Innovative passive solutions: Designing for 2050
Report Workshop CLIMA 2022

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Report on the CLIMA Workshop on the 23rd May 2022 in Rotterdam on:

Innovative Passive Solutions: Designing for 2050

Chaired by Sue Roaf and Peter van den Engel

1. Introduction

This interactive, 90-minute workshop was proposed to encourage designers to take stock of innovative ventilation solutions being built today and then consider what might be effective design solutions for buildings in 28 years' time, in 2050. The aim was to explore how shared learning might influence how we think about designing resilient buildings today for a different future.

Attendees were handed a two sided questionnaire at the start of the session on one side of which were questions to be answered at the start of the workshop and on the reverse, questions for the end of the workshop to try and understand how much thinking had changed over the 90 minutes.

Peter then gave his talk on Innovative Passive Solutions and the attendees got into groups and discussed how they would answer the first set of questions. The agreed answers were put up on sticky notes on the wall under the titles: Resilient building features; 2050 technologies and Human factors. Sue then gave her talk on Designing for 2050. She used the case study of the Oxford Ecohouse she built 28 years ago as an example of a building that would still perform well in the much hotter climate predicted for 2050. 28 years in the future. After her talk, and during the round-up discussions people were asked to note down any changes in thinking under those three titles to try and get a feel for how much the workshop has affected their ideas on these issues. Peter then collected the questionnaires and sticky notes and recorded the results that are presented below.

2. Results

2.1 Results after Peter van den Engel's presentation about innovative passive solutions on the Questionaires:

A1) What are the 2 or 3 most important features of resilient buildings for 2050?

- Mass of floor, wall and roof (4 x)
- (Climate) adaptive (3 x)
- Insulation, high thermal performance envelope (2 x)
- Robustness and robustness of components (2 x)
- Understandable (2 x)
- Low glass percentage (2 x)
- Ways of keeping the heat out: solar radiation (2 x)
- Simple systems (1 x)
- Shading (1 x)
- Greenery (1 x)
- Low solar transmission (1 x)
- Beneficial to its surroundings (1 x)
- Energy producing (1 x)
- Maximal usage of building physics
- Be prepared for future climate (1 x)
- Include operable systems (windows, etc.) (1 x)

- Provide comfort conditions (1 x)
- Less energy consumption (1 x)
- Facilitating user control (1 x)
- Suitable for sufficient ventilation (enough space) (1 x)
- Optimized low window to wall ratio (1 x)
- Green roofs (1 x)
- Low/no carbon emission materials (1 x)
- Light/white facades (1 x)
- Integrally designed (comfort, health, energy-efficient) (1 x)

A2) What are the 2 or 3 most important technologies for 2050 buildings?

- Local battery for energy from sun or wind (4 x)
- Smart control, optimization of comfort and energy (3 x)
- Exterior and interior sensors and software that produces info (2 x)
- Storage of heat (2 x)
- Usage of artificial intelligence (1 x)
- Isolation (1 x)
- Optimization (1 x)
- Robust BMS (1 x)
- Storage of gas (1 x)
- Heat pump (1 x)
- Controlled ventilation (1 x)
- PV (1 x)
- Façade and roof produce energy (1 x)
- Climate adaptive building wall and windows (thermal) (1 x)
- Solar energy usage (PV or heat collectors) (1 x)
- Heat storage (1 x)
- Sun-shading (1 x)
- Thermal mass (1 x)
- Summer night ventilation (1 x)
- Availability of data (1 x)
- Predictive control of windows, heating, cooling, ventilation based on the future weather (1 x)
- Smart ventilation with high/good filtration (1 x)
- Ventilative cooling technologies (1 x)
- Glazing technologies (1 x)

A3) What are the 2 or 3 most important human factors for 2050 buildings? (behaviours, controls, management, etc.)

- Knowledge and consciousness (3 x)
- Having control over their environment (2 x)
- Intuitive control, automatically user will do the right thing (2)
- Acceptance of differences of indoor environmental conditions (1 x)
- Windows (1 x)
- Simple controls (1 x)
- User adaptation (1 x)
- Learning from the occupants about the building (1 x)

- Individual control (1 x)
- Feedback on energy use (1 x)
- Enable adaptable systems (1)
- Window opening control (1 x)

A4) Name a modern building that you think will perform well in 2050

- Co Creation Centre (2 x)
- Echo building (1 x)2.2

2.2 Results from sticky notes

A1) Resilient building features

- Thermal mass: floor, wall, roof
- Glass percentage
- Optimized window-wall ratio
- Adequate isolation of the envelope
- Low or positive energy balance
- Responsiveness of climate
- Natural air forces
- White facades
- When technology fails a still acceptable climate
- Integration and communication in the early design stage between architect, engineering, HVAC, etc.
- Local produced renewable energy
- Orientation
- Resistance against extreme weather events and shocks, like a heatwave and power outrages
- Flood protection
- Materials and CO_2: 50 % lower, low carbon/energy materials, circular construction
- Responsive to the requirements of grid (capacity, signals, etc.)
- Adequate window dimensions
- Effective solar shading both structural and movable
- Moving air by natural means
- Robustness
- Adaptiveness
- Keep it simple
- In a passive way balancing gains and losses
- Adaptation in case of malfunctions
- Flexibility in control strategies
- Maximum of building physical solutions
- Sufficient battery capacity and thermal storage
- Green roofs
- Operable windows for ventilation
- Usage of daylight
- Understandable

