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Open House International

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University Teknologi Malaysia (UTM) Resource Development Division, Perpustakaan Sultanah Zanariah Universiti Teknologi Malaysia (UTM) 81310 Skudai Johor, Malaysia (Anuar Talib) anuar@psl.utm.my http://portal.psl.utm.my/psl

Philadelphia University, Engineering & Architecture Department, Faculty of Engineering, P.O Box 1, Jordan. (Ahmed Abu Al-Hajja) ahajja2@gmail.com www.philadelphia.edu.my/content/view/448500/

University of Malaya, Faculty of Built Environment, 50603 Kuala Lumpur, Malaysia. (Md Nasir Daud) nasimadad@yahoo.com http://www.fbe.um.edu.my
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Edited by Nicholas Wilkinson RIBA, Eastern
Mediterranean University, North Cyprus.
DPU Associate, University College London, UK.
nicholaz.wilkinson@emu.edu.tr
ADAPTING BUILDINGS TO CLIMATE CHANGE

Guest Editors:
Dr Monjur Moushed, Building Energy Research Group, Loughborough University, UK.
Email: m.m.moushed@lboro.ac.uk;
Prof Fuad H Mallick, Department of Architecture, BRAC University, Dhaka, Bangladesh.
Email: fuad@bracu.ac.bd

ABSTRACT
Adapting buildings to the projected changes in climate is challenging because of the interdependence and feedback between climate impacts mitigation and adaptation. Increased emphasis on mitigation without much consideration of the dynamics between buildings and future climates may require energy intensive adaptation to ensure occupant comfort and wellbeing. Regions with a prevalence of high temperatures such as overpopulated cities in the tropics may experience higher than the projected temperatures because of the nocturnal urban heat island effect. The urban poor living in congested communities can be disproportionately affected by increased temperatures than their well-off neighbours. A fuller understanding of all socio technical issues is required to tackle the challenges of adaptation. Factors affecting adaptation potential are interdependent and therefore requires an integrated and multidisciplinary approach. This special issue aims to address the socio-technical aspects of climate change adaptation, in particular the strategies to address integrated and multidisciplinary decision-making.

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Avi Friedman’s new book, DECISION MAKING FOR FLEXIBILITY IN HOUSING has much going for it. The main arguments and objectives are set out here in this manuscript which opens with a short introduction whose first sentence is “narrow houses were a product of necessity”. It goes on to cover facets of his work in this area on construction technologies, and materials arguing also for higher density living. He succinctly makes a case for the narrow frontage town house derived out of the concerns related to environmental and socio-economic issues. Sustainability, among other key factors, receives full attention making this book and manuscript worthwhile having on your bookshelf and in your University library. (page 6) Order address carol@openhouse-int.com

Flexibility remains central to JIA Beisi and Kim Sung-Hwa in their expose on Traditional Korean Architecture. Here flexible building forms give the main line of debate showing us how ordinary buildings change over time in an interaction with people giving the possibility of developing “long lasting and sustainable mass housing in Korea and Asian cities”. To help and encourage this thesis construction systems are analysed including how the building industry is organised in relation to residents decision making roles. A point worth noting is how the argument supports the idea of the “easy replacement and re-use of building materials”. (page 16)

On a different level Urban Squatting in Latin America The Guided Occupancy Programme is followed by the authors who demonstrate the more tolerant attitude being taken towards urban squatting by most Latin American countries through “amending their municipal, provincial and national legislation...” and are supporting the squatting activity for improvement in this area. (page 28)

Broadening out into the area of Architectural Design, Saim Nalkaya is well travelled in the USA, where he lived for some years, and Europe and in his own country of Turkey where he ran a thriving architectural practice. Nalkaya writes about the structure of the design process “......in the ration to the levels of decision making concerning the process “. Professional degree programmes and their study areas are seen with the incremental steps of problem solving activity. These are covered in a clear and understandable way making the complex process of Architectural Design more accountable and accessible. (page 38)

Khan and Dhar focus on flexibility in Hong Kong Private Housing. These two authors give an excellent overview of the private housing property market. A strong emphasis is put on house plan options and house size. Flexibility is measured in terms of potential layout options. Different levels of construction are analysed i.e structure, envelope, building services and infill. The authors conclude that whilst flexibility in private flats is reducing they also offer more varieties in size and layout design. (page 48)

A team of authors (Alavarado, Bruscato, Kelly, D’Amico and Oyola) aim in their manuscript “Connecting up Capacities...” to follow the dimensions of integrated design as a strategy to develop sustainable architectural projects in housing, south of Chile. This incorporates multidisciplinary work and environmental performance assessments. Planning and construction of energy efficient housing lie at the centre of their arguments. An integrated design approach is contrasted with normal housing design practice in Chile. The authors finalise with the indentification of features and resources which promote environmental improvements. (page 60)

The Abandoned Housing Project manuscript seeks to establish criteria for resident’s satisfaction on completion and occupation after abandonment. Better housing quality is achieved through a rebuild/renovation and sell approach, (page 72).

