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NATIONAL PRECAST CONCRETE ASSOCIATION AUSTRALIA

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PERTH's Exciting New Convention Centre

The $350mill Perth Convention and Exhibition Centre is a world class development located in the Perth Western Australia bounded by the Swan River, Narrows Bridge Interchange and the Perth CBD. It sits on reclaimed land previously owned by the Perth City Council and used as a car park. The adjacent bus port will become an integral part of the overall development.

The project consists of six Exhibition Halls (65mx40m), Crucible, Plenary Hall and Hotel with undercroft car parking covering an area of approximately 30,000m2.

Part of the project also includes an off ramp bridge and a six level office block.

The entire floor for the Halls is suspended to provide undercroft car parking and is designed to take a 20kPa live load for access for exhibition equipment deliveries.

Design consideration needed to take into account the enormity of the project, poor foundation conditions, restricted site and an extremely tight construction program. In addition the number of car bays needed to be maximised.

Multiplex Constructions proceeded to review alternative forms of construction including conventional reinforced insitu concrete, post tensioned floor slab, structural steel composite and precast concrete in order to minimize activity on site and maximize speed of construction.

Delta Corporation Ltd ,the consulting engineers and Multiplex worked together to develop a precast concrete solution. After various alternative precast schemes were prepared and priced the most economical and efficient solution was presented to the builder for consideration.

The solution comprises a typical prestressed concrete inverted 'T'Beam, 10.4m long 2.4m wide and 490mm thick with 175mm thick flanges. Hollowcore floor panels 350mm and 400mm thick spanning 8.4m were used as the main deck infill. Post tensioning cables were placed parallel to the beam up-stand together with reinforcement and tied together with a structural concrete topping. (refer Fig 2 for details of this unique precast connection)

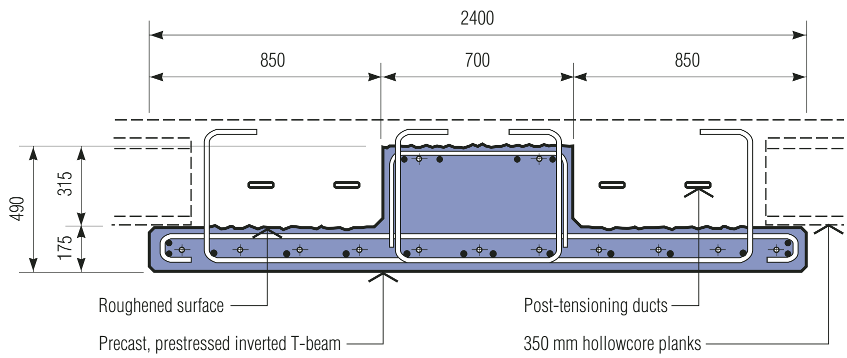
The aim of the proposal was to allow manufacture and storage of the precast off site well ahead of site requirements. This would ensure erection could proceed at a rate to suit the construction program.

Early award of the supply contract enabled the precaster to upgrade its production facilities and procure new extruders for the DC350 and DC400 sections.

Fig 1:The Convention Centre nestled between the Swan River and the Perth CBD at the early stage of construction.

Erection on site involved placing the prestressed beams over threaded starter bars at the top of the in-situ columns, grouted and bolted down. The beams were propped both ends to resist rotation during eccentric loading whilst hollowcore floor panels were being placed. Reinforcement and post tensioning strands was placed and structural topping poured. The system worked extremely well and easily met construction program requirements.

In all some 4,963 precast elements were used in the 6 key sections of the project, broken down as follows:



Hollowcore floor panels (up to 350mm thickness)	3854 No
T-Beams, Shell Beams and Girders (up to 21.5m length)	669 No
Seating Platts	253 No
Wall Panels	56 No
Retaining Walls	47 No
Parapets	84 No

This is one of the largest structural precast concrete projects ever undertaken in Perth and owes its success to the co-operation of all parties involved from conceptual stage to completion.

