

The Climate-Adaptive Vernacular Architecture of Asia-Pacific

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Figure 1: Traditional Central Japanese tatami room, with view onto courtyard
 (Image: iStock)

ABSTRACT

This note is based on research undertaken as part of a Churchill Fellowship, which included field study in Vigan City, the Philippines; Fujian, China; and Central Japan. The research focused on lessons in climate-adaptive vernacular architecture that can be applied to contemporary works of architecture, thus making our built environment better prepared to cope with climate change.

The locations visited during the course of research regularly experience monsoons, typhoons and large seasonal variations. They are on the same latitudes (16 to 35°) as some of the most populous areas of east coast Australia, with Vigan City on approximately

the same latitude as Townsville, Fujian on the same latitude as Rockhampton, and Central Japan equivalent to Sydney and southern NSW.

With the Australian east coast already experiencing more extreme and variable weather due to climate change (see EDG 66 MSa), designers can draw some valuable lessons in adaptive strategies from the Asia-Pacific region.

Introduction

"To know its environment is to understand an architecture."

Zialcita et al. 2002

Architecture must be suited to its environment, just as much as to its cultural, technological and economic context. The research presented in this paper is concerned with an architecture of resilience, where the prevailing climate has been accommodated through a number of generations, and where severe weather events are a normal occurrence, not just a recent effect of climate change.

Even as weather events are becoming more severe, there is a growing need to move away from an overdependence on energy-consuming climate modulating systems such as air-conditioning and heating. Buildings have to both decrease energy use so as to reduce greenhouse gas emissions, and at the same time be built to adapt to the consequences of climate change (EDG 66 MSa). Therefore it is of outmost importance to look for passive design strategies which can accommodate severe weather events while still providing solutions for human comfort.¹

This paper is based on research undertaken as part of a Churchill Fellowship, which included overseas travel and field study in the Philippines, China and Japan. The research has focused on lessons in the vernacular that can be applied to contemporary works of architecture. The paper contends that it is possible to learn from the Asia-Pacific experience of designing for extreme and variable weather patterns, and to transfer its strategies to an Australian context.

Background

The three localities that were researched were selected both for their climatic conditions and because they have long histories of permanent urbanised settlements where architecture has had the possibility, over generations, to develop subtle and sophisticated strategies to modulate the climate.

The locations regularly experience monsoons, typhoons and large seasonal variations. They are located between latitudes 16 to 35N, thus sharing climatic conditions with a significant portion of coastal Australia, i.e. lat 16 to 35S (Vellinga et al. 2007).

The majority of buildings surveyed fall into the typology of residential architecture. This was not a pre-requisite of the study, however the ease of access to residential buildings, their influence in contributing to the overall urban form and the scale of the buildings made this typology ideal for study. Religious and public buildings were another typology which was easily accessible and well preserved.

Because the locations share climatic conditions with large parts of Australia, it was the hypothesis of the study that climatic responses and principles of climatic design would be transferable to Australia. Despite cultural and historical differences, it will be clear by the conclusion of this paper that this is indeed the case.

Locations

Vigan City, The Philippines: Located on the northwest coast of Luzon island around latitude 16N, Vigan City's climate is classified as equatorial monsoonal/wet tropical. It is affected by both the southwest and northeast monsoons as well as tropical cyclones and typhoons originating in the Pacific.

Vigan City's architecture is one of the best preserved examples of Spanish-Filipino fusion. Inscribed into the UNESCO World Heritage List in 1999², Vigan is cited as



Figure 2: Vigan, The Philippines

¹For the purposes of this research, the definition of 'human comfort' is based on ASHRAE Standard 55-2010, which incorporates the Adaptive Method of thermal comfort, which acknowledges natural ventilation for more sustainable, energy-efficient and occupant friendly designs. To another extent this is intuitive knowledge, because the concept of 'comfort' varies with location, cultural externalities, upbringing, body mass, gender etc.

²Historic Town of Vigan, UNESCO World Heritage List, <http://whc.unesco.org/en/list/502>

representing ‘a unique fusion of Asian building design and construction with European colonial architecture and planning’.

Fujian Province, China: Fujian is located across the strait from the island of Taiwan, around latitude 26N. Its climate is classified as warm temperate and is affected by the Pacific current, seasonal monsoons and regular typhoons. Fujian has some of the highest rainfall in the country, and the relative humidity can reach 85 per cent. It experiences usually mild winters with warm to hot summers.

