

How does a well-insulated building, during a UK heat wave, perform in comparison to its predicted performance?

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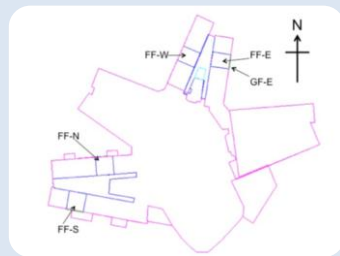
Overview

Current data shows that the UK is experiencing more extreme weather events, which are thought to be as a consequence of climate change. This affects the performance of our buildings. Recent low energy building design has emphasised the importance of high thermal mass and high levels of insulation in order to reduce heat loss in the winter and impede heat transmission into the spaces of the building during summer. To save energy many larger public and education buildings are now being designed without mechanical ventilation. Instead natural ventilation strategies are in place to maintain a comfortable and healthy environment and are designed and tested against warmer weather files, but not extreme weather conditions or temperatures, such as heat waves. For this reason there may be a safety and welfare risk to the building's users if such events occurred.

The balance of energy use against the comfort within buildings becomes more important when user's health and well-being is at risk, not just their comfort.

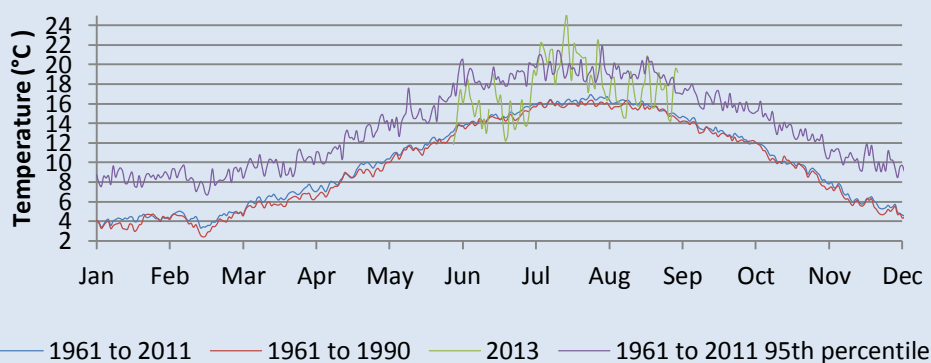
How we did it

- The building studied is a newly constructed, naturally ventilated secondary school in the UK.
- A combination of data analysis and computer simulation.
- Dynamic thermal simulation software was used with a Design Summer Year and morphed data based on data collected from site.
- Measured data and simulation results were compared to validate the model.
- Effects of future, higher temperatures were then explored.



We defined a UK heat wave as "A period of 5 consecutive days, when the daily mean temperatures are above the 95th percentile of the whole year's temperature distribution when compared to the baseline temperatures of the previous 30 years".

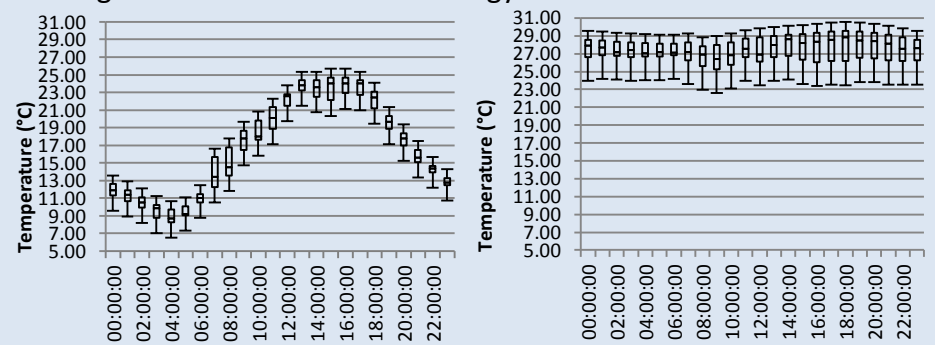
With this applied to the data from the building considered here, a heat wave was identified between 08/07/2013 and 02/08/2013 as can be seen from figure 1 where the 2013 daily average temperatures exceed the 95th percentile of the 1961 to 2011 baseline.



Results

We found that:

- The heat wave stopped the thermal mass acting passively;
- The use of insulation can prevent a building from losing heat, but in hot weather this can increase the risk of overheating; and
- The ability to cool was inhibited due to persistent high temperatures fully loading the structure with heat energy.



Heat Wave Diurnal Curve

Fully Loaded Diurnal Curve

Prior to the heat wave all rooms displayed standard summer diurnal curves, but after a single week into the heat wave this curve mirrors the external temperature because the mass and insulation is now having no effect.

During the heat wave the average daily temperatures ranged from 23°C to 30.2°C which is a 7.2°C difference between two internal spaces, 2.2°C greater than the allowable 5°C internal to external average temperature difference stated in BB101.

Up to three weeks after the heat wave all the rooms displayed weekly diurnal curves with $\pm 0.5^\circ\text{C}$ variation. This flat profile continued as the building recovered from the heat wave before returning to its regular temperature profile.

Impacts

Naturally ventilated, highly insulated buildings risk overheating or require hybrid/mechanical ventilation to manage hotter periods of the year and can only have their desired effect (increasing time lag and lessening the extremes of temperature) if the correct nighttime purge/ventilation strategy is employed. In order for these buildings to recover from a UK heat wave, up to 3 weeks of lower-than-average, average and normal temperatures are required.

The difference between internal spaces in temperature extremes, normal building performance and future climates has the potential to be developed into a new standard to which building types where occupants move around often are designed, critiqued and analysed.

In order to future proof the designs of naturally ventilated, highly insulated and thermally massive buildings to sufficiently perform, there needs to be high level analysis regarding insulation levels so that the construction does not put the building at risk of overheating in hotter periods of the summer. A reduction in insulation may increase the winter heating costs but could be outweighed by the reduced summer cooling demand.