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THE OTHER SIDE

Building occupants are either used or compelled to live in overheated indoors in buildings, particularly in urban environments in the tropics. It doesn't mean that they are acclimatized to overheated indoors. This scenario has become a normalcy in the current building design and operational practice. The failure of building design to control heat transfer from outside to inside and remove indoor heat generated by occupants and equipment in buildings to the outside is seen as a major reason for indoor overheating. This normalcy is problematic for the occupants in particular and to the environment at large. It is problematic because of its negative effect on the indoor comfort level on one hand and associated emissions due to wasteful (or rather extensive) use of energy for cooling on the other hand. Overheating elevates the indoor thermal environment particularly the standard effective air temperature higher than the preferred thermal comfort range. Similarly, the dramatic effect of daylighting that could be generated from architectural space is seen as least regarded and not taken into the indoors meaningfully in today's average building design and practice, thus largely depending on active systems. Lack of optimum balance in daylight, artificial or mixed mode visual environments demands more energy either to maintain indoor visibility or to combat glare and heat stress associated with tropical daylighting, or both. This overall practice uses extensive amounts of active energy to maintain indoor comfort (both thermal and visual) contributing to emissions and weakening the demand side efficiency of operational stage.

Exploitation in design practice

Surprisingly, investors, occupants and decision makers do not see this as a critical problem but consider as a normalcy. It is a missed opportunity and the nucleus of the larger problem in the emission scenario associated with buildings in the context of climate emergencies, on top of many other specific issues related to building occupancy such as indoor thermal and visual discomfort. Unfortunately, it is neither visible nor sensible to the stakeholders in general. The easiest and direct response to address this unfavorable normalcy is seen by making overheated indoors actively conditioned for cooling and integrated with artificial lighting, despite potential for defensive interventions to minimize overheating or optimizing strategies for daylighting without or with minimum heat gain using architectural design.

Unfortunately, contribution from the architectural design is least explored in many of our buildings. It is due to lack of expertise in climate responsive design or exploitation of resources leading to an energy intensive outcome based process involved in the production of architectural space. Such practices separate the indoor environment, physically and environmentally, from its immediate surrounding or climate leaving the occupants passive in day to day operations and away from unconscious psychological stimulation or satisfaction with the changing moods of the nature around us and thereby leading to less productive at the end of the day. Heat stress from the surrounding climate on physical properties of the design and lack of interventions in the architectural design to avoid this problem, together with methods of removing internal heat loads, are main reasons for this indoor overheating scenario. In overall, we have a complex building population that largely depends on active systems contributing to emissions.

This is an exclusivity that disregards the presence of the climate which is just outside the facades of a building. Climate is a catalyst, thus essentially be taken into consideration with the architectural space, innovatively and defensively against negative elements like heat stress. This exclusivity in the "building – climate" interplay that is visible in the current practice in Colombo for example needs to be structured and revisited to make the interaction more benign to occupants and environment.

A Moratuwa research, funded by National Research Council Sri Lanka, on developing a generic model for low energy buildings in tropics demonstrates, that measure demand side energy efficiency. Despite set point temperature being fixed at 24° C degrees in air conditioned mode of buildings with EUIs lower than average level (250 KWh/m2/a), conditioned indoor air temperature was seen diverse in different zones in respect to the distance from facades, moving well above set point temperature and in most cases reaching a range of 29-34° C degree as well (Figure 2). Then there is a concern about expected thermal and visual comfort levels as well. Since most of the buildings are designed as compact sealed volumes and each floor is stacked one over the other, there is a great potential to become the indoor overheated and reaching its air temperature close to 40°C

