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A Precast Concrete Lifeline to the Ocean

The Gold Coast Desalination Project Tunnels

Thirty metres below the seafloor and 50 metres below sea-level, two 150-tonne Tunnel Boring Machines (TBMs) have been working day and night to create the intake and outlet tunnels which will link the largest desalination plant on the Eastern Seaboard to the ocean.

Once complete in February 2008, the 2.2 kilometre intake tunnel and 2 kilometre outlet tunnel will be lined with almost 21,000 precast, reinforced concrete segments, constructed by Queensland precaster Precast Concrete Products Pty Ltd.

These two tunnels are a vital part of the Gold Coast Desalination Project – a $1.2 billion joint initiative between the Queensland State Government and Gold Coast City Council - which will provide 125 ML/day of clean, fresh water for South-East Queensland.

The project is currently under construction near the Gold Coast Airport in Tugun, and will begin producing water at the end of November 2008. It will operate at full capacity by January 2009.

The nature of the project and the strict time frames for its construction required the employment of leaders in this field nationally and globally. At the helm of the project's tunnelling operations is Tony Bermingham, who has worked on a number of iconic tunnels throughout the world, including the Channel Tunnel linking the UK to France. Mr Bermingham said the tunnel design and construction provided numerous challenges, which his expert team has eagerly met.

"We chose two purpose-built TBMs because they have minimal impact on both the environment and the community compared with other tunnelling methods," he said.

"We also needed to ensure the tunnel lining was durable enough to cope with the constant flow of saltwater, seventy metres underground for the design period of 100 years."

To this end, the concrete segments, of which six link together to form a ring inside the tunnels, had to be created from a special concrete mix. The mix was formulated following a testing process undertaken over many months prior to the start of tunnel construction.

The tunnel lining specifications included:

- A compressive strength of 50 MPa;
- A first crack flexural strength of 4.6MPa; and
- Quality benchmarked to a Quality System AS/NZS ISO 9001:2000.

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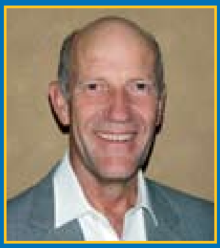
Presidents Column



Relatively few construction projects are truly successful delivering an end result to the full satisfaction of all interested parties. It is worthwhile considering the factors that influence this outcome.

Certainly the degree of complexity need not be an issue.

Some important considerations are:

- Competent contributors are assembled as a team. (Consultants, head contractor & sub-contractors)
- Clear communications are made in an environment where timely input from all is encouraged.
- Clarity is achieved on the obligations of each participant.
- Contractual arrangements are put in place which are fair and reasonable.

For a number of reasons the corporate members of the National Precast Concrete Association punch above their weight and feature in more 'successful' projects than their turnover would suggest.

Why? Because they are competent and will generally only work with competent clients. Because they fully appreciate the need for close coordination and are used to working in a team environment. Because they deliver what they promise.

Continual improvement in the level of service is always possible but this is primarily a function of the input from the team rather than the individual sub-contractor. The worst case scenario is a late decision of who is required to do what by when coupled with contractual conditions which are unreasonable or are unreasonably interpreted.

Significant construction time can be saved by prefabricating off-site but adequate planning is a pre-requisite. The sooner an input from a precast supplier is sought and the sooner a precast solution is confirmed, the more value can be added. Too often only part of the precast advantage is realised which could have been fully optimised by an earlier involvement and an earlier decision.

Alan Morrison
President

… story continued from front page

Forty-eight machine moulds were designed and fabricated by the precaster and were required to form the segments. Trapezoidal vertical joints were incorporated in the design to ensure the structural integrity of each tunnel and to allow rapid installation.

To ensure durability and strength and to minimise any porosity, the concrete mix included silica fume and fly ash. In addition, a high-range water reducer was used to provide a low water/cement ratio to enhance durability, and steel fibres (35 kilograms per cubic metre of concrete) were included to increase corrosion resistance and ductility of the segmental lining.

