"The huge projecting window canopies with intricate fretwork are for providing shade to the rooms within- an adaption to the tropical heat. The large entrance hall immediately behind the central portico is the Town hall proper, with a row of fluted Corinthian columns that have gliding on the capitals. The strong interplay of light and shade accentuates the neo classical austerity of that area.The Town Hall was the centre of civic activity and debate, and the Asiatic Society was a centre of research on and documentation of knowledge of the Orient."(Ganesh K., Thakkar U., Chedda G., 2008)

The town hall is oriented in East West axis and is two storied building. The building is rectangular in plan admeasuring 200ft X 100ft. The West façade dominates the building as it is columnated with Doric fluted columns. The masonry walls and a load bearing pitched roof enclose the programs of the building.

THE LAYOUT OF THE ORIGINAL BUILDING IN RESPONSE TO THE PASSIVE TECHNOLOGIES IN ABSENCE OF ELECTRICITY.

The town hall was built to host a convention hall with proposal to allow various functions to be organized. As the layout suggests that the most important part of the building, the grand hall was located at the centre of the plan. This was surrounded by symmetrically arranged library and administration areas on North and South sides. Preliminary the segregation of the original layout can be done where the quite zones were separated from the nosier areas. The hall and the ceremonious areas were at the centre where colonnade of Doric orders glorified the function. The record rooms were placed with the store rooms and council rooms at ground floor area. The important Grand hall with reading areas and the prestigious Asiatic Society is located on the intermediate floor which is connected directly by the grand stairs.

The East and the West façades were protected by a colonnade suggesting gothic architectural influenze on west façade with a non decorative yet a protecting lean to roof. It can be noted that due to absence of electricity a clear intentetion to introduce elements of daylight and natural ventilation are stressed upon. The care has been taken to understand the low sun on the west face and preventive measures in form of second façade to shade the internal wall is implied. The windows are further protected by sun shades or "Jhilmils". The authors observe that the window shutters are installed with a louver system which not only keeps west, south west wind flow intact but also obstructs the harsh evening solar ingress.

OVERLAPPED PROGRAMS AT LATER STAGE AND USER INTERFACE.

The town hall presently is converted completely in to library. The ceremonious Grand hall accommodates a reading section and temporary offices on the ground floor section. Although the library still is not air conditioned and daylit, artificial light and mechanical wall fans help achieve the comfort. It can be noted that the ground floor occupies government offices which function with complete change in the layout as designed. The use is segregated with the public areas occupying the above floor and the lower floor being occupied by the admistrative and non public functions. The town hall is merely a building without the original function and intent.

OUTCOMES

The site was comparatively open when the building was designed and hence the cross ventilation along the building can be noted to be an important factor in attaining the orientation. The planned layout with the Bombay Greens, Horniman circle at the centre facilitates the wind flow with strengthening the wind currents from West. The climate is Warm and Humid which results in cross ventilation as an effective comfort strategy. In this scenario the East-West building orientation seems apt solution for natural ventilation and cooling. It can be clearly noted that the building responds to the overall function carried inside and is evident from the r. The appropriate sizing of the windows and protective layering of appropriately designed shades enable the internal areas to be adequately lit and naturally ventilated. The louvered windows are designed as to control the opening size of the shutter. The user can achieve desired comfort by controlling the angles of the wooden louvers. Not only the daylight is optimized but also this arrangement avoids solar ingress and allows uninterrupted wind flow.

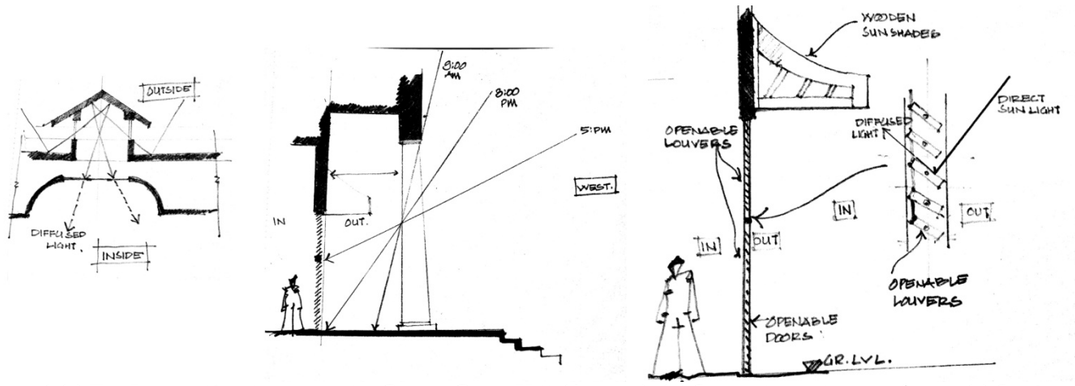


Figure 1 (a) The Lantern light located at the Central Grand Hall (Authors). (b) Sun angles at the west façade (c) Section showing the weather shade (Jhilmils) and louvers (Authors).

