INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 9, ISSUE 04, APRIL 2020 ISSN 2277-8616

Modelling Of Ecological Regenerative Nest For Special Children (ERNS) Using Regenerative And Bio-Mimicry Concepts

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Abstract: The building design must include tracing the sun-path and wind rose for the correct orientation, use locally available materials for lesser energy consumption and have low environmental impact throughout the design life. Regenerative design coupled with Bio-mimicry concepts is an idea that was used in this study to identify low embodied energy materials for modelling an Ecological Regenerative Nest for Special Children (ERNS). Homes were planned in a circular form and the fenestration was oriented using the natural conditions. The entire plan included community consisting of hostels housing four categories of special children, school for the disabled children, pipe layouts for drinking water and sewage. The materials, which were used for planning ERNS, were regenerative in nature, meaning they can be reused after its design life. The capacitive insulation of these materials will help in reducing the operational energy and the impact on the environment..

Index Terms : Regenerative concepts, Bio-mimicry, Rural technology, Low Embodied energy materials.

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1. INTRODUCTION

Building sector account for massive environmental impacts since it produces 35% of the annual carbon emissions and consumes 40% of the primary energy [**Error! Reference source not found.**]. This over exploitation is not seen as a long-term sustainable solution and consequentially requires a framework, which is holistic in nature. A long term solution has to take into the energy analysis (Embodied and operational) and life cycle assessment into account. Embodied energy (EE) is the energy usage from extraction of the raw materials to the disposal stage for the same and the extent of the measurement depends on the boundary conditions (although cradle to grave gives the best result) [**Error! Reference source not found.**]. Operational energy (OE) measures the energy required to run and maintain a comfortable stay for the occupants according to US Energy Information Administration, operation of buildings. In the preceding works, the emphasis has always revolved around operational energy since it accounts for 80% of the total energy usage in the design life of the building [**Error! Reference source not found.**]. This is true in most of the conventional building made from the usual components (concrete and steel) but when the design involves the usage of passive or low energy principles, EE becomes vital to the total energy consumption [**Error! Reference source not found.**]. Life cycle assessment of the buildings have become all the more important since the impacts on the environment like potential for global warming, ozone depletion, primary energy demand etc. can be studied [**Error! Reference source not found.**, **Error! Reference source not found.**]. The above stated parameters become critical in the coming years since residential and commercial buildings are being built rapidly all over cities. Multiple papers embraced the idea of regenerative and locally available materials since it doesn't require to be manufactured which saves a major portion of embodied energy [**Error! Reference source not found.**, **Error! Reference source not found.**]. Another method to save the EE was to reuse materials from building compoents [**Error! Reference source not found.**]. Three tier approach

for reducing OE provides an idea for implementing passive technologies and HVAC installations in buildings [**Error! Reference source not found.**]. However, the usage of artificial technologies can contradict the idea of reducing the total energy since the installation of such complicated devices will increase the EE although decreasing the OE [**Error! Reference source not found.**]. Hence, a combination of careful selection of materials and planning of the building according to natural conditions will lead to reduction of total energy consumption. In addition, the assessment for such planned building based on optimization of materials will reveal lesser impacts on the environment [**Error! Reference source not found.**]. This paper tries to make use of such regenerative and locally available materials for planning a community with amenities for disabled children.

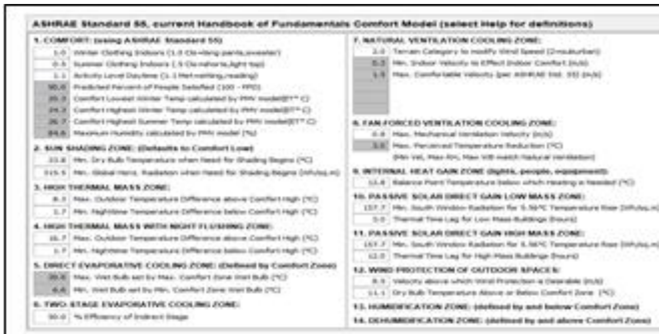

Fig. 1. Data used for thermal comfort calculation.

