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Comparing residential building design pre and post application of ECBC-R, with respect to passive design principles.

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ABSTRACT

ECBC-R is the energy efficiency code for residential buildings. This is a very important regulatory measure to promote energy efficiency in the new residential building sector. These codes are already in use for the commercial sector since 2017. The code for residential buildings has been developed as Eco-Niwas Samhita 2018.The code is applicable to all residential buildings and residential parts of 'mixed land-use projects', both built on a plot area of ≥500 m2 , new residential development post 2018.In the current scenario, the demand for marketable floor space overtakes all other considerations while designing new residential buildings. ECBC-R is an attempt to change some of this focus towards energy efficiency through passive design in order to reduce GHG emissions from buildings lifetime. This research aims to compare residential building planning from pre ECBC-R period to post ECBC-R implementation, to enquire whether the design focus has been redirected to energy efficiency. This shall be done by comparing as built building plans with proposed design of new buildings post ECBC-R. Thus, we can find out whether ECBC-R has incentivized energy efficiency in design thinking. This research will focus on comparing residential buildings limited to Pune, Maharashtra.

Keywords: ECBC, passive design, residential, energy efficiency.

1. INTRODUCTION

ECBC (Energy Conservation Building Code) for commercial building was launched in 2009.

Energy Conservation Building Code – Residential (ECBC-R) or Eco-Niwas Samhita 2018 is the energy efficiency code for residential buildings. This is a very important regulatory measure to mainstream energy efficiency in the design of new residential buildings. The code is applicable to all the residential buildings and residential parts of the 'mixed land-use projects. Through the application of this code, the aim is to realize the potential for energy savings to the tune of 125 Billion Units of electricity per year by 2030, which is equivalent to about 100 million tons of CO_2 emission [1]. The energy savings are envisaged by decreased demand for thermal comfort inside habitable spaces. This is to be achieved through passive design, proper orientation and use of appropriate construction materials and finishes which reject heat build-up inside spaces.

In practice however, the demand for marketable floor space overtakes all other considerations while designing new residential buildings. Eco-Niwas Samhita (ECBC-R) is seeking to redirect a proportion of the design focus towards achieving energy efficiency during the "in-use phase" of residential spaces.

The main purpose of this research is to explore whether the ECBC-R codes are implemented in buildings post 2018.Whether these codes must be made compulsory or has it already penetrated into the design thinking and construction industry. This research is going to do case studies to examine the extent this has been achieved or not.

1.1. LITERATURE REVIEW

Rajat Gupta, Matt Gregg and Shashwata Joshi research paper titled “Performance evaluation of a certified green-rated housing development in the warm humid climate of India” (2), discuss that the green building movement in most of the countries in the world, including India, are for most of the part lacking an important link that makes sure the design intent of similar structures is realized. For the design IGBC, GRIHA, LEED certified case study of residential development, no performance evaluation was officially performed after the certification. One more significant limitation is the current lack of published findings, data or feedback on these POE/ BPE- related credits. The research shows the process of testing the I- BPE methodology on a Platinum- certified green development in India. The field study was carried out for 30 days which included spot measures, data monitoring, walkthroughs and inhabitant checks. The field study offers a ready guideline for replication of BPE and benchmarking data for green residences in India and specifically for southeast India. The coming step in the Learn-BPE design involves testing the I- BPE approach on several other case studies enforced by scholars using a programme developed for this purpose. The I- BPE case studies intend to demonstrate factual performance of pukka green structures in India, publish the data, and continually give a testing platform for refinement of the I- BPE frame for operation in India. Eventually, the I- BPE case studies are also intended to make trust in the assiduity by strengthening the relationship between the assiduity professionals and experimenters in academia.

Thus, it can be concluded that energy performance evaluation in energy efficient buildings is a must and the above technique can help in following through the process.

2. METHDOLOGY

Two case studies of residential high-rise building in Pune were studied. Sample Building 1 being a premium project built in a prime location before 2018(Pre ECBC-R) and Sample Building 2 being a residential project in upcoming commercial area currently in progress. (Post ECBC-R).

In addition to this a survey tool was created to assess the understanding of general population. about the energy conservation codes in building industry. The subjects surveyed are from architectural profession, academicians, and common people and were selected at random. Mode of survey was through a questionnaire with multiple choice answers.