The impact of passive design on building thermal performance using a number of devices such as shading, insulation, natural vegetation and solar panels are put forward by Emad S. Mustaha. He examines the effect of these devices in relation to thermal priorities. The structure proposed is to help guide designers and constructors for new development and construction. (page 81)

Nicholas Wilkinson RIBA.

ERRATUM

The editor apologises to Nese Dikmen and Soofia Tahira Elias-Ozkan for incorrect captioning of their figure 1 and table 1 on Vol.37 No.1 page 34 and page 37 respectively. They should read: Figure 1 Proposed integration of the participatory approach in current strategic planning procedures, followed by the Turkish Ministry of Public Works and Settlement, for post-disaster reconstruction and housing procurement and Table 1 Comparison of Dinar and Cankiri cases in terms of housing procurement methods in rural areas.
DESIGN PRINCIPALS OF NARROW TOWNHOUSE; FOR AFFORDABILITY AND ADAPTABILITY

Avi Friedman and Robyn Whitwham

Abstract
Recognized for their high density and resources conservation, townhouses are attracting homebuyers and builders once again. With housing affordability being an issue in many nations, the interior and the exterior must be cost effective. Their proportions, however, pose a particular design challenge. The typically narrow width limit design options and the long footprint restrict the amount of light that reaches the dwelling’s center.
This article presents strategies used by designers of notable townhouses with a width smaller than 6 meters to best solve those challenges. The authors studied interior design of 28 narrow units and drew conclusions about key principles that facilitated their planning. The research demonstrates that space efficiency can be achieved by employing open plans, minimizing circulation, using light colors, varying ceiling heights, suitable window placement and creative storage fixtures.

Keywords: Narrow townhouses, Space efficiency, Adaptability, Affordability.

INTRODUCTION

Narrow Houses were a product of necessity. Small areas in walled cities forced economy of land. In the Middle Ages, narrow structures accommodated both private and public realms with street-level shops and residential floors above (Binney 1998). The Industrial Revolution introduced new construction technologies and materials. Not only was this a time of cheaper building means, but also it attracted the working class to urban centres, which increased demand for high-density living. The proliferation of the single-family detached home in the post-World War II era, particularly in North America, saw sharp decline in construction of townhouses. Yet, contemporary environmental and socio-economic concerns lead to renewed interest in narrow homes and in particular townhouses. An old form was adapted for new use. Sustainability, flexibility, and affordability, have become valued elements in contemporary housing design.

Stemming from their high density and resource reduction, townhouses contribute to sustainability, and regarded a solution to the consequences of urban sprawl. In a society that is becoming increasingly aware of the human toll on the environment, common housing practices are being re-examined to lessen their impact. As such, architects and planners have been encouraged to investigate smaller housing prototypes and densification strategies. The search for an affordable housing option for new, smaller households as well as a reduced environmental footprint prevailed.

In regard to resource efficiency, the shared walls between units of a row, causes a significant reduction in material requirements; in middle units, exterior wall surface can be decreased by up to 53 percent. Furthermore, townhouses can consume approximately 68 percent less energy than detached homes (Friedman 2001). When heat escapes through the common wall between units, it is likely to flow into an adjacent home. Simply put, joining dwellings result in greater environmental sensibility.

The narrow footprint and the limited options for window placement, however, represent significant challenges for designers of townhouses. With thoughtful conception, this dwelling type can, nevertheless, contain the same basic functions as detached home without compromising on quality of interior spaces. Added attention will need to be paid to space saving measures, while a deep floor...
plan will require a creative approach to spatial arrangements and the limited amount of natural light (Gauer 2006).

Following a study of 28 contemporary townhouses with a width narrower than 6 meters, some free-standing and others that were built in a row, strategies for improving their interior space efficiency has been prepared (Friedman 2010). These principals and their analysis will be outlined and illustrated below.

BASIC SPATIAL ARRANGEMENTS

Principal approaches to the interior design of narrow dwellings have been suggested over the years. They were commonly the outcome of cultural or social attitudes and architectural trends. When homes are built in a row, one of the most important tasks for a designer is to maximize space efficiency. Hunter (1999) argues that cultural and personal differences influence how a household defines zones within a dwelling. Emphasis on formal areas, service spaces, private and public rooms will vary depending on the economic and social context at the time of construction. Nonetheless, in varying degrees, all townhouses have room arrangements that address occupant requirements for privacy, light and spatial efficiency, regardless of their geographic location.