Builder:	Multiplex Constructions Pty Ltd
Architect:	Cox Howlett Bailey & Woodland, Architects & Planners
Engineers:	Arup Consulting Engineers
Precast Supplier:	Delta Corporation Ltd

Fig 2: Details of innovative connection in Exhibition Halls between precast beams, columns and floor panels).

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EFFECT ON A/C PLANT SIZE
of various proportions of precast, glazing and shading
By Dr Edward L Harkness FRAIA FIEAust CPEng

Introduction

Building design professionals might find useful a method of quickly comparing the loads on A/C plant that result from differences in the design of façades. They might find useful information about the comparative contribution to the cooling load on A/C plant of heat flow through the various component parts of the façade.

Heat may be admitted through the various component parts of a façade as follows:

- The vision panels admit: a proportion of the direct component of solar radiation instantaneously; a proportion of the diffuse component of solar radiation instantaneously; and heat conducted and reradiated without significant time lag.
- The non-vision panels admit: heat conducted in a time delayed by the mass in the panel / wall section (this heat is transmitted as a function of the thermal insulation in the non-vision panels, its surface solar absorptance and surface conductance and the temperature difference between the inside and the outside with the equivalent temperature of the outside face being adjusted depending upon the incidence of the direct and diffuse components of solar radiation.)

Design professionals who are informed about these various contributions to the required size of A/C plant may make value judgements about the significance of design decisions in the selection of: glazing systems; solar absorptance, insulation and mass of non-vision panels; and the use of sunshading systems.

CALCULATIONS OF COOLING LOADS ON A/C PLANT FOR VARIOUS FAÇADE OPTIONS.

This procedure is for comparing estimates of A/C plant size for different fenestration designs.

The two variations to be compared are

(1) a flush glass façade with high performance glass; and

(2) a façade on which sunscreens shade clear glass.

* These variations are shown in Figs 1, 2 and 3

March has been selected as the month in which this method of calculation will be illustrated.

The reason for selecting March is although at that time the outside air temperatures are close to the required indoor temperatures and therefore little heat would be conducted as a function of air temperature alone, radiation effects raise the sol-air temperature of opaque surfaces resulting in significant conducted heat gain through those opaque surfaces; and high levels of instantaneous heat gain occur by radiation through unshaded glazed areas.

Calculations have been made for 3 pm in March at Latitude 32.5 S. (Perth, Adelaide, Sydney and Newcastle are close to this latitude.) Average temperatures for Williamtown (north of Sydney) have been used. Readers may substitute relevant air temperatures and radiation intensities.

Assumptions:

- 5 hour thermal lag in the spandrel panel.
- 10am outside air temperature: 22.5 °C.
- 3pm outside air temperature: 24.8 °C.
- Inside air temperature: 22.5 °C.
- The external surface conductance: 10.
- The external surface absorptance: 0.5.
- Precast concrete spandrel U value: 1.0.
- Solar radiation intensities on a vertical northern plane at 10 am:
  - Direct solar radiation of 400 watts/sq.m
  - diffuse solar radiation of 130 watts/sq.m
- Solar radiation intensities on a vertical northern plane at 3 pm:
  - Direct solar radiation of 300 watts/sq.m
  - diffuse solar radiation of 110 watts/sq.m

Note: Q followed by a numeral represents a component of the quantity of heat to be calculated.

Initially heat gains will be calculated for 1 square metre of glass and spandrel.

NORTHERN FAÇADE TYPE A:
Flush glass façade with high performance double glazed vision panels

Q1. Calculate the <u>instantaneous</u> heat gain through the window from the <u>*direct*</u> component of solar radiation at 3.00 pm.

Say the instantaneous short wave transmissivity of the high performance glass to the direct component of solar radiation is 0.40.