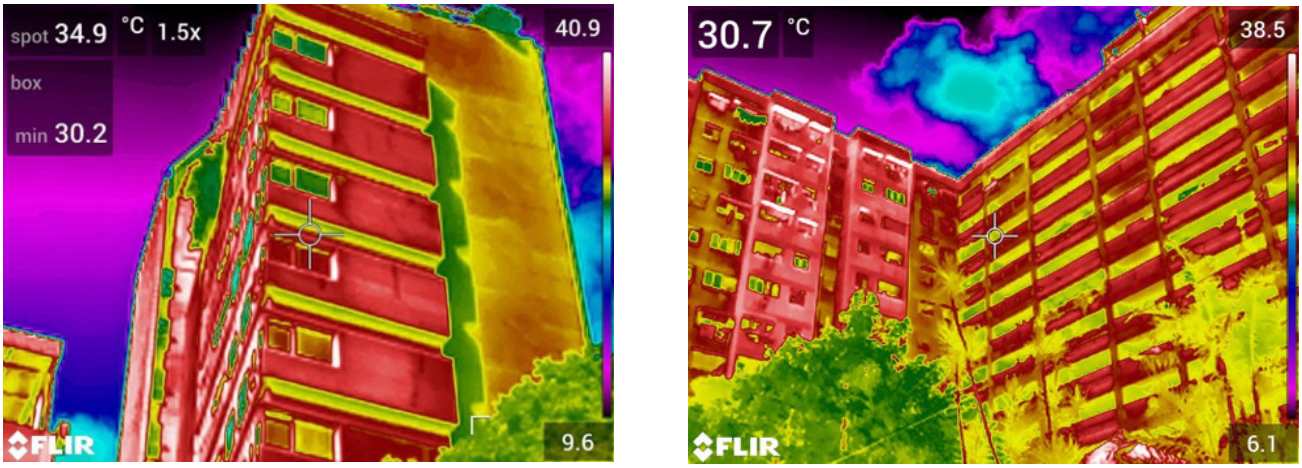

Figure 1: Infra red thermal images of two large complex buildings in Colombo shows heat stress on facades and a need for defensive design interventions

average Energy Utility Index (EUI) of office buildings in Colombo remains around 250 KWh/m2/a. This is extensive given a large number of opportunities for design interventions for low energy operation. Infra-red thermal images taken on the building surfaces depicts one aspect of the critical situation with surface temperatures reaching extensively high as 39-40°C degrees. Sealed compact building forms, unshaded building facades, in appropriate and greater exposure of facades and building sections to solar access, lack of interventions in the building section to remove indoor heat are some of the areas that contribute to overheating (Figure 1)

A more detailed diagnostic study on thermal performance of 86 office buildings in Colombo city reveals that EUI cannot be used as an indicator to degrees during non-air conditioned mode. This was evident during the diagnostic study in weekends.

Evidence suggests that a new design culture is in need. Attitude change in the expectations of architects, engineers, investors and occupants on what they finally have in reference to indoor air and day-lighting levels would benefit. They should be able to decide on the kind of architectural space and its indoor thermal –visual environment as a result of "building + climate interplay". An architectural space modified with indoor air temperature lower than the ambient is more conducive when bringing it further lower towards the comfort zone using active systems than a space with an elevated indoor air above ambient levels during the day time.

