THE A.V. JENNINGS CHURCHILL FELLOWSHIP to study passive design methods which can accommodate severe climate patterns while providing solutions for human comfort.

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Signed   Carol Marra        Dated   16 April 2010
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>Executive Summary</td>
<td>4</td>
</tr>
<tr>
<td>Programme</td>
<td>5</td>
</tr>
<tr>
<td>China</td>
<td>7</td>
</tr>
<tr>
<td>The Philippines</td>
<td>14</td>
</tr>
<tr>
<td>Japan</td>
<td>18</td>
</tr>
<tr>
<td>Design Principles/Conclusions</td>
<td>24</td>
</tr>
<tr>
<td>Recommendations</td>
<td>25</td>
</tr>
<tr>
<td>Bibliography &amp; References</td>
<td>25</td>
</tr>
</tbody>
</table>
Introduction

“To know its environment is to understand an architecture”. Encapsulated in this succinct quotation is the driving force behind my Churchill Fellowship research. Years of study and practice have taught me that first and foremost, Architecture must be suited to its environment, just as much as it must be suited to its cultural, technological and economic context. So I set out to discover what I call an Architecture of resilience, where the prevailing climate has been accommodated thru a number of generations, and where severe weather events are a normal occurrence, not just a novelty of climate change. I chose places that have very long histories of permanent settlements, where Architecture has had the possibility to develop subtle and sophisticated strategies from generation to generation to modulate the climate. I am aware that Architecture is not just the result of response to climate, yet in places where the climate is severe, this is the most important role that must be acknowledged.

The locations of my study are regularly visited by monsoons, typhoons and large seasonal variations. They are also located between the latitudes of 20 to 40, thus sharing climatic conditions with most of coastal Australia.

The focus of this research fellowship has been to look for lessons in the vernacular that can be applied to contemporary works of architecture, thus making our built environment better prepared to cope with changing climate patterns. Regardless of the causes of climate change, there is documented evidence that weather events are becoming more severe. At the same time there is a growing need to move away from an overdependence on energy consuming climate modulating systems such as air-conditioning and active heating. 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.

I would like to thank all the people who assisted me in this endeavour: The Winston Churchill Memorial Trust, my sponsor AV Jennings, Kenneth Yeh, Goldie Peligrino, Jamie Chan, Caroline Pidcock, Anna Rubbo, Tom Heneghan, Gerlinde Leiding, Dan Abramson, Mayor Medina, Puay Peng Ho, Augusto Villalon, Ron Knapp, Fujioka Ryusuke, his daughter and the staff at his office. And I would also like to thank all the Architects and Craftsmen who created such works with sensitivity, care and foresight.
Executive Summary

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Project description: to study climate adaptive architecture, to find solutions to accommodate severe climate patterns while providing human comfort.

Trip Highlights:

China: The traditional neighbourhoods visited in Fuzhou and Quanzhou, as well as the many ordinary Chinese people who graciously took the time to invite me in and explain the workings of their buildings.

The Philippines: Vigan City due to its World Heritage Status and largely intact urban form. Of particular interest is the fact that Vigan is still a functioning community, not a tourist town. The buildings preserve their original character but accommodate everyday activities. The Mayor of Vigan, Ms Medina, was very helpful in meeting with me and discussing how Vigan has protected its heritage while accommodating change. Marjo Gasser, a local businesswoman, was very gracious in opening her home to me for detailed study.

Japan: The many traditional buildings still in use and in particular meeting Architect Fujioka in the ancient capital of Nara. I was able to visit a number of his works where he very clearly articulates and combines old and new, demonstrating the value of Japan's Architectural tradition.

Recommendations:

- Building codes and regulations need to acknowledge the impact of climate change on the built environment and encourage performance based innovation in building design
- Urban design needs to acknowledge that our cities must become more dense and provide urban typologies which accommodate density without destroying privacy, community and security
- Building designs which are compact and efficient, flexible and capable of a multiplicity of uses should be encouraged
- Buildings and in particular housing must be designed to better modulate a changing climate which anticipates more severe weather, including hotter temperatures, higher rainfall and stronger storms.
- Australian architecture should move away from its Colonial heritage to create works which are truly Australian and respond to the particular climate, landscape and local conditions.