Aim of part 1: To understand designers’ knowledge.

The buildings are studied as per the Part1 building envelope being the first part of ECBC-R. These are simple to apply equations which require simple calculations based on inputs from architectural design drawings. It does not require any simulation software. Software like MS Excel was used for calculations. Though there are various compliance tools available in the market and also on BEE website we have done our compliance check manually using the formulae given in the codes.

For each sample building following criteria were studied and calculated as per the provisions in the code:

1. Openable window to floor area ratio (WFRop)

$$WFR_{op} = \frac{A(Openable)}{A\,(Carpet)}$$

where,

WFR *op*: openable window-to-floor area ratio

A (*op*): openable area (Sq.m); it includes an openable area of all windows and ventilators, opening directly to the external air, an open balcony, ‘verandah’, corridor or shaft; and the openable area of the doors opening directly into an open balcony.. Exclusions: All doors opening into corridors. External doors on ground floor, for example, ground-floor entrance doors or back-yard doors are excluded.

A (*carpet*) : carpet area of dwelling units (m2); it is the net usable floor area of a dwelling unit, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah area and exclusive open terrace area, but includes the area covered by the internal partition walls of the dwelling unit.

2. Visible Light Transmittance (VLT)

$$WWR = \frac{A\ (Non\ opaque)}{A\ (Envelope)}$$

3. Thermal Transmittance of Roof (U_{roof})

$$U_{Roof} = \frac{1}{A_{Roof}}$$

where,

U_{roof} : thermal transmittance of roof (W/m2 .K)

A_{roof} : total area of the roof (Sq.M)

U_i : thermal transmittance values of different roof constructions (W/Sq.m .K)

A_i : areas of different roof constructions (Sq.m)

4. Residential envelope transmittance value (RETV) for building envelope (except roof) for warm- humid climate.

where,

$A_{envelope}$: An envelope area (excluding roof) of dwelling units (Sq.m). Is the gross external wall area (including the area of the walls and the openings such as windows and doors).

$A_{opaquei}$: areas of different opaque building envelope components (Sq.m)

$U_{opaquei}$: thermal transmittance values of different opaque building envelope components (W/m2. K)

$A_{non\text{-}opaquei}$: areas of different non-opaque building envelope components (m2)

$U_{non\text{-}opaquei}$: thermal transmittance values of different non-opaque building envelope components (W/m2. K)

$SHGC_{eqi}$: equivalent solar heat gain coefficient values of different non-opaque building envelope components (refer to Annexure 7) (7)

ω_i: orientation factor of respective opaque and non-opaque building envelope components; it is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation (values are given in Annexure 6

As per the conclusions from each of the above points the buildings were checked for compliance with the code.

A comparative analysis was performed on basis of calculations done as per the codes prescribe and provides an overview of the research that is to be described in greater detail in the sections to follow.

2.1 Sample Building 1:

Built in 2017, this is a premium project located in a prime area of Pune city. This has 2 buildings of identical layout. It is an 18 storied building with 2 basements. This has 4 bedroom living kitchen and servants' quarters with 2 dwelling units per floor. The study of this building sample was done by actual site visit and taking all the required measurements by the author. All the measurements were then formulated into tables and then by use of prescribed formulae the results for each criterion were derived.'

As per the ECBC-R code the building shall comply with all 4 criteria to certify as ECBC-R complaint building.

As per the above calculations the figures shall be compared with the ones given in the ECBC-R manual and accordingly results were derived.

2.2 Sample Building 2:

Designed in 2019 and execution of the same is ongoing. This is a standalone building. It is 19 storied and has one basement. The dwelling unit are of one bedroom, living, and kitchen nature. Each floor has 8 units with identical layouts.

The study of this sample building 2 was done by use of drawings available with the author, since the project is still not completed. All the measurements were taken from drawings and then formulated into the equations as per ECBC-R manual. Thus the results were derived.

SHGC values were considered as per standards.

As per the ECBC-R code the building shall comply with all 4 criteria to certify as ECBC-R complaint building.

As per the above calculations the figures shall be compared with the ones given in the ECBC-R manual and accordingly results were derived.

Aim of part 2: Understanding in general if user demand is good drive for energy efficiency and how it helps ECBC-R.

