INFORMATION TECHNOLOGY

Lavarack Barracks, Townsville

The new Accommodation Units at Lavarack Barracks showcase tropical architecture, extensive prefabrication of building components, and fire engineering design. OneSteel's products feature strongly, with structural steel sections, reinforcement and DuraGal® products used widely in the construction. OneSteel's fire engineering technology enabled a cost saving of $150,000 by demonstrating, through scale model tests carried out at VUT, that all exposed structural steel elements did not require fire protection.

Project Team

Client:
Department of Defence

Managing Contractor:
Thiess Pty Ltd

Consulting Architect:
Bligh Voller Nield Pty Ltd /
Troppo Architects (Qld) Pty Ltd

Consulting Structural Engineer:
MPN Consulting Pty Limited

Quantity Surveyor:
Douglas Stark Pty Ltd

Specialist Fire Engineering:
BHP Steel / VUT (Dr Ian Bennetts)

Steel Fabricator & Erector:
Cairns Steel Fabrications Pty Ltd

Shop Detailer:
Cairns Steel Fabrications Pty Ltd Private Building Certifier Rod Smith (special projects consultant for Maroochy Shire Council)

FIRE SAFE

The design and construction of the new $62M Living-In Accommodation is the major component of the $139M Stage 2 redevelopment of Lavarack Barracks in Townsville. Home to 1RAR and 2RAR of the Australian Army's 3rd Brigade, which form the Ready Deployment Force currently serving a peace keeping role in East Timor, the new accommodation will replace existing buildings built in the 1960's. The twenty-month redevelopment will provide 1000 new accommodation units, with completion scheduled for December 2001.

Thiess Pty Ltd, as Managing Contractor for the Department of Defence, recognised early in the project that the high degree of repetitive construction required would afford an excellent opportunity for a fully integrated precast and prefabricated building system. Thiess engaged structural consultants MPN and architects Bligh Voller Nield in conjunction with Troppo Architects (Qld), to evaluate existing industry prefabrication systems. None of the existing systems however were able to satisfy the stringent requirements for design flexibility, value for money, durability and volume capability unique to the project.

Thiess, in cooperation with the design consultants, developed an innovative design and construction system that is fast and economical to construct, whilst providing a framework for traditional high quality residential finishes.

ARCHITECTURE

The architects paid careful attention to the siting and orientation of the accommodation buildings so as to create a positive identity for Lavarack Barracks. The architecture of the accommodation units reflects the principles of passive energy efficiency through appropriate north/south orientation, sun shading, colour and appropriate use of building materials. Acoustic privacy, design for the hot humid tropics and energy efficient low maintenance and low life cycle costs are also addressed.

Some of the strategies employed by Bligh Voller Nield/Troppo Architects to reduce life cycle costs included the maximisation of natural lighting and ventilation, the selection of minimum maintenance external materials and finishes and the use of lightweight insulated external walls. This was exemplified by the choice of:

- Lightweight steel framing, light coloured steel cladding and modulated facades responsive to the tropical climate and environment
- a narrow floor plan complimented by large window openings, thereby maximising cross ventilation
- deep overhanging roofs and sun shading and weather protection to windows, entries and stairs

Construction solutions also needed to suit off-site fabrication, minimise site disturbance and offer low maintenance.

STRUCTURE AND CONSTRUCTION

According to Murray Frame, Thiess's project manager, **structural steel was a natural choice** for major elements of the accommodation buildings as it consistently satisfied the project design brief through **its ability to be prefabricated, its cyclonic strength, durability, low maintenance and speed of erection.**

The building system incorporates a number of pre-finished and prefabricated structural steel elements including:

- Structural steel channel section beams and hollow section columns, supporting precast concrete floors
- Prefabricated structural steel bracing/infill walls
- Prefabricated roof structures
- Awnings and sunshades
- Stairs and balustrades
- Security gates and privacy screen frames

The structural framing system, designed by MPN, comprises precast concrete floor slabs supported on a system of steel beams, precast concrete end walls and precast concrete dividing walls between units. The precast concrete floor units are supported on steel brackets that are connected to the concrete wall panels. Longitudinal stability of the building is provided by steel framed external bracing walls, whilst lateral stability is provided by the precast concrete end walls and dividing walls (which also serve to provide the necessary acoustic and fire separation between units). The external wall cladding is a combination of precast concrete, structural plywood and steel cladding, whilst the roof is steel framed and steel clad.

A critical element of the building system is the steel-framed infill wall panels which were prefabricated, complete with windows, external cladding, permanent bracing and pre-drilling for electrical services. The use of prefabricated panels provided such additional benefits as:

- Minimising the necessity for temporary propping
- Improving site safety by reducing the risk of 'prop failure'
- Improving the speed of construction
- Eliminating the need to use external scaffolding, which would have been otherwise required to apply finishes
- Ensuring partly erected buildings are always fully secured in the event of a tropical cyclone

Prefabrication also applies to the bathroom modules which were completed off-site (including all fixtures, fittings, tiling and zincalume cladding) before being transported to site, lifted and fixed in final position.