I intend to disseminate the findings of my Fellowship in the following manners:

- Making presentations to local Councils, government agencies and agencies responsible for building regulations
- Committing to giving lectures to the general public and members of my profession
- Contributing to the growing body of knowledge in this field by making a submission to the CSIRO
- Teaching the principles of climate adaptive design to current and future students at the University of Sydney
- Employing the principles of climate-adaptive architecture in my own work
Programme

04 January – 08 January 2010
Hong Kong
  Ping Shan Heritage Trail
  Yu Kiu Ancestral Hall
  Tang Ancestral Hall
  Sheung Cheung Wai walled village
  Kun Ting Study Hall
  Ching Shu Hin

09 January – 12 January 2010
Fuzhou, Fujian Province, China
  Sanfang Qixiang district
  Walled neighbourhood off Huayuan Rd
  Fuzhou Confucian Temple
  Former Residence of Shen Baozhen

13 January – 19 January 2010
Quanzhou, Fujian Province, China
  Kai Yuan Temple & Grounds
  Licheng District
  Bei Men Neighbourhood

20 January – 24 January 2010
Xiamen, Fujian Province, China
  Tulou (earthen houses), Nanjing village
  Nan Putuo Temple
  Gulangyu Island

Key Contacts:
  Professor Puay Peng Ho, Director, Centre for Architectural Heritage Research, The Chinese University of Hong Kong
  Hong Kong Antiquities and Monuments Office
  Daniel B. Abramson, Associate Professor and Associate Chair of Urban Design and Planning, Adjunct Associate Professor of Architecture and Landscape Architecture, College of Built Environments, University of Washington (USA)
25 January – 27 January 2010
Manila, The Philippines
   Casa Manila
   Intramuros

28 January – 31 January 2010
Vigan City, The Philippines

Key Contacts:
   Eva Medina, City Mayor, City of Vigan
   Augusto Villalon, Architect, Heritage Conservation Society Board Member

01 February – 04 February 2010
Tokyo, Japan
   Nihon Minka-en, Open Air Architectural Museum
   Tokyo National Museum
   Asakusa District

05 February – 12 February 2010
Kyoto, Japan
   Kyoto Imperial Palace
   Nishijin District
   Tenryu-ji Temple
   Gion District
   Inari Shrine

13 February – 18 February 2010
Nara, Japan
   Horyu-ji Temple
   Naramachi District
   Naramachi House Private Museum
   Office of Architect Fujioka
   Restored traditional houses

19 February – 21 February 2010
Ise Peninsula, Japan
   Ise Grand Shrines
   Oharaymachi village

Key Contacts:
   Tom Heneghan, Professor, Department of Architecture, Tokyo University of the Arts
   Fujioka Ryusuke, Architect, Nara
Hong Kong and Fujian province, China

Climate overview: Fujian is located across the island of Taiwan, around lat 26. Its climate is affected by the Pacific current, seasonal monsoons and regular typhoons. It has some of the highest rainfall in the country, usually mild winters with warm to hot summers. The relative humidity can reach 85%. Hong Kong has a climate that ranges from cold to hot and humid. Hong Kong is regularly visited by tropical cyclones and typhoons, bringing strong winds and high levels of rainfall in short time periods.

Prior to my trip to China I had studied the architecture of the Straits Chinese, where the urban shophouse, long, tall and narrow, has defined the built form and character of cities from Singapore to Penang, all along the Straits of Malacca. This building typology is an amalgamation of traditional Chinese forms with British urban planning modified to fit the hot and humid climate of SE Asia. I was surprised however to discover how prevalent the Chinese courtyard typology is, not just throughout the Straits but all the way to Hong Kong and Beijing. Thru further research I learned that in China the use of courtyards has a long history, dating back to at least the 11th century BC. A variety of courtyard houses can be identified, the diversity revealing the versatility and flexibility of the form¹. The size, shape, height and detail of the courtyard varies according to location and prevailing climate.