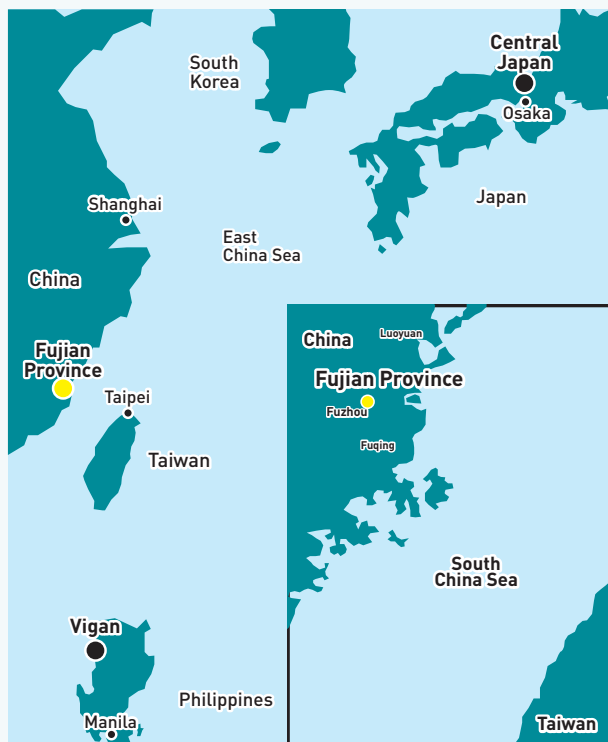


Figure 3: Fujian Province, China

Fujian Province is mountainous, water-rich and geographically remote. These characteristics have contributed to the unique language, customs and architecture of the region. The Fujianese have always been known for building for better comfort in summer – strategies such as sunshading, cross ventilation, drainage, condensation prevention and typhoon protection define their built environment.

Central Japan: Located around lat 35N, the area known as Central Japan centres on Kyoto, Nara, and the Ise Peninsula. Its climate is classified as temperate. It presents mostly hot and humid summers with normally short, but sometimes harsh winters.

Japan’s climate is influenced by its closeness to the Asiatic mainland, by contact with the Pacific Ocean, by exposure to the warm current from the south (Kuroshio) and also at times by the cold current from

the north (Oyashio). Regular monsoons, typhoons and high levels of precipitation in short time spans are prevalent weather patterns.

Summer in Central Japan tends to be the most uncomfortable season, and thus climatic adaptation in the architecture tends towards this extreme.

Kyoto served as the capital of Japan for over 1000 years and was its imperial and cultural centre. Because of this special status, Kyoto was exempt from official regulations on styles and materials of construction imposed throughout the rest of feudal-era Japan.



Figure 4: Central Japan

Kyoto thus evolved a typology of townhouses and urban architecture that became the model throughout the nation, as well as originating the modular building system based on tatami mats (see Materials and Detailing, px).

Environmental Challenges

The research sought to provide strategies for coping with environmental challenges. The most comprehensive solutions will address environmental challenges holistically; however solutions can also be used to address particular challenges, as might be the case in retrofit situations, particularly in already built-up urban areas.

The study focussed on three major challenges:

1. Heat gain
2. Wetness, rainfall and risk of flooding
3. Natural light

Heat gain is the unwanted penetration of heat into internal areas of a building. Unmitigated heat gain increases the temperature of indoor spaces, causing discomfort to occupants and increasing the potential use of energy intensive cooling devices such as air conditioning.

Wetness, rainfall and risk of flooding are climatic factors whose effects ranges from discomfort due to increased humidity, to deterioration and damage to building structures, to potentially fatal events. Mitigating wetness is of particular importance due to the beneficial aspects of rainfall, including a drop in ambient temperature – thus design strategies must allow for cooling breezes to be captured without at the same time introducing wetness.

Natural light is a component of solar radiation whose introduction into building spaces is welcomed as long as it does not increase unwanted heat gain. The design of fenestration must carefully consider the introduction of natural light within buildings. Similarly, urban and building form can be optimised to allow or restrict natural light depending on the desired effect.