QUANTITATIVE ANALYSIS

Daylighting

The Quantitative analysis was carried out to explore the light inside the spaces of the building. The identification of Town halls lighting techniques used was carried out with the help of identification of strategies used in the building which were apart from any electrical source. The method is where the source of day light is separated with onsite identification of the techniques. A detailed understanding of the type of lights is carried in order to understand the implications of each source of light.

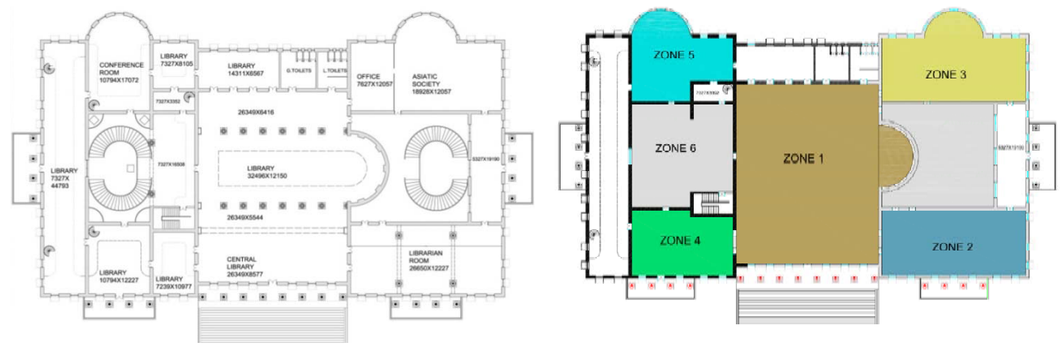


Figure 2 (a) Plan Main Floor Library (Padmashree, M. 2012) (b) Zones for daylight analysis (Authors).

Computer simulation of the luminous environment inside the town hall building was also conducted by using the software Autodesk Ecotect 2012. The available photographs and the drawings of the interiors and the sketches from the previous site visit helped gain extra inputs to the construction of the physical and computer model. The daylight measurement plane was set at 800mm form ground surface. Zones were formed according to the light typologies and were designated according to the function it carries. The zones demarcated is as follows,

Zone 1: The Hall, **Zone 2**: The library rooms on the south west, **Zone 3**: The Asiatic library office on south east, **Zone 4**: The Office areas on north.

The daylight studies were carried out by using Radiance a Radiocity based simulation plug-in for Ecotect which can provide more accurate simulation results. The daylight in the building is derived from three sources, Jhilmils, the windows on the walls, lantern light in the central Grand hall and skylights in the intermediate transition areas.

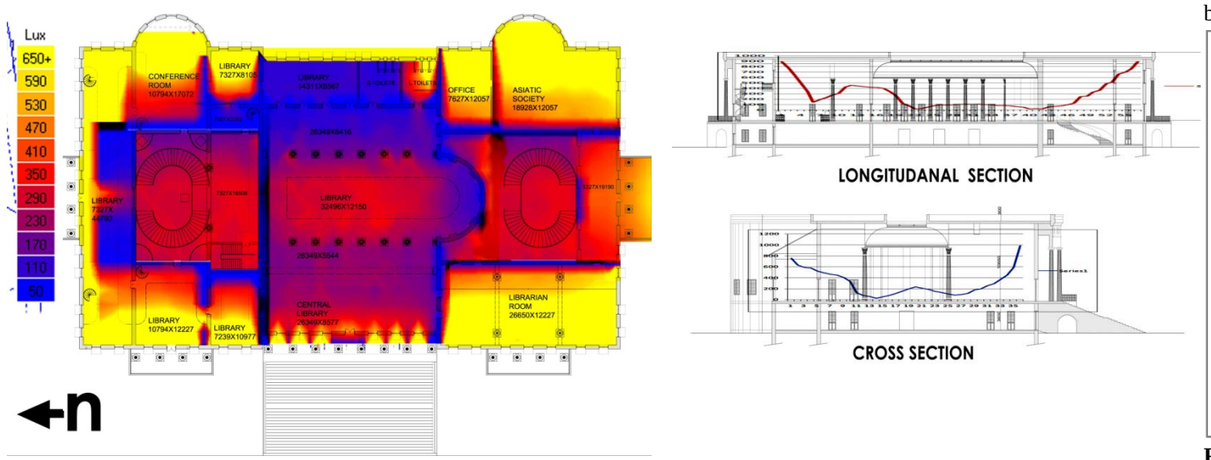


Figure 3(a) Isolux contour graph overlaid on the plan (Authors) (b) Sections showing the daylight factors over the sections (Authors).

READINGS AND SUMMARY OF DAYLIGHTING INSIDE THE BUILDING

The daylight distribution graphs suggest that the town hall was a designed as a daylit building and care was takes to see that all the areas receive daylight throughout the day. (Figure 3b)

Zone1-the hall is daylit by a lantern light at the roof level which provides sufficient daylight for the activities carried inside. It can be stated that the levels due to the elaborately designed skylight provides a lux level in the range of 100 to 120. Considering the area as public gathering hall, the lux levels can be said to be sufficient.