Q1 = 1.0 sq m area of window x 300 x .40
= 120 watts

Q2. Calculate the <u>instantaneous</u> heat gain through the window from the <u>*diffuse*</u> component of solar radiation at 3.00 pm

Say the instantaneous short wave transmissivity of high performance glass is 0.40 to diffuse radiation

Q2 = 1.0 sq m area of window x 110 x 0.4
= 44 watts

Q3. Calculate the heat <u>conducted</u> through the *window* glass. Assume U value of double glazing to be 3.0.

Q3 = Area x U x (To -Ti)
= 1 x 3 x (24.8-22.5)
= 6.9 watts

Where: To and Ti are the outside and inside air temperatures and U is the overall air-to-air thermal transmittance

Q4. Calculate the heat <u>conducted</u> through the *spandrel* panel.

Assuming a thermal lag of 5 hours, use the external air temperature and the solar radiation intensity at 10.00 am.

$$\text{Sol Air Temperature} = To + \frac{I \times a}{f}$$

where:

I is solar radiation intensity
a is the external surface absorptance
f is the external surface conductance

At 10.00 am the intensity of *direct* solar radiation incident on the northern façade is 400 watts/sqm.

At 10.00 am the intensity of *diffuse* solar radiation is 130 watts/sq.m.

Assume the external surface absorptance (a) to solar radiation is 0.5

Assume the external surface conductance (f) is 10

The Sol-Air Temperature on the outside surface of the spandrel panel is therefore

$$= 22.5 + \frac{530 \times 0.5}{10}$$

$$= 49\ °C$$

Assume the U value of the spandrel is 1.0
The heat conducted through the spandrel panel is therefore

