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YULARA TOURIST RESORT FABRIC SHADES AND ROOF

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SUMMARY

The paper describes the fabric shades and roof structure currently being constructed for the Yulara Tourist Resort. Details are given of the various fabric elements and the supporting structure, in addition the methods adopted in the form finding and structural analysis are briefly described.

INTRODUCTION

The Yulara Tourist Resort is located on the outskirts of the Uluru National Park in the heart of Central Australia. The Park is situated 460 kilometres south-west of Alice Springs and contains a number of unique geological formations including Ayers Rock and the Olgas.

In the past visitors to the Park have been accommodated in Motels and at a camping ground in close proximity to the Rock. These facilities are no longer able to cater adequately for the increase in tourist demand. In addition, the existing accommodation is a random and uncoordinated development.

The principal objective of the Yulara Tourist Resort is to provide accommodation and servies to meet the demands of the increasing tourist industry whilst creating a development which respects the natural environment. The resort will cater for 4200 visitors per day and approximately 400 residents in a virtually self contained village.

The initial conceptual design for the project introduced the idea of using shade structures over part of the development. The fabric shades form parasols over buildings and pedestrian spaces providing protection from the hot summer sun whilst allowing warming winter sun to penetrate the spaces below. In addition the shades will provide a significant visual impact and a sense of three dimensional enclosure to public pedestrian spaces. The shades also reduce the heat load on buildings below and hence the air conditioning requirements.

In addition to shade structures the architectural concept includes a fabric roof over a major part of the central facilities to Resort Hotel 2. Being translucent the roof will provide a significant visual impact internally during the day and externally at night.

During the design development stages of the project considerable effort was directed towards the provision of the most suitable solution to the architectural concepts. Extensive studies into the availability and performance of suitable materials were undertaken and discussions took place both in Australia and overseas. As a result of these discussions suitable fabrics were identified which were economical and could adequately resist the environment at Yulara.

GENERAL DESCRIPTION

The description is divided between the shade structures, roof structures and supporting structures.

Shade Structures

Shade structures are provided in a number of locations, these being:

i) Over the plaza and buildings of the Visitor's Centre - 2700 m^2

ii) Over the pedestrian spine between the flats along the Mall - 250 m^2

iii) Over the shopping square - 500 m^2

iv) Over and around the central facilities to Resort Hotel 2 - 4300 m^2

v) Over pedestrian spaces in Resort Hotel 2 - 400 m^2

vi) Over the community facilities amphitheatre - 200 m^2.

vii) Adjacent to the camp ground control building - 240 m^2

Fabric Elements

Of the total fabric area of approximately 8600 m^2 the majority are in a hyperbolic paraboloid or hypar shape, these being over the Visitor's Centre, Resort Hotel 2 central facilities, the shopping square and the camping ground. The hypar is in essence a square piece of fabric supported at each corner with two opposite corners higher than the two other corners. The shades span approximately 10.8 metres and have a rise between high and low points of 2.6 metres. The lowest part of the shade is between 4 and 6 metres above finished ground level.

The selection of the hypar is conditioned by architectural requirements and the need, in a tension membrane structure, to adopt an anticlastic shape. An anticlastic shape is one in which reverse curvatures exist at any point on the surface and enable upward and downward loads to be supported by the fabric acting in tension, while providing drainage to all sections of the shape.

To eliminate flutter and to reduce deflections it is necessary to prestress the fabric. This is achieved by boundary cables in a catenary form which pass through flaps formed at the edges of the fabric elements.

The hypar shape is achieved by patterning the fabric into strips with curved edges. The fabric pieces are welded together to form the completed shape.

The shades over the pedestrian spine are a rectangular shaped prestressed shade supported by tubular steel portal frames. The span of these shades is approximately 1.8 metres.

The shade elements in Resort Hotel 2 rooms are in the form of an inverted anticlastic cone. Two sized elements are used, one on a 7.1 metre grid and the other 7.1 metres by 5.2 metres. The shades are supported on a steel frame fixed to the buildings with a central cable at the low point anchored to the ground beneath.