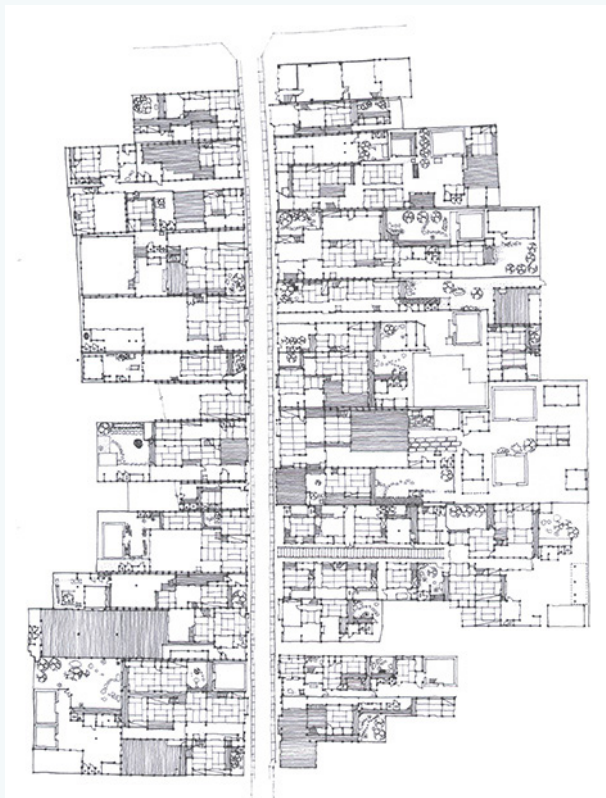


Figure 6: Kyoto street plan
(source: Futagawa 1983)

Design Strategies

To deal with local environmental challenges, Asia-Pacific vernacular architecture employs a mix of passive design strategies. These can be covered off under five headings:

1. Urban form
2. Building form
3. Fenestration
4. Materials and detailing
5. The wet edge



Figure 7: Fuzhou street plan
(source: Ho 2003)

Urban Form

Urban form consists of the layout of cities, the density of buildings within a given area and the hierarchy of transportation corridors. Urban form also defines the relationship between neighbouring buildings, the public and private spaces in between, and the overall pattern of development.

In each of the locations, similar principles have been employed in the layout and organisation of urban developments. High densities and compact form are two main characteristics, as well as the prevalence



Figure 8: Fuzhou laneway

of low and mid-rise buildings. Furthermore there is a clear hierarchy of the streets, laneways and alleys which define the public realm.

Heat gain is mitigated by narrow spacing between buildings, preventing solar radiation from directly falling on exterior surfaces of buildings. Similarly, pedestrians are protected from driving rain along the narrow lanes and alleys.

In order to counteract the more extreme weather patterns that affect the exterior façade of buildings, a combination of various fenestration elements can be seen on the facades facing open streets.

Building Form

Building form and urban form must be considered hand in hand because the one influences the other. In all the locations, the most common vernacular building form is the courtyard typology. This typology allows dense and compact urban plans without loss of amenity for occupants.

In China, courtyard buildings have been in usage since at least the 11th Century BC, with the large variety of courtyard houses revealing the versatility and flexibility of the form. The size, shape, height and detail of the courtyard varies according to location and prevailing climate.



Figure 9: Kyoto street

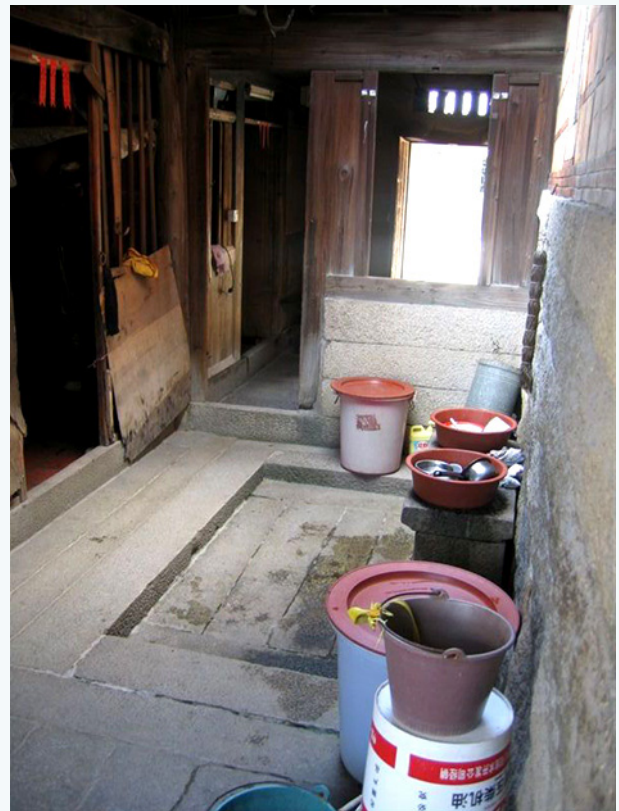


Figure 10: Fujianese skywell

[Source: Assoc. Professor Daniel Benjamin Abramson, University of Washington]