"QA is always at the top of our minds on this project, so all elements and aspects of the segment fabrication process were required to be tested, including the raw materials from the quarry," Mr Bermingham said.

"Our tunnel design and construction is the result of considerable research to ensure the best possible product for the South-East Queensland community – tunnels that will be able to help provide drinking water for the region for at least 100 years."

Dimensional, material and concrete tests were conducted on each segment fabrication shift. The moulds were also required to undergo significant testing in order to meet tight dimensional tolerances for approximately 500 casts.

Colin Ginger, of Precast Concrete Products, said the amount of testing undertaken for this project was the highest recorded since the company was established 40 years ago.

In order to meet the strict time frames required for the project, the company operated two shifts throughout the manufacturing process, with 48 segments cast twice a day (early morning and evening), six-days-a-week.

This allowed for approximately ten truck loads of segments to be delivered daily to the project site at Tugun. Once delivered, the segments were carefully lowered into the tunnel shaft, 70 metres below ground, and taken – by locomotive – to the TBMs for installation.

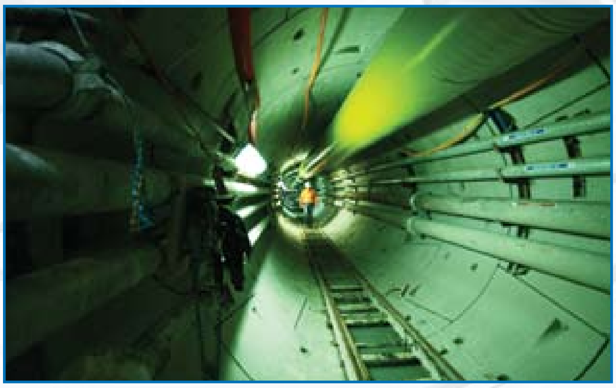
Each TBM has a round, rotating cutter head which is covered in disk cutters (like giant teeth). As the head spins, the teeth cut into the rock. The rock is crushed and mixed with a naturally occurring lubricant – bentonite clay – to form a slurry. It is then pumped, via pipelines inside the tunnel, to the surface at the plant site.

After the TBMs cut through 1.2 metres of rock, they stop and the lining is erected from the back of the machines. Six segments are linked together to form a ring, which is grouted into place.

Using hydraulic rams, the TBMs then thrust off the completed ring and begin the cutting process once again.

These rams are capable of pushing about 1200 tonnes on the edge of the segments – a critical issue that also needed to be considered in the design and fabrication of the segments. Failure to do so would have resulted in local pressure points which would cause cracks and possible failure of the segments.

The segment geometry is also complex, as all of the longitudinal joints are offset 10 degrees to the axis of the tunnel, resulting in trapezoidal shaped segments. In the circumferential joints the nominal 1200mm long ring tapers from 1193mm to 1207mm allowing the tunnel to navigate around large radius bends.

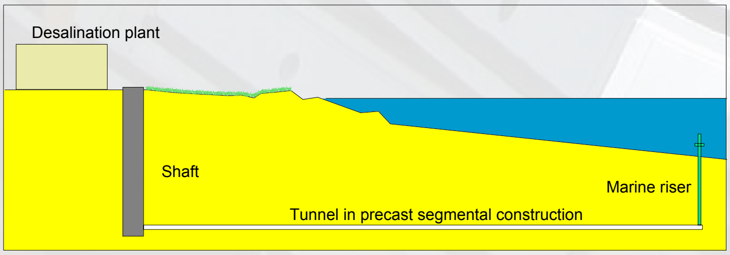


"We used 3D computer software to model the mould components in a language that could be directly downloaded to the machine shops that milled the parts, and then assembled all of the fabricated components in our mould workshop," Mr Ginger said.

"A special curing regime was also used with variable amounts of steam piped to each mould. The temperature of the concrete and rate of temperature rise were tightly controlled to allow for stripping of the moulds only six hours after casting. This enabled us to undertake the daily double castings.

