Energy efficiency and comfort

Two experienced building services engineers explain the principles behind achieving comfort in auditoria and ways of reducing the energy used in theatre buildings, whilst a third introduces the concept of computational fluid dynamics which were employed in the ventilation of the London Coliseum.

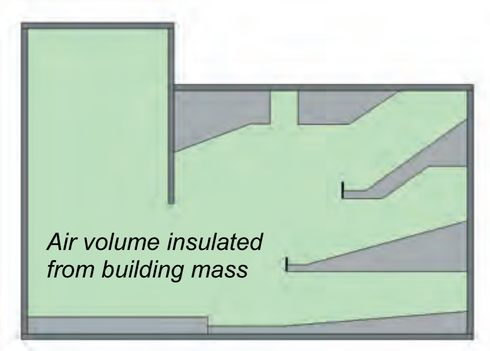
If we apply that to buildings and look at our model theatre again, it is probably cold after being left empty overnight and before the start of activities during the day. But in typical theatres architects are very keen on lightweight finishes – lots of drapes, lots of applied finishes to decorate the auditorium – and this tends to isolate the thermal mass of the building from the air inside the space. Therefore when you apply your heat sources, the air in the space heats up and, in the absence of any other effects, it just keeps heating up. And it heats up very quickly, because the capacity of air to hold energy without the temperature rising is very small. So with a very small amount of energy put into an air space the temperature rises very rapidly.

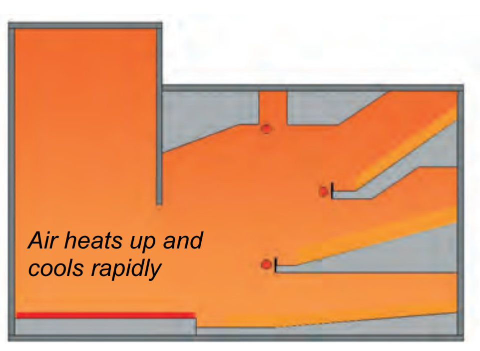
If we now consider the response to an applied heat load – and in a theatre we look specifically at intermittent loads because the duration of a performance is relatively short compared to a 24-hour period – the space-temperature responds very rapidly to these loads in a typical lightweight theatre auditorium. It responds equally rapidly at the end of the performance when the audience leaves, the lights are all turned off, and the temperature drops away again. This is shown in the top set of diagrams below.

If we take our cold auditorium but we eliminate all of these lightweight finishes and connect the air volume, that is the mass of the air space, to the mass of the building structure itself, we' proposition when it sources into the sp energy into the spac we also have to hea building itself and, s structure of the bui enormous compare more energy can be the same unit Conversely, for the same energy input the unit temperature rise is much smaller. That's the principle of thermal mass cooling.

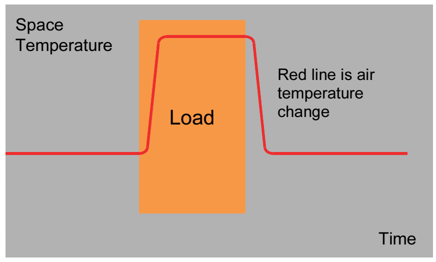
We are able to use thermal mass cooling based on this slow response. The building as a heating–cooling system, as indicated by the green line in the lower set of diagrams, responds much, much less quickly than does the air inside the volume. We find very often in an intermittent occupancy like a theatre that the building doesn't heat up to a great extent before the audience leaves again, the lights are turned off and it starts to cool down. So we can use that effect to, again, displace the cooling load.

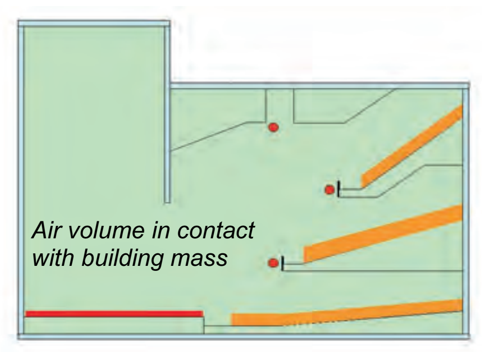
Now this is something that theatre managers actually understand empirically, but they don't recognise exactly what's going on. If you plot the typical profile of the load in a theatre space over 24 hours, you might start with some casual occupancy around about

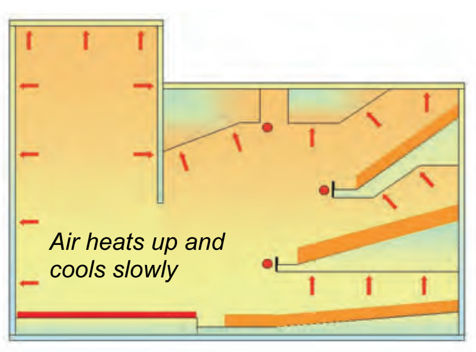




Top: auditorium with lightweight finishes.







Bottom: auditorium with air in contact with building mass.