A Fujianese building is typically arranged around one or more courtyards, ranging in scale. Fujianese courtyards are predominantly small and rectangular, with sometimes circular and octagonal variants. Particular to Fujianese architecture are the small courtyards called skywells, often located in the kitchen and service areas of buildings.



Figure 11: Fujianese courtyard in a rainstorm

(Source: Assoc Professor Daniel Benjamin Abramson, University of Washington)

The skywell provides light and ventilation to an area which carries an additional heat load due to cooking. As the skywell is open to the sky it induces stack effect ventilation to remove heat from the space, while its narrow dimensions minimise direct solar radiation. It also collects water via an outlet, which in many cases is connected to a rainwater tank underground.

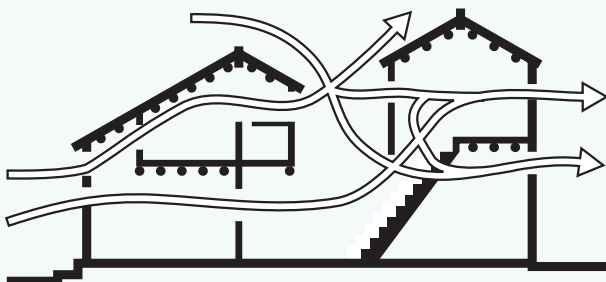


Figure 12: Fujian building section showing cross ventilation

(Source: Knapp 2000)

Each courtyard is a sunken platform, particularly useful during heavy rain because the courtyard acts as a water catchment, detention and dispersion system, much less likely to be overloaded than gutters and downpipes. This methodology of dispersing heavy rainfall keeps the buildings dry and free from dampness.

Also apparent is the fact that with a courtyard typology the rooms on all sides are narrow, and narrow rooms are much easier to ventilate than deep ones. Ventilation is often provided via screened openings which are carefully sized and placed in opposing walls to ensure cross ventilation is effective.

Fenestration

Fenestration describes the system of openings which restrict or allow solar radiation, ventilation and natural light into a building's interior. Fenestration can be conceptualised as an opening in a wall or, as in the case of the Vigan house, a wall which is an opening.

Deconstructing a section of wall of a Vigan house reveals a very sophisticated set of strategies for coping with the extreme heat and wetness of the region, where restricting solar radiation but inducing ventilation is paramount to achieve comfort within.

The fenestration system is made up of several parts which work together to allow varying degrees of control over internal climate:

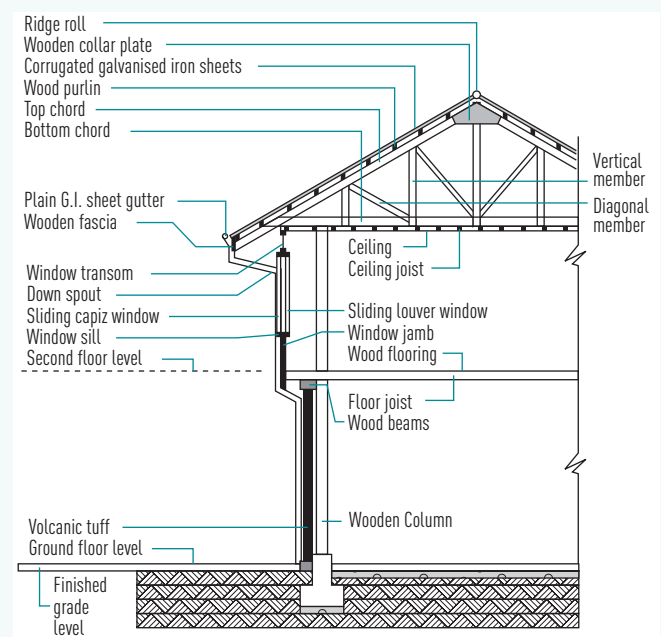


Figure 13: Section of a typical Vigan house

(source: Oliver 1997)