The amphitheatre in the community facilities is to be covered by a free form fabric structure with overall plan dimensions of 10 metres by 20 metres. The form consists of 4 high points and 4 low points. The fabric shape is defined by the patterning, masts and cables to provide a uniformly stressed shape.

Supporting Structure

The supporting frame for the hypar consists of a series of vertical steel masts on a 10.8 metre grid. The masts are stabilised by cables in the form of an 'X' in a vertical plane. The height of the X is 2.6 metres and coincides with the fixing points for the shade fabric. At the boundaries the masts are stabilised by inclined steel cables which are fixed directly to the ground or via inclined struts.

The cables are pretensioned and resist the forces induced by pretensions applied to the fabric and wind induced loads on the fabric and masts. To minimise the size of the masts all of the lateral forces are resisted by the cables and bending forces in the masts are reduced as much as possible.

The masts are fabricated from circular hollow sections 168 or 219 mm in diameter. Plates are welded to the tubes to provide a connection for the stabilising cables. Cables are galvanised strand with appropriate end fittings and turnbuckles which allow for adjustment and a means of tensioning the structure.

The supporting framework over the pedestrian spine is a welded structure fabricated from 76 mm diameter tubes. The framework is connected to adjacent buildings for stability. The individual frames are connected together and stabilised by braced frames at appropriate locations along the length of the spine.

In the case of the rooms to Resort Hotel 2 the inverted cone elements are provided with boundary cables and a central ring. The boundary cables are connected to steel frames which are supported on the main building frame and the central ring is pulled down by means of a cable to an anchor foundation.

For the amphitheatre to the community facilities the supporting structure is an integral part of the fabric shade and consists of tubular masts connected to the fabric by boundary cables and stabilised by inclined cables to anchor foundations.

In all cases where foundations are required these are reinforced concrete bases. Where uplifts occur the bases are buried and the mass of concrete and soil utilised to resist the uplift forces. Alternatives were considered but the number of bases required and possible geometrical problems precluded the use of alternatives such as tension piles.

Roof Structures

A tension fabric membrane roof is used in the main public areas of the central facilities to Resort Hotel 2. The total roof area is approximately 2000 m^2.

Fabric Elements

The roof is a double reverse curved anticlastic shape in the form of a saddle. The fabric passes over curved arches and is patterned to achieve

the doubly curved shape. The fabric is tensioned in one direction only, along a line parallel to the direction of span of the arches. The warp of the fabric runs at right angles to the direction of span of the arches and tensioning in the weft direction will straighten the yarns which will induce a pretension in the warp.

The fabric is be free to slide along the direction of the arches and is tensioned into a box gutter. The end bays of the barrel vaults are terminated by bringing the fabric down to the gutter and eliminating an arch rib in the end panel.

Supporting Structure

The supporting structure consists of tubular curved arch ribs at 3.6 metre centres which span between steel box gutters. The box gutters span 10.8 metres between tubular masts which also support shade elements above. The arch ribs span 5.4 metres and a box gutter is located midway between the masts which are on a 10.8 metre grid. This gutter is supported by means of a hanger from the cables which stabilise the masts. Around the perimeter of the building the gutters are supported on 76 mm diameter tubular mullions at 1.8 metre centres. A horizontal cable spans between the arch springing points to reduce the spread of the arch under pretension loads on the fabric.

FABRIC SELECTION AND SPECIFICATION

Over a period of several months a detailed investigation was conducted to identify suitable materials for the project.

During the early stages solid and open weave fabrics were investigated. As the project progressed it became apparent that open weave fabrics would not be suitable and the effort therefore concentrated on solid membranes. Suppliers throughout the world were contacted and details of various fabrics obtained. A range of suitable fabrics was identified and included in the specification for the work.

The materials considered in detail are listed below. From the investigations carried out it became apparent that either a good quality PVC coated polyester or teflon coated fibre glass were appropriate. On the basis of cost PVC coated polyester was selected.