Efficient and rational space planning creates zones within the home. Zones can be organized in multiple ways depending on privacy, light and utility requirements. Most commonly, rooms are grouped together based on similar function. Otherwise, they are organized based on specific functional needs, such as privacy, lighting, utility or circulation. Figure 1 shows a floor plan of a narrow home with a typical internal spatial arrangement.

When considering privacy, recognizing zones as public, semi-private and private is a way to establish the appropriate locations and boundaries between specific rooms. As townhouses are multi-story dwellings, public spaces are typically located at entrance level or in the basement. An example of a public space is the dining room or the living room that are used by both the household members and their guests. Semi-private rooms are mostly used by the household members and occasionally by guests, like the kitchen or powder room. Private zones are often placed on upper levels and include bedrooms and bathrooms for use by the residents. These conventions can, however, be inverted in townhouses built on sloping sites. In this case, public zones may be located on the upper floor, where the main entrance level might be. The private spaces will then be located on the lower level where they benefit from direct access to exterior areas.

Spaces may also be zoned according to their function, such as living, sleeping or service areas, as shown in Figure 2. The advantage of this type of classification is for proximity and simplicity in plan. Grouping the bedrooms together, for instance, is preferred because they require a quiet area of the house. Service zones like bathrooms and laundry rooms can be placed at a central core to benefit from vertical plumbing lines. Typically the grade level is reserved for living areas, while the
upper floors accommodate sleeping zones, as is illustrated in Figure 2a. However, conventions may be reversed in a home built on a sloping site, when two levels have access to the ground, shown in Figure 2b (Macsai 1976).

OPEN PLAN VS. COMPARTMENTALIZATION

One of the design decisions architects face is whether to create an open floor plan, free of any interior walls, or compartmentalization, where each space is sectioned off. Sometimes, in the case of private areas like bathrooms and bedrooms, the solution is trivial, but at times one must look at the advantages and the disadvantages of each.

An open plan that integrates multiple activities into a single space can make it look and feel larger. The option of having an open plan in townhouse design is possible because the small width allows for the party walls to be the only load-bearing structural elements. Avoiding partitions will let natural light reach the core. Horizontal circulation is implied by the placement of furniture, and is therefore minimized by the elimination of hallways. According to Morcos (2009), spaciousness can be enhanced by using a single light colour or material.

There are several ways to maintain clarity and separation of rooms in an open plan. A larger floor area can subdivide according to the activities that are to take place in it. Furniture arrangements, for instance, can define smaller spaces and can be easily modified when the use of an area change. Movable closets and shelving are versatile room dividers which can help accommodate much needed storage in a small dwelling.

The manipulation of ceiling heights was another effective means used by some designers to define space without building walls. Low ceiling heights foster privacy, whereas a tall ceiling will recall a more spacious, formal, public space. When the height permits, a mezzanine can be introduced to function as an additional flexible space which can be used as a bedroom, a home office or storage area.

While townhouses draw a number of benefits from open floor plan strategies, creating segregated spaces has some noteworthy merit. Sound transmission within the home, for example, is more controlled. Finally, circulation that avoid movement through rooms, increases their privacy and efficiency. In a townhouse designed by Robert M. Gurney in Washington D.C., shown in Figure 3, the ground and the second floors have an open concept and a well conceived circulation, while the third floor conserves privacy with separate rooms.

MOVING THROUGH AND MOVING UP

Circulation will critically influence the overall functioning of a narrow townhouse. In general, reducing the amount of space allocated to circulation would be an objective. The degree of connectivity between rooms will determine whether the spaces are public, semi-private or private (Pfeifer and Brauneck 2009). A front entrance with a direct view of the living room will highlight the public nature of this space, whereas a closed corridor leading to a bedroom will reinforce privacy. A passageway through a home must, therefore, be designed as a
comprehensive system that promotes efficiency, accessibility and comfort. In small homes, interior horizontal and vertical circulation must be minimized so as not to take space away from living areas. The common approach would be to use the less lit areas for movements, which in townhouses, will be along the longitudinal wall. This ensures that the main living spaces remain unhindered and have maximum area for functional purposes.

**HORIZONTAL CIRCULATION**

The path of movement on each floor may be literal, with walls creating hallways and corridors, or implied by furniture arrangement in an open plan. It also may be pushed along the party wall to form a single-loaded corridor, or be centrally placed, to create a double-loaded corridor. Positioning the path slightly off-center provides room on the smaller side of the divided space for stairs, storage, services and utilities. Placing the route in the plan’s center tends to create two extremely narrow spaces on either side too small to be functional. However, when the width of the house permits, it is just as suitable as the other options; again, the stairs, storage, service and utilities may be located to one side of the plan.

The entrance is significant in the horizontal circulation, as it marks a transition from outdoor to indoor space and offers the first impression of the interior (Gallagher 2006). Since space efficiency needs to be at its maximum, a small entryway is typically used to make this transition. Sometimes, a simple vestibule with two doors (also known as an airlock) acts as a climatic buffer zone in colder months and can be a storage area for coats and boots.

