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Consulting Engineers & Landscape Architects

RESEARCH & DEVELOPMENT

Double Skin Technology

Buildings are typically responsible for circa 50% of a nation's energy requirements and 30%-40% of the carbon dioxide production. This energy is used in an attempt to provide an internal environment that will be comfortable for all occupants. Recent studies have indicated that these heavily and uniformly conditioned environments do not present high levels of comfort. "Sick Building Syndrome" is often encountered whereby productivity is reduced to 80%.

Double skin facades, with their ability to harvest or protect from the external environment according to the season, are able to address both issues. Occupant control is restored, natural ventilation is possible, high levels of natural daylighting can be achieved, good thermal closure is possible and consequently energy savings are delivered.

Above: GSW Headquarters, Berlin, Germany
Top: SIDC Headquarters, Kuala Lumpur, Malaysia

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ENVIRONMENTAL CONTROL

The facade governs the interaction between the building's internal environment and the external climatic forces.

The environmental second skin facade is able to delivery high levels of occupant comfort in an energy efficient fashion due to its ability to respond to the changes in the external environment provides occupant comfort.

Comfort is a complex balance of four key criteria:

- Light - visual environment
- Heat - thermal environment
- Noise - acoustic environment
- Smell - air quality

The sense of comfort is linked to the seasons and level of expectation, whereby people expect it to be cold in winter and warm in the summer and therefore are willing to accept a range of comfort conditions throughout the year, rather than requiring a given constant condition to be maintained throughout the year.

The components (or devices) forming the double skin are:

- Outer glazing
- Inner glazing
- Intracavity devices (blinds, light shelves, etc.)
- Low level openable areas
- High level openable areas

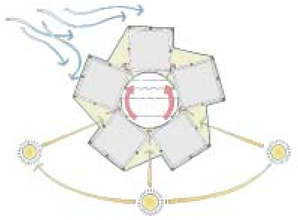
These components interact with the external environment and must be considered in terms of:

- Heat - radiation
- Heat - conduction
- Heat - convection
- Ventilation
- Light - illumination
- Light - glare
- Sound
- Air quality

OPERATING MODES

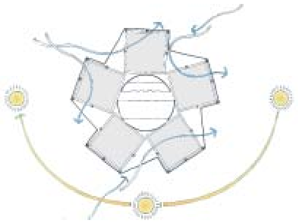
Winter Conditions

- During winters the external skin is closed, this deflects the cold winter winds away from the main body of the tower
- The buffer zone between the two skins acts as a thermal store, collecting heat from the direct solar radiation penetrating the external skin reducing space heating requirements as this store can pre-heat fresh air entering the occupied space
- A simple heat exchange module located within these buffer zones is then able to transport this heat to where it is needed, the north side of the tower



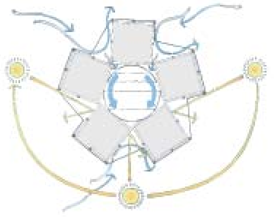
Mid-Season Conditions

- Both the external and second skins are opened to allow external air movement
- For the individual comfort of building occupants, windows are installed into second skin, opening into the buffer zone
- With both skins open, the buffer zone is kept cool by the threw flow of external air
- Without the buffer zones acting as thermal insulation a greater percentage of the thermal mass of the tower is exposed to the external elements, this prevents overheating
- Daytime air conditioning loads can be further reduced by using free night-time cooling



Summer Conditions

- With the inner office skin consisting of reflective glass, a vast amount of solar radiation is prevented from entering the office space, greatly reducing solar gains., instead becoming trapped in the second skin
- This trapped heat is then disposed off, being ejected to the outside environment
- Without direct sunlight the towers north side remains cool. Using the heat exchange modules this cooler air can be transported to the warmer, south side
- As with mid-season conditions night-time cooling can be utilised to keep the building cool as well as again the large thermal mass preventing overheating



CONCLUSION

A comprehensive survey of double skin buildings within the built environment was performed. Commonalities were sought, allowing buildings to be categorised according to the facade configuration and manner of operation. Five main categories (sealed inner skin, openable inner and outer skins, openable inner skin, sealed cavity, and acoustic barrier) were identified, each containing a large number of sub-groupings. This categorisation attempts to develop a common language with which to describe double skin configurations.

MODELLING DYNAMIC

Thermal modelling and CFD (computational fluid dynamics) tools were employed to explore the thermal behaviour of the various double skin configurations, at the seasonal extremes (peak load prediction) and also throughout the entire year (to observe the annual performance). Environmental services solutions necessary to deliver occupant comfort were addressed and results for different facade configurations were compared.

DAYLIGHT MODELLING

Numerical and physical daylight modelling was undertaken to quantify improvements in daylight availability and consequently, improved comfort and energy saving. The effects of blinds and other solar control devices, such as light shelves were explored.

COST ANALYSIS

This exercise, performed in collaboration with Franklin and Andrews Cost Consultants, investigated both the capital, operating and maintenance costs issues. Capital costs were compared for a conventional facade building and a building employing a double skin. An elemental rate for a high quality double skin facade was determined and was found to be circa 20% more expensive than a comparable conventional facade.

Above and Operational Mode Images: The Okhta Centre, Gazprom Tower (Photo-realistic Image: RMJM Architects)

Considering reductions in plant costs (due to improved environmental performance), the narrow plan double skin building was found to be 7.5% more expensive whilst the deep plan building was found to be 4% more expensive. The value engineering exercise reduced this difference to 5% and 2.5% for the narrow and deep plan respectively

ENERGY CONSUMPTION

Two building designs (narrow and deep plan) and seven facade configurations, including a high performance conventional facade baseline, were identified for detailed analysis. Elaborating further the modelling results presented above, energy utilisation indices, (kWh/m^2), energy cost indices (£/m^2) and carbon dioxide emission indices (kgC/m^2), differentiated by end use, were presented for the fourteen project engineered examples. It was found that the double skin building offer significant reductions in energy consumption, CO2 emissions and running costs when compared to the single skin benchmark.

Configurations employing the cavity to pre-heat fresh-air or extract exhaust air were found to give 30%-40% reductions in energy utilisation, whilst those adopting mixed mode or natural ventilation produced reductions of circa 50-65%.