"Concave and convex vacuum lifters were custom made for us in Melbourne. These were used to lift the segments out of the mould and move them to storage. In addition, a customised rotating device was built and attached to a forklift, allowing the segments to be rotated 180 degrees prior to delivery to Tugun."

The Gold Coast Desalination Project is being constructed by the GCD Alliance, comprising John Holland Constructions, Veolia Water Australia, Sinclair Knight Merz and Cardno. The Alliance will also operate the project for 10 years.



Note:Image is not to scale and is an artists impression of the plant and tunnel design

Thermally efficient design with precast

By Ric Butt, Strine Design

What is thermal efficiency?

Thermal efficiency is part of energy efficiency and energy efficiency is one part of sustainability. Sustainability includes not only energy but also considerations of water, materials, food, waste and air quality, to name but a few. Thermal efficiency in a building is achieved when minimal energy is consumed, so as to maintain thermal comfort.

How a building or building element such as a wall, floor or roof performs thermally has a significant impact on its energy consumption. Energy consumption in Australia normally means greenhouse gas emissions, as most energy used in buildings is coal-fired electricity.

Section J of the BCA

Edition 46 of National Precaster (November 2007) outlines the new Section J of the Building Code of Australia (BCA), specifically written to establish energy efficiency measures.

Section J covers most of the elements of a building that contribute to its energy consumption:

- Building fabric
- External glazing
- Building sealing
- Air movement
- Air conditioning and ventilation systems
- Artificial lighting and power
- Hot water supply
- Access for maintenance.

For the precast industry, the relevant part of Section J is that of Building Fabric (p.439, BCA Volume 1). This section must be read with the identified class of building (Part A3) and climate zone (see Climate Zone Map in Part A1 – Interpretation [the definitions]). In particular:

J1.2 – Thermal construction general
Covers insulation and refers to the thermal properties of materials listed in Specification J1.2

J1.3 – Roof and ceiling construction
Specifies requirements for insulation values – see Specification J1.3

J1.5 – Walls
Specifies requirements for insulation values with options from tables J1.5a or J1.5b and Specification J1.5

J1.6 – Floors
Specifies requirements for insulation values with options from table J1.6 and Specification J1.6.

Thermally efficient buildings rely on three key factors: climate, physics and design.

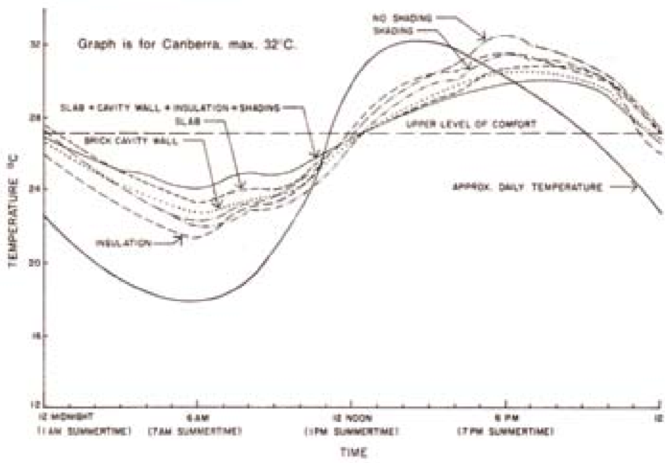
Three key factors: climate, physics and design

Climate

Every building site comes with a piece of climate, for free!

Climate is a non-steady state which creates periodic heat flow. Diurnal variations (i.e. variations within the course of a single day) create repetitive cycles of temperature: peaks during the day and troughs during the night.

INTERNAL TEMPERATURE VARIATIONS ON A HOT SUMMER DAY FOR HOUSES OF VARIOUS CONSTRUCTIONS



In Australia, environmental heat generally flows into a building during the day and out of the building at night. The performance of the building envelope in modifying these environmental heat flows dictates the indoor temperatures experienced in the building.

Human comfort requires that indoor temperatures are kept constant or within a narrow zone of temperature and humidity. The thermal performance of the building envelope is therefore critical and needs to be designed and constructed appropriately.

