, transportation and industrial sectors, reaching energy consumption of 40 EJ (Chaturvedi, Eom, Clarke, & Shukla, 2011). Currently, the residential and commercial sectors account for 30% (22% residential and 8% commercial) of total electricity use and consumption in these sectors is rising at 8% annually (Dr Satish Kumar, USAID ECO - III Project, 2011). The increase in energy intensity per unit area of floor, combined with an increase in floor area, has placed discriminating pressure on energy demand for buildings. The Bureau of Energy Efficiency, a Government agency, forecasts that India's constructed floor area will increase by around five times or more from 2005 to 2030. India has begun the regular introduction of energy efficiency solutions in the building sector. In 2001, the Indian Government introduced the Energy Conservation Act (Bureau of Energy Efficiency, 2011). As an outcome of this act, a first generation building code, the Energy Conservation Building Code (ECBC), came into effect in 2007. Currently, ECBC applies to buildings that have a connected load greater than 100 kW or contract demand greater than 120 kVA (Bureau of Energy Efficiency, 2011). In practice, ECBC requirements are generally only applied to buildings with air-conditioned floor areas of over 1000m2. In principle, the ECBC also applies to large residential complexes, when their connected load or contract demand exceeds the thresholds. However, the current national policy priority is to enforce the code at state level for large commercial buildings only. The Bureau of Energy Efficiency has introduced the Energy Conservation Building Code, with effective adoption and enforcement of this code, commercial energy use is predicted to grow from 0.656 EJ in 2005 to 2.648 EJ in 2030.

1.1 ENERGY CONSERVATION BUILDING CODE (ECBC)

The Indian Bureau of Energy Efficiency (BEE) had launched the Energy Conservation Building Code (ECBC) on February 2007. The code is set for energy efficiency standards for design and construction with any building of minimum conditioned area of 1000 Sq. mts and a connected demand of power of 500 KW or 600 KVA. The energy performance index of the code is set from 90 kW•h/sq./year to 200 kW•h/sq.m./year where any buildings that fall under the index can be termed as "ECBC Compliant Building" More over the BEE had launched a 5 star rating scheme for office buildings operated only in the day time in 3 climatic zones, composite, hot & dry, warm & humid on 25 February 2009. Energy conservation building codes set the minimum energy efficiency standards for design and construction at the same

time in encourage energy efficient design without constrain on the building function comfort health or the productivity of the occupants with proper regard for economic considerations.

1.2 WHOLE BUILDING PERFORMANCE METHOD:

The whole building performance method (WBP) offers considerable design flexibility and allows for conformance with the ECBC to be achieved by optimizing the energy used by various components and systems in order to find the most effective solution. The WBP method requires the use of an energy simulation software to simulate and compare energy use of the proposed design and standard design of the building. The conformance is achieved if the energy consumption of the proposed design is no greater than the energy consumption of the standard design.

1.3 ECO nirman WHOLE BUILDING PERFORMANCE TOOL:

ECO nirman whole building performance tool is energy simulation software provided by BEE too assist architects and engineers in assessing the conformance of their buildings with the ECBC using the WBP Method. It is a web based tool that is made available to the users over the internet with minimal learning involved, a user having knowledge equivalent to that of a fifth-year architecture student with access to about one hour of HVAC engineers time, can use the tool to demonstrate conformance with ECBC. The tool requires inputs about the building from the user. Based on the inputs, it runs simulation of the proposed design and the standard design of the ECBC and compares the energy performance intensity (EPI) of the simulation results. The tool also generates a report that may be submitted to the authority having jurisdiction to demonstrate conformance with the ECBC.