Fabrics considered included:

i) Acrylic Canvas
ii) PVC Coated Polyester
iii) Hypalon Coated Polyester
iv) PTFE Coated Glass

STRUCTURAL DESIGN

General

It was considered important to provide a support structure which is visually light and in principle all structural members were required to be slender. A number of possible alternatives were investigated and the final solution consisted of a series of steel tubular masts on a 10.8 metre grid stabilised by guy cables and braced so that any one or all of the fabric shades can be removed at any time.

Loadings

The principal loading applied to the shade structures is that due to wind. Wind loads were determined on the basis of the Australian Wind Code (AS1170) in conjunction with a number of other codes and references. Wind tunnel test results were used to establish the pressure distribution over the hypar elements.

Form Finding

Whilst in some cases physical models were used to assist in the architectural design, for structural purposes mathematical models were used to determine the form of all fabric elements.

The form finding analysis was carried out using a computer program developed by Ove Arup & Partners in which the structure is divided into a series of triangular elements. The surface is described initially as a flat sheet and then modified to allow for fixed boundaries. Applied forces to the system take the form of fabric pretension and, where appropriate, boundary cable pretension. The analysis method is based on the fact that to get from one state of equilibrium to another a structure must move. By writing the equations of motion and applying damping to make the structure come to rest, the analysis method is following exactly the procedure that occurs in nature.

The output from the form finding analysis is a series of coordinates which describe the shape of the structure prior to the application of external loads. The form finding analysis can be extended to produce cutting patterns.

Fabric Analysis

The analysis of the fabric to external loads was carried out using the same program as that used for the form finding.

External applied forces in the form of boundary cable pretension, fabric pretensions and pressure loads on the fabric surface were applied to the form found shape and deflections, stresses and reactions obtained.

Supporting Structure Analysis

The fabric is non linear by virtue of the fact that large deformations take place which modify the shape of the structure and the fabric does not have the ability to support compressive loads. The supporting structure is relatively stiff and large deformations are not a consideration, however cables have been used extensively, and it was necessary to allow for this in the analysis.

A finite element computer model was used and pretensions were applied to the cable members as a temperature load. External forces in the form of reactions from the fabric elements were applied and an iterative analysis performed in which the inability of the cables to carry compression loads was modelled.

Construction Progress

All fabric items have been fabricated and installation is well underway. 23 hypar shades have been erected in the Visitor's Centre as have 2 hypars at the campground.

The shades for the flats and mall, Resort Hotel 2 rooms, Retail Square and Amphitheatre are expected to be erected in June/July. Erection of all fabric elements is expected to be complete by September.

