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MIX

TIPS

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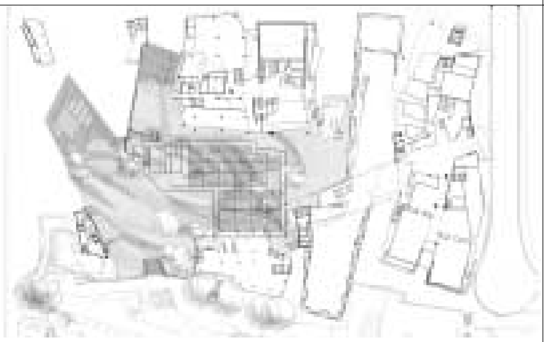
CEMENT & CONCRETE ASSOCIATION OF AUSTRALIA
Leading Knowledge-Sharing Information

THE LABYRINTH UNDER FEDERATION SQUARE

The Labyrinth at Federation Square is a 1,600 square metre maze of zigzag off-form surface-corrugated concrete walls. It is the major component of a unique passive cooling/heating system and provides environmental climate control for the square's vast glazed atrium. The north section of the atrium is effectively a glazed covered street. It provides a forecourt to the gallery through a large open interior volume which is 16 metres high and up to 20 metres across. The high projected costs of mechanically cooling/heating this space motivated the search for passive measures and resulted in this unusual design response.



Plan of Federation Square showing the relative size and location of the Labyrinth below.

At an approximate cost of $3 million, the Labyrinth is positioned beneath the civic plaza and above the railway deck utilising a space that would have otherwise not been occupiable. The maze of precast walls are of varying heights between 2.1-3.5 metres, and are spaced at approximately 600 mm centres. The walls of the Labyrinth incorporate a corrugated surface which results in an appreciable increase in the overall surface area of exposed concrete. This treatment provides the structure with a greater potential for the collection and storage of energy, or Fabric Energy Storage (FES), whilst simultaneously supporting the plaza deck slab and creating its final surface topography.

Utilising the specific climatic qualities of Melbourne, which has a relatively high diurnal temperature variation typical of a temperate climate, air is passed through the Labyrinth to be cooled or heated depending on the time of year. During the warmer months, cool air is pumped through the Labyrinth's cells at night, which in turn cools the concrete walls. By day, air is again pumped through the cells, this time being cooled by the concrete. In winter, the Labyrinth's high thermal mass maintains an inherent warming potential, which will be supplemented as required.

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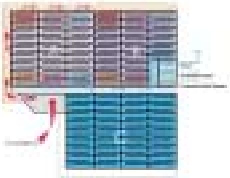
UMPTION



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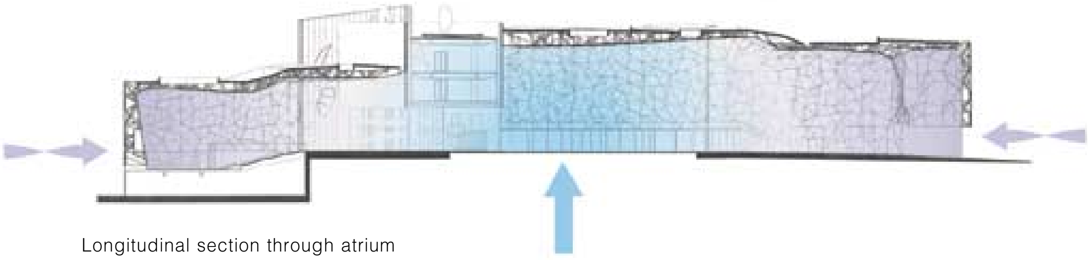
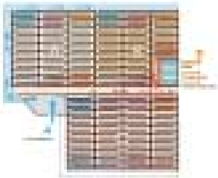


Longitudinal section through atrium



Hot air intake illustrated at top and cool air below. Note, the total air volume to atrium and arcade will be controlled by CO_2 sensors.

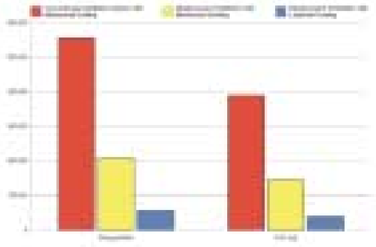
The system directs air to the atrium, which is introduced at floor level and dispersed by a low-velocity displacement system. In peak summer conditions, the Labyrinth is capable of delivering air to the atrium at up to 12°C below the external ambient temperature. This is equivalent to conventional air-conditioning but uses one-tenth of the energy consumption and generates less than one-tenth of the carbon dioxide emissions.

Dynamic modelling revealed additional secondary benefits of the Labyrinth, including its use as a pre-cooling system for the Australian Centre for the Moving Image (ACMI) when the system's full capacity is not required for the atrium. This supplementary capacity helps to significantly reduce the overall energy consumption on the site.