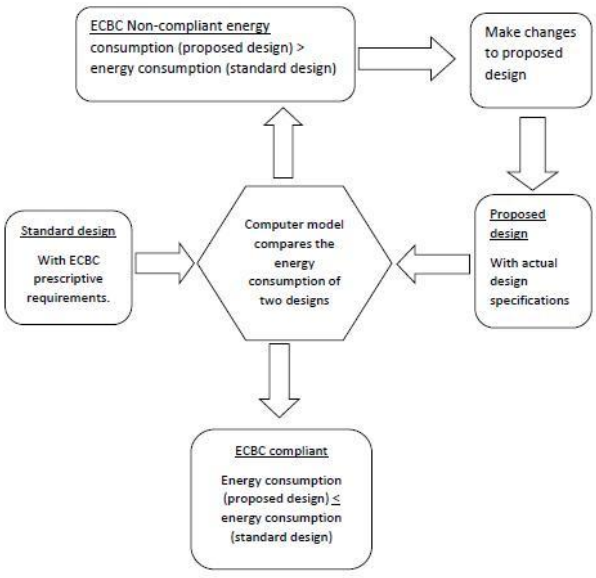

Figure.1. Flow chart for eco nirman web tool

The objective of this study is to determine the status of the residential sector and commercial sector. Overall scenarios on emerging technologies in construction sector are studied. The study specifically focuses on assessing the status of residential buildings by studying different aspects such as minimum dimensions, orientation of rooms, grouping, circulation and privacy of the building envelope and commercial buildings by using ECBC(Energy conservation building code) in order to achieve energy efficiency buildings. This study answers the following five sub-objectives:

1. To provide status on residential buildings throughout India in different composite climates.
2. To provide quantifiable information on commercial building energy use.
3. To determine the severity of growth rates in energy consumption in this sector and identify the savings potentials.
4. To recommend future actions and new technologies to target and harvest saving potentials.
5. To provide a reference point for future residential and commercial impact studies.

2. METHODOLOGY

This section shows the methodology for Phase 1 and 2 of the study – the survey of residential buildings and commercial buildings.

2.1 SURVEY METHODOLOGY

The Literature Review has indicated the need to collect good quality data in order to better understand residential buildings and commercial buildings. The objective of the survey design was to gather residential buildings and commercial building planning data to complement nationally available statistics.

2.2 SCOPE OF THE SURVEY FOR RESIDENTIAL BUILDINGS

The total sample size (India) equally divided into different climate zones based on energy conservation building code such as hot & dry, composite, temperate, warm & humid, cold. Different cities were selected according to climatic zones, a total of 15 cities were selected. Based on the literature review and past studies, the following elements have been identified as key variables:

i. Residential floor area – It is important to correlate floor area with annual and seasonal energy consumption. Definitions of floor area can vary and this can lead to data interpretation errors. In this study, we measured the gross floor area inclusive of enclosed balcony areas.

ii. Dwelling type and number of floors – The focus of the study was energy consumption in single-family attached/ detached homes and multi-family apartment complexes. Surveyors gathered this information based on site observation

iii. Number of bedrooms – The number of bedrooms is an important variable in correlating energy consumption and is related to the number of occupants. Surveyors gathered this information through site observation.

iv. Floor area distribution- this information, to analyze the impact of layout, for this several floor plans are required. Hence, plans of the residential buildings have been collected.

v. Orientation- It is an important variable which plays an important role in energy demand.

2.3 CITY SELECTION

The variation in climate, in terms of temperature and relative humidity, leads to varying degrees of comfort and, therefore, energy consumption. Four representative cities based in different climate zones were selected for the survey: Ahmadabad, city, representing a hot and dry climate zone (Bureau of Energy Efficiency, 2011)

i. Pune, city, representing a temperate climate zone (Udyayar R, 2013)

ii. Mumbai, city, representing a warm and humid climate zone (Bureau Of Energy Efficiency, 2011)

iii. Delhi, city, representing a composite climate zone (Bureau of Energy Efficiency, 2011)
iv. Visakhapatnam representing warm & humid (ECBC)
v. Vijayawada & Guntur representing warm & humid.
vi. Chennai, representing warm & humid (ECBC)
vii. Bangalore, representing a temperate climate zone (ECBC)
viii. Kerala, representing a warm and humid climate zone (ECBC)
ix. Hyderabad representing a composite climate zone (Bureau of Energy Efficiency)
x. Mohali representing composite climate region.
xi. Himachal Pradesh represents cold climatic conditions (ECBC)
xii. Bhopal representing a composite climate zone (Bureau of Energy Efficiency)
xiii. Guwahati represents cold climatic conditions (ECBC)
xiv. Bhubaneswar representing a warm & humid region (ECBC)