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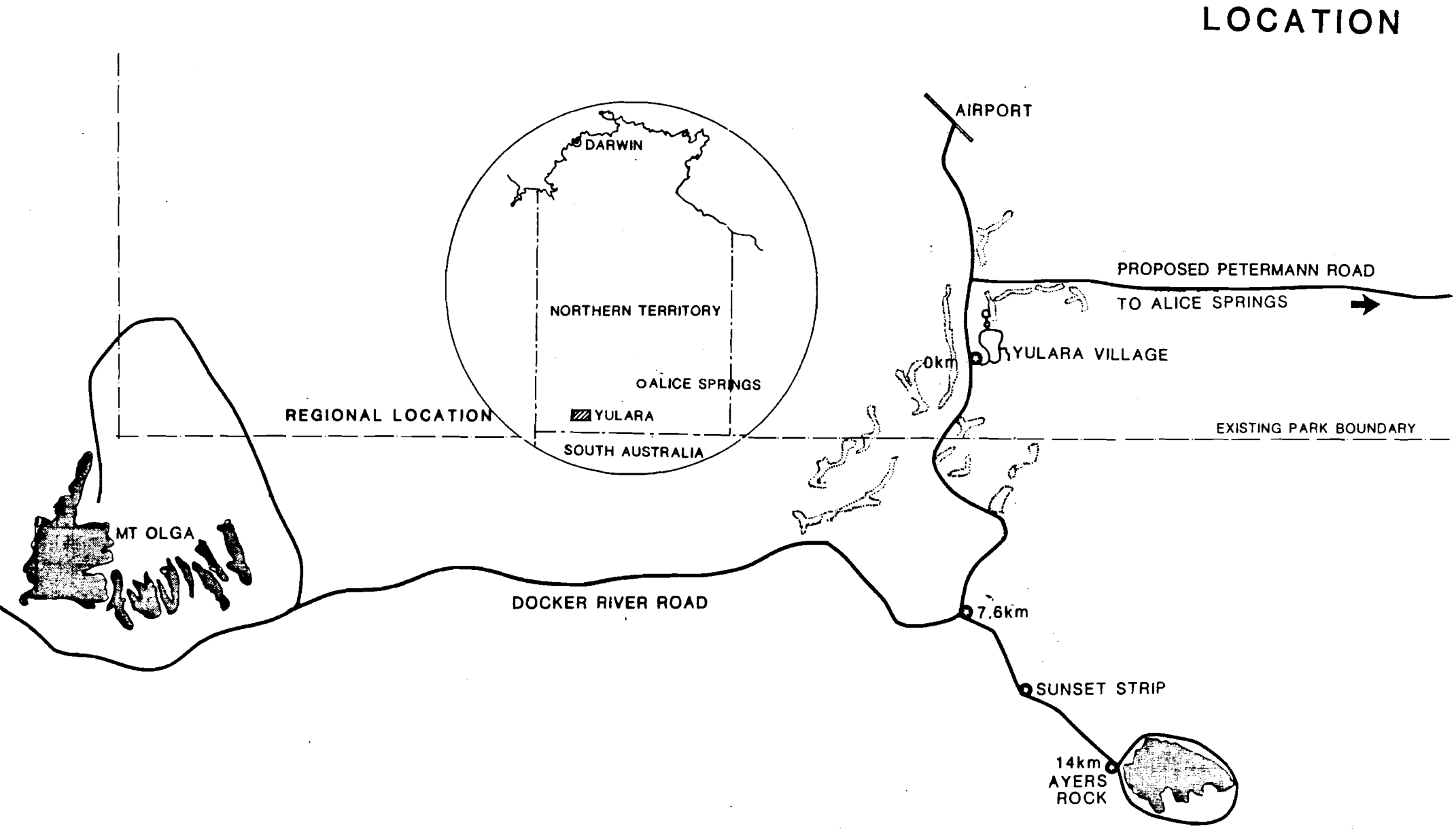
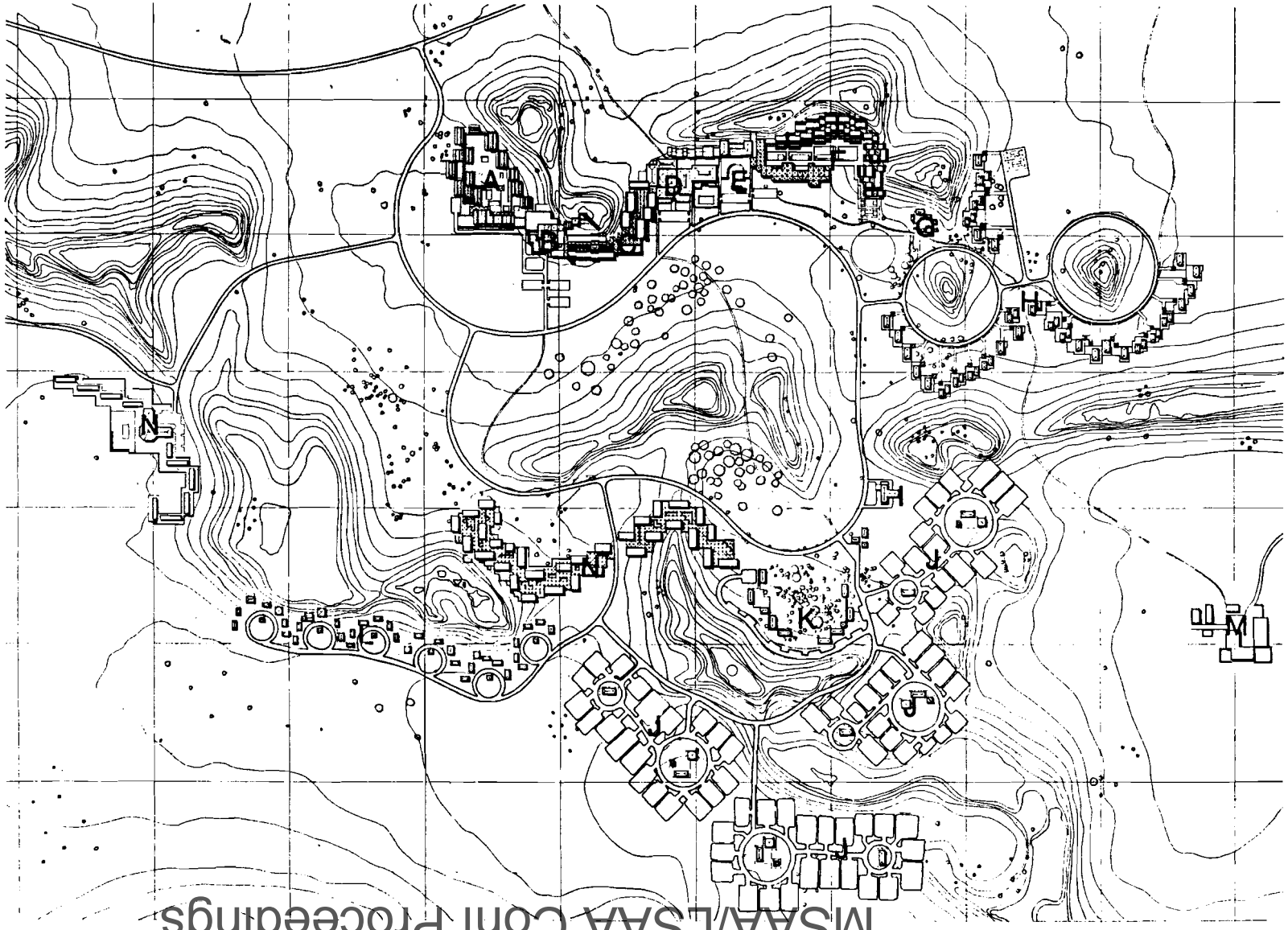
Client - Yulara Development Corporation
Project Manager - White Industries Limited
Architect - Philip Cox & Partners Pty Ltd
Construction Manager - P.D.C. Constructions (NT) Pty Ltd
Consulting Engineers:
Structural - Ove Arup & Partners
Services - D S Thomas Weatherall & Associates Pty Ltd
Quantity Surveyors and Cost Planners - W T Partnership
Main Contractors - Leighton Contractors Pty Ltd
Barclay Bros Pty Ltd
Jennings Pty Ltd
Sub-Contractor - Humes Ltd/Sarna Kunststoff AG