The Labyrinth is a sophisticated and innovative example of FES, which utilises the thermal mass and large inherent thermal lag properties of concrete to absorb and store energy.

Additional effectiveness is achieved through the incorporation of high surface area elements, such as the corrugated face of the precast concrete wall elements.

The concrete Labyrinth at Federation Square is a response to a major challenge to provide a passive means of heating and cooling to a vast atrium volume without relying on high-cost capital works during construction. The adoption of ESD principles will also provide the facility with affordable ongoing post-occupancy services and improved life cycle costings.



Graph showing comparative levels of energy (left) and CO_2 (right) use.

Note that red = conventional ventilation system with mechanical cooling; yellow = displacement ventilation with mechanical cooling; and blue = displacement ventilation with Labyrinth cooling

ARCHITECTS: Lab + Bates Smart
CLIENT: Federation Square Management
STRUCTURAL ENGINEER: Hyder Consulting
ENVIRONMENTAL ENGINEER: Atelier Ten
BUILDER: Multiplex
PHOTOGRAPHY/IMAGES: Lab architecture studio
ACKNOWLEDGEMENTS: Elly Bloom
LINKS: www.labarchitecture.com

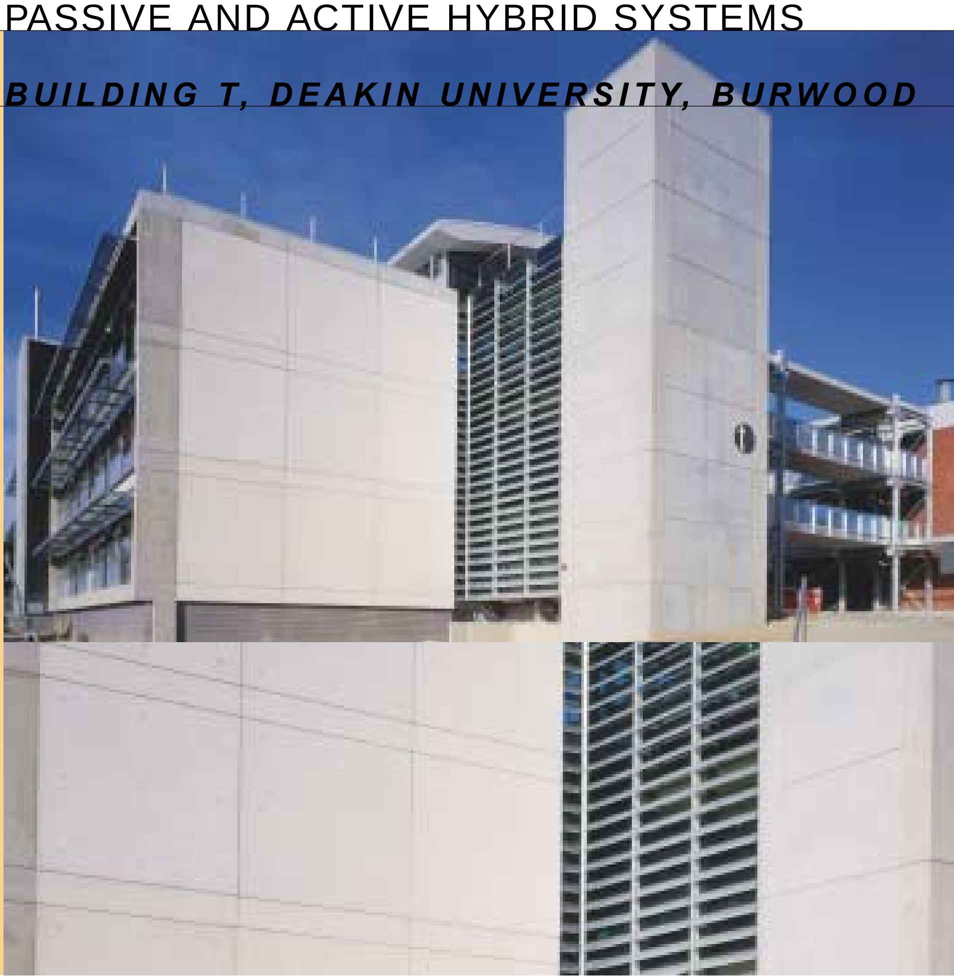
BUILDING T, DEAKIN UNIVERSITY, BURWOOD

Building T, by DesignInc Melbourne Architects, is designed to conform to the University of Deakin's ESD policy which promotes passive ventilation and maximum natural light. Where environmental control is critical to the function of a space—such as computer laboratories—mechanical air conditioning was permitted.