2.4 SCOPE OF THE SURVEY FOR COMMERCIAL BUILDINGS

For the analysis of commercial buildings, BEE (BUREAU OF ENERGY EFFICIENCY) has provided ECO nirman whole building performance tool which is based on ECBC code. Prerequisites for energy simulation software:

The following checklist of items is to be gathered while using ECO nirman WBP Tool:

i. Total interior floor area
ii. Marked-up plans by space type
iii. Floor area for each space type
iv. Lighting power density for each space type
v. Space types marked as conditioned or unconditioned
vi. Ventilation requirements
vii. Envelope construction assemblies (for walls, roofs, windows, and skylights) and shading.

Questionnaire survey has to be conducted for eco nirman web tool by taking help of particular architect, structural designer of a commercial building. Following are some of sample questions to be conducted in questionnaire survey:

a) Is the U-factor for overall fenestration (including the sash and frame) determined in accordance with ISO-15099, as specified in appendix C 11, by an accredited independent laboratory, and labeled and certified by the manufacturer or other responsible party?
b) Is the U-factor for sloped glazing and skylights determined at a slope of 20 degrees above the horizontal?
c) Is the default table in appendix C 11 used for determining the fenestration properties of unrated products? SHGC

3. STATUS OF RESIDENTIAL APARTMENTS IN INDIA

Different residential apartment floor plans were collected from major construction companies such as DLF, UNITECH, NCC, CITY ESTATE MANAGEMENT, UNIHOMES and other local builders throughout India for selected cities. The main aim is to find out different aspects such as minimum dimensions, orientation of rooms, grouping, circulation and privacy of the building envelope. To find out these aspects a statistical analysis was conducted. For this purpose entire study area is divided into 4 climatic regions:

i. Hot & humid,
ii. Hot & dry,
iii. Composite,
iv. Cold climatic conditions.

The following sample floor plan is from Bangalore which is a temperate climate region.

3.1 SAMPLE FLOOR PLAN & STATISTICAL ANALYSIS SPECIFICATIONS:

Adarsh Retreat Apartment (Bangalore):

i. Flooring: 24" x 24" Vitrified tiles in Living, Dining, Bedrooms and Kitchen. Laminated wooden flooring in Master Bedroom. 12" x 12" Ceramic tiles in Toilets.
ii. Doors: All doors with Engineered door frames and shutters.
iii. Windows: Powder coated Aluminum or UPVC sliding windows with three tracks (one with mosquito mesh)
iv. Toilets: Ceramic glazed tile Dado up to 7 feet height in all toilets. Single lever diverter for showers and single lever mixer for washbasins. Health faucet in all toilets. Glass Shower Cubicle in Master Bedroom toilet. Geysers in all toilets.
v. Kitchen: Granite Platform with Stainless steel single bowl and Vegetable bowl sink. 2 feet Dado above Platform area with Ceramic glazed tiles.
vi. Painting: Interior Painting with Plastic Emulsion and Exterior Painting with Acrylic Emulsion paint.

Figure.2.Floor Plan of Adarsh Retreat Apartment (Bangalore)

TYPE-1

MINIMUM DIMENSIONS	dimensions(mts)	area in Sft	area in Sqmt	area occupancy in %	orientation w.r.t N
plan area		1320	122.628		
master bed room	4.5720*3.535	173.96637	16.16202	13.17971426	NW
2 bed room	3.9624*3.2309	137.80072	12.80211816	10.43980018	W
kitchen	2.743*3.435	101.41967	9.422205	7.683567374	SE
toilet attached to master bed room	1.706*2.438	44.769514	4.159228	3.391744137	NNE
common toilet	1.605*2.438	42.119033	3.91299	3.190943341	E
dining room	3.635*1.716	67.141548	6.23766	5.086652314	SSE
living room	6.0960*3.535	231.95516	21.54936	17.57295234	SW
balcony	1.525*3.535	57.836587	5.3732	4.381707277	W
balcony attached to master bed room	1.525*3.535	57.836587	5.3732	4.381707277	NW
utility	1.525*3.515	57.69854	5.360375	4.371248818	E
lobby	1.706*1.706	31.327642	2.910436	2.373386176	SE