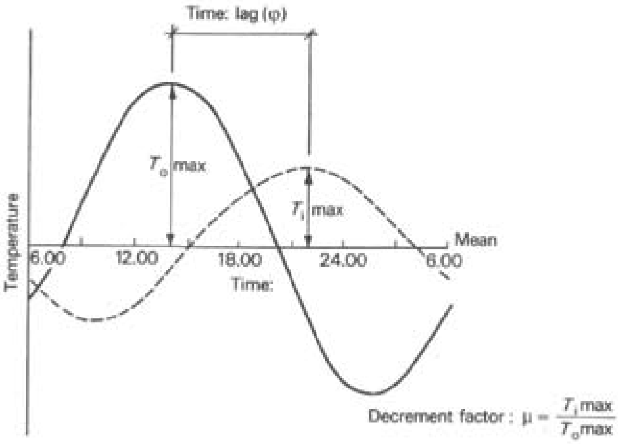
Thermal design needs to consider the thermal performance of the materials used in the building envelope. Controlling air temperature alone is not an accurate determiner of human comfort. The Environmental Temperature – which combines surrounding surface temperatures with the air temperature – must be controlled. The 'sensible' radiant heat gain or loss to the surrounding surfaces is the critical factor for human comfort. Human thermal comfort is not possible where the air temperature and the mean radiant surface temperature differ by more than 5˚C.

Physics

Concrete is the perfect material to satisfy the requirements for human thermal comfort. The physics of heat flow in buildings is the reason why.

Physics tells us that energy flows by conduction, convection and radiation. In building envelopes, the conductivity of a material is central. The reciprocal of a material's conductivity is its resistivity (refer to Section J Specifications above). While concrete is a good conductor (in other words it has low resistivity), it has a high density and a high volumetric heat capacity.

This gives concrete a very high thermal mass (the capacity to store energy). Concrete also has two other characteristics which make it an ideal material for use inside a building envelope: the time lag for heat to travel through the material and the decrement factor (the reduction in amplitude of the indoor building temperature). These combine to create the thermal lag or thermal fly-wheel effect which allows concrete to flatten out the temperature peaks and troughs inside a building: it takes a long time to heat up and a long time to cool down (see diagram).



Concrete	Time lag	Decrement
100mm	3 hours	0.45 (55% reduction)
200mm	6 hours	0.20 (80% reduction)
300mm	9 hours	0.10 (90% reduction)

For concrete to be an appropriate material for thermal design and energy efficiency in a building, it needs to be fully insulated from the outside climate. Section J of the BCA focuses on insulation and the conductivity of materials, as these reduce energy consumption and increase thermal comfort by increasing the mean radiant surface temperatures of the building envelope. As a result, less energy is consumed and therefore there are fewer greenhouse gas emissions contributing to climate change.

Insulation on the outside of the building envelope also reduces the incidence of condensation. Any material with warmth on one side and 'coolth' on the other can have condensation occur on the warm side if the dew point is reached. Insulation and/or a vapour barrier will prevent condensation.

For thermal mass to be effective, it should also be exposed to the interior and its occupants, not covered up with cosmetic finishes such as plasterboard.

Design

If heat inflows and outflows from a building are other than zero, the building will need heat input (heating) or removal (cooling). The difference between the climatic conditions and the nominated building internal conditions creates the level of heating or cooling required. This can be satisfied by passive (climatic thermal design) or active (HVAC) measures. Appropriate climatic thermal design of buildings can eliminate or significantly reduce building heating and cooling requirements. High thermal mass inside a building has its most significant impact on reducing cooling, a benefit for a world facing global warming.

Design factors affecting the thermal design of buildings are:

- Shape
- Fabric
- Fenestration
- Ventilation.