3. RESULTS

Sample building 1 was found to be non-complaint.

1. Openable window to floor area ratio (WFRop) - Non complaint – significant difference found in the prescribed ratio and derived ratio.
2. Visible Light Transmittance (VLT) – Complaint- Falls just within the range prescribed.
3. Thermal Transmittance of Roof (Uroof) – non complaint – significant difference found in prescribed range.
4. Residential envelope transmittance value (RETV) for building envelope (except roof) for warm- humid climate. – Non complaint- significant difference found in prescribed range.

Table 1: SAMPLE BUILDING 1			
No	Parameter	Values	Required values
1	WFR	12.20 %	<16.60%
2	WWR	0.176	0-0.3
3	U *Roof*	2.3	<1.2 W/Sq.m K
4	RETV	15	<15

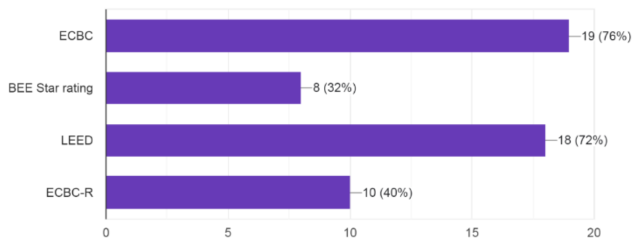
Sample building 2 was found to be complaint with the code.

1. Openable window to floor area ratio (WFRop) - complaint –does fall within prescribed range
2. Visible Light Transmittance (VLT) – Complaint- Falls just within the range prescribed.
3. Thermal Transmittance of Roof (Uroof) – Complaint – Falls just within the range prescribed.
4. Residential envelope transmittance value (RETV) for building envelope (except roof) for warm- humid climate. Falls just within the range prescribed.

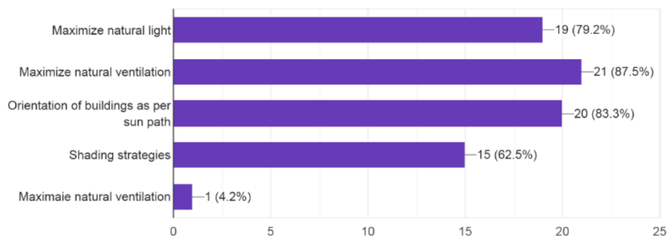
Table 2: SAMPLE BUILDING 2			
No	Parameter	Values	Required values
1	WFR*op*	16.70 %	<16.60%
2	WWR	0.12	0-0.3
3	U *Roof*	1.1	<1.2 W/sq.m K
4	RETV	14	<15

SURVEY RESULTS:

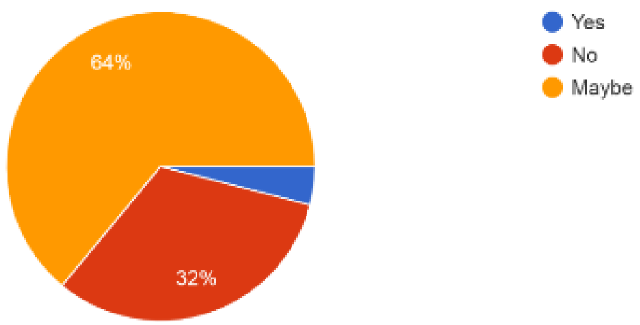
1. Which energy norms are you aware of for residential buildings?



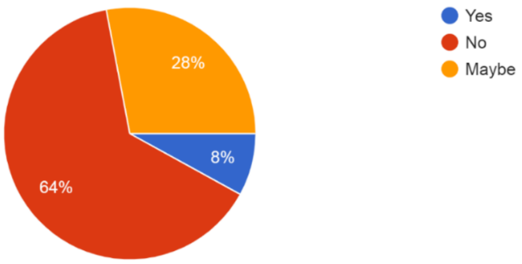
2. Do you design your buildings according to passive design princples?



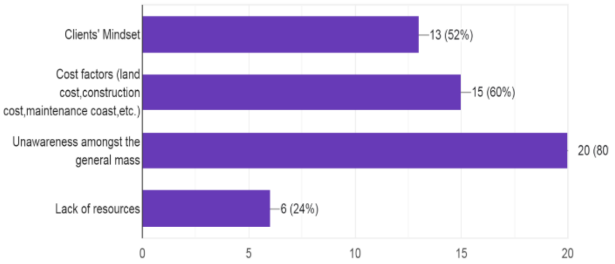
3. Do you feel that energy efficiency norms contradict with development control rules?