The stairs, balustrades and sunshades are significant architectural features. The stair stringers are galvanised steel and the balustrades are framed in steel SHS, in-filled with small aperture mesh, and hot dipped galvanised. Awnings have galvanised angle frames and have been designed for ease of erection. The steel elements therefore complement the overall architectural concept whilst meeting the client's requirements for a low maintenance building fabric.

Roof elements are steel and are designed to be pre-assembled at ground level, including all roof and ceiling cladding. The completed roof elements are then be lifted in segments into final position and fixed in place.

FIRE ENGINEERING

To achieve further economies, Thiess engaged OneSteel to carry out a fire engineering study to determine the extent of fire protection required to the exposed structural steel elements. The study was undertaken on OneSteel's behalf by Dr Ian Bennetts of Victoria University of Technology. The research, which included fire tests on a scale model of a typical accommodation unit, concluded that passive fire protection could be deleted from all exposed steel elements, resulting in a saving of $150,000 to the project.

Alternative Design

An alternative design solution was proposed in preference to the conservative provisions of the Building Code of Australia (BCA), satisfying the fire safety objectives and relevant performance requirements of the Code. In summary, the BCA objectives require the building to be designed to:

1. Allow safe evacuation of the occupants
2. Not put the fire brigade at risk
3. Avoid the spread of fire to other buildings
4. Avoid damage to other buildings

The BCA is concerned with ensuring adequate life safety for all occupants of a building on a site. Objectives (1) and (3) are particularly concerned with this since occupants may be threatened by a fire which initiates within the building they occupy, or by a fire which spreads to their building from another building. Objective (2) is unlikely to be an issue with these residential units due to their limited height and the fact that the fire brigade will have a limited role in effective fire fighting. Objective (4) is concerned with protecting third party property and is a consideration in this instance, notwithstanding the fact that the Department of Defence owns all the assets on the Barracks.

The proposed construction comprises mainly precast concrete and steel framed elements. The precast concrete floor units are supported on steel brackets that are connected to the precast concrete dividing walls and end wall panels. The external wall cladding is a combination of precast concrete, structural plywood, and steel cladding, whilst the roof is steel framed and steel clad.

For the proposed construction to satisfy the Building Code of Australia's deemed-to-satisfy provisions, all elements (apart from the roof) would require an FRL of 90 minutes. In addition, there would need to be at least 6m separation between adjacent buildings such as the residential units and the carports. The alternative solution that was successfully proposed did not require the structural steel members to have an FRL of 90 minutes, and a separation of less than 6m in some locations.

PRECAST CONCRETE PANEL REINFORCEMENT

The precast concrete floor and wall panels were supplied by Precast Concrete Group and featured the use of OneSteel Reinforcing's 500 Mpa Ribbed Wire Mesh and N10 deformed bar (a OneSteel 500PLUS® Rebar product). OneSteel Reinforcing was heavily involved in detailing the reinforcing mesh combinations required for the panels and also manufactured the mesh specifically for the project. This assisted in reducing scrap and cutting on site.

STEEL FABRICATION AND ERECTION

Cairns Steel Fabricators fabricated approximately 1,000 tonnes of steel for the project, including RHS columns, PFC floor beams and rafters, and handrails. This also included 140 tonne of OneSteel 75x40 DuraGal Channel in wall frames, typically 2.4m high and 3m to 6m in length.

FIRE ENGINEERING IN DETAIL

Acceptance Criteria

The performance criteria relevant to the use of structural steel members associated with the proposed construction is CP1, which is concerned with structural stability. A conservative acceptance criterion is therefore:

Acceptance Criterion 1 – that the Alternative Solution incorporating structural steelwork will be acceptable provided the steel members do not collapse in the event of exposure to the relevant design fires.

The performance requirement relevant to fire spread between buildings is CP2.

Acceptance Criterion 2 – that the Alternative Solution spaced closer than 6m to the adjacent carports will not experience spread of fire should a fire develop within a carport.

Design Fires

Design Fire 1 – a fully developed fire associated with a ground floor unit (a unit fire is potentially most serious if it occurs on the ground floor since it has the potential to affect those people within the units above).

Fire load density of a typical unit is 18 kg/m² of equivalent wood mass per unit floor area. Various approaches to assessing the potential fire severity were used.

Small scale fire tests were utilised where steel members representing external beams and columns were instrumented with thermocouples and the air temperatures were measured at these locations within the unit throughout the tests. The combustibles within the unit were represented by methylated spirits in trays. Two tests were conducted, each with a different level of fuel within the trays. The tests showed that the rate of burning within the unit was as if the fuel was located in the open with air flowing in and heat flowing out of all openings (windows and doors) associated with the unit. For the higher quantity of fuel, the fire burnt for 4 minutes with air temperatures of more than 800 deg C. The steel temperatures reached by the external members were substantially less than that achieved by the internal members.