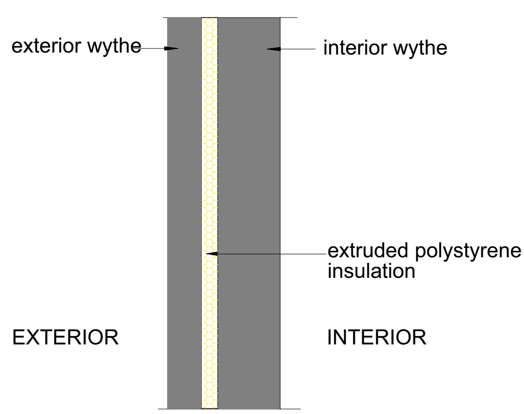
Precast solutions for thermal performance

It is widely accepted now that thermal bridging – conduction paths between the inside and the outside – has a significant detrimental effect on building performance. As well, the combination of thermal mass on the inside and insulation on the outside of a building envelope significantly increases comfort and also reduces energy consumption.

Knowing this, the precast industry has developed a new way of detailing, to eliminate thermal bridging and to develop heavyweight, mass interiors that are insulated from the exterior: precast sandwich panels.

Precast sandwich panels consist of two layers of concrete that are factory-made with a central layer of uninterrupted rigid insulation. They typically have a narrow (say 50 - 75mm) outer precast skin which is attached through the insulation to a wider (say 100 - 200mm) load bearing inner precast section, using non-conductive ties (connectors). Precast sandwich panels achieve the ideal thermal solution as they combine high internal mass insulated from the outside in a form of construction that has no thermal bridging.

PRECAST SANDWICH WALL PANEL

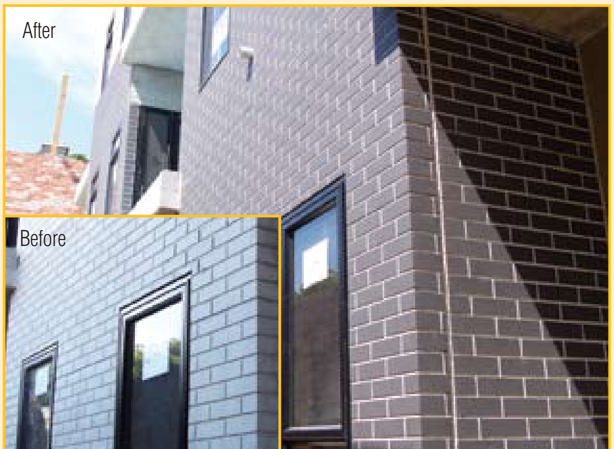


To make precast concrete sandwich panels, a first concrete slab is formed, into which one end of the connectors are embedded. A layer of rigid insulation is positioned over the connectors and a second layer of concrete is cast to cover the protruding ends of the connectors. The connectors provide resistance to shear in at least two directions.

New dimensions in grey wall panels

In 2006 new technology for colouring concrete was introduced to the precast industry. When combined with one of Reckli's 300 standard formliners or custom-made moulds, the application of Nawkaw's coloured emulsions and stains results in design possibilities which are now only limited by the imagination.

Nawkaw's specialty is in matching the colour requirements of any project by custom-blending and hand-applying their products to the surface of the moulded, cured precast. The result can mimic traditional brickwork, blockwork, stone work, slate, sandstone, or timber, and the penetrating colour finish is guaranteed for 25 years.



Using the stained formliner combination is less than half the cost of the traditional method of casting slips of stone and snaps of bricks into the precast surface, and does not limit the architect to only those colours of masonry units which are available.

The industry is starting to take notice of the significant benefits realised when using the stained formliner combination. Builders are enjoying the more than fifty percent cost savings as well as increased turnaround time, whereby panels can be supplied three times faster than the traditional alternatives. And the architects prefer the increased flexibility and more vivid colours which can be achieved.

Melbourne's Mt Martha bridge was specified with a 'cream splitface architectural CMU blockwork finish'. Precaster Humes realised that there were significant time and cost savings in casting the bridge sections with a blockwork relief formliner in grey concrete, then staining the moulded surface. The result is one that is indistinguishable from the traditional blockwork that was specified.