Figure.3. Statistical analysis of floor plan

4. STATUS OF COMMERCIAL BUILDINGS USING ECONIRMAN WEB TOOL

For presenting the status of commercial buildings in terms of energy consumption and also ECBC Standards we have opted eco nirman web tool which is developed by BEE (BUREAU OF ENERGY EFFICIENCY).

ECO nirman web tool is used for finding energy demand for proposed design. it is also used to find whether the building is satisfied according to ECBC standards and we can assess the rating for building.

ECO nirman whole building performance method prerequisites:

1. Site layout, orientation, individual built-up area, window to wall ratio, doors and windows details.

2. HVAC details (if any), electricity consumption details, envelope construction assembly details.

3. Total interior floor area

4. Insulation details

5. A questionnaire survey details conducted with particular site engineer or design engineer or architect. A field survey is to be conducted for above details before going to use eco nirman web tool.

4.1 PROCEDURE FOR FINDING THE STATUS OF COMMERCIAL BUILDINGS USING ECO NIRMAN SOFTWARE:

a) Project:
Proposed office building for district livestock development association, Visakhapatnam.

b) Client:
Andhra Pradesh medical services infrastructure Development Corporation

4.2 STEPS INVOLVED IN ANALYSIS USING WEB TOOL:

Step 1:
In first step we have to create an account in eco nirman web tool and to be login. After that we have to give project details such as name, location, building use, dimensions.

Step 2:
After general information we have to give building shape, size and orientation.

Step 3:
In this area we have to give space use and zoning was done.

Step 4:
In this step we have to give envelope details such wall construction, roof construction, type of windows and doors.

Step 5:
In this step we have to provide HVAC details and give detailed information about space type, dimensions, conditioned space and type of conditioning systems.

Step 6:
This stage is called as conformance check. In the final step we conducted a questionnaire survey and we have provided answers to check list in the software.