In Fujian province the courtyards are predominantly small and rectangular, with sometimes circular and octagonal variants. Often called skywells, these small compact courtyards restrict infiltration of intense sunrays and induce ventilation throughout the house. Because buildings are set out as a series of courtyards bounded by rooms, as one moves inward from the street increasing levels of privacy, both visual and acoustic, are achieved. All rooms receive sufficient levels of natural light and ventilation due to their placement alongside inner courts. Sunken courts also function as part of the infrastructure of the building. Gutters and downpipes are dispensed with and rain falls directly from roofs onto the sunken courts which have perimeter drains to collect and channel the water. This is particularly useful during the frequent heavy rainfall as gutters and downpipes can prove too small for the sudden volume of water, leading to backflow and flooding. The Fujianese have always been known for building for better comfort in summer – strategies such as sunshading, cross ventilation, drainage, moist prevention and typhoon prevention.
The main principles of southern Chinese architecture can be summarised as follows:

- Internal courtyards relieve the feeling of enclosure but at the same time provide safe havens from the busy and noisy streets.
- Courtyards, screens and operable walls work together to induce or reduce ventilation depending on the season.
- Loggias and verandas add a secondary layer of protection to the inner rooms and provide an indoor/outdoor space which can suit a variety of uses.
- Inside/outside relationship is clearly defined being both highly functional and poetic.
- Smaller than courtyards, skywells serve to lead cooling breezes into the building, allow hot air to escape, collect rainwater for domestic use and prevent direct sunlight from entering.
- Courtyard typology reduces the need for the external walls of the building to bear the full brunt of climatic forces. Instead the exterior wall acts as a protective layer, allowing internal spaces to progressively open up to the outdoor space within. In this scenario, climate modulation and comfort is easier to achieve under a wider range of climatic conditions.

Materials

Consistently throughout Hong Kong and southern China, granite, masonry and timber are the most common traditional building materials due to their once natural abundance. The base of walls is commonly constructed of granite to offer better protection from dampness and because of its higher bearing capacity. Columns within Ancestral Halls, Temples and other important buildings are commonly made of granite with carved bases, whereas in houses these elements are constructed from timber. The roof structure is composed of an interlocking system of timber beams protected by wide overhanging eaves. Green-grey bricks make up the walls, interspersed with timber and glazed tile screens, opening and doors. Only in Quanzhou did I encounter rich red bricks used extensively for walls and pilasters. Brick, tile and stone is extensively used for floor coverings, providing internal thermal mass which can help to counteract fluctuations in temperature.

Outside Xiamen, in the village of Nanjing, stand a large number of 'Tulous', the traditional dwellings of the Hakka people. These are constructed from rammed earth and timber. These unique dwellings have stood for over 700yrs, with some constructed as recently as the 1960's.
Detailing

Durable materials such as stone are usually used where the building meets the ground, to support pillars, walls, doors, etc. This prevents dampness and sudden increases in water level, as during heavy rains, from damaging timber, bricks and other less durable materials. This detailing also allows ventilation at the exposed ends of timber elements, such as doors, where they are most susceptible to weathering.

Openings are detailed in ways which allow constant flow of ventilation but yet provide an acceptable level of privacy and security within.

Wide overhangs at the roof structure, besides preventing rain from penetrating within, allow the building to be kept open even during periods of heavy rain which also bring lower temperatures and favourable breezes. Incidentally the main halls of dwellings are usually left open with no screen to separate inside from outside, so that air can circulate freely within the building. Because living spaces open onto an internal courtyard or skywell there is no fear of visual or physical intrusion by others. Within villages houses are packed tightly along narrow pedestrian and cycle lanes. This arrangement allows houses to mutually shade each other’s external walls, thus preventing heat gain build up.

Nanjing Tulou

Tulous, literally ‘earth buildings’, are the traditional dwellings of the Hakka people. Built of rammed earth and timber, these imposing structures sit gently along terraced landscapes and can be called the ultimate courtyard house. Tulous come in various shapes, from square to rectangular, elliptical to round. The most successful Tulous seem to be the round houses, enclosing the greatest area with the least amount of material, having no odd corner junctions to deal with, and encouraging the deflection of high winds. Each Tulous is cut up into wedges, usually 3 to 4 stories high, each family occupying one wedge. On the ground floor are kitchens, bathroom and common areas. The higher floors contain individual bedrooms for family members.
Manila and Vigan City, The Philippines

The Philippines is located at the intersection of trade routes and trade winds. Throughout its history it has been first a Spanish then an American colony, and due to its location influenced by Chinese and Latin American settlers. Its islands are regularly visited by both the southwest and northeast monsoons as well as tropical cyclones and typhoons originating in the Pacific. It thus presented itself as an ideal place for the study of resilient and climate adaptive architecture.