With an overall building budget of $5.8 million, and an average cost of $1,650/m², the operating temperature range of the building is achieved between 18°C and 28°C. The predicted total energy consumption is a low 360 MJ/m², around one-third of most university buildings. The adoption of optimum orientation for passive solar design can save up to 30% of energy operating levels on a typical building.

The design brief was for a three-storey building with flexible office and teaching spaces. The architect's response was to split the building into two wings, providing a central atrium with natural ventilation and day lighting. The high thermal mass of the concrete-framed structure (floor slabs, roof slab and shear walls) was selected to provide an optimum working environment.

Building T is orientated north-south for maximum solar and day-lighting performance, whilst the east and west ends have limited fenestrations, minimising heat loads. The north glazing is shaded, excluding direct sunlight to the interior during summer.



A

D

Externally, the building's overall composition highlights a consistent and well-explored concrete palette and comprises an as-delivered grey insitu concrete pier and beam structure with light coloured infill panels. The concrete plinth is black pigmented concrete with decorative horizontal banding. These elements are set against the lift shaft of grey concrete with expressed joints.

The east and west walls are constructed of *Thermomass* insulated precast concrete sandwich panels. These panels comprise a Styrofoam board core, which is set between two precast panels with an overall thickness of 250-mm. This provides an extremely efficient thermal mass with the equivalent inertia in solid concrete of around one metre in thickness. The thermal mass is exposed internally, promoting greater transfer of stored energy between the building mass and internal spaces, which assists in reducing internal temperature fluctuations. The panels were pigmented with a white mineral oxide resulting in an even, pale finish.

Hollowcore Flooring Systems

Deakin University worked with its design team to specify hollowcore flooring, *Termodeck®*, for the ventilation of the building. This is an adaptive mixed mode ventilation system, which uses the thermal mass provided by the concrete structure and plays a pivotal role in the passive ventilation and air temperature control. The flooring system, which has been applied extensively in Europe and Scandinavia, acts as a plenum using the holes in the hollow core concrete planks as ducts to circulate air.

Computer modelling was carried out by Professor Mark Luther from the University's School of Architecture & Building to determine the effects of the thermal mass and air flow requirements using 200-mm hollowcore planks with 150-mm diameter holes. Air is delivered into the slabs via low-velocity fan coil units to minimum BCA ventilation requirements of one to two air changes per hour. Depending on environmental factors, air is drawn from the most acceptable source: the outside air, the internal atrium or centralised plant. The hollow core planks act as an energy exchange device, adding or removing heat from the ventilated air depending on ambient temperatures and seasonal factors.

Passive—Active Hybrid Systems

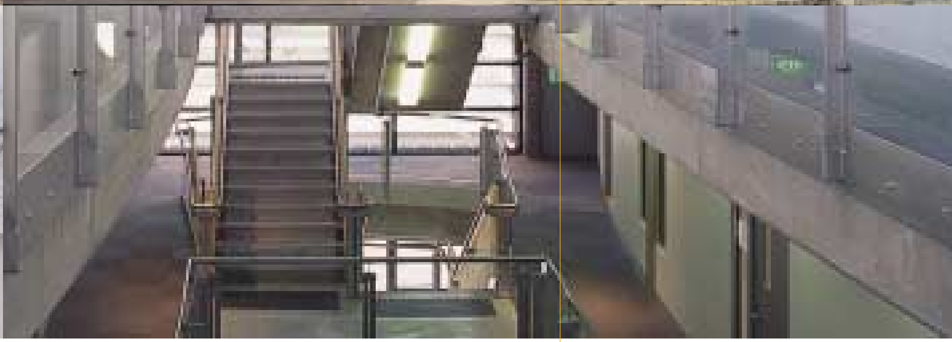
The internal planning of the building is divided into self-contained 'pods' served by individual fan coils. Each 'pod' can be mechanically

LINKS: DesignInc Melbourne PL: www.designinc.com.au; Composite Systems PL (*Thermomass*): www.compositesystems.com.au; Hollow Core Concrete PL (*Termode*

ARCHITECT: DesignInc Melbourne PL
PROJECT ARCHITECT: Rohan Wilson
CLIENT/PROJECT MANAGER: Deakin University, Buildings and Grounds Division
BUILDER: Wycombe Constructions
STRUCTURAL ENGINEER: Meinhardt Consulting Engineers
ESD CONCEPTS: Prof Mark Luther (Deakin University), DesignInc and ULA
PHOTOGRAPHY/IMAGES: Shannon McGrath
ACKNOWLEDGEMENT: Rohan Wilson (DesignInc)

B

C



isolated from the rest of the floor as required. On days of extreme temperature, air is pre-cooled by a centralised plant and ducted via the plenums under the atrium balconies to individual pod air-handling units. This is referred to as tempering of the required ventilation air as opposed to air-conditioning.