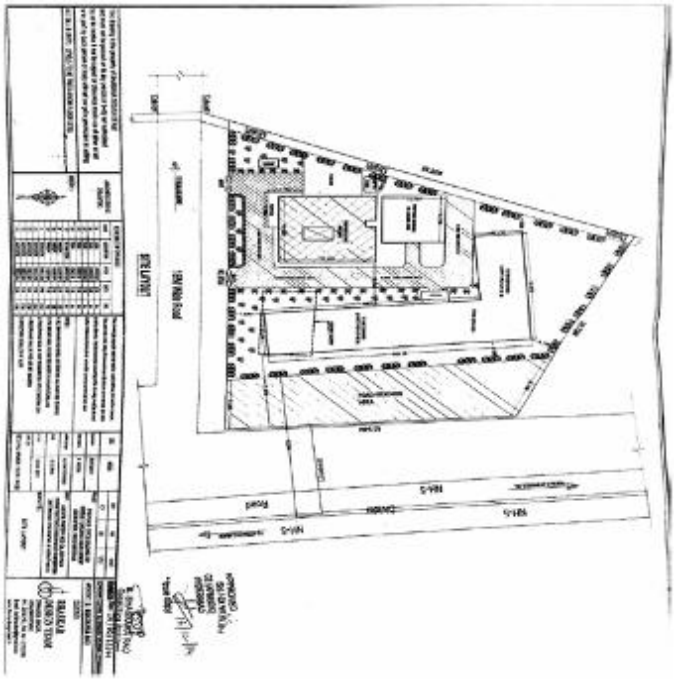

Figure.4. Site layout

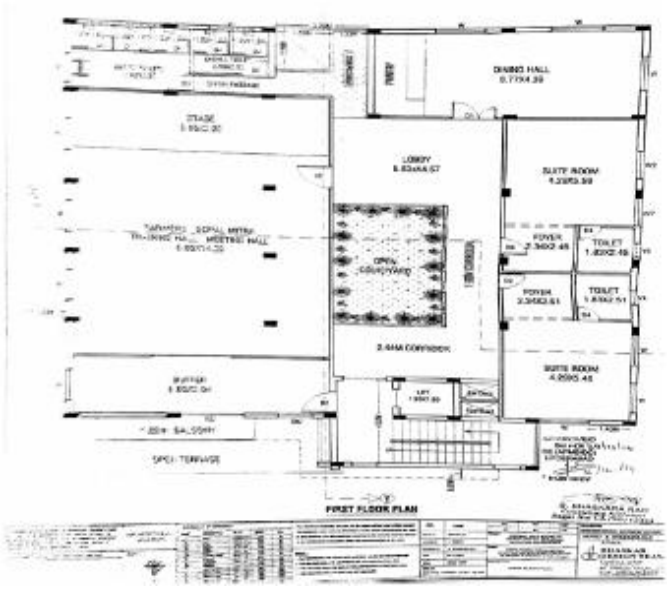

Figure.5. First floor plan

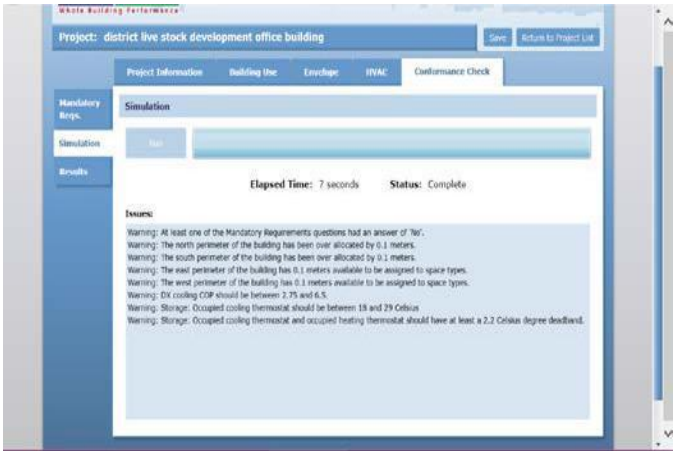

Figure. 6. Sample Image from Econirman Web Tool

5. RESULTS AND OBSERVATIONS:

5.1 RESULTS AND OBSERVATIONS FOR RESIDENTIAL BUILDINGS IN INDIA

Table.1.Observations for Residential Apartments

Cities Covered All Over India	Carpet Area In Total Built-up Area In % 3bhk	2bhk	No.Of Floors In a Building
Visakhapatnam	65.68	74.30	Up to 30 Floors
Vijayawada/Guntur	65.19	70.15	Up to 12 Floors
Hyderabad	66.69	74.61	Up to 42 Floors
Delhi	54.96	46.90	Up to 40 Floors
Kerala	67.18	60.23	Up to 55 Floors
Ahmedabad	57.87	62.33	Up to 57 Floors
Mumbai	54	65	Up to 61 Floors
Chennai	61.02	60.71	Up to 30 Floors
Bhopal	64.69	57.94	Up to 27 Floors
Bihar	83.71	68.44	Up to 30 Floors
Bhubaneswar	58.51	60.60	Up to 22 Floors
Guwahati	62.33	66.35	Up to 17 Floors
Punjab	69.08	73.8	Up to 30 Floors
Bangalore	75.26	76	Up to 50 Floors

Table.2.Observations

CITIES COVERED IN INDIA	OBSERVATIONS
VISAKHAPATNAM/VIJAYAWADA/GUNTUR	• Individual Flats(with No Common Walls) • Vastu Compliant, not using Any Energy Saving Techniques.
HYDERABAD	• Going For Independent Flats, energy Saving Techniques Are Not Adopted
DELHI	• Apartments Are Constructing In A Vast manner, flats Up to 8000Sft were built without energy saving techniques
CHENNAI	• 1BHK Are adopting in high rise apartments
AHMEDABAD	• Going up to 5BHK,4BHK Keep in view of big families • Every apartment consist of a pool or pond in front of it.
PUNJAB	• Going for less thickness in walls, in deep which leads to more carpet area, not following mandatory orientations.