The traditional Philippine house falls into one of two categories, corresponding to pre-Hispanic and post-Hispanic settlement. The earliest houses, known as the *bahay kubo* (cube house), are the ultimate in environmentally friendly design:

“Posts of bamboo or wood raised the whole structure from the ground as protection from groundwater or intruders. Flooring was of either split bamboo or wood planks. Steep grass or palm leaf thatch roofs shed rain quickly. The thick, thatched roof insulated the house from tropical heat, while its steep slope and wide overhangs not only protected the house from heavy rain but also cast shadows that shaded walls and windows, further preventing the heat of the sun from penetrating the interior. Walls of woven bamboo kept rain and sun out but let in air to cool the house, while the floor of bamboo strips allowed air from the open space underneath the house to circulate throughout the enclosed sleeping area.”

Being so successfully adapted to both environment and availability of building materials has ensured the longevity of the *bahay kubo*; it is still easily found throughout rural areas of the Philippines. Besides being modest in size and use of materials the *bahay kubo* employs a sophisticated structural system whereby structural posts stand about a metre away from the inside of the walls, with the outer cladding cantilevered away from the posts, in the manner of a curtainwall. This clever separation of structure and skin keeps the roof independent of the walls and therefore accommodates maximum sway, protecting the house from strong wind and rain as well as frequent earthquakes.

Spanish settlement of The Philippines brought changes to both the architecture and the establishment of cities. The latter were laid out in accordance with the Law of the Indies, while the former incorporated the European preference of building for permanence. This equated building with stone and brick, materials and methods of construction completely foreign to the Filipino. This change saw not so much the destruction of the *bahay kubo* as its transformation;
“In looking for an architectural archetype that was suited to local climatic and environmental conditions, the early Spanish builders turned to the bahay kubo, enlarging and strengthening it to fit their standards as well as adapting traditional rural dwellings into the series of new urban settings that they were establishing throughout the country.”

One of the best preserved examples of Spanish/Filipino fusion is Vigan City, located on the northwest coast of Luzon island. Inscribed into the UNESCO World Heritage List in 1999, Vigan is cited as representing ‘a unique fusion of Asian building design and construction with European colonial architecture and planning.’ In Vigan, as in Manila and other Spanish settlements, the bahay kubo evolved into the bahay na bato (house of stone).

Materials

Incorporating Spanish skills of stone and masonry construction, the bahay na bato is a more durable structure than its bahay kubo predecessor, and better at withstanding typhoons and monsoonal downpours. As in the bahay kubo, the bahay na bato retains the structural system which separates structure and skin. The ground floor walls, made of stone or masonry, form an overall protective skin. The structural system is still timber post and lintel members set inside the stone walls, supporting the upper floor and roof. This simple arrangement offered better protection from frequent earthquakes, but also created a curtain wall and led to the non-structural exterior walls being available for a range of large openings with elaborate, layered window and screen elements.

Detailing

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. The system is made up of several parts which work together to allow varying degrees of control over the weather:

- An outer window screen built as a timber lattice and infilled with capiz (mother of pearl) shell. This screen filters sunlight as it enters the rooms, diffusing the harsh tropical sun.
- 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 thru or shutting it out completely. When the opening is covered by the screen but the louvres 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.

The magic 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.

Internally the bahay na bato follows the traditional Spanish courtyard typology. Much larger than but similar to the courtyards observed throughout southern China, Filipino houses are internally opened to their courtyards on a permanent basis, allowing light and more importantly constant ventilation throughout the living spaces. Interior rooms flow into one another but can be physically separated by sliding screens. The top of interior walls maintains a degree of openness with a decorative carved screen, which in turn maintains the flow of air throughout the house.