A2) 2050 technologies

- Smart active glazing, low emissivity glazing
- Robust design like shading
- Air-conditioning only for short events
- Deep radiative cooling
- User based technology with feedback
- BIPV
- Batteries for storage of energy of sun and wind
- Heat pump or something better
- Not too many control systems, simple working different systems
- Low exergy environmental heat sinks
- Indoor environment forecast
- Sensors for external and internal environment, software to process data
- Renewable energy generation systems
- Energy storage
- Predictive smart control
- Data (sensors, BMS, etc.)
- Thermal inertia, heat and cold accumulation
- Blockchain technology
- Symbiotic interfaces
- Knowledge: hvac/climate/energy/common people
- Acceptance of differences in IAQ
- Widespread knowledge of sustainable behaviour and buildings
- Buildings that have a heat sink, carbon sink and more natural ventilation
- Managing expectations
- Indoor environment forecast
- As much passive as possible
- Controlled ventilation, natural when possible
- The technology is user-feedback based. Asks and learns from the occupants
- Low energy for filtration
- Façade and roof produce energy

A3) Human factors

- Natural ventilation
- Instructions how to use it for every occupant
- Smart people who act, dumb buildings, occupants need to take control again
- Accept differences
- Occupant feedback
- Knowledge, adaptable, intuitive
- Adaptive
- Intuitive
- Knowing what occupants prefer (differences)
- Awareness and feedback of indoor air quality and energy
- Comfort, pure air. The control system knows what the occupant prefers and adjust to the occupant.
- Opening of windows and shading

- Providing simple feedback to humans so he/she can adapt
- Be aware of adaptive comfort against conservative behaviour
- Make an operable system
- Personalised human indoor comfort
- Learning for the occupants and the building
- Able to accommodate all types of users
- Skills and experience in delivering low/net zero energy/carbon buildings
- Behaviour of tenants, like the thermostat setting

2.3 Results after Sue Roaf's presentation about new thinking for 2050 design

A1) What are the 2 or 3 most important features of resilient buildings for 2050?

- Adaptility (1 x)
- Mass (3 x)
- Renewable energy storage (2 x)
- Passive and local design strategies (1 x) Readiness (1 x)
- Resilience (1 x)
- Back-up systems (1 x)
- Thick buildings with energy storage in the thermal mass (1 x)
- Thin layout (1 x)
- Pay attention to the environment (1 x)
- Thermal landscapes/buffers (1 x)
- Flexible, so you can move to and are ok with the appropriate spot (1 x)
- Building not in flood areas (1 x)
- Entry halls (1 x)
- Buffer spaces, especially for east/west orientation
- Orientation
- Should be designed by thinking about the future and environment (1 x)
- Ready for extreme temperatures (+ and -)
- Affordable. Everybody deserves a good living environment (1 x)
- Climate change, energy prices, thermal comfort: hope for the best and design for the worst (1 x)
- Extreme buildings: cut down of natural ventilation (1 x)
- Thermal comfort (person's adaptation to environment) (1 x)
- Climate adaptive (1 x)
- Dynamic system (maintaining safe temperature). Tolerable between 10 – 35 ^{o}C, depending on climate and culture (1 x)

A2) What are the 2 or 3 most important technologies for 2050 buildings?

- Energy storage + conservation + charging/discharging (2 x) Shading (1 x)
- Natural ventilation (1 x)
- Passive cooling strategies (1x)
- Low tech (1 x)
- Understandable/repairable by occupants (1 x)
- Process not a product (1 x)
- Backup (no power) (1 x)
- PV
- Use wind and solar energy to reduce the energy demand (1 x)

- Insulation (1 x)
- Provide comfort conditions by consuming less energy (1 x)
- Think in changing conditions: yearly, daily, hourly (1 x)
- Design for a different type of climate (1 x)
- Caretaker / Concierge (1 x)
- Flexibility (1 x)
- Thermal landscaping (1 x)
- Adaptive opportunities (reduce heating, cooling, discomfort) (1 x)
- Air locks for building design (1 x)
- Ventilation design Dutch adaptive house (Noortje Alders PhD) (1 x)
- Oxford Ecohouse (Sue Roaf) (1 x)
- Air condition, only when it is too hot (1 x)
- Architectural design should be climate adaptive (1 x)
- Maybe less technology (1 x)
- Utilization and solar gains mitigation (external shading) (1 x)
- North cool zone versus hot summer zone (1 x)
- Heat sinks (1 x)
- Renewable energy generators (1 x)

A3) What are the 2 or 3 most important human factors for 2050 buildings? (behaviours, controls, management, etc.)