LOCATION
AIRPORT
DARWIN
NORTHERN TERRITORY
ALICE SPRINGS
YULARA
SOUTH AUSTRALIA
REGIONAL LOCATION
PROPOSED PETERMANN ROAD
TO ALICE SPRINGS
YULARA VILLAGE
0km
EXISTING PARK BOUNDARY
MT OLGA
DOCKER RIVER ROAD
7.6km
SUNSET STRIP
14km
AYERS
ROCK

COMPONENTS

A RESORT 1
B VISITOR CENTRE
C FLATS
D SHOPPING SQUARE
E COMMUNITY SQUARE
F RESORT 2
G SCHOOL
H HOUSING
I SERVICE STATION
J CAMPING
K BUNKHOUSES
L ABORIGINAL HOUSING
M POWER STATION
N FUTURE TOWN EXPANSION



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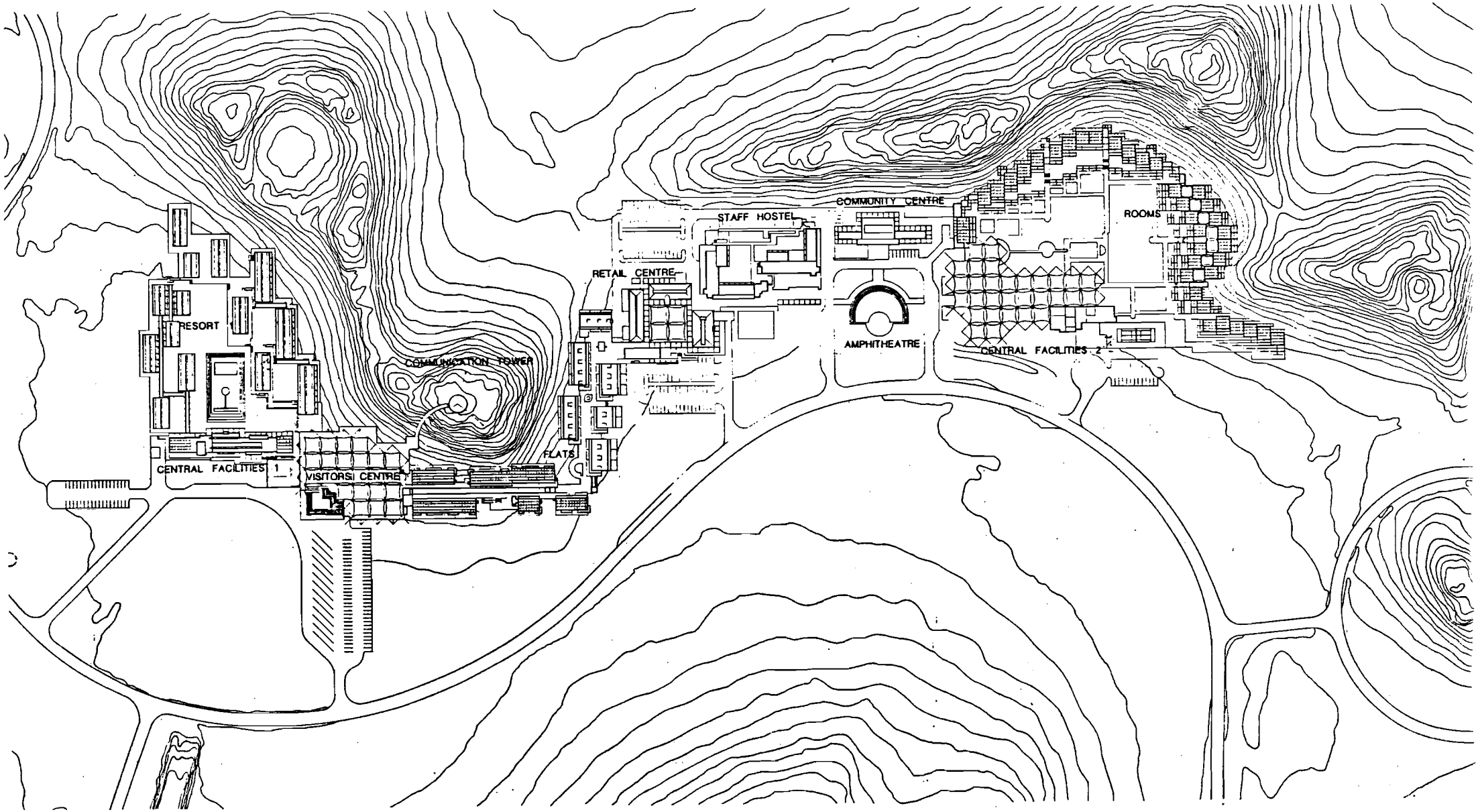
RESORT
CENTRAL FACILITIES 1
VISITORS' CENTRE
COMMUNICATION TOWER
FLATS
RETAIL CENTRE
STAFF HOSTEL
COMMUNITY CENTRE
AMPHITHEATRE
ROOMS
CENTRAL FACILITIES 2
YULARA TOURIST RESORT
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