The active system works in synchronisation with passive measures, such as the building's thermal mass and results in a thermal lag of about 24 hours. The active system switches on and off as required, maintaining the thermal mass at constant temperatures and the internal spaces within an acceptable temperature range of 18°C to 28°C.

The system has minimal 'pull-down' capacity and is designed to operate as a sequence of slow responses (flywheel effect), rather than triggered by urgent demands.

During consecutive days of extreme temperatures, despite the thermal mass and other passive measures, the spaces within the building can approach the upper limit of accepted temperatures and the active system switches on, providing tempered air into the spaces via the slabs.

During cooler months, air to the fan coil units which provide heating for the building, is drawn from the bank of warm air in the atrium and blown directly into the slabs if sufficiently warm. If not, additional heating is provided from the heating coil in the fan coil units and blown into the slabs. The warmed air drops into the spaces, below where ceiling fans assist in circulation. Hot water is piped to the fan coil units from the central boiler and motorised dampers are provided with the fan coil units to allow them to draw air direct from the atrium. During winter, these dampers are open all the time; during summer they are closed to allow the bulkheads to act as plenums.

Night ventilation

Overnight ventilation strategies are a major feature of the building. When conditions are extreme during summer, the active system purges the building of hot air from daily build-up, recharging the thermal mass. Purging of the atrium is achieved via smoke extraction fans and dampers, which are positioned at the base of the atrium, and open to permit adequate ventilation and air exchange.

The thermal mass in the pods are recharged with coolth at night in preparation for the following day. If available, cool night air is used from the atrium. If not, the active system will deliver tempered air from the tempering units in order to recharge the slabs.

A

The high thermal mass of the west facade showing pigmented *Thermomass* precast panels and insitu concrete piers and beams. The lift shaft is constructed from plain precast panels with expressed joints. At the base of the building is a band of decorative black pigmented concrete plinth, with horizontal banding.

B

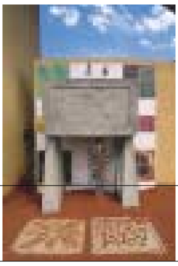
External upper level circulation link constructed of 15-m span precast concrete planks. The precast lift shaft is seen on the right and thermal mass walls on the left.

C

Front facade showing *Thermomass* precast walls placed between insitu concrete piers and beams. Note the 'light scoop' adjacent to the clerestory, placed to direct the north light into the central atrium.

D

View of the atrium showing the polished concrete floor at ground level. Note the curved insitu balcony edges in foreground.



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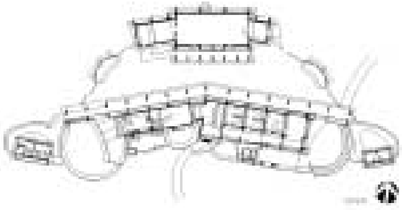
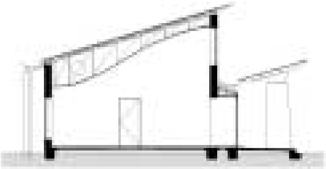
TJULYURU NGAANYATJARRA

CULTURAL AND CIVIC CENTRE, WARBURTON, WESTERN

The Tjulyuru Cultural and Civic Centre is the home and exhibition space for the Warburton Art Collection, which is nationally recognised as the most substantial collection of art in Australia still under the direct ownership and control of Aboriginal people. The Centre is owned by Warburton Community Inc. and operated and managed by the Shire of Ngaanyatjarraku. Located In the Gibson Desert, halfway along the Great Central Road between Kalgoorlie and Uluru, the Centre is located in the heart of Ngaanyatjarra land and close to a community of around 450 people. The Ngaanyatjarra's ambitious arts program, the Warburton Arts Project, has found in its Centre, an expression for the community's diverse and distinctive artistic style.



Plan of the Centre



Typical Section

Insideout Architects were commissioned to design the Centre in 1998 and the practice set up in Warburton for the duration of the design, documentation and construction stages. The architects were also responsible for the interior design and project management.

The building program called for a facility to house art works, provide a retail outlet with visitor amenities, a regional gathering place and offices for the local government. It was essential that the Centre satisfy the sensitive management of community expectations and result in a building with low ongoing maintenance and operational costs suited to the desert environment. Structural systems were also selected for ease of construction and transportation, via road train over 500 kilometres of dirt roads.

Warburton's daytime temperatures are commonly in excess of 40°C in the summer months and below freezing overnight during the winter. During construction, a CSR concrete batching plant was set up on site to manufacture concrete for the project. Locally sourced creek pebble aggregate and red dune sand, *tali*, were used for the concrete slab floors. White cement from Perth was used and the architect, engineers and contractors worked together designing a suitable concrete mix to incorporate the uncommon aggregate. The slab was subsequently ground back and polished to reveal the creek pebbles resulting in a unique high quality finish.