Precast does it for the $100M IKEA Perth superstore

Construction work on the new $100M IKEA Perth store commenced in October 2006 and has a target completion date at the end of February 2008. The development comprises a combined 5,100m^2 showroom and 7,000m^2 warehouse, a 400-seat family restaurant and an IKEA style children's playground, and undercover parking for over 1,000 cars. It will be the largest single tenant retail store in Western Australia with floor space of approximately 26,500m^2.

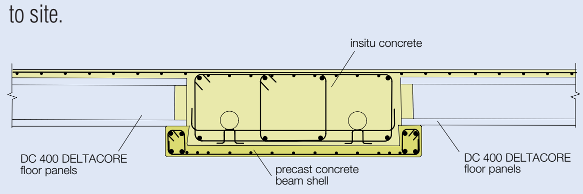
The entire floor for the store is suspended to provide undercover car parking and is designed to take a heavy live load for access for deliveries and storage racks. Design consideration needed to take into account the enormity of the project, foundation conditions, site access and an extremely tight construction program. In addition the number of car bays needed to be maximised.

Precaster Delta Corporation Ltd, consulting engineers Worley Parsons and head contractor Multiplex Constructions, worked together to develop a precast concrete solution. Early award of the $5M precast supply-only contract allowed for off-site precast manufacture and storage, well ahead of site requirements. It comprises Deltacore hollowcore floor panels with precast beam shells as the main deck supported on insitu concrete columns. Post tensioning cables are incorporated in an insitu structural concrete topping bonded to the hollowcore. The beam shells are propped until post tensioning is completed.

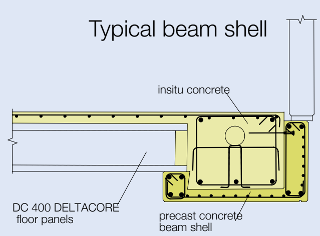
In all some 1,618 precast elements are used in the key sections of the project, broken down as follows:

- Deltacore floor planks (up to 400mm thickness) 1,260 No
- Beam shells 312 No
- Retaining wall units 46 No.

The Deltacore totalled 20,750m^2, in thicknesses of 400mm, 250mm, and 200mm. There were 2,445 lineal metres of beam shells delivered to site.



Typical beam shell



Beam shells at perimeter

New Precast Seminars in 2008

Precast for Architects

Shape, Colour & Texture: Your vision into reality with precast concrete
Thursday 10th April 2008 at Form & Function, Sydney

Building with Precast: A panel of professionals
Friday 11th April 2008 at Form & Function, Sydney

Section J & Precast Concrete
Saturday 12th April 2008 at Form & Function, Sydney

Refer to the Form & Function website for times and locations at Form & Function 2008 **www.formandfunctionexpo.com.au.**

Precast for Structural Engineers **NEW!**

One Day Seminars – Presented by John Woodside (winner of the John Connell Gold Medal) together with local NPCAA precasters and engineers.

City	Date	Venue
Hobart	Thursday 28th February 2008	The Old Woolstore
Adelaide	Wednesday 12th March 2008	Housing Industry Association
Brisbane	Tuesday 13th May 2008	Hotel Grand Chancellor
Melbourne	Tuesday 17th June 2008	Designbuild
Canberra	Tuesday 8th July 2008	Master Builders Association
Perth	Friday 17th October 2008	Designbuild

This seminar is for recent structural engineering graduates, those who wish to freshen up on the latest precast trends around Australia, and those who are new to precast construction.

The seminar will cover: Materials & Tolerances, Precast Building Design, Manufacture, Transport & Erection, Design of Elements, Contractual Issues, Connections, Fixings & Joints. Opportunities to discuss your own precast challenge with industry representatives will be available at different times throughout the day. Handouts include The Precast Concrete Handbook on disk, worth $180.

For more information call Nicole at the Concrete Institute on **(02) 9736 2955**, email **admin@concreteinstitute.com.au** or go to the Seminars & Workshops tab of **www.nationalprecast.com.au.**

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