- An outer window screen built as a timber lattice and infilled with capiz shell. This screen filters sunlight as it enters the rooms, diffusing the harsh tropical sun, allowing natural light to enter but reducing heat gain.
- On the inner side of the opening is located a set of operable louver shutters. These can be slid entirely out of the way or they can cover the opening. The louvers can be turned to either an open or closed position, allowing ventilation through or shutting it out completely. When the opening is covered by the screen but the louvers set to the open position, ventilation can enter the rooms during the night without compromising security.
- The lower part of the opening, below the window sill, is a solid movable panel at floor level. This allows occupants varying degrees of ventilation while keeping the upper portion of the opening shut for privacy. A fixed balustrade on the outer face of this lower opening prevents household items, children and pets from falling out.
- At the roof area vent gaps or decorative punched metal eaves allow ventilation into the roof cavity, removing hot air and keeping the spaces below the roof cool.
- Large awnings on slender metal supports provide sun and rain protection for the window openings.



Figure 15: Mixed masonry wall resting on stone base. Fujian



Figure 16: Durable materials used internally and externally, timber columns are lifted off the ground to prevent water damage. Fujian

The superior passive design of the Vigan house can only be appreciated when one enters its cool and breezy interiors despite the heat of the day. The size of the openings coupled with the range of window treatments allow for a full range of options to accommodate varying degrees of light, ventilation, privacy and security.

The Vigan house is a sophisticated response to difficult climatic conditions which remains relevant and in use, offering a wealth of lessons for contemporary architecture.

Materials and Detailing

All over Asia-Pacific, traditional materials of construction were chosen for their ready availability, durability and flexibility. Brick, masonry and stone were routinely used wherever durability was required. Timber was used because it is easily available and easily workable, the craft of carpentry spreading from China to the Philippines and Japan.

Consistently throughout Fujian, granite, masonry and timber are the most common traditional building materials, due to their natural abundance. The base of walls is commonly constructed of granite to offer better protection from dampness and because of its higher bearing capacity.



Figure 17: Screens, sunshades and ventilated eaves on a Vigan house

Walls and floors are made of masonry or stone, materials that can be used both externally and internally due to their durability. These materials can better withstand events like heavy rainfall or flooding, therefore minimising overall damage to the structure and allowing occupants to quickly resume their lives after severe weather events.

The roof structure is composed of an interlocking system of timber beams protected by wide overhanging eaves, offering protection from heat gain and rainfall. The large roof overhangs create intermediate spaces such as verandas, giving another layer of protection to external walls. This layer effect allows in many cases the main living areas of buildings to be left completely open, facing the internal courtyard and allowing air to circulate freely through the building.

In Vigan City is found the Philippines' best fusion of Spanish stone and masonry construction with Filipino timber craft, creating a more durable structure than its all-timber counterparts, better able to withstand typhoons and monsoonal downpours. Similarly in the use of finishing materials, the Spanish introduced ceramic tiles and other forms of masonry which were then incorporated into the walls and floors of buildings, creating surfaces able to cope with heavy rains.

The Vigan house retains the structural system which separates structure and skin, typical of earlier Filipino construction. The ground floor walls, made of stone or masonry, form an overall protective skin of very thick thermal mass that moderates internal temperatures. The structural system is still timber post and lintel members set inside the stone walls, supporting the



Figure 18: Charred cedar finish on external wall. Central Japan

upper floor and roof. This simple arrangement offers better protection from frequent earthquakes, but also creates a curtain wall which led to the non-structural exterior walls being available for a range of large openings with elaborate, layered window and screen elements. Much of the detailing effort in Vigan's architecture is concentrated on the curtainwall elements and the external façade; punched metal eaves for roof ventilation, sunshading hoods at opening and the various screens that make up the opening itself.

Traditionally, Japanese architecture has made use of timber as its primary material of construction. Timber



Figure 19: Timber column raised on stone base. Central Japan



Figure 20: Tatami mats forming floor covering

is used for all the major components of the structure, posts, beams and roof, and as lattices to form the shoji and other screens and partitions. Usually the timber is only oiled at regular intervals but otherwise receives no surface finish, except when used externally. One ingenious finish used for exterior cladding is termed yaki sugi, literally burnt cedar. This process entails the controlled burning or charring of a thin layer of the wooden planks which creates an excellent weatherproof finish. Many new buildings still utilise this method, which requires no further attention or maintenance.