The bahay na bato is a sophisticated response to difficult climatic conditions which remains relevant and in use, offering a wealth of lessons for contemporary architecture.
Tokyo, Kyoto, Nara & Ise, Japan

Japan is a collection of islands which range between latitudes 25 and 45N. The areas visited during my Fellowship are located around lat 35, in the area known as Central Japan. This area presents mostly hot and humid summers with normally short winters, although during my visit there were a series of snowstorms. Summer however tends to be the more uncomfortable season and thus climatic adaptation in the architecture tends towards this extreme. In addition 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. Furthermore, regular monsoons, typhoons and high levels of precipitation in short time spans are prevalent weather patterns.

Japanese architecture has been shaped for more than a thousand years by tradition, craft and imposition. Since the Middle Ages design and construction of the Japanese house has been controlled by an elaborate system of standardised measures and modules. This is readily evident as one travels within Japan from city to town to village. The Japanese house therefore has evolved as a series of refined elements which work together to achieve climatic control.

At the most elemental level Japanese architecture can be described as a raised platform with a large overhanging roof above. Walls as such do not really exist and neither do windows. The space between platform and roof is populated 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 it to be lifted off the ground. This can be as little as a couple of steps in a house or as much as half a dozen or more in temples and larger structures. This simple response prevents dampness from entering the building, 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 of long continuous eave and floor platform is described as 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. 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.

The third element of Japanese architecture 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 when the need arises.

- **Fusuma** panels, 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.

- **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 are adjustable 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 thru. 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 instead. Another function of the multiplicity of panels is to enlarge or diminish the dimensions of the interior spaces since these flow into one another rather than being separate rooms bounded by permanent walls. They also control light levels within and the level of privacy between adjacent spaces.
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. At the Emperor’s residence in Kyoto’s Imperial Palace I found the ultimate engawa, composed of not one but two layers of protection and modulation between the inner rooms and complete exposure to the elements. Most houses however have a more modest single layer engawa with a set of sliding screens on both inner and outer faces.

The most common type of traditional urban building throughout Japanese towns and cities is the machiya, essentially a long and narrow town house composed of linked spaces separated by gardens. The machiya is both shop and house, having a space at the street interface from which to conduct business. Similarly to the houses encountered in southern China and the Philippines, the machiya is a courtyard typology. Here the courtyard is usually a small garden, usually at least one near the front of the building and another towards the rear. These gardens provide light, air and are private open spaces within. A unique feature of the machiya is the long passage, usually along one side but sometimes in the middle, which runs the entire length of the building, from street to rear boundary. This passageway retains in many instances its earthen floor and 2-story volume, being located at street level, a couple of steps lower than the main floor of the building. The kitchen would traditionally be located along this passageway. Because of its height smoke could easily escape via a set of double hung screens, one for light and the other for ventilation. Regardless of what functions are placed within it, the passageway is more importantly a conduit for air movement, providing ventilation to the whole building. The earthen floor, if retained, is the only source of internal thermal mass and due to its placement within the ventilation passage it can cool down at night and become a heat sink during the day.

Materials and Detailing

Traditionally Japanese architecture, whether a farmhouse, machiya or temple, has made use of timber as its primary material of construction. Although many people do not consider timber to be a long lasting material Japanese buildings prove otherwise. It has often been fire and wars rather than decay that has been the cause of their destruction. Japan is home to the world’s
oldest wood buildings, Horyu-ji temple complex in Nara, standing for over 1300 years. The use of wood has in fact ensured the longevity of much of Japan’s traditional buildings. Besides being a renewable building resource wood is easily worked which has led to the development of refined carpentry and joinery skills throughout the centuries. When a piece of structure is in need of replacement or repair, that is exactly what happens. Rather than demolishing the entire structure, only those pieces are replaced or repaired, using minimal material and allowing the carpentry craft to endure.