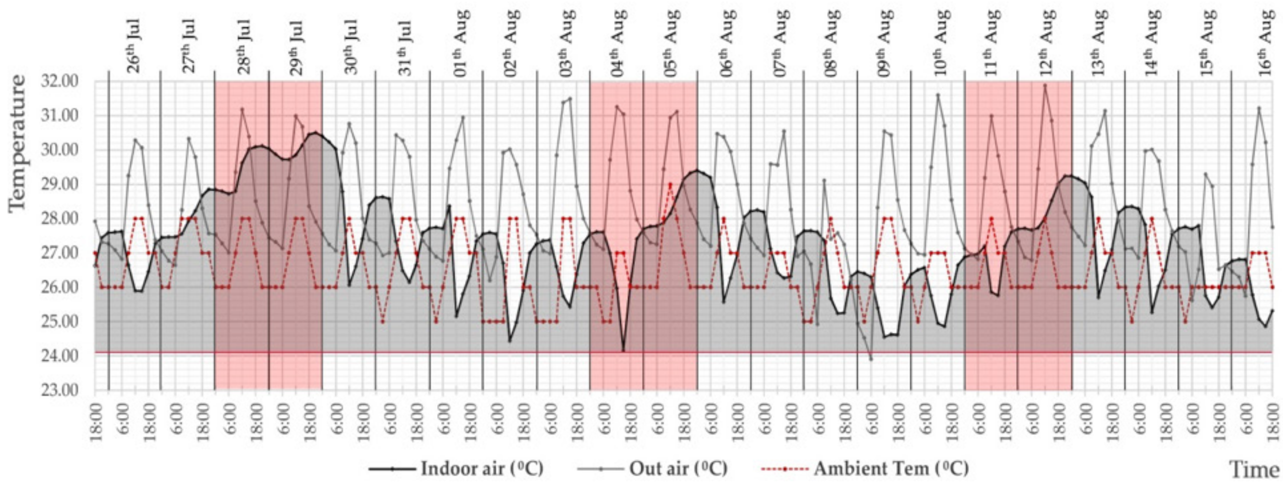

Figure 2: Indoor air temperature in most of multi-level office buildings in Colombo moves well above set point temperatures at 24°C degrees

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THE OTHER SIDE to the exploitation in the design practice is promising but challenging. It is promising because of the flexibility and robustness in the architectural design that can offer ways and means of addressing negative effects of climate while accepting favorable effects of climate. This is the meaningful way of climate response design which is inclusive in "building-climate interplay". This inclusive mode of design practice employs design interventions at four main areas in the process of making architectural space namely the microclimate, plan form, sectional form and building envelope.

Following are few of many opportunities in the design process:

- Microclimate enhancement with shading on the facades and air flow openings by manipulat ing the three dimensional form of the building geometry along with solar access and wind flow
- Crafting plan form and sectional form of the building to optimize shading on the facades, min imizing heat stress from outside to inside through an appropriate dialog in the building-cli mate interplay, optimizing daylighting without heat gain, mixed mode interventions in respect to zoning with regard to orientation to solar access, airflow and the program needs, enhanc ing thermal stratification and removal of indoor heat wherever possible
- Optimizing the sectional form for night ventilation and take the advantage of night cooling to inside on the following day
- Integrating heat sink effect of thermal mass in the building envelope with the effects of night ventilation using building section and plan form innovatively
- Articulating façade architecture involving the plan form, sectional form and placing the open ings for night air receipt and removal to work as one integrated system in the climate re sponse.

Conventional wisdom suggests that use of thermal mass with night ventilation in the building section and envelope is effective in regulating indoor air to the comfort zone in hot arid regions. However, recent works (both research and practice) in Sri Lanka highlights reasonably large diurnal ranges in the climate and heat sink effect of thermal mass with night ventilation is capable enough in bringing the indoor air to the comfort zone during the daytime (Figure 3 and 4).

Figure 3: Use of different types of thermal mass, earth bricks, rammed earth and concrete in buildings