Q4 = A x U x (Sol air temp - Ti)
= 1 x 1.0 x (49 - 22.5)
= 26.5 watts

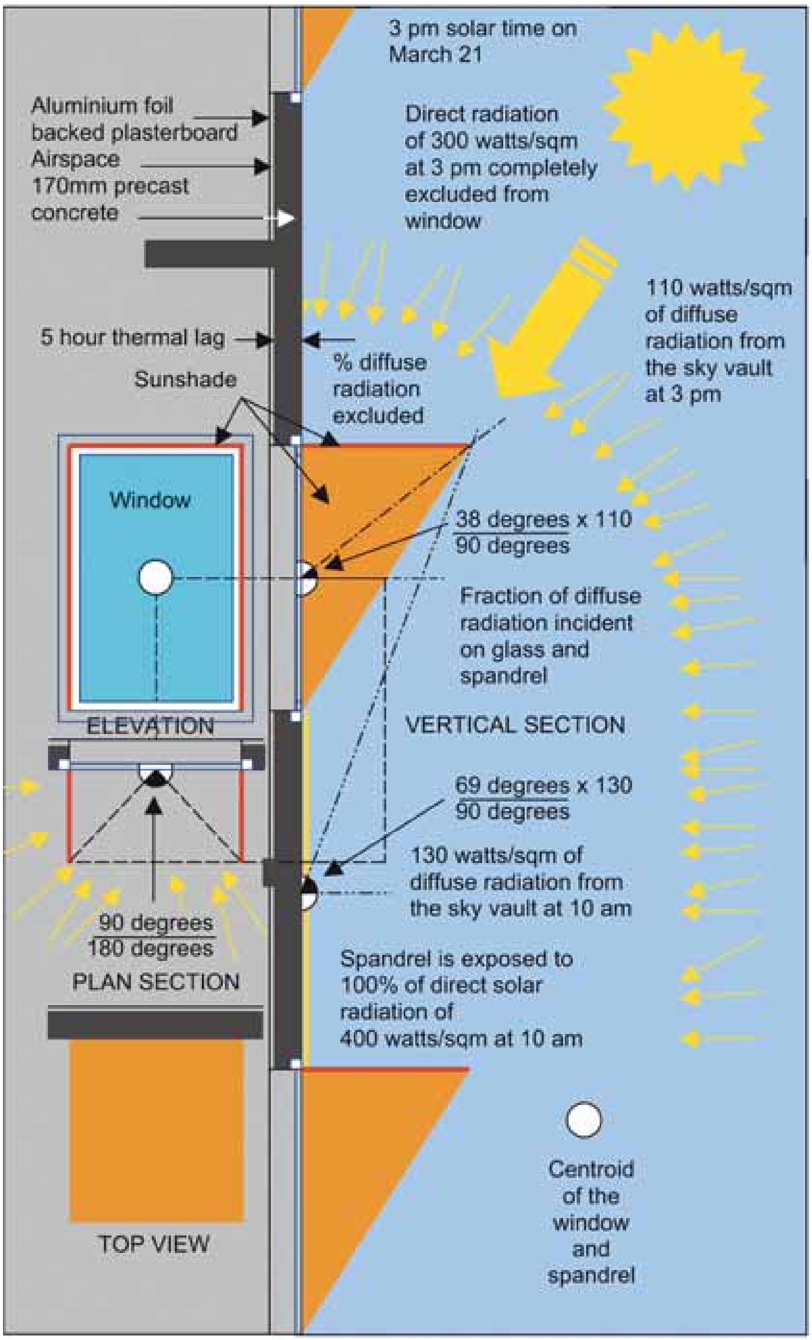


Fig. 1. A simple sunshade in front of a north facing window at latitude 32.5 degrees South showing exclusion of the direct component of solar radiation from the window, incidence of the direct component of solar radiation on the spandrel; and incidence of a fraction of the diffuse component of solar radiation on the window and spandrel.

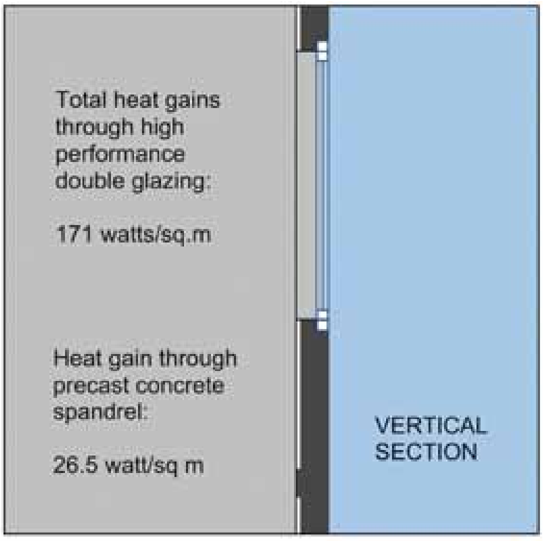


Fig. 2. Heat gains through unshaded high performance double glazing and spandrel.

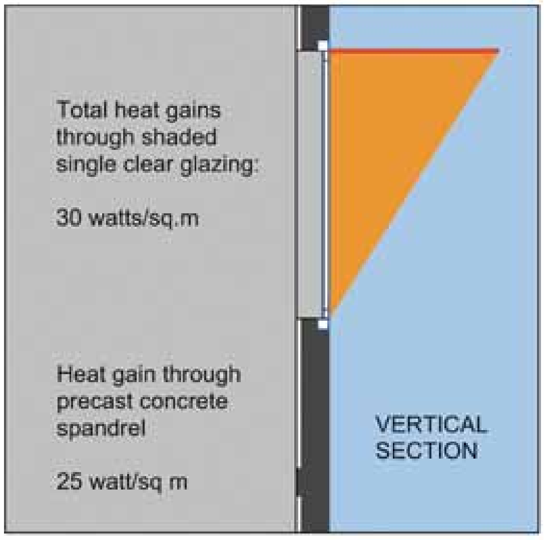


Fig.3. Heat gains through shaded single clear glazing and spandrel. Spandrel not shaded from direct solar radiation. If spandrel were shaded from direct solar radiation, heat gain through the spandrel in March would be almost negligible. All of this 25 watts/sq.m results from the Sol-air temperature.