Planning the community required knowledge about materials and their properties. Normal conventional buildings will use materials like cement, aggregates, steel etc. which have high embodied energy (EE) which is not sustainable [8]. Conventional materials will result in usages of mechanical ventilation, dehumidifiers; evaporators for maintaining the comfort range inside the building increasing the Operational energy (OE). A study of the location based thermal comfort

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was done to prove the above statement using a software "CLIMATE CONSULATANT". The calculation was based on the data collected for the particular location and conformed to AASHRAE standard 55 [10]. Metabolism, clothing type was also taken into account for the study. Predicted Percent of People Satisfied (PPD) is used for the thermal comfort calculation.

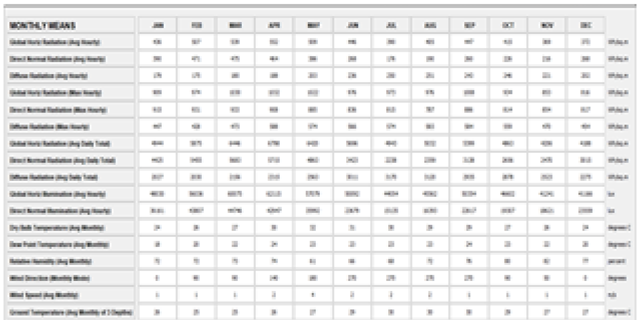

Fig. 2. Location based weather data provided by the softwar

Other factors like sun shading, natural & forced ventilation, thermal factors of the locality, usages of high heat producing devices etc. are used as shown in Figure 1.

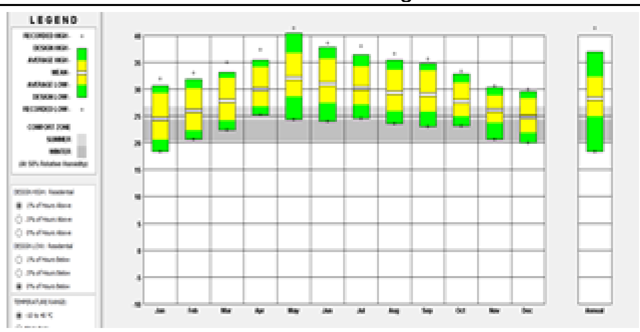

Fig. 3. Maximum and minimum temperatures in each month the year.

All these factors are used for calculating the thermal range of a
conventional building made up of the materials like concrete, steel.

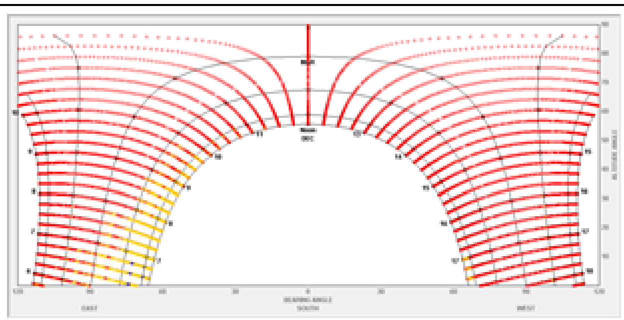

Fig. 4. Sun Chart.

The data provided by the software has been collected for the past 30 years and is really useful in location based climate studies. Figure 4 provides vital information about the sun chart by which the shading devices (vertical and horizontal) can be designed.

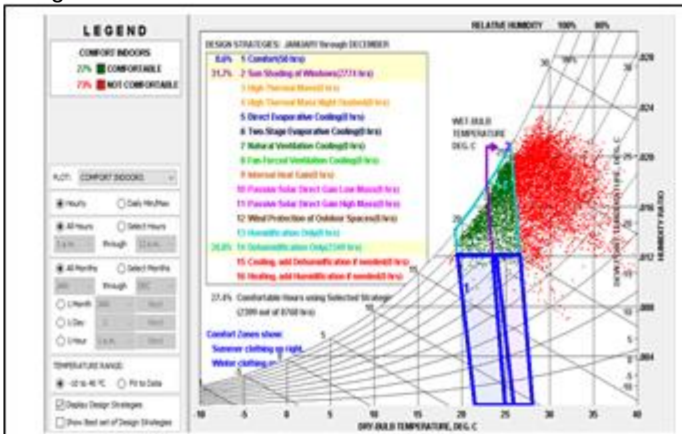

Fig. 5. Psychrometric Charts displaying the thermal comfort based on the PPD model.