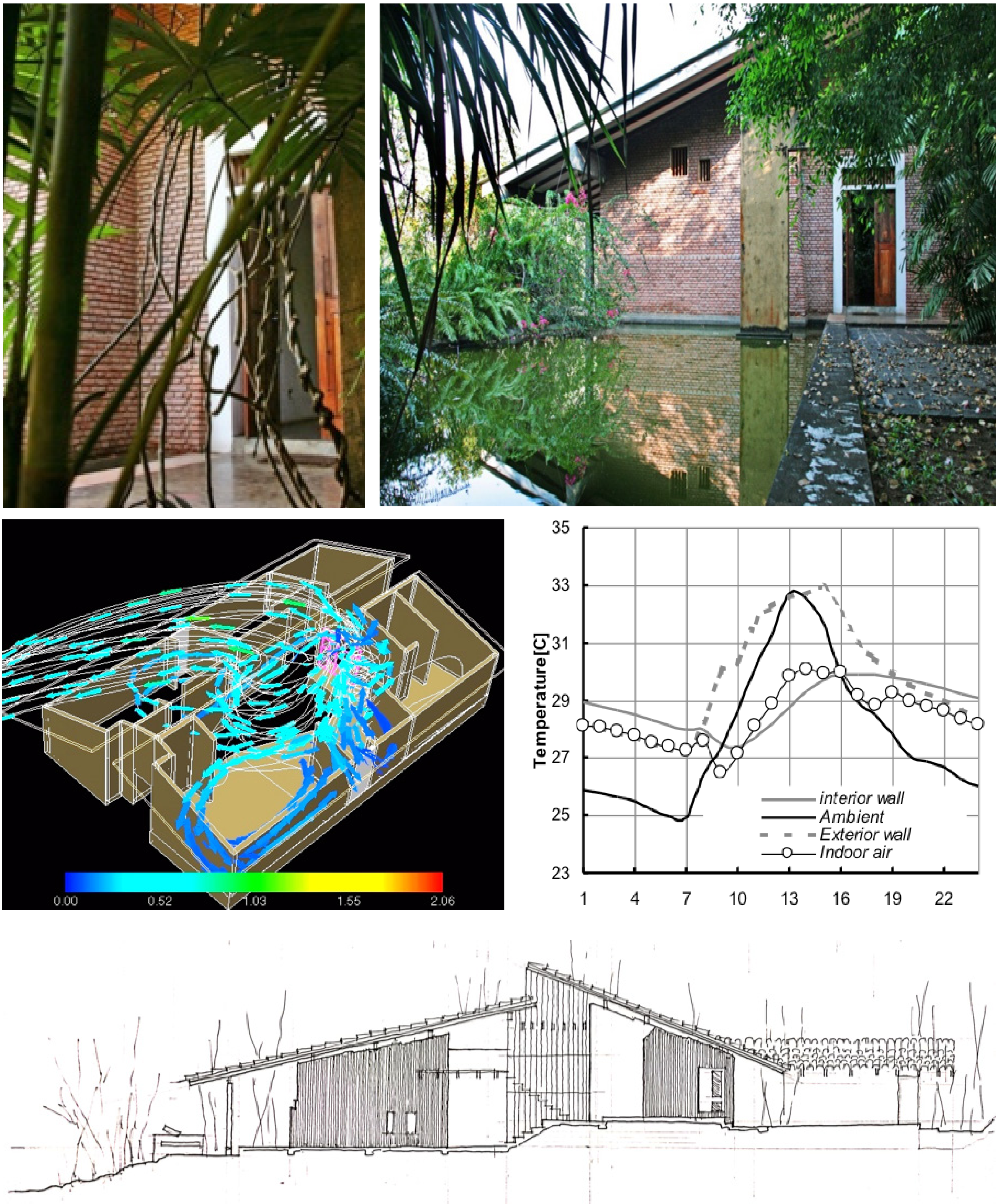

Figure 4: a courtyard house designed for night ventilation with thermal mass works as an air funnel and allows cooling during the daytime

Architecture at net-Zero

On-going research and practice provide some evidence for architecture at net-Zero. This idea is based on maintaining standard effective air temperature to move somewhere below the ambient as a result of thermal mass and night ventilation with the design, needing relatively less energy input from the grid or renewable energy resources to further bring down the levels to comfort zone. In the case of moving indoor air within comfort zone in the morning or in some spaces, an effect attributed to passive influence of the design, a mixed mode strategy consisting of both passive active modes could be effective, leading to demand side efficiency.

