Little Green Island QLD

NEW HOME
ZONE 1: High humid summer, warm winter

Topics covered
Passive cooling
Orientation and natural ventilation
Rainwater harvesting
Greywater recycling, Compost WC
Design for waste minimisation
Renewable energy generation

AccuRate (thermal comfort)	5.2 (full rating)

This case study is an example of a fully autonomous house that uses no mechanical cooling, generates its own electricity, harvests rainwater and recycles wastewater.

DESIGN BRIEF

The owner (a writer), required a small house that he could use as a retreat to allow time for thinking and writing. The house was to have a large bedroom and living area plus a bathroom, kitchen and a storeroom. Occasionally the owner would do some entertaining so a separate bathroom and multi-purpose, open-plan living area was required.

The house was also to be used periodically for retreats and by guests for meetings. So the building needed a flexible arrangement of spaces. The owner also required that the house should provide maximum comfort but, given its remote location, could not rely on any services from outside the site.

A maximum level of security was essential because of the remote location and the likelihood that the house would be unoccupied for extended periods.

LOCATION AND CLIMATE

The house is located on an island in Queensland. The site is a large area of 30 hectares. It is sited on the only available flat, sheltered area. Existing vegetation filters the extremes of the south easterly winds whilst allowing the elevated design to benefit from controlled cross ventilation.

The climate is highly humid with high rainfall during the three to four month wet season. There are long periods of relatively dry and sunny weather for the remainder of the year. Council required that the house be designed for category 1 cyclone conditions.

Council had no prescriptive planning controls that affected the design due to its remote location. [See: 2.0 Sustainable Communities]

DESIGN RESPONSE

This house has a dominant roof form over open walls that indicates its interaction with the prevailing breezes for cooling. In hot humid climates, wide roof overhangs are required for shading.

The roof is twisted and split open along the long axis of the house to maximise its role in ventilation. Large areas of louvres under the eaves are crucial in providing cross ventilation.

The open plan nature of the house and its flexibility allows the living and bedroom areas to be doubled by the use of adjacent decks. This is important in retaining the feel of the `Queenslander' house style in the tropics.

The design makes maximum use of available breezes to provide year round cooling. Daytime temperatures usually exceed comfort levels.

The cooling design principles were to:

> Elevate the house to increase exposure to cooling breezes filtered through the existing tree cover.

> Provide a large overhanging roof in all directions to minimise direct solar heat gain.

> Ventilate all the eaves edges of the roof to at least one metre high.

> Use a central ventilated ridge that functioned like an aeroplane wing to create uplift and draw cross-draughts of breeze through the house during low breeze conditions and allow convective or stack ventilation.

The house was designed to be built from modular components, fabricated off site and transported to site by barge for erection. A 900mm modular design allowed standard material sizes to be used throughout. This reduced costs and minimised wastage in construction. All plywood and aluminium paneling was made to a 900mm wide grid to minimise any waste at the factory and to ensure that there was no site waste generated from construction.

DESIGN SOLUTIONS

The house has a linear rectangular form with living area and bedroom at each end. The service areas are grouped together either side of a short central corridor.

Decks provide extended living areas on both sides and an extension to the bedroom to the north. In the tradition of the original Queenslander, occupants access rooms via the surrounding verandahs. These external spaces are shaded by wide roof overhangs.

The house has sliding shutters, flyscreens and glass doors, allowing for maximum manipulation of the external envelope. The living area and bedroom have multiple sliding glass doors with matching flyscreen doors. A cyclone proof shutter is fitted in the bulkhead over the doors. This allows equalisation of wind pressure inside and outside the house.

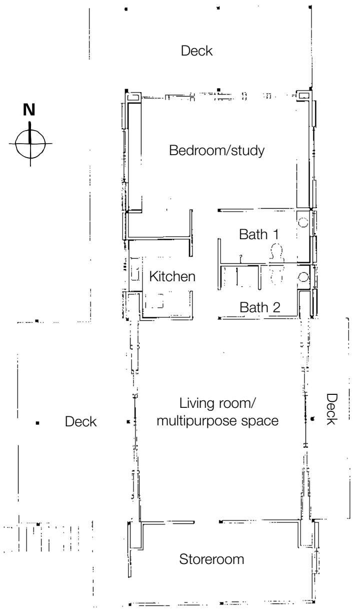
This arrangement allows for four different conditions:

> Shutter closed for cyclone protection.

> Glass doors closed for cooler weather.

> Flyscreened spaces for insect protection.

> All doors open for integration of inside and out.



Orientation and windows

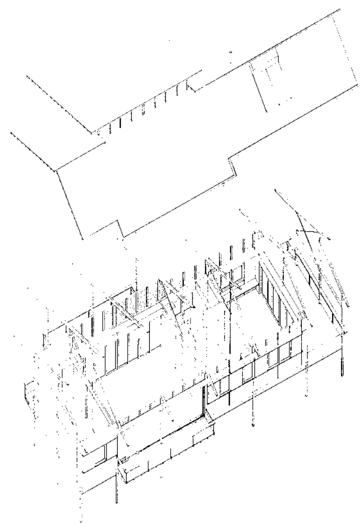
The best aspect is to the north and west, looking out over water with spectacular views of another part of the coastline. Given the shape of the site, the house is oriented to those views from both the living and bedroom areas with a substantial overhang to the west. Existing tree cover to the west also shades the house. The bedroom is oriented north since this is the one space that can benefit from some early morning sun penetration in cooler months. [See: 4.3 Orientation]

Structure and envelope

The main structure of the house comprises steel column and beam sections that provide efficient strength and rigidity against cyclonic conditions. As the site has a high termite content, no timber structure contacts the ground and a large undercroft area allows inspection for termite activity.