Table.3.Observations

CITIES COVERED IN INDIA	OBSERVATIONS
KERALA	• Kitchen is placing on west and south west side. • 4 side balconies, 4 side ventilations.
BHUBANESWAR	• Single balcony, not much ventilated, kitchen in south & south west side, not much vastu compliant.
BHOPAL	• Going for thicker walls which in deep reduces carpet area.
BIHAR	• In 2 BHK these are utilizing more carpet area than others by providing less thickness in walls
GUWAHATI	• Buffering spaces in between the buildings are more. • No independent flats are noticed.
MUMBAI	• Servant rooms and dress rooms are preferred in apartments, kitchen in south west.
HIMACHAL PRADESH	• Wooden flooring, walls are thicker than conventional walls.

5.2 RESULTS FROM ECO NIRMAN WEB TOOL FOR COMMERCIAL BUILDINGS:

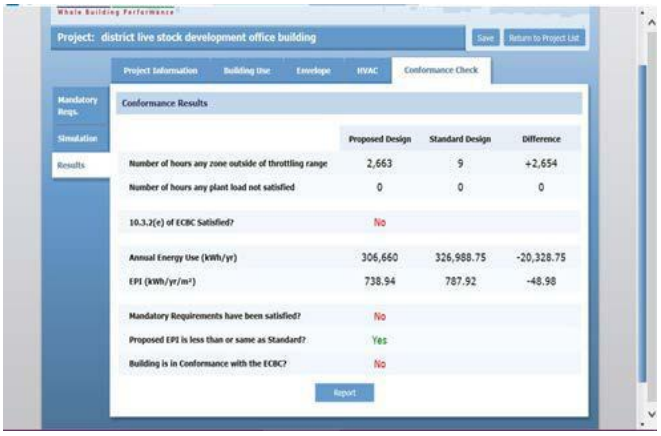

Figure.7.Results from Web Tool

From the above result we can conclude that the commercial building which we have tested is not qualified for ECBC standards.

6. CONCLUSIONS

i. Residential buildings in India are not following optimized orientations, minimum dimensions for carpet area, minimum buffering spaces.

Ii. Carpet area is main important factor in electricity demand, less thick walls to be suggested which indeed increase carpet area. Grouping of rooms are good. No changes required.

Iii. Rain harvesting, solar panel installation recommendations should be strictly implemented in ECBC framework for residential buildings.

Iv. Recommendations for minimum dimensions between buffering spaces for buildings to be give importance in ECBC framework.

v. Awareness, advantages of new technologies and materials should be discussed in ECBC framework clearly to encourage in residential sector.

Vi.Window to wall ratio (WWR) to be increased and minimum values should be recommended in ECBC framework.

vii. Usage of panels such as GFRC, INSULATED CONCRETE FORMS should be encouraged which decrease the cost of a building up to 50%

viii. Qualification for designer, architect, approval officer should be discussed in ECBC Framework.

ix. By using materials like Celitement in place of cement carbon emissions can be controlled up to 50%.

x.Large commercial complexes like hospitals, offices, shopping malls, are not using existing ECBC Code, before approval of buildings ECBC norms should be checked by particular authority.
xi.By using econirman web tool analysis, we have finded that commercial buildings are not following any insulation materials, occupancy sensors, which decrease use of electricity.
xii.If all recommendations in ECBC are used electricity consumption will be decreased up to 30%.

6.1 SCOPE FOR FURTHER STUDIES

i. More research work can carried out on residential floor plans by using present work as a base study, research work can be carried out on materials like Celitement.
ii. More residential and commercial buildings are to be studied for more efficient management in floor area distribution and energy resources.
iii. Research should be carried out on new technologies and methodologies in construction of residential and commercial building sector.
iv. Research should be carried out on green building materials and probability of using or recycling waste products.

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