# *Lightweight Structures in Europe, USA and Australia*

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## SYNOPSIS

There are many cultural, commercial and geographical influences that lead to differences in the architecture and engineering of lightweight structures internationally. This paper considers the response of designers in different countries to the issues raised by climate and environmental control, using a series of recent projects engineered by Ove Arup & Partners.

Northern Europe is cold for much of the year, has relatively little sunshine and has rainfall distributed across the seasons. A consequence has been the generous use in lightweight structures of clear and translucent cladding, given the attraction of natural light, and given that the risk of overheating in summer is less than for southern climates. Peter Rice took advantage of this opportunity with the suspended single glazed verrieres at the Science and Technology museum in Paris. Glass fixing technology received a major stimulus, and many subsequent projects benefited. His glass roofs at Chur, Lille and Roissy all provide a measure of environmental control against winter winds and rain. They have open end walls and side walls that are not fully sealed, so potential summer heat build–up is dispersed. His glass roof over the Richelieu Gallery at the Louvre on the other hand is fully sealed and uses slender white polymer rods as a reflective screen to reduce heat again and diffuse direct sun.

Many spaces in these cool climates achieve reasonable thermal control with single skin fabric enclosure, like the Schlumberger research laboratories at Cambridge, Ron Herron's imagination Studios, or the Amenity Building at IRS, Nottingham. Summer cooling is rarely a problem with adequate openable areas, and winter heating can be provided local to occupants by slab coils, radiant panels or low level air systems.

The USA has a range of climates, and corresponding architectural and engineering responses. Recent Arup–engineered projects in the colder northern states include the planned new Detroit air terminal complex with its cable–stayed vault roof. The vault shape works well with the proposed low–level large jet supply air system. Spent warm air reservoirs at the crown of the vault and is drawn back down ducts in the shallow roof structure space to discharge into the setdown roadway enclosure, providing that semi–enclosed space with improved thermal comfort and pressurised air to dissipate car exhaust.

Further around the Great Lakes, at Milwaukee, the new Brewer's Baseball Stadium will feature a fully retractable, segmental fan–shaped roof. Snow loading will be critical for roof segment design. The brief requires a quick response to sudden worsening of weather, such that temperatures at grandstand seating level need to be raised by a specified amount within a specified time of closure. Computational fluid dynamics studies are presently in hand, examining air movement in relation to the insulated roof system and the potential for detachment and cold downdrafts. An important factor will be limiting thermal inertia in the structure and fabric of the seating system, to maximise the thermal responsiveness of the whole space.

In the hot south–western USA, the new Phoenix Central Library was opened recently. The 11m tall top storey reading room is roofed with a prestressed cable truss system which is stiffened with a 200mm deep profile metal deck placed across the trusses. The space receives cool air from floor grilles, and hot air is returned from above occupant level. The metal deck is adequately insulated externally to limit radiant effects internally. The fully glazed south wall has a BMS controlled external louvre system and the north wall has vertical outstand fabric shades for low angle east and west sun protection. Internal exposed concrete, on the flanking shear walls and underfloor, allows use of night time cool air flushing which is particularly useful in the desert climate.

Crossing the Equator, and the Pacific, the new Kanak Cultural Centre is nearing completion in Noumea. The climate of New Caledonia features hot, humid periods with little wind at low levels. Renzo Piano's response was to design tall wind scoops, facing oneanother across the single–level gallery spaces below. The scoops magnify air pressure differentials available from the high level breezes, and so draw air down and through the galleries. While night–time flushing is valuable in hot climates where significant diurnal fluctuations exist, humid climates are better considered in terms of enhanced air movement.

In Sydney, construction has started on 20,000 $m^2$ of large–span exhibition space for the Royal Agricultural Society's new premises at Homebush Bay, also to be used for indoor Olympics events in 2000. The 110m span timber–gridshell dome will be cooled by a combination of low–level displacement–type air–conditioning using buried perimeter ducts, with a central cooled slab using embedded pipes and chilled water.

The adjacent , 67m span halls will be naturally vented. They have vaulted roofs with high level extract louvres and low level supply through side wall louvres. Fluid dynamics studies were carried out using various exhibition partition configurations to test comfort levels and to examine the effect of supply air enhancement using a system of underfloor tunnels.

Lightweight structures are usually more than large–scale pieces of outdoor sculpture of structural engineering interest. They are typically intended to have a climate–modifying function as well, and with increasing interest in energy efficiciency in building spaces, the environmental performance of lightweight structures in different climates will become a subject of increasing interest as well.

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| Phoenix Central Library | Architect: Bruder – DWL |
| Kanak Cultural Centre, Noumea | Architect: Renzo Piano Building Workshop |
| New Sydney Showground Exhibition Halls | Client: Olympic Coordination Authority<br>Architect: Ancher Mortlock Woolley |