Roofing and ceilings are in corrugated steel sheet on steel purlins.

Flooring is sustainably logged local hardwood joists with hardwood floors.



Walls are lightweight modular panels which reduced transport costs. The design was based on a series of panels and structures to allow offsite prefabrication.

Thermal mass and insulation

The house requires cross ventilation in order to attain thermal comfort. The walls are insulated and two layers of insulation in the roof system reflect radiant heat and prevent heat loads from reaching the structure. Convection and cross ventilation remove heat from the building.

In high humid climates with high humidity and low diurnal temperature ranges; thermal mass is of little benefit. Low mass construction responds rapidly to the effects of cooling breezes and has lower embodied energy – particularly on a remote site. [See: 4.7 Insulation; 4.6 Passive Cooling]

Cladding and lining

The external walls are lined with lightweight, high strength, aluminium sandwich panel modules. They provide substantial protection from cyclones and security risks, transport easily and are highly durable in a marine environment. The interior is lined with plantation grown, hoop pine plywood.

Ventilation

Cross ventilation is encouraged through the use of adjustable sliding doors and the permanent louvering system above the doors and at the ridge vent.

Sliding doors are standard sashes fitted to custom designed heads and sills that allow for multiple stacking of the doors, allowing rooms to be completely opened. The windows are also made from standard sliding sash sections with customised heads and sills. They have flyscreens with sliding aluminium screens for external security.

Services

The house has no heating or cooling systems other than the designed, natural systems.

Rainwater / stormwater

Gutters fitted with leaf guard drain to two rainwater tanks beneath the house. Water is sand filtered and drinking water is reverse osmosis filtered. The tanks are sized to allow for collection of the whole year's rainwater supply during the monsoon season. [See: 7.3 Rainwater]

Lighting and daylighting

The house has compact fluorescent fittings installed throughout to reduce energy demand. Using one fitting type on a remote site simplifies maintenance. Waterproof fittings used inside and out keep insects away from the light fittings, extending their life and reducing maintenance.

Uplights are mounted on the wall and use reflectors and the ceilings to distribute the light throughout the house. There are lowered ceilings in the bathroom and kitchen areas to provide lower reflection levels and increase light levels in the service areas. [See: 6.3 Lighting]

Water heating

The house is fitted with a solar hot water system.

All shower and tap fittings are WELS 3 Star rated to limit water wastage. [See: 7.1 Water Use Introduction;]

Energy and appliances

A Remote Area Power Supply system is installed. The system used is a commercially available system (Pyramid Power). This includes a solar tracking array of Photovoltaic

cells, an inverter, a battery bank and a backup generator. The batteries and control system are mounted in a pyramid shaped storage box underneath the panels. The backup generator is rarely required.

Energy from the PV cells is stored in batteries with 12 volt DC output and is converted to 240 volt AC by the inverter to supply the house. This allows use of conventional lights, stereo, computers, etc. The fridge and small cooktop run on imported LP gas to reduce electricity demand. Even the most energy efficient fridge in the tropics would require an excessive number of PV panels, beyond the financial resources of the owner. [See: 6.6 Renewable Energy]

Black / greywater systems

The house is fitted with a single composting toilet system (Rotaloo) that has two pans arranged back to back in the two bathrooms. The system is commercially available and allows for up to two pans and provides a system of composting bins that may be rotated when full to allow full composting before it is removed for use in the garden.

The dry residue has nil health risk if composted properly. The system has Australia wide health department approval. [See: 7.7 Low Impact Toilets]

The waterless toilets reduce water demand by up to one third, reduce the volume of wastewater that must be dealt with and simplify the wastewater treatment system by not mixing pathogens with wastewater. Greywater from the basin, shower and sink is treated in a reed bed system before being used to water non-edible plants. [See: 7.4 Wastewater Re-use]

Landscape

The immediate site area around the house is kept clear of vegetation with a gravel bed. The original mango trees and surrounding tropical forest is maintained in all directions.

Siting the house to have a view of a Hoop pine tree directly outside the kitchen has provided a curiosity as this tree species was used in all the plywood panels lining the internal walls of the house.

EVALUATION

The house has worked as designed for several years. The thorough application of passive cooling principles maintains acceptable levels of thermal comfort year round.

The owner is extremely pleased with the design solutions and said that the house worked well.

The mechanical tracking system on the PV panels failed but the falloff in output was negligible.

Better leaf guard systems combined with a first flush diverter system would reduce water contamination. [See: 2.0 Sustainable Communities]

PROJECT DETAILS	
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