Introduction

A building envelope is that which defines a boundary between in and out. Whereas the envelope has an opening, which acts, in the form of regulatory and protective functions and provide light, ventilation and climate control for rooms. Treated openings can also be defined as a space or void allowing access or vision to a space or surface, such spaces or surfaces act as openings or open spaces. At the same time, they are essential functional and design elements of facades, enabling communication between indoor and outdoor spaces as transparent or translucent structural components. Openings are broadly classified into two major types A) Vertical openings ie (Doors, windows ) and B) Horizontal openings ie (Skylights and courtyards). While looking for the aspect of sustainability, habitat able spaces should be taken into consideration, which are utilized for throughout the year, where the concept of sustainability starts working. Thus this study mainly focuses on the comparative analysis of such type of vertical treated openings and its building physics, in Central part of India (Nagpur region), where it mainly deals with the function of the different types of treated openings at different locations within a structure, the style and its use, different materials and techniques used in construction an lastly change in scale of the openings for over a period of 100 years.

Importance of Building Physics

Building Physics is a science that deals in hydrothermal, acoustical and light related properties, and the performance of building materials, building assemblies such as (roofs, facades, openings, walls, spaces, building as a whole and the overall built environment. Building Physics has to operate within an architectural framework, floors, facades, openings and roof form, aesthetics and choice of materials are all elements which shape the building and whose design is based on among others, the performance requirements which building physics imposes. The need to build a comfortable indoor environment that protects humans against vagaries of the outside climate, defines the role of building physics. it deals with variety of criteria- on one hand, requirements related to human comfort, health and wellbeing, and on the other hand restrictions because of architecture, material use, economic and sustainability demands. The building, which has been designed and constructed according to requirements, that reflects a correct understanding of building physics could generate a better sustainable habitat. Of overall building envelope, a single element of treated Openings is considered for analysis and comparative study with respect to its building physics in the following cases studies.

Case study 1 (Year 1921-30)
Location: Model Mills chawl
Nilay Murarka Marg, Near Ganeshpeth Bus stop Ganeshpeth, Nagpur
The Model mill chawl at Nagpur is the oldest settlement consisting of total 416 units, which is spread over 3.16 acres of land in the heart of the city. The site is situated exactly opposite to Godrej Anandam Township, Model Mill Compound on Nilay Murarka Marg, which lies in the centre of the city. The chawl came into existence on 4th July 1921 for the workers of the Model mill which was closed down in the year 2003. The condition of chawl is down at heel, looks old and no longer in good condition. Each unit consists of approximately 30-32 sq.mts in area with 2 nos of doors and a small window with roof projected outside acting as shading device with toilet facilities in public toilets Figure 1-4.

**Figure 2:** Model Mill chawl Source: Google maps.

The image (Figure 5) below represents brick arch openings for doors and windows with wooden lintel low height opening size of 0.60m X 1.50m. Vertical bars are used as grill and the panels are fixed inside the grill. The unfinished arched openings with key stone (brick) in the centre gives the effect of colonial style of architecture.

**Figure 5: Represents opening details at Model Mill Chawl.**

**Case study 2 (Year 1941-50)**

Location: Kumbharpura, Lalganj, Residence of OP Devikar Dahi bazaar road, Nagpur

**Figure 6:** Represents residence at Lalganj area Source: Actual image at site.

**Figure 7:** Represents treated opening details at Kumbharpura Lalganj.

<table>
<thead>
<tr>
<th>No.</th>
<th>TYPE OF OPENING</th>
<th>MATERIAL</th>
<th>SOURCE</th>
<th>BUILDING TECHNIQUE</th>
<th>WALL</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wooden door</td>
<td>1.65 m x 3.20 m</td>
<td>Local</td>
<td>With frame, the shutters are directly attached to the frame by hinges on both the sides</td>
<td>Local</td>
<td>semi skilled</td>
</tr>
<tr>
<td>2</td>
<td>Wooden door</td>
<td>1.65 m x 3.20 m</td>
<td>Local</td>
<td>With frame, the shutters are directly attached to the frame by hinges on both the sides</td>
<td>Local</td>
<td>semi skilled</td>
</tr>
<tr>
<td>3</td>
<td>Wooden door</td>
<td>1.65 m x 3.20 m</td>
<td>Local</td>
<td>With frame, the shutters are directly attached to the frame by hinges on both the sides</td>
<td>Local</td>
<td>semi skilled</td>
</tr>
<tr>
<td>4</td>
<td>Wooden door</td>
<td>1.65 m x 3.20 m</td>
<td>Local</td>
<td>With frame, the shutters are directly attached to the frame by hinges on both the sides</td>
<td>Local</td>
<td>semi skilled</td>
</tr>
<tr>
<td>5</td>
<td>Wooden door</td>
<td>1.65 m x 3.20 m</td>
<td>Local</td>
<td>With frame, the shutters are directly attached to the frame by hinges on both the sides</td>
<td>Local</td>
<td>semi skilled</td>
</tr>
</tbody>
</table>