In these simple calculations thermal lag has been considered but thermal capacitance has not. Consideration of thermal capacitance would further reduce calculated values of heat gain through the spandrel.

Thermal capacitance has not been included here because benefits of the thermal capacitance of concrete would be small compared to the benefits of shading which is the focus of this article.

NORTHERN FAÇADE TYPE B: *Windows shaded by sunscreens with clear single glass in the windows.*

Q1. Calculate the instantaneous heat gain through the window from the *direct* component of solar radiation at 3.00 pm.

Given that the glass is entirely shaded from the direct component of solar radiation, the instantaneous heat gain from the direct component of solar radiation is zero.

Then Q1, the instantaneous heat gain, from the direct component is **zero watts.**

Q2. Calculate the <u>instantaneous</u> heat gain through the window from the <u>*diffuse*</u> component of solar radiation at 3.00 pm

Say the transmissivity of clear glass to diffuse radiation is 70%

Assume a sunscreen that admits diffuse radiation in the vertical section for 38° of 90°

ie $\frac{38}{90}$

Assume the sunscreen admits diffuse radiation in the horizontal section for 90° of 180° ie $\frac{90}{180}$

Q2 $= 1.0 \text{ sq m} \times 110 \times .7 \times \frac{38}{90} \times \frac{90}{180}$

= 16.2 watts

Q3. Calculate the heat conducted through the *window* glass. Assume U value of single glazing to be 6.0.

Q3 = Area x U x (To -Ti)
= 1 x 6 x (24.8-22.5)
= 13.8 watts

Q4. Calculate the heat conducted through the *spandrel* panel.

Assuming a thermal lag of 5 hours, use the external air temperature and the solar radiation intensity at 10.00 am.

Sol Air Temperature = To + $\frac{I \times a}{f}$

At 10.00 am the intensity of *direct* solar radiation incident on the northern facade is 400 watts/sqm.

At 10.00 am the intensity of *diffuse* solar radiation on the northern facade is 130 watts/sq.m.

Assume the external surface absorptance to solar radiation is 0.5

Assume the external surface conductance is 10.

Assume that the centre of the spandrel is exposed to, say, 69/90 of diffuse radiation from the sky vault; because the sunscreen above which shades the vision panel also excludes some diffuse radiation from the spandrel panel.

The Sol-Air Temperature on the outside surface of the spandrel is therefore

$$= 22.5 + \left\{ 400 + \frac{130 \times 69}{90} \right\} \frac{0.5}{10}$$

= 47.5 °C

Assume the U value of the spandrel is 1.0

The heat conducted through the spandrel panel is therefore

Q4 = A x U x (Sol air temp - Ti)
= 1 x 1.0 x (47.5 - 22.5)
= 25 watts

Total cooling load through Northern façade (A) for 20 floors.
Flush glass facade with high performance double glazed vision panels but no sunscreen.

120 + 44 + 6.9 = 170.9 watts per square meter admitted through the glass

Assume area of glass is 1.5 x 20 and that there are 20 floors.

Then the cooling load admitted through flush glazed high performance glass is

1.5 x 20 x 20 x 170.9 = 102,540 watts

Assume area of spandrel is 2 x 20 and that there are 20 floors

Then the cooling load admitted through the spandrels is

2 x 20 x 20 x 26.5 = 21,200 watts

Total cooling load through 20 floors with Northern façade A = **123.7 kW**

Total cooling load through Northern façade (B) for 20 floors.
Windows shaded by sunscreens with clear single glass in the windows.

0 + 16.2 + 13.8 = 30 watts per square meter admitted through the glass.

Assume area of glass is 1.5 x 20 and that there are 20 floors.