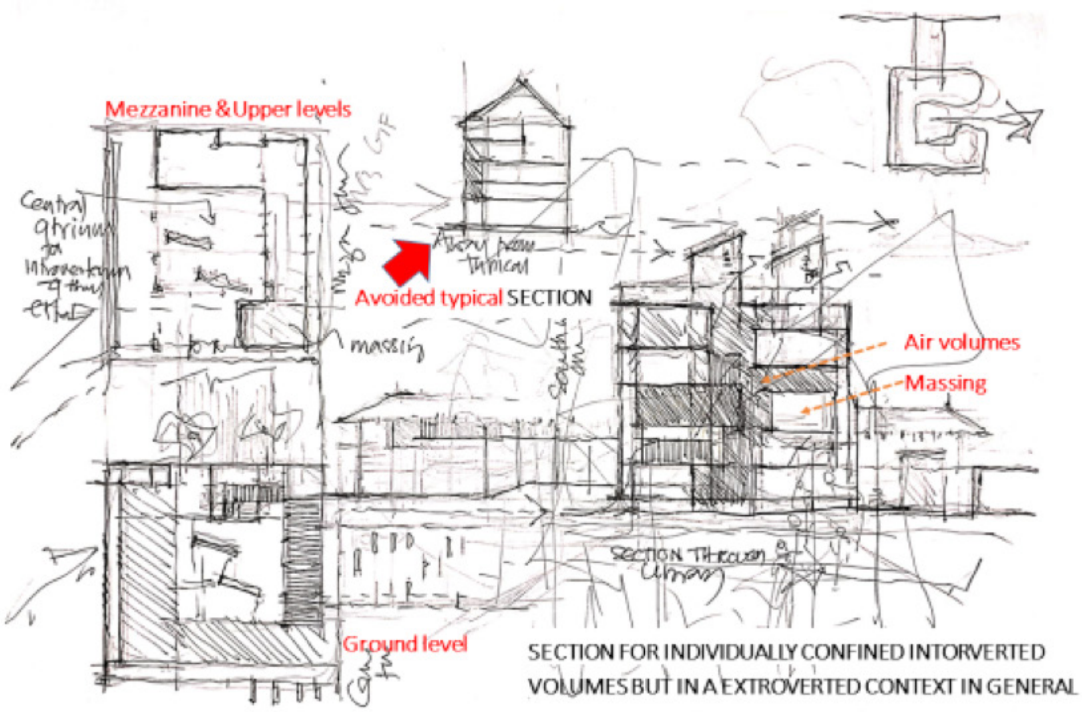

Figure 5: Design process, three D form and sectional geometry towards architecture at net-Zero

A building program to facilitate teaching Theravada Buddhism in North Western Province in Sri Lanka offers an opportunity to explore architectural space as a medium for supporting mindfulness of the users. The main library space is evoked from an idea based on a courtyard form to accommodate spaces for study, referencing and learning in an introverted ambience enriched with serenity, in a context of diverse moods of sun and air flow. The design process (Figure 5) explores development of the spatial arrangement on a vertical profile to encode spirit of place with light and shade. The central atrium forms a staggered vertical dialog, thermally and visually, across few multi levels. Heat stress on the whole space and volume is minimized to a greater extent with interventions by reflected daylight through shaded voids, optimum shading on the facades, limiting air flow inlets to shaded zones at the lower level of the sectional profile on the wind word direction and air flow outlets to the higher zones in the building section on leeward orientation. The whole building section facilitates nocturnal ventilation with thermal mass in the envelope. Rammed earth in the two thermal shafts in the atrium works well as a heat sink, absorbing heat from the indoors for cooling in the daytime. Double skin wall to the west façade protects the internal thermal wall of rammed earth and compressed bricks from heat stress while its cavity and openings provides nocturnal ventilation in the night. This effort presents a new air funnel typology for architectural space for cooling, daylight efficiency and minimum use of renewable energy for achieving net-Zero status.

Conclusion

Sri Lankan architectural landscape needs new design and building culture that cares people and the environment at large, in the context of climate emergencies. Concerns with regard to emission reduction targets for buildings can be effective in the intellectual process of design. It is the responsibility of the architects to think differently and encourage the public and the investors on the benefits of architecture at net-Zero, THE OTHER SIDE than what we see today unfortunately.

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