Wood 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 wood is only oiled at regular intervals but otherwise receives no surface finish, except when used externally. One ingenious treatment used for exterior cladding is termed yaki sugi, literally burnt cedar. This process entails the controlled burning or charring of a thin (3-5mm) layer of the wooden planks which creates an excellent weatherproof finish. Many new houses 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. Bamboo is a commonly used material, although Japanese bamboo is not suited for structural purposes due to its thin cellular wall structure. Therefore most bamboo is used for items like fencing, furniture, garden implements, panels and blinds. Rice paper is extensively used for the shoji screens as well as for other items like lamp shades. The tatami mat is both a system of measure (rooms are usually noted as being 6 or 8-tatami, etc to denote their size) and a floor covering. Originally tatami were considered furniture and would be taken from house to house when the occupants moved. That is no longer the case but 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.

Despite the uniformity of form throughout the country I found Japanese buildings to be incredibly detailed and sophisticated. Whether shaped by culture, tradition or need, these buildings have developed highly refined methods of climate control, craft and detail, and their principles can serve as a platform for the design of climate adaptive architecture.
Design Principles / Conclusions

Put simply, good architecture needs to be a climatic architecture; it either counteracts climate by basic measures and features or adapts itself to climate. Climatic response must be one of the driving aspects of architecture, not an add-on or an afterthought. Although we cannot predict the future, we can learn from past experience and assess what has worked, what has been adaptable and successful thru the centuries. Building is an act of permanence, an act of settlement. As such, we must build for the present and the future. One of the most sustainable aspects of buildings is their ability to endure thru generations, to adapt to change and to continue being relevant in a given society despite the changes.

The major lessons learnt thru my Fellowship travels and research are:

- Compact and efficient: the great majority of buildings I visited had carefully planned layouts without wasted space. The compact form of buildings allowed for cities and towns to be similarly compact, taking up the least amount of space and allowing agricultural land to remain close to the centres of commerce. Compact buildings also shield each other from wind, rain and heat exposure.

- Flexibility and multiplicity of uses: Particularly successful in Japanese architecture, the design of spaces was always conceived to be flexible so that over the course of the day a multiplicity of activities could take place. This simple concept allows a multitude of uses to happen without the need for ever larger and more complex space requirements.

- Channel light and ventilation: Of paramount importance for comfort is the effective use of ventilation and the diffusion of light. As seen in the Vigan houses, layering of screen elements and other window coverings is essential to give users choice and control over their environment.

- Provide open space and privacy: Particularly important in dense urban settings, the provision of open space must consider issues of privacy in order to be really useful.

- Courtyards and enclosed gardens: The most common form of open space encountered, the courtyard or inner garden provides a wealth of benefits; open space which is protected from the elements; openings which are internal and therefore can be left open at times of inclement weather or in the evenings to allow ventilation without lack of security; climatic forces act on the exterior skin which becomes a protective shell for interior spaces; a typology which allows for high densities without loss of open space and privacy; courtyards create narrow buildings allowing better sun penetration and cross ventilation.

- Relationship to the ground: A simple but important device is to lift the building off the ground, eliminating dampness, reducing risk of flooding and providing longevity to structural members.

- Integration with the landscape: On a macro scale, choosing locations and sites which are naturally protected from the worst weather and provide the best aspect, capturing cooling breezes and other desirable climatic aspects.

- Subtle and sophisticated detailing: Rather than looking for complex technological solutions, employing a multiplicity of small but effective elements to modulate the climate gives the greatest choice and adaptability to users. It also creates architecture which is of its time and place.
**Recommendations:**

- Building codes and regulations need to acknowledge the impact of climate and climate change on the built environment and encourage performance based innovation in building design.

- Urban design needs to acknowledge that our cities will become more dense and provide urban typologies which accommodate density without destroying privacy, community and security.

- Building designs which are compact and efficient, flexible and capable of a multiplicity of uses should be encouraged.

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- Australian architecture should move away from its Colonial heritage to create works which are truly Australian and respond to the particular climate, landscape and local conditions.

I intend to disseminate the findings of my Fellowship in the following manners:

- Making presentations to local Councils, government agencies and agencies responsible for building regulations
- Committing to giving lectures to the general public and members of my profession
- Contributing to the growing body of knowledge in this field by making a submission to the CSRIO
- Teaching the principles of climate adaptive design to current and future students at the University of Sydney
- Employing the principles of climate-adaptive architecture in my own work

**Bibliography & References**