What is likely to be the severity of a fully – developed fire within the residential unit? Tests conducted by British Steel indicate that the fire is likely to be equivalent to a standard fire test exposure of about 20 minutes. Calculations using mass loss rates associated with wood cribs indicate that it would be expected that the fire will burn out in about 15–20 minutes, with high temperatures (>500 deg C) being experienced for about one–half of this time. It is expected that the maximum air temperature would be 900 – 1000 deg C.

Design Fire 2 – is associated with a fire in a carport. Fire starts in carparks are very rare, being about an order of magnitude less than fire starts in offices. In the barracks situation, security will be tighter than in normal carparks and the likelihood of a fire being deliberately started will be even lower than for normal carparks. Nevertheless, it is possible that a fire associated with a car may develop. Based on test observations associated with previous BHP carpark fire tests it is considered that the flaming

FIRE ENGINEERING MODELLING AT V.U.T.

"...an excellent opportunity for a fully integrated precast and fabricated building system."

associated with a car fire may result in a vertical sheet of flame 2.5m wide x 4m high with a temperature of 900 deg C. This can be assumed to be issuing from the rear edge of the carport roof. This corresponds to an emitted radiation of 96kW/m², assuming an emissivity of 0.9. Other combustibles within the carport or the timber associated with the carport construction may be involved in a fire; but these are not considered likely to give rise to a more severe radiating vertical plume.

Impact of the Design Fires

Design Fire 1 – there are two steel beams and one steel column within the residential units. The steel beams are above the bathroom module and the steel column is located adjacent to a wall. Should the steel members be unprotected, limiting steel temperatures may be achieved, given this design fire. If the space above the bathroom module is closed with ordinary plasterboard, this will prevent flames entering this space for some time and will offer sufficient protection to ensure that the temperatures achieved by the steel members are well below the limiting value of about 600 deg C.

The internal column, if clad with ordinary 13mm plasterboard, will have a temperature that is well below the limiting value. The steel brackets providing support between the precast wall elements and concrete floors will not get sufficiently hot to result in failure due to the shielding offered by the concrete elements (i.e. the steel brackets are not exposed to fire on all faces) and their reserve capacity. Calculations based on the model tests indicate that the beam supporting the stairs may reach 350 deg C and the exterior columns, about 200 deg C. All of these temperatures are well below limiting values.

The occupants of the unit of fire origin will need to have evacuated well before full fire development if they are to survive due to the severity of smoke and flames within the unit. The biggest life safety issue is in relation to the potential occupants above the unit of fire origin. In this regard there are two possibilities for survival ie. the occupants leave prior to full fire development or, the occupants remain where they are and hope that the fire does not spread to their unit from the unit of fire origin below. It should be noted that should the fire reach full development, it will not be possible for the occupants to pass the stairs due to the level of radiation. This is because the flames will travel along the balcony/landing and upwards – and there will be additional radiation from the other openings. A fire capable of heating the supporting beams to 300 deg C will result in excessive radiation as far as human tenability is concerned.

Design Fire 2 – in this case, the occupants will only be at risk if the fire spreads to the adjacent units. A radiant heat exposure of 20 kW/m2 is required for spread of fire to adjacent buildings. This value must not be exceeded at the facade of the residential units. Radiation calculations associated with this design fire indicate that the radiation at the facade of the residential units varies with distance as given below:

Distance b/w Carport and Units (m)	Incident Radiation (kW/m²)
3	24
4	16
5	11
6	8

It follows that the distance between the carports and the facade of the units should not be closer than 4m.

Impact on Fire Brigade – Since the residential units are restricted in height, fire fighting can be undertaken from outside the building. Should fire break out in an upper level residence, direct access can be obtained by the stairs. The structural adequacy of the building will be maintained in the event of a major fire.

Evaluating the Alternative Solution

A comparison of the Acceptance Criteria with the outcomes presented above demonstrates that the Alternative Solution satisfies the criteria provided that the internal steel members are protected as described, and that the spacing between residential units and the carports is not less than 4m. Accordingly, performance requirements CP1 and CP2 will be achieved.

Specifically:

- Structural steel members external to the proposed units do not require fire protection.
- Structural steel members inside the residential units should be protected with 13mm standard plasterboard. In the case of the beams above the bathroom module, the cavity should be blocked with a bulkhead to reduce exposure of the steel beams to fire. In the case of internal columns, these should be clad with a single layer of plasterboard.
- The spacing between the carports and the faces of the residential units should not be less than 4m. If this is the case then fire spread between carpark and residential units will not occur.
- Some means for early fire detection and warning system should be considered – particularly to give early warning to those occupants above the unit of fire origin.
- Adequate means for occupant fire fighting should be considered.

Footnote: At the time these tests were conducted OneSteel was BHP Steel, a division of BHP.

FIRE SAFE