The thermal comfort showed that 27 percent would be satisfied with the present conventional conditions and materials. More comfort can be obtained by using forced ventilation which would increase the OE and was not sustainable. The software did not have facilities to change the material properties of the building. Nevertheless, it provided details, which could be useful in planning the communities.

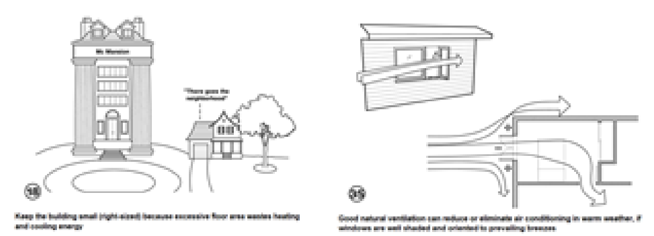

Fig. 6. Design principles provided by the software shows that th homes need not be very large and can be provided with natural ventilation based on the orientation.

2 PLANNING AND DISCUSSIONS

The usage of regenerative materials reduces the operational energy, life cycle cost and life cycle energy of the structure. The plans of ERNS included six communities (5 for children and 1 for staff) of four homes each, school plan, amenity zone, canteen, hospital, pipe layout and sewage water pipe layout.

2.1 Hostel Home

The first plan shows the model of circular hostel structure oriented in the direction shown in Figure 7. The model was planned in such a manner that all the materials were natural regenerative materials like cob, thatch, earth etc. [2, 20]. The following materials are used in the components shown in Table 1

***Table 1:** Components and its respective materials*

S.No	Component	Material
1	Building envelope	Cob
2	Roof	Thatched
3	Plastering	Cob
4	Floor	Earth

The technical specifications (Table 2) are conforming to National Building Code for special children and the room was designed in such a way that it can accommodate four children of different disability (Non Ambulatory, Semi Ambulatory, Sight, and Hearing). The room was designed in a spacious manner for the children to have sufficient comfort with an attached washroom. The steps have a longer thread and lesser rise for facilitating the movement for the children. A provision of a ramp parallel to the steps for the movement for the non-ambulatory members

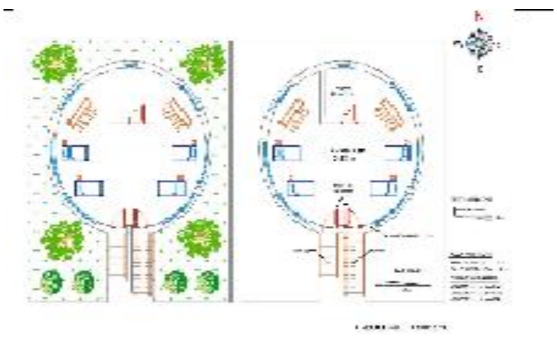

Fig. 7. Single hostel room

Another important parameter was the orientation and the shape of the hostel room the plays an important role in this. The circular room has multiple fenestration openings oriented in the east and west directions giving the occupants the maximum sunlight during the early and late hours of the day.

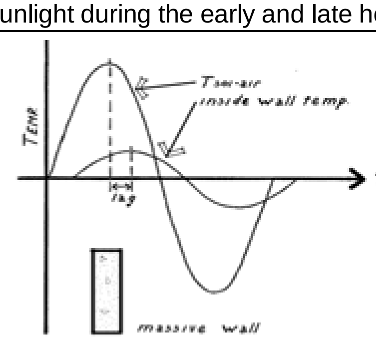

Fig. 8. : Difference between the Tsol temperature and the inside walltemperature using theTemp -Time graph. The figure also shows the time lag between for the heat to ent the inside environment

The usage of natural regenerative materials develops capacitive insulation, which does not let the heat inside the building during the daytime and dissipates the heat to the outside environment during the nighttime, maintaining a very comfort stay for the occupants as depicted by Figure 8, thereby decreasing the operating energy [8].