Then the cooling load admitted through the shaded clear glass is

1.5 x 20 x 20 x 30 = 18,000 watts

Assume area of spandrel is 2 x 20 and that there are 20 floors.

Then the cooling load admitted through the spandrels is

2 x 20 x 20 x 25 = 20,000 watts

Total cooling load through 20 floors with Northern façade B **= 38.0 kW**

TABLE 1

Cooling loads on A/C plant for various façade options.*

Façade Options	Cooling loads kW
1. High performance double-glazing and no shading. 100% continuous strip glazing.	123.7**
2. (1) above with 50% of glass replaced with precast concrete	80.4***
3. (1) above with 66.6% of glass replaced with precast concrete	65.9***
4. Shaded single clear glazing. 100% continuous strip glazing.	38.0**

* Façade 20m long and 20 floors high with 1.5m high glass and a 2m high spandrel; being a northern orientation at Latitude 32.5 S and calculated at 3pm in March

** Calculations shown in this article.
*** Calculations based on calculations shown in this article.

Summary

The simple calculation method presented may be used at the initial design stage to determine orders of magnitude of cooling loads on A/C plant resulting from selection of façade options.

Shading glazing is an effective means of reducing cooling loads on A/C plant.

Reducing areas of unshaded glazing reduces cooling loads.

If opaque surfaces could be shaded against solar radiation in March, when the outside air temperature approximates the required indoor air temperature, heat gain through opaque surfaces could be almost completely eliminated. Shading of opaque surfaces would reduce heat gain throughout the warmer portion of the year.

There is therefore a case for reducing energy consumption by the use of precast concrete moulded to provide shading or by attaching sunhoods to the precast facade units.

Acknowledgements

Appreciation is expressed to the following who made helpful comments on this article: Steve Hennessy, AHA Management Pty Ltd; Bruce Forwood, University of Sydney; and John Burke, Rescrete Industries Pty Ltd

PRECAST CONCRETE
Leads the Way in Medium Density Housing

Demand for medium-density housing has ballooned as a result of urban renewal policies in capital cities which bring the population closer to both the CBD's and to public transport access to workplaces. Builders and developers have accommodated this social change by choosing precast concrete systems that can be readily built on restricted sites and that provide design flexibility. Owners and occupiers are attracted by various architectural styles of residential complexes that also offer greater security with modern town houses and facilities available in many varying developments, eg: swimming pool, gym, spa, sauna, BBQ/entertaining areas etc.

Precast concrete is being used extensively in these projects for the following reasons:

- Aesthetically appealing textures and surface finishes
- speed and ease of construction
- superior acoustic and thermal performance
- product accuracy
- cleanliness of the site

Sydney builder, Baseline Constructions, recently won the 2003 HIA Excellence in Housing Award, the Metro Village development at Rosebery with the judges recognising that "precast concrete allowed the design-and-construction team to develop solutions that have delivered the most efficient product".

Site project manager, Peter Groenewegen says "We have decided to construct our buildings in nearly all precast product using steel only to bridge or temporarily support elements until these are finally held after placing insitu connecting concrete and roof structures. Baseline use precast walls, floor panels, as well as beam shells - vertical duct shafts and feature panels."

The size, strength and quality of the precast concrete industry is evident by the way in which it has met the growing demand within medium density residential developments in every state of Australia.

Award-winning residential development, Metro Village at Rosebery in Sydney - all precast except the slab supporting the apartment blocks.

Precast used for the external walls can be profiled to specific architectural requirements and can be supplied ready to receive an on-site painted or applied textured finish or they can be supplied pre-finished from the factory with a variety of finishes.