Stone in Japanese buildings is usually reserved for elements at the base of buildings such as columns, steps and thresholds, raising the building off the ground to keep it dry.

The tatami mat is both a system of measure (rooms are usually noted as being, for example, six-tatami, to denote their size) and a floor covering. Tatami continue to be manufactured and widely used. Because they are made from rice straw, a by-product of the rice harvest, the mats have the ability to absorb and release moisture, providing both insulation and humidity control.

The Wet Edge

Over the course of centuries, the architecture of Central Japan has developed sophisticated strategies for adapting to climate. One of these strategies is the engawa, or wet edge, a transitional space between indoors and outdoors which incorporates a number of flexible screens and movable wall elements.

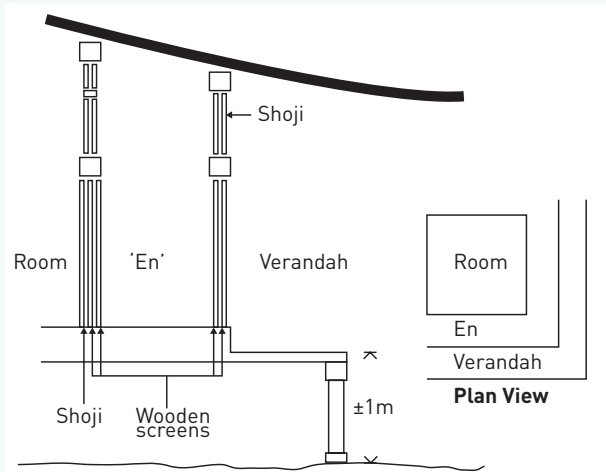


Figure 21: Typical plan of vernacular Central Japanese house

At the most elemental level, Japanese architecture can be described as a platform with a large overhanging roof above. The space between platform and roof is infilled by a post and beam structural system which provides a framework for the incorporation of panels and partitions. It is these that act as separators, connectors and demarcators of spaces within the larger composition. These also serve to create openings or restrict them.

The platform and roof are two elements which modulate climate. Due to heavy rainfalls, the Japanese building's first response is to be lifted off the ground. This can be by as little as a couple of steps for a house, or by as much as half a dozen or more in temples and larger structures. This simple response prevents dampness from entering the building, creates a vertical barrier in the case of rising water levels, allows subfloor ventilation, preventing decay of structural members, and creates a subtle but important sense of separation between private and public domains.

The roof element is usually characterised by its high pitch, long eaves and secondary roofs to protect individual openings and verandas. The combination



Figure 22: The engawa (wet edge)



Figure 23: Glass sliding door working in conjunction with shoji

of long continuous eave and floor platform is the wet edge, protecting the interior spaces from the rain even when the entire elevation is left open. This is highly useful and desirable during the hot summers and long rainy season so that cooling breezes can flow within the building despite inclement weather. This space also shields the interior from solar radiation in the hot months while allowing it to enter to varying degrees during the more pleasant seasons and to the full depth of rooms in winter.



Figure 24: Amado – rain shutters covering the external opening are slid into the box at right



Figure 25: Sudare – reed blinds

The third element of Japanese architecture used to modulate climate can be described under the collective heading of flexible devices. These include screens, panels and partitions which can be moved or removed to modulate climate, falling under several categories:

Shoji screen, a timber lattice panel covered with translucent rice paper on one side. The shoji is a lightweight panel which glides easily and silently on wooden grooves. Its translucent quality produces a soft light when sunshine enters a room. Although fragile the shoji can be easily patched and repaired with minimal cost. More contemporary version of the shoji are made with translucent glass or plastic composites and may run on metal tracks.

- Fusuma panels are similar to shoji but covered with opaque paper on both sides of the wooden frame, thus creating a more solid panel which does not admit light.
- Glass sliding doors, an addition of the 20th century, work in conjunction with shoji to allow or restrict ventilation, turning the engawa into a double skinned façade.
- The amado, solid wooden rain shutters, usually placed in front of the glass sliders, can be fully concealed within a wooden box which protrudes from the façade of buildings.
- The sudare, reed or bamboo blinds which function as sun interceptors during hot months. These can be rolled away or lowered as desired and hang freely from the edge of eaves.