***Table 2:** Technical specifications of the hostel room*

S.No	Component description	Dimension
1	Room	12 m
2	Toilet (attached)	2.5 m x 3.5 m
3	Wall	0.5 m
4	Basement	0.3 m
5	Ramp	1 in 12 slope
6	Steps	6 steps Riser of 4.28 cm and tread of 40 cm.
7	Total Area	310 sq. m.

2.2 Community Home

The community of area 1310 sq. m. was a collection of four hostel homes with a passage connecting them all. A single community consisted of a grand total of 16 children who can help each other for day to day activities. The passage of 1.5 m enables easy movement of the children and a sit-out was planned at the center of the community

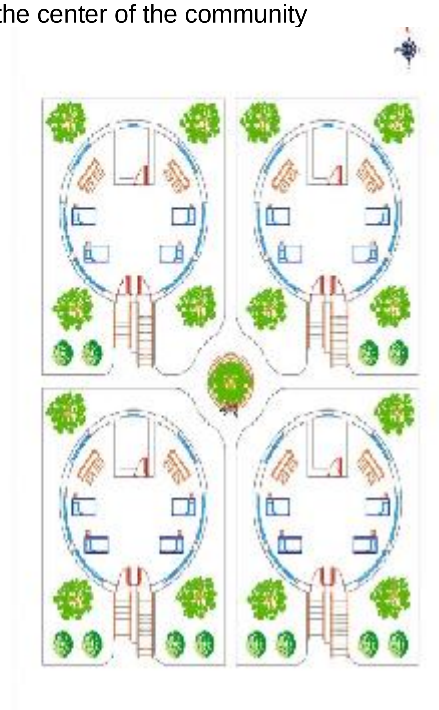

Fig. 9. Single community of hostel homes

The community has a lot of greenery around it, which acts as the vertical shading for the homes, decreasing the direct radiation.

2.3 School plans

Schools were planned separately for each disability making a grand total of four schools according to the disability constraint. The materials for the various components in the school was similar to the hostel rooms given in Table 1. The children with movement disability was planned for the specifications in Table 3

Table 3: *Technical Specifications of the school for movement disability children*

S.No	Component description	Dimension
1	Classroom	14 m x 14 m
2	Toilet	3 of dimension 2.5 m x 3 m
3	Playground	15.7 m x 8 m
4	Wall thickness	0.5 m
5	Basement height	0.6 m
6	Ramp	1 in 12
7	Total area	1310 sq. m.

Fig. 9. Single community of hostel homes

A ramp was provided in the school for with movement disability, while the other three schools for children with other disability had steps specified by the norms provided by NBC.

Table 4: *Technical Specifications of the school for other disability children*

S.No	Component description	Dimension
1	Classroom	14 m x 14 m
2	Toilet	3 of dimension 2.5 m x 3 m
3	Playground	15.7 m x 8 m
4	Wall thickness	0.5 m
5	Basement height	0.6 m
6	Step	11 steps Riser of 5 cm and tread of 40 cm.
7	Total area	1310 sq. m.

Overall, 80 students of various disability were provided four schools as shown in Figure 9.