The design of the individual buildings comprise a series of skillion roofs, with eaves protecting cement rendered concrete blockwork external walls, selected for durability. The overhangs are designed to passive solar principles, permitting winter solar gain and shading the summer sun. Concrete slab floors add to the high thermal mass ideally suited to the high diurnal temperature swings. Low peripheral courtyard walls of rendered concrete blockwork define the complex, shielding the courtyards from excessive wind-driven dust. External courtyard circulation is provided by concrete pavements, practical during rainy weather. As a result, people are able to move around the Centre and find ambient morning or afternoon comfort during both winter and summer.

Environmentally Sustainable Design (ESD) principles were high priority design-brief elements. Their application has resulted in a user-friendly system which is able to monitor and temper the internal environment, daily or seasonally; as well as mechanically, by heating or cooling, and manually, by cross ventilation. The Centre, is however, not reliant on high operational expenses and has an annual

LINKS: Tjulyuru Cultural Centre: www.tjulyuru.com; Insideout Architects PL: www.insideout-architects.com; Heritage Collections Council: www.amol.org.au/craft/pu

AUSTRALIA

ARCHITECT: Insideout Architects PL
CLIENT: Warburton Community Incorporated
LANDSCAPE DESIGNER: Jude Prichard
SLAB CONTRACTOR/FINISHER: Trevor Cook; Gallery slab finish by Territory Concrete Services
STRUCTURAL CONSULTANT: Sinclair Knight Merz, Townsville
BUILDER: Sitzler Bros, Alice Springs
FOREMAN: Michael Betteridge, Betteridge Building Services, Alice Springs
ARTISTS: Pulpuru Davies, Lala West, Murtle Holland, Tjatjitjarra Robinson

running cost of around $14,000. Internally, the two principal exhibition spaces, gallery store and curatorial office are constructed of concrete blockwork for thermal insulation and isolation of thermal loads. The building's high exposed thermal mass gives favourable condensation and thermal absorption properties, which is desirable for the storage and display of the gallery's collections which are rotated on a three monthly basis.[1]

Insideout Architects was awarded three 2001 RAIA Northern Territory Chapter Awards for this project: the Commercial Architecture, Energy Efficient Design (Environment Award) and the Tracy Memorial Award.

Architect's Statement

Tjulyuru ('dhul-u-roo')—The mound of dirt created when a Malu (kangaroo) digs for water. The Centre comprises constructed and non-constructed environments and is woven into the Ngaanyatjarra people's front yard along the Great Central Road. It is a container of aspects of Ngaanyatjarra (this/separate/people), and immerses users (visitors and locals) in a significant mutual space, where visitors can experience Ngaanyatjarra culture and society. The space is one in which the sacred and temporal are fused, and this amalgamation is the underlying concept within the built form and surrounding landscape.

The architectural form of the building and its extension into surrounding places through the landscape has many references to Ngaanyatjarra culture and society. Also, there are plenty of doors connecting the inside to the outside. Consideration of the development process of the Centre was as important as its physical construction; the site itself is of cultural significance. Construction in one of the most remote locations in Australia was not easy. A mix of Ngaanyatjarra people and outside contractors were employed and a considerable number of logistic hurdles and cultural issues had to be met. The project was completed within budget and nine weeks early.

Hundreds of local people worked with me from the beginning, telling me what they wanted and patiently watching over the development of the design. Every community member approved the design; many worked with Sitzler Bros on the actual construction and later on the landscaping. In particular, every family in this community contributed physically, even *tjitji*, the children who provided art glass panels that are incorporated into the furniture. I thank the Ngaanyatjarra people for entrusting me with their special project.
Tania Dennis: Insideout Architects PL

PHOTOGRAPHY:
Eye Saw Studios PL
ACKNOWLEDGEMENTS:
Tania Dennis, Insideout Architects PL

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[1] *Guidelines for Environmental Control in Cultural Institutions,* Heritage Collections Council, 2002. Commonwealth Department of Communications, Information Technology and the Arts. Commonwealth of Australia.

ublications/hcc/environment_guide.asp

OSCAR NIEMEYER, THAT MAN FROM RIO

A *Itamaraty Palace*

B *Julia Kubitschek Elementary School*

C *National Sports Stadium*

Much of Oscar Niemeyer's work over the last 65 years involves rigorous experimentation with modern concrete construction. Practical durability and thermal performance have been central to his selection of concrete as a preferred construction material. His iconic works in Brasilia were designed as lasting monuments to Brazil and the visionary era led by Juscelino Kubitschek preceding decades of military dictatorship. Niemeyer's works in concrete were designed to endure and his structural exploration, often untested and without precedent, acknowledges and addresses climatic considerations. Passive solar measures, such as generous verandahs and high thermal mass (concrete) construction, resulted in built works suited to climates of high diurnal temperature swings, such as the hot arid climate of Brasilia. Additionally, the use of the concrete brise soleil in high rise at Rio de Janeiro and Sao Paulo indicate that climate control was an integral part of the design process. The potential of concrete to manipulate structure and form is central to Niemeyer's investigations and this aspect of his work is discussed in the following article.