Zone-2 and Zone-4- the library rooms on south west are most likely to have solar ingress. The shading devices control the light levels and keep them in an acceptable range of 550lux. The area being designated to be used for reading purpose the daylight can be found adequate.

Zone-3and Zone-5 offices on East show a graph of lux levels which are in the range of 250-550lux. The use of the area is general office area and the light levels can be found to be adequate.

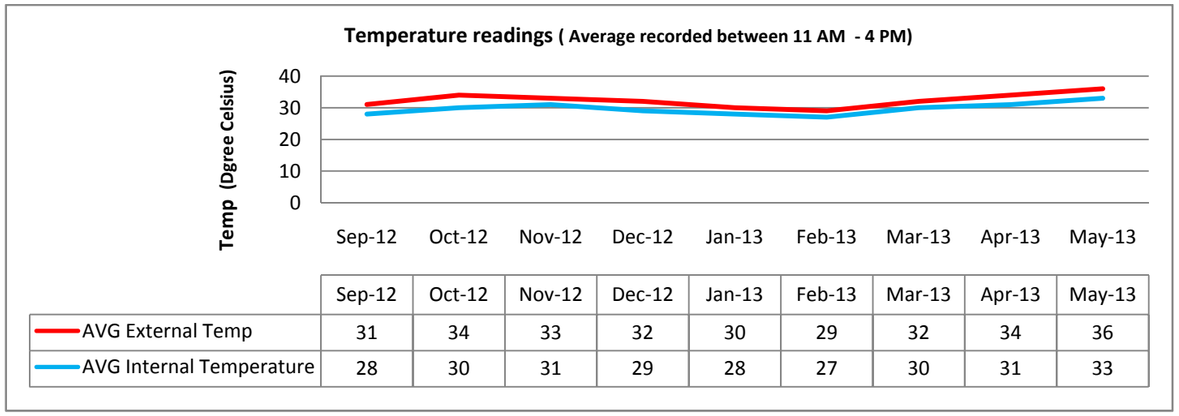
Zone 6, the intermediate and staircase areas are dominantly illuminated by the sky lights. They provide a lux level in range of 75lux to 120 lux. These areas are transition areas and the light levels can suffice the function.

The Window to wall ration (WWR) is less than 30% for all the facades which strategically controls the light and air movement. All the fenestrations have operable wooden louvered design further helping in controlled wind-flow and ventury effect for inducing cooling effect inside the building when required.

THERMAL BEHAVIOUR OF THE TOWN HALL

Thermal measurements were physically recorded on site to check the comfort factors of town hall. The temperatures inside and outside were verified at the intervals of 7days starting from Sept'12 to May-13. The set was averaged out to get an understanding of temperature variations inside the building. The temperatures were taken at a distance of 10feet outside the buildings on all sides. The internal temperatures were recorded at the grand hall, which falls in the centre of the building. The recorded temperatures show average of 3.5°C difference between external and internal temperature.

The major factor contributing to this temperature fall is raised platform directly facing westerly winds and colonnaded cooling like cross ventilation, shading devices, louvered windows, double facades on west and east sides, false ceilings and coffer ceilings on timber supported clay tile covered roofs seems to be still efficient through the noted temperature readings even though the building use has been totally changed. The wind movement has been induced merely by use of fans inside the building. But at the entrance porch, one can clearly feel the comfort provided by shade and the westerly winds. Also behind louvered windows the ventury effect is felt.



	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13
AVG External Temp	31	34	33	32	30	29	32	34	36
AVG Internal Temperature	28	30	31	29	28	27	30	31	33

Figure 4 Graphs indicating the temperature variations (Authors)

From above observations and readings it is to be noted that even the building use has been changed building still functions without active mechanical means of thermal comfort because of the passive design strategies thought at that time. Given a building is again used as public town hall, it can set a working and functional example for the passive building design.

CONCLUSION

The research can be concluded that the town hall building was not only designed in isolation but also the overall planning of the surroundings was considered. The building functions efficiently in terms light and ventilation without the use of any electrically operated active systems with its as designed functions. These techniques most likely used of compulsion are now a need of day. The methodology of analyzing the building used by the author can be helful for future studies on buildings which were designed in absence of electricity. The inferences and understandings for passive design concepts taken from such studies shall be incorporated in modern buildings for superior passive designs. These studies can help the contemporary building designers to strategiez the comprehensive energy saving techniques for modern buildings. This in turn would make noticeable change in perspective towards creating the energy efficient structures based on passive design strategies in energy guzzling metropolis like Mumbai. However the success of passive design strategies in building lies in the organized management and maintenance over a period of time.

ACKNOWLEDGMENTS

The authors would like to thank Ms. Padmashree Maharaj and Mr.Unmesh Chaphekar, Consultant at MTSU for their support and inputs during the working of this research.

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