4. Do you think designing passive residential buildings is expensive?



5. Which of the following do you think is the main hinderence towards the slow progress of energy efficient building?



4. ANALYSIS:

The above results compel us to do a comparative analysis of the two sample buildings.

Let us compare all the parameters one by one to understand how the rules have affected the design thinking.

1. WFR*op*: Openable window to floor area percentage: As per the guidelines given in the ECBC-R manual the percentage should be 16.6% for Pune which falls under warm and humid climate zone. In building 1 the wall to window ratio is found to be 12.2% and in building 2 it is 16.7%. In building 1 though the windows provided were adequate and huge in size the openable areas were only 50% effective. Here is where the percentage fails to achieve the required value. In building 2 though the opening sizes are standard the ratio of openable to non-openable was more that 60% and hence the prescribed percentage is achieved in this case.

   Hence building 2 becomes complaint with the norms and building 2 fails by mere 4.4%. This could have been achieved if the number of fixed windows (non openable) was reduced or by simply using casement windows. In building 2 though it is compatible with the norms it falls just within the prescribed values. Here too use of casement windows would have increased the percentage significantly.
2. VLT and WWR: Visible Light transmittance of the envelope of the building. Here as per the equation WWR (wall to window ratio should be in the range of 0-0.3. In building 1 it was 0.12 and in building 2 it was found to be 0.17. here for building 1 since the number of windows and their sizes are huge it complies with the norms for visible light transmittance. Whereas for building 2 even though it falls in the range the value is higher than building 1, still within the compliance factor but non-significant.
3. Thermal Transmittance of Roof: U *roof:*

   This value gauges the thermal performance of the building and required value is 1.2 W/m2 K. This value entirely depends on the sensitive use of materials used for roofing system. In building 1 the values are too high that is 2.3 W/m2 K and in Building 2 it is 1.1 which makes it compliance to the norms and building 1 non-compliant. Here in building 1 the passive strategies were either not thought of or this use of specific materials was subject to poor choice of materials and neglect towards the thermal roof comfort. Also, we must note that building 2 barely fits into the criteria by replacing just one material thus improving the thermal transmittance of the roof compared to sample no. 1.
4. RETV: Residential envelope transmittance value, which as per norms is recommended to be maximum 15 W/m2.here Sample 1 is complaint since its values are 15W/m2. And Sample 2 is complaint with 14W/m2. Here in sample 1 due to huge sizes of openings and comparatively smaller areas of projections around the windows increases the value. But here the glazing given to the windows has better SHGC values due to double glazing than in sample 2 where the single glazing is used.
5. As far as the survey is concerned one can see that people are still unaware about ECBC-R. They know about ECBC which is for

commercial structures but a provision for residential is known only to 32% of persons that were surveyed.

Also, it is a general consensus that subjects did not think that building energy efficient buildings is expensive and rather they are trying to implement this in their design as a default. But here we can see that 80% of the subjects think that general unawareness about energy efficiency amongst the common mass is the main reason why the progress towards energy efficient buildings gets hampered.

Here one need to understand that these norms would bring about a definite change in terms of heat exchange and thermal comfort required in residential buildings. But general awareness needs to increase tenfold so that people opt for passive design strategies. Also looking at our sample building just by making very few changes these building can be complaint with minimum effort.

5. CONCLUSION

Residential sector takes up maximum energy and one must be sensitive towards the design approach. As we saw in the above result and its analysis few changes make great difference and if the design thinking is approached with passive design strategies in mind one can easily accomplish compliance with these norms. Also, we can conclude that energy efficiency is not the main criteria for design and more awareness must be generated regarding energy norms amongst the general public. In conclusion these norms should be made compulsory so that the energy efficiency of the buildings can increase thus leading to a better, comfortable habitable space. Also, there should be a post-performance evaluation done. The limitations here is basically unawareness amongst the mass. Another limitation is the land costs which greatly affect the orientations of the buildings. Then norms compliance is easy to calculate and there is software provided by BEE for ease of process.

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