Precast concrete floor systems provide a cost-effective solution with excellent noise control and safety on site as the precast flooring system once in place provides a safe working platform. As with precast wall panels the precast flooring system can be delivered to site when required, reducing the requirement for on site storage. The elimination or reduction of propping further assists with site safety as follow up trades have easier access. Precast flooring systems include hollowcore planks, permanent or lost formwork systems or prestressed beams with infill panels. Some of these systems require a topping slab to be poured insitu, most systems provide columns and beams to complement the floor system. To find which systems are available in your State please check the NPCAA web site (www.npcaa.com.au)

Precast can also be used for internal walls, load bearing party walls, stairwell shafts, custom made balconies and stairways. Please check the NPCAA web site for manufacturers and availability.

Many NPCAA corporate members are experienced in medium density residential projects. Check with your local NPCAA member to see what innovative and cost effective solutions they can develop with you for your next medium density residential project at the planning stage.

Hume Hwy, Liverpool NSW. Residential development, incorporating cast-in architectural features along with cast in fitments such as electrical switch boxes, antenna outlets, conduits and telecommunication boxes

At Ormond Esplanade, Elwood Vic, the project team took advantage of the speed of construction achieved through the use of precast concrete whilst enhancing the visual aesthetic.

Design flexibility of precast as exhibited at Balmoral St, Prahran Vic. This apartment block has a number of design features including dummy grooves, projections, ornate corbels and splayed window sills.

Division walls being rapidy erected on a completed precast floor of Metro Village.

GUIDE to the new NPCAA web site

A few clicks away from everything you need to know about Precast

We recommend you visit the reconstructed NPCAA web site which provides builders, designers, engineers, architects and students with up-to-date information on all aspects of precast concrete construction.This article is a brief guide on how to get the best out of this site.

The new **home page** (shown opposite) has a central navigation panel to access the various areas on the site. As the cursor is run over each item, an expanded explanation of the area contents is revealed. This same navigation bar, without the expanded explanation, is used on each of the pages within the site.

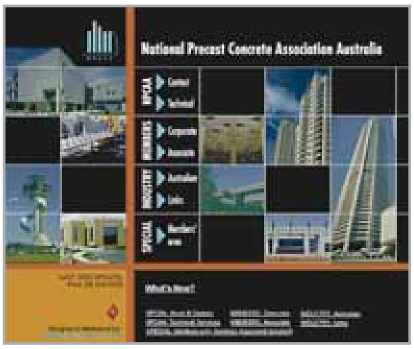
The central area of the site is the **Technical Services** page (shown opposite). It has access to the four major information areas of the site.

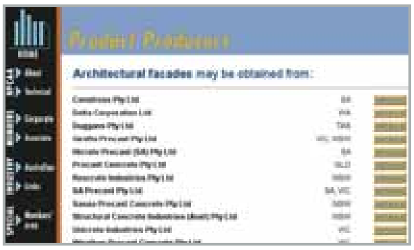
- **Guide to Precasters and Products**, helps with selecting the product for a desired application and then to choose a NPCAA manufacturer to carry out the project.
- Technical information, offers a range of technical data to assist in the design and product selection process, including how to obtain the *Precast Concrete Handbook.*
- Provision for specific information on the five major precast categories (walling, flooring, structural, drainage and GRC)
- **National Precaster** magazine, which includes the current issue online, plus back-issues, as well as a comprehensive index of articles for easy location and reference.

The **Guide to Precasters and Products** allows you to select the product in which you are interested, then to choose a NPCAA member to manufacture the product (shown opposite). Drop-down menus in each of five categories are available. If, for example, you select the *Walling* category and are interested in *Architectural facades*, you will be taken to a list of recommended precasters who can supply these (second screen opposite). From here you may select the *Details* button to be taken to the precaster's contact and profile information, including a link to their web site (bottom screen).

There are plans to expand the amount of technical information, especially free online material. If you become a regular user of this site, a useful feature can be found on the home page (top screen). Just below the central navigation panel is a link called, **What's New?** This will take you to a continually-updated list of additions to the site, with a direct link to the new information.

The NPCAA, through this reconstructed web site, hopes to provides ready access, for members and their customers, to the latest information on the benefits of precast construction.





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