All the above elements can be adjusted by sliding or rolling and can also be completely removed and easily stored away. This is especially true during hot and humid weather when for example the shoji and fusuma are replaced with reed panels which allow breezes to flow through. The Japanese house breathes in simultaneous pulse with the seasons and is in

continuous organic change. It calls its occupants not to sit in passive awareness but to sensitive reaction and practical participation.

Together, the platform, roof and flexible devices create the engawa, an indoor/outdoor space which gives much of the traditional character to Japanese buildings and is one of the most sophisticated aspects of Japanese architecture. The engawa is an in-between space which accommodates myriad activities as well as being the space for climatic, visual and social transactions.

Conclusion

Vernacular architectural traditions throughout the Asia-Pacific region are rich and varied, shaped by tradition, culture, politics, environment and climate. When long periods of peace and prosperity characterised the times, the vernacular had a chance to develop, through trial and error, into an architecture of subtle relationship to climate and sophisticated detailing. The result is a legacy rich in lessons for contemporary architecture, in both technical and aesthetic terms.

The major lessons learnt from the vernacular of Asia-Pacific encompass a holistic approach to climate and environment, taking into account both the overall urban form and the individual building form. The compact form of buildings allowed for cities and towns to be similarly compact, providing shade and protection from inclement weather to the pedestrian environment.

Buildings and their internal spaces are organised around a single or multiple courtyards. A building typology with a number of benefits, the courtyard provides an internalised open space which is both private and protected from the elements; similarly, openings face this internal courtyard and can therefore be left open at times of inclement weather, channelling cooling breezes into the building. Whether tiny skywells, as are found in Fujian, or a series of small gardens typical of the Japanese townhouse or its larger counterpart in Vigan, the courtyard was the most common building form and type of open space encountered.

Rather than looking for technological solutions, the vernacular architecture of Asia-Pacific relies on a multiplicity of small but effective elements to modulate the climate. As seen in the fenestration of the Vigan house and the wet edge of Japanese buildings, architectural systems and detailing which seek to accommodate the full range of climatic challenges give the greatest aesthetic delight, choice, adaptability and comfort to users.

References and Further Reading

EDG 66 MSa 'Climate Change Adaptation for Building Designers: An Introduction', Mark Snow and Deo Prasad 2011

Dai, Z 2003, *Min Tai min ju jian zhu de yuan yuan yu xing tai* (The origins and form of traditional architecture in Fujian and Taiwan, Fujian ren min chu ban she, Fuzhou Shi

Engel, H 1964, *The Japanese House: a tradition for contemporary architecture*, Charles E Tuttle, Rutland

Futagawa, Y (ed.) 1983, *Traditional Japanese Houses*, New York, Rizzoli

Ho, P 2003, 'China's Vernacular Architecture' in *Asia's Old Dwellings*, Knapp, Ronald G eds, Oxford University Press, New York

Knapp, RG 2000, *China's Old Dwellings*, University of Hawaii Press, Honolulu

Knapp, RG G, 1990, *The Chinese House: Craft, Symbol, and the Folk Tradition*, Oxford University Press, Hong Kong

Nitschke, G, 1993, *From Shinto to Ando*, Academy Editions, London

Oliver, P (ed.) 1997, *Encyclopedia of Vernacular Architecture of the World*, Vol. 2 : Cambridge University Press, New York

Vellinga, M, O, P and Bridge, A 2007, *Atlas of Vernacular Architecture of the World*, Routledge, Abingdon

Villalon, A 2003, 'The Evolution of the Philippine Traditional House' in. *Asia's Old Dwellings*, Knapp, Ronald G. eds. Oxford University Press, New York

Zialcita, F and Tinio, M 2002, *Philippine Ancestral Houses*, GCF Books, Philippines

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Carol Marra (BArch) is the better half of Marra+Yeh Architects. A graduate of the University of Texas, she has carried out commercial and residential projects in the US, Malaysia and Australia. Specialising in environmentally responsive buildings, her designs aim to be functional, invigorating and give delight. In 2009 she received a Winston Churchill Fellowship that took her to Japan, China and the Philippines to examine vernacular traditions which can accommodate severe climate patterns.

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