The most striking images in Phillipe de Broca's 1963 film 'That Man from Rio' are those of Jean-Paul Belmondo struggling to fly his plane over Brasilia. We see split-second glimpses of his very shaky point of view, as he passes over various Oscar Niemeyer buildings. Even when seen subliminally, in such distorted viewing conditions, Niemeyer's buildings have an incredible power as modern, almost futuristic images. There are very few architects of the last century who had such an aptitude for producing buildings as images.

Modernist assessments of Niemeyer's work often stop at a lyrical or baroque interpretation of the architectural ideas of Le Corbusier.[1] In his memoirs however, Niemeyer talks about being viewed contemptuously as gratuitous and unnecessary. He states:

> *People talked about purism—about the machine for living in, less is more, functionalism, and so on—without understanding that this would be derailed by the plastic freedom made possible by reinforced concrete.*[2]

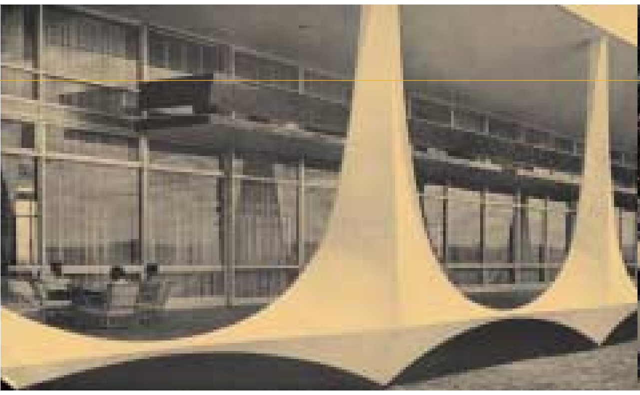
It is partly due to the classical underpinning of modernism, as well as the modernist distaste for decoration that Niemeyer was treated this way. However, his perceived manipulation of Le Corbusier's formal vocabulary for concrete construction is a more likely reason.

Le Corbusier's 1916 manifesto on the 'Maison Dom-Ino' followed by 'Les 5 Points d'une Architecture Nouvelle' in 1926, were analyses of new possibilities of concrete construction and its affect on architecture. Important for Niemeyer, was that Le Corbusier envisaged this system so it could be built by unskilled labour, and therefore ideal for Brazil. Le Corbusier's basic premise was that the new concrete construction of slab and column allowed for new, freer, design possibilities. In particular, the building's elevation from the ground, the development of a free plan (with walls no longer required to be load bearing), a free façade and the roof garden.

However, Niemeyer should not really be seen as 'sub-Corbusian'; he was not obsessed with 'Les 5 points'. For him, the concrete slab and column are the basic elements of all architectural form; Le Corbusier simply gave them a moral imperative.

From 1936, when Niemeyer first collaborated with Le Corbusier, he began a process of interrogating the logic of concrete construction. Niemeyer's take on the 'Corbusian' points, progressively subjected concrete to more and more (neo) baroque manipulations, focusing on his interest in working with the primal elements of concrete construction, the column and the slab. These elements became doubled up,

Oscar Niemeyer was born in Rio de Janeiro in 1907 and was awarded the Pritzker Prize in 1989 LINK: www.niemeyer.org.br



D Palacio de Avorada, Presidential Residence

E Igrejinha Nossa Senhora de Fatima

F Supremo Tribunal Federal

ARTICLE: Toby Reed
Toby Reed has a Bachelor of Architecture and a Masters degree in Cinema Studies. He has written for various publications in Australia and the USA, and has lectured in Architecture and Cinema Studies at RMIT University. He is currently writing and producing films in France.

IMAGES: Unless noted otherwise, Lorina Nervegna

blurred with other components, distorted and displaced.

For instance, in the Metropolitan Cathedral, (Nossa Senhora Aparecida, Brasilia 1959-70), the columns/structure become roof-lattice, column and wall. In his 1959 design for the Presidential Residence, Palácio de Alvorada, Brasilia, the columns become the wall and balcony, a variation on the brise soleil, totally throwing Le Corbusier's free façade into the realm of the kitsch. In his 1954 secondary school at Belo Horizonte, Minas Gerais, the roof slab is folded into the floor slab, on both the rectilinear and curvilinear buildings. The Presidential Chapel in Brasilia, 1958, is a series of folded and bent slabs, hovering over the ground plane.