**Figure 4:** Represents treated opening details at Model Mill Chawl.

**Figure 3:** Actual pic at Model Mill Chawl.

**Figure 4:** Represents treated opening details at Model Mill Chawl.

**Figure 5:** Represents opening details at Model Mill Chawl.

**Figure 6:** Represents residence at Lalganj area Source: Actual image at site.

**Figure 7:** Represents treated opening details at Kumbharpura Lalganj.

**Citation:** Barik DA and Thomre A (2021) Comparative Analysis of Treated Openings and Comprehensive Study of its Building Physics in Context with Sustainability in Nagpur (India). Environ Sci Ecol: Curr Res 2: 1019
The residence of OP Devikar, tailor by profession and a Resident of Lalghanj Kumbharpura chowk, Nagpur residing in the dwelling of 400 sq. m area for more than 75 years. Its old construction of three rooms with no front or backyard. The condition of the residence looks old and no longer in good condition. The temperature inside is cooler as the wattle and daub wall thickness varies from 1’-1’6”. The low height openings were 3 in no with double shuttered ledge and battened door and 3 window supported on wooden lintel in wattle and daub wall with MS horizontal bars acting as grill, and roof projected outwards acting as shading device for the openings Figure 6.7.

Case study 3 (Year 1961-70) Location: At Mahal, opposite Kalayaneshwar Mandir Residence of Yashwant Wardilwar Nagpur

The study and analysis of treated openings at residence of Y Wardilwar’s, who runs a newspaper agency from Mahal area was built around 50-55 years ago was built in colonial style of architecture. The low height openings were 9 in no with double shuttered framed and panelled door and 4 windows supported on Brick lintel brick wall with MS horizontal bars acting as grill Figure 8.

Further to carry, the comparative analysis of treated openings at Aakar nagar, Katol road, were the resident is a Retired Government Employee, where the structure is G+1 was built around 30 years ago. The residence is a duplex row house is located on rectangular plot with its longer sides facing north-south axis (which are attached to common walls of neighbours) Figure 9.10.

Case study 4 (Year 1981-90) Location: B-69 Aakar Nagar, Katol road, Nagpur Residence of RC Sonkusare

In total, it has 11no of panelled doors with height of the opening as 2.10 mts, 6 double glazed aluminium framed windows are provided treated glass are used. Double glazed reflective glass with cavity (air gap) insulation in between is used for window panels, which ceases 20 % of heat coming inside, with rcc 0.60m chajja as an shading device Figure 11.

Case study 5 (Year 2001-2010) Location: KT Nagar, Katol road, Nagpur Residence of Ashok Nanwani

The last example to analyse was at KT nagar, Katol road, were the resident is a businessman and deals in Electrical equipments and the structure is semidetached G+1, where the plot size measures about 1891sq.ft was built during the period of 2003-2007. The building is equipped with all the latest techniques of construction and materials and is installed with solar power generation. The total no. of openings in the structure consists of 12 Teak wood framed and panelled doors with 7nos of double glazed large glass windows. Maximum no. of openings are covered with porch, which acts as shading device Figure 12.
Conclusions

Over the period of 100 years, the study displays the following change in building physics. In older times, storage spaces were maximum in all activities, flexibility of activities or performing activities in different manner ensured multiple use of same space, creating multiutility spaces. Thus minimizing the requirement of exclusive spaces. As the size of the structure increased over the years, this building envelope changed.

With this change in envelope, the need of exclusive spaces increased which resulted into increase in no of treated openings and its accessories. In recent times, carbon neutral building concept has become a popular catchphrase to describe the synergy between energy-efficient building and renewable energy utilisation to achieve a balanced energy. Energy is one of the most important factors in economic growth and social development in all countries. A building consumes energy at different levels in every stage of the life cycle, whereas building materials occupy a great share of this consumption. The choice of building materials can have multiple effects on a building's energy consumption. Therefore, the amount of embodied energy consumed by materials used for treated openings in buildings plays an important parameter in determining the energy efficiency of the buildings. The timber doors required for no. of doors and windows are obtained from forests whereas steel and glass are altered in form with the help of human and machine skill and manufactured with mine ore with heavy industrial process involving external use of fuel/electricity and energy. Over the years, the materials used for openings in buildings have higher environmental impacts than those used in traditional buildings Figure 13.

References

1. www.googlemaps.com
2. Actual site photographs.
3. Building Physics, heat, Air and Moisture by Ernst and Sohn.
5. A pdf on A building envelope is a boundary between inside and outside.