- Willingness of people to adapt (3 x)
- Consciousness, awareness (2 x)
- Behaviour (1 x)
- Management (1 x)
- Change places during the season (1 x)
- Prepare for extremes (1 x)
- Accept temperatures (1 x)
- Safety (1 x)
- Personal controls (1 x)
- People will try to restore their thermal comfort, and should be made aware of how to improve their thermal comfort themselves (1 x)

3. Summary, discussion and conclusions

This workshop was meant to involve the participants as much as possible and it was very interesting to see the wide range of different answers that were given during this short workshop. It showed that there are already a wealth of ideas in circulation on the subject before the two lectures and also that a slight shift in emphasis emerged after them on the best ways forward when designing for 2050. It was also inspiring to see new avenues for research emerging and appreciate the many common sense points raised on the fundamentally important issue of resilient design, giving some hope that people are already beginning to think realistically about new directions for design in a much hotter future. We particularly like the recommendation for more Block Chain!

3.1 Better role model buildings for the future:

The Chairs thought it a little strange that the Co Creation Centre and the Echo-building at the TU-Delft campus were considered as most optimal buildings for the future, although both buildings were designed with the intention of being so. The Echo-building has overhangs all around that reduces the cooling demand. Green creepers will reduce the solar load a well. It has no “perfect” outside sunshade like the Co Creation Centre. The Echo building has the intention to become a *Plus Energy Buildings* due to a sufficient amount or the future option of PV-panels. The Co Creation Centre has the option to become a *Plus Energy Building* as well with more PV on the roof. However, this is only one of the many criteria to assess a building on resilience. The large amount of glass of both buildings leads to an unnecessary high heating demand and cooling load and increases the glare-risk. On top of that, in the Co Creation Centre the dark interior makes the building less efficient related to lighting energy. This makes these kind of design features less economic.

Perhaps two better measures of the thermal resilience of a building were flagged by Sue in her talk. The first is the amplitude of the indoor temperatures over a day, week or month when no mechanical conditioning systems are on, influenced strongly by how much glazing there is to connect the indoor conditions to the outdoor climate. The second might be the rate at which the temperature indoors loses or gains heat over time when there are no mechanical systems in play. This latter one was a measure developed largely in the USA during the Texas Ice Storm in February 2021 when a critical issue was how long indoor thermal conditions remained safely warm indoors when the power grid failed. Similarly, in July 2021 in the N.W. USA and BC, Canada what became a critical factor was how long homes stayed cool enough to occupy, even when there was power. Some 1700+ people died in that one event largely in poorer districts where household could not afford the electricity to run air-conditioning systems, or even fans. If indoor temperatures degrade slowly enough to keep people safe over a week, or ten days, they were largely able to survive the short term heat wave and cold events they faced.

This must lead to us urgently questioning the cost effectiveness of the glass walls and deep plans of the buildings. The Co Creation Centre was actually even designed from Day 1. to enable researchers to investigate what the effects are produced in terms of energy demand and thermal comfort in an extremely transparent building. It was not designed as the most optimal passive design solution. However, the Oxford house of Sue Roaf was also mentioned as a good example for the future. This house has a much more passive starting point.

		
Co Creation Centre, East and South façade (Green Village, TUD, 2021)	Echo building, West façade (multi-purpose educational building TUD, 2022)	Oxford house, South façade (Sue Roaf, 1995)
The three buildings that are mentioned during the workshop		

Interestingly, and this was not anticipated before the workshop, thermal mass figured largely in the answers given before and after the lecture as did need for passive adaptive features on buildings, and an emphasis on natural ventilation. There was an early mention of robust BMS systems early on but then the properties of the building itself became the most important in terms of designing for resilience. In terms of the technologies the use of solar systems with batteries was a leading solution and fared well in the discussions after the talks. This discussion shows that more fine-tuning of assessment methods of resilient buildings is necessary.

3.2 Energy, materials and air quality

This item was not discussed by the presenters and during the workshop, but in practice the choice of materials and the effect on energy and environment during the production process and on indoor air quality is also relevant. Lightweight constructions like wood will have effect on the thermal mass and energy storage of the building and the kind of diurnal swing of the indoor temperature. The total environmental footprint should be considered. Materials have also effect on air quality. This could be a focus for another workshop.

3.3 Education

Several times the need for occupant training and education, and student curriculum improvements to ensure that all involved can facilitate the effective interactions between buildings and occupants to restore comfort indoors when needed. The need for 'adaptive buildings' to be matched with well trained 'adapting occupants' emerged as a key theme for building 2050 ready solutions. Putting control of the building back in the hands of the occupants through being able to control passive features like shades and blinds and active features for personal comfort systems and the optimization of building conditioning systems was seen as key. So too was being able to move around to find the most comfortable places to be in the indoor thermal landscapes of the building, not least during extreme weather events.

Finally

We would like to thank all those who attended and so actively contributed to the workshop.

We hope it made them think anew about designing buildings that will be Fit for Purpose in 2050

In only 28 years-time.