Bent, folded and cut-out slabs abound in his architecture. His plans are often like the free plan gone wild, exploded by unknown forces. Le Corbusier's system wrenched architecture from the figure-ground relationships of the nineteenth century, into the object-plane relationship of modernism. This way of conceptualising built form, as objects floating on an abstract plane, can also be seen in the work of early twentieth century abstract painters such as Malevich.

Niemeyer produced one of the most succinct expressions of the object-plane relationship of modernism; a building/site relationship which is illustrated by glancing at any snapshot of Brasilia. His manipulation of the object-plane relationship has within it the seeds of its opposite, a new condition for architecture that has now become more relevant. This new condition can best be described as a type of folding of surfaces, where the area between object and plane is explored.

Niemeyer has consistently explored these ideas in all his work. Ground planes and datum lines are delineated and messed with. Slabs are curved and bent, as for instance with the chapel of São Francisco de Assis, in Pampulha built in 1943; or moulded, like the two giant domes of the 1958 National Congress complex in Brasilia.

Niemeyer's manipulation of the concrete slab has consistently denied the 'Platonic' separation between elements—between wall and roof, roof and floor, roof and ground plane, column and wall; and he has been able to achieve this while at the same time producing strong, almost pre-lingual images. This can be seen in the relation of his sketches to the finished buildings. His buildings like his sketches are diagrams, at once sign and structural solution, and he has consistently infiltrated the blurring and folding of elements into this schema.

A Ministry of Foreign Affairs, Brasilia, 1962
Sculpture '*Meteoro*' by Bruno Giorgi

B Elementary School, Diamantina, 1951
Source: 'Oscar Niemeyer' by Stamo Papadaki, George Braziller, 1960

C National Sports Stadium

D Palace of the Dawn, Brasilia, 1959
Source: 'Oscar Niemeyer' by Stamo Papadaki, George Braziller, 1960

E Chapel of Our Lady of Fatima, 1959
Brasilia

F Federal Supreme Court, Brasilia, 1958

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1. See *Oscar Niemeyer*, by Stamo Papadaki, George Braziller Inc. New York 1960, p.25; or *Modern Architecture; A Critical History*, by Kenneth Frampton, Thames and Hudson, New York, 1992, p.243.
2. *The Curves of Time; The Memoirs of Oscar Niemeyer*, Phaidon, 2000.

FABRIC ENERGY STORAGE WITH CONCRETE

A GUIDE TO THERMAL MASS DESIGN

The following is an extract from an article by Dr Jacqueline Glass, which first appeared in 'Interface', the newsletter of Trent Concrete Limited. Dr Glass is the Senior Lecturer in Architecture at the Oxford Centre for Sustainable Development, Oxford Brookes University. She specialises in research in concrete construction and is also an architectural consultant to the British Cement Association and the Reinforced Concrete Council.

On entering a cathedral in mid-summer, most people notice instantly how cold the internal environment seems in comparison to the outside air. The massive walls have an enormous capacity to store and release heat, thereby tempering the internal environment by reducing and delaying the onset of peak temperatures. This effect, sometimes called thermal mass or thermal capacity, but referred to here as Fabric Energy Storage (FES), can be optimised through good design and construction, and is now used in many commercial concrete office buildings to create more comfortable working conditions and reduce energy consumption.

THERMAL COMFORT

Many commercial buildings have a substantial cooling requirement throughout the year as a result of computers, printers and photocopiers. In air-conditioned offices, the electrical power used for refrigeration, pumps and fans is second only to that used for lighting and is the fastest growing consumer of electricity in the commercial/services sector. With growing concerns over carbon dioxide emissions, global climate change, and the possible restriction on the use of air-conditioning in the future, designers are looking for low energy methods of achieving thermal comfort.

FABRIC ENERGY STORAGE

FES uses the building fabric to attenuate and delay peak internal temperatures during the occupied period. For many clients, the use of concrete frames, floors and walls has provided much needed thermal mass in buildings susceptible to overheating caused by both equipment and solar gain. Although any part of a concrete structure can be used for FES (façade, frames or walls), the inside or undersides of concrete floor slabs are particularly suitable. This is because they form the largest volume and surface area of the structure, and are evenly distributed throughout the building. The optimum solution is one where there is maximum 'thermal linkage' between the heat source and the concrete. However, the final design strategy will also depend on the predicted heat load and other considerations such as aesthetics, maintenance and end-use.

IMAGES:
Vitra Fire Station 1993 (top) by Zaha Hadid and Igualada Cemetry 1993 (bottom) by Miralles Y Pinos.
Source: 'Contemporary European Architects'. Taschen, 1995.