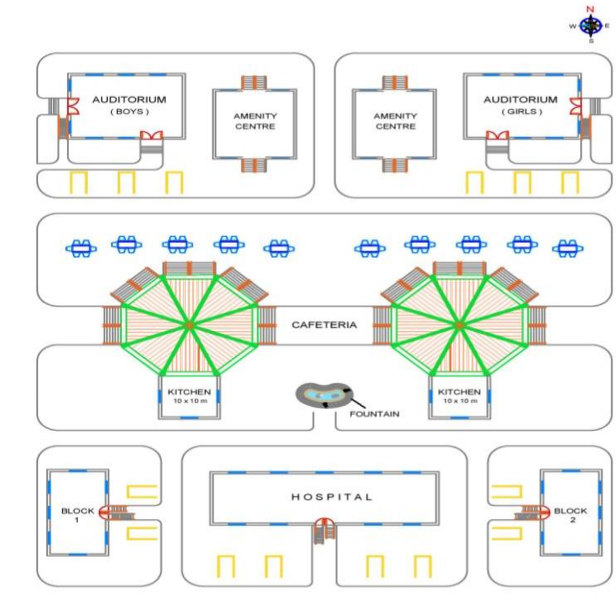

Fig. 10. Amenity Zones

2.4 Amenity Zones

Amenities for the children were also provided for them to feel relaxed and happy. Café with attached kitchens, separate auditoriums for boys and girls were planned as shown in Figure 10. Hospitals with a couple of blocks on either sides was also modelled and shown in the same.

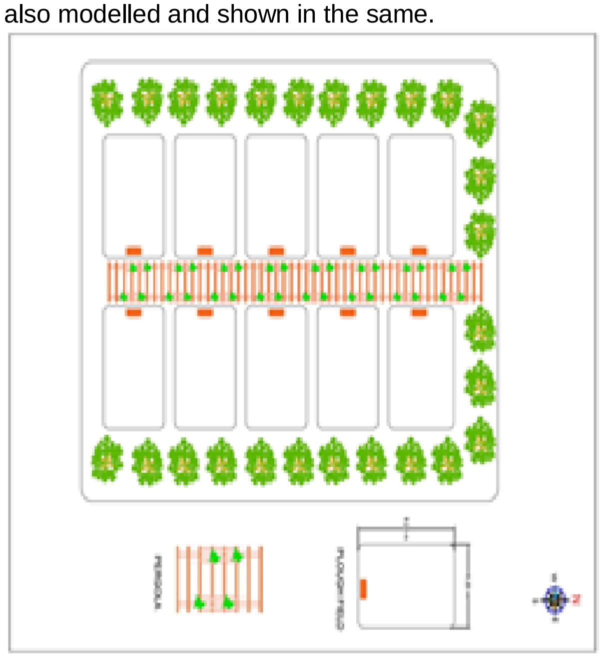

Fig. 11. Farming Zone

2.5 Farming Zone

Farming zone is a place where children can utilize their free time by planting and taking responsibility of small plants and saplings. Ten plough fields (6.2 m x9.2 m each) were provided for the children to display their farming skills. A pergola acts as a pathway in the middle of the fields and gives an architectural finish to the zone as shown in Figure 11.

The usages of regenerative materials will have the following advantages compared to the conventional buildings.

- Low embodied energy & operational energy.
- Higher thermal comfort.
- Living with nature with harmony and being regenerative in thoughts.

3 CONCLUSIONS

An Ecological Regenerative Nest for Special Children (ERNS) was completely designed based on the regenerative concept. This concept gives way for more advantages rather than building with high-embodied energy materials. The usages of high-embodied energy like concrete releases high levels of toxic gases hindering the environment.

- Climate consultant was used for determining the location based thermal comfort based on PPD and also to show the conventional materials doesn't provide the necessary comfort without the usages of artificial or forced ventilation.
- Based on some of the design principles provided by climate consultant, regenerative materials could play a vital role in decreasing the overall energy consumption (EE & OE).
- Regenerative materials like cob, straw, thatches, mud, abode bricks etc. have low or zero embodied energy. In addition, being regenerative, it can be reused again even after the design life of the structure ends.
- The orientation of a building plays a major part in providing comfortable conditions for its inhabitants. Properly planned fenestration and building shape according to the sun path was used. This would have a major say in maintaining thermal comfort range in the area.
- The plans included community of four hostels, amenities, schools and pipe line layouts. The regenerative materials not only decreased the overall energy of the building, it also decreased the impact on the environment.
- The children would have a good environment where they could regenerate themselves and learn to live in harmony with nature.

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