LINK: www.trentconcrete.co.uk

FES DESIGN STRATEGIES

There are two basic design strategies for utilising FES in concrete: passive and active systems.

passive

In passive solutions, concrete surfaces are exposed to allow heat exchange with the air volume and surrounding surfaces. Exposed slabs, using flat, contoured or troughed surfaces with raised floor systems above, can absorb heat gains from occupants and equipment.

active

Active solutions achieve an enhanced heat transfer as a result of forced ventilation through a concrete element, such as a hollow-core slab. Alternatively, this transfer can be achieved across a concrete surface by means of a plenum or walls, such as the Labyrinth at Federation Square (featured on page 2 of this issue).

heat loading

FES can reduce peak internal temperatures by 5°C and shift the reduced peaks to later in the day where, in a commercial setting, this may occur after the occupants have left for the day. A passive FES building can contribute a cooling effect of 15-20W/m^2, which is sufficient to counteract the effects of computers and printers for an averagely sized office. A greater cooling effect of 25-35W/m^2 can be achieved with an active solution, allowing comfort to be maintained at higher levels of internal heat gain.

exposing the concrete

As a heavyweight material, concrete offers a substantial capacity for FES. The exposure of columns, beams, walls, slabs and soffits is an effective means by which the building structure can contribute to the thermal ‘flywheel’ effect. Precast concrete in particular plays a unique role in providing fast, high quality and long lasting exposed frame elements and soffits.

If a significant area of concrete is to be exposed, consideration should be given to the attainment of an appropriate exposed surface, colour consistency or off-form finish. FES soffits in particular, are most effective for daylighting and lighting if they have a white or pale-coloured finish, helping to reflect light onto work-spaces. Special architectural concrete may be employed to achieve the desired finish, or alternatively, standard structural concrete may be painted.

pre-planning

Pre-planning can enhance the operational longevity of a concrete FES building and its design should address the issue of coordination and integration of services at the concept design stage. Early resolution of servicing runs is desirable so that any precasting design work can be started in earnest early on.

ESD AND CONCRETE

TIPS

KEY POINTS TO CONSIDER

Concrete structures, such as the Pantheon in Rome (124 AD), demonstrate a life-cycle potential which is unrivalled by any other manufactured construction material. The significance of concrete's durability is heightened when it is used in conjunction with Ecologically Sustainable Development (ESD) principles such as passive solar design, thermal mass and passive/active hybrid systems.

life cycle assessment Life Cycle Assessment (LCA) takes into consideration the whole-of-life of a building, encompassing the total environmental and economic costs. It is an important tool for ESD and forms part of the ISO 14000 series of standards on environmental management. LCA encompasses the initial and recurrent embodied-energy, operational energy (over the lifetime of the building) and the disposal/recyclability potential of its components. It is generally accepted as a comprehensive method of analysis (cradle to grave/cradle), as opposed to assessments based on one of its components alone. Since operational energy has been found to be the highest source of energy consumption, maximum energy savings can be made from minimising dependence on mechanical means. Concrete is readily available in urban centres and is easily manufactured in remote locations; it is therefore ideally placed to assist in minimising operational energy in the constructed environment.

passive solar design Thermal mass is required within a structure to passively store solar energy, harness energy and moderate diurnal temperature swings. This is referred to as Fabric Energy Storage (FES) or thermal mass (which equals R-values + thermal diffusivity + time lag decrement).

Internal walls and floors slabs of exposed, painted or integrally coloured concrete are ideally suited for passive solar design. In winter, stored heat is re-radiated within an internal space when outside temperatures drop. In warmer months, adequate solar protection to north and west facing glazing must be provided to avoid over heating. Measures such as these can reduce dependence on mechanical means, lowering the overall operational energy consumption.

sensitive sites Concrete is a suitable construction material for footing design in most terrains and has the ability to be exploited on environmentally sensitive sites. This is possible due to the ability of reinforced concrete to achieve large spans and cantilevers leading to minimal natural ground disturbance. A well-known historical example is the Kaufmann House ('Fallingwater') at Bear Run, Pasadena 1937 by architect Frank Lloyd Wright.

condensation control In *Guidelines for Environmental Control of Cultural Institutions* a document prepared by the Consortium for Heritage Collections and their Environment (www.amol.org.au/craft/publications/hcc/environment_guide.asp), studies indicate that high thermal mass elements such as exposed concrete interiors, whether painted or integrally coloured, assist in offsetting the building's dependence on operational energy. High exposed internal thermal mass also gives favourable condensation absorption properties and some humidity buffering can be achieved. This is of particular importance in institutions such as museums and galleries where humidity levels and fluctuations are significant in storing and displaying collections.

THE **CEMENT & CONCRETE** ASSOCIATION OF AUSTRALIA (C&CAA) IS A NOT FOR PROFIT ORGANISATION DEDICATED TO PROMOTING ARCHITECTURAL AND TECHNICAL EXCELLENCE IN THE USE OF CONCRETE.