In addition to freeing up floor area through efficient circulation patterns in a home, careful design can allow for it to make a house feel bigger. By planning movement so that smaller rooms are entered at an angle, one views the space along its diagonal, which is the longest dimension in square or rectangular areas. This will also increases the perception of space (Friedman 2005).

**VERTICAL CIRCULATION**

Vertical circulation is a defining characteristic of a multi-story townhouse. There are a number of possibilities for locating a stair and designing circulation in a narrow house despite its small width. On occasion, different staircase types may be combined to respond to the layouts of different floors. The location of the stair and its chosen type will determine the overall layout of upper or lower levels, room arrangement and the unit’s potential convertibility. Reaching the middle of the sleeping floor or the attic will be preferred since it will free the extreme ends for bedrooms. This will be less of a priority in a basement level, when it exists, where the space commonly house service function such as laundry and storage.

There are a variety of staircase types that work well in narrow dwellings. A simple condition is the Straight Run, which in an attached dwelling can be placed along one party wall, at the front of the house near the entrance or further down the wall, for central location. This position interfered the least with living spaces and frees up the floor for a

![Figure 3. A townhouse in Washington D.C. by Robert M. Gurney. The ground and second floor are free of interior columns or walls to create an open plan. This creates perception of a larger space, and let natural light into the core of the home. The layout of the third floor is more appropriate for sleeping areas because it maximizes privacy and controls sound (Source: Robert M. Gurney, Architect).](image)
maximum number of spatial configurations, as shown in the Glass Shutter House designed by architect Shigeru Ban and built in Tokyo (Figure 4). When the stair is in the middle, it is usually surrounded by “wet functions” such as the kitchen, a bathroom, and closet to form a core. It is also worth noting that similar strategies have been used by Le Corbusier in some of his projects including Unite d’habitation in Marseille, France.

Another commonly used stair is the L-shape which can be placed in a variety of locations. The ninety-degree turn allows to tuck it nicely into corners, and therefore it is usually placed close to the entrance. A turn at the beginning and the end forms a U-shaped stair, and when there is a central void, an atrium can be created. When a skylight is placed on top, natural light flows down. U-shaped staircase can expand to encircle the perimeter of the house, creating a large uninterrupted core. Figure 5 shows examples of how these different configurations fit into the home.

**LETTING NATURAL LIGHT IN**

Because narrow townhouses have only two exposed facades and a roof, several design strategies need to be implemented to maximize natural light. Windows and their strategic size and placement play an important role in this aspect of the design. Designers need to be concerned with privacy and restricting outside views. Several design strategies can help alleviate these constrains.

The open plan concept is the most common way to let light flow through. On public and semi private floors, spaces can be defined by furniture arrangements, varying floor levels or ceiling heights rather than solid partition walls to allow light from either facade to reach the inner core. The use of transparent and reflective materials will evenly spread the light and therefore increase the apparent size of a space (Kubba 2003). When partitions are necessary, translucent screens, glass framed doors, and glass blocks let natural light through them.

Since attached narrow houses have only two fenestrated façades, reducing the amount of glazed area for privacy reasons is not a desirable option since it would significantly reduce the amount of natural light. The use of frosted glass is one method to retain ample light while still achieving privacy. Alternatively, locating windows away from the common wall can ensure that enough sunlight enters without compromising privacy. For example, taller and/or high windows will limit views into the home without compromising entrance of light. Alternatively, window treatments such as blinds, shutters, awnings and overhangs can also ensure privacy. When landscaping, deciduous trees with large canopies can be planted in the front and rear yards to act as natural privacy screens. Denser shrubs, fences and trellises around the periphery of
the property can serve as exterior walls that delineate private exterior areas.

Positioning openings that are visible from the entrance to a room will foster a greater sense of spaciousness. When the occupants enter a room, they will see past the boundaries of the home into the outdoors, as shown in Figure 6. Windows that focus on interesting landscape features will also draw attention to the exterior. In more generously proportioned rooms, panoramic windows and sliding glass doors maximize natural light and views. On the other hand, tall and narrow windows can be installed in small spaces such as stairwells, niches and corridors. Additionally, skylights and atriums can be used in denser urban areas where views and light are often obstructed by surrounding buildings. For deep houses with room partitions, bringing light into the center may be difficult. In this case, depending on the upper floors, an atrium of light well can be used to receive sunlight from above.

DESIGNING FOR ADAPTABILITY

Designing for interior adaptability and flexibility has become necessary in contemporary society. Suitably planned townhouses allow for homeowners to add their individual expression and organize the space around their own lives (Habranken 1976, Schleifer 2007). Dwellings that offer adaptable spatial configurations and technologies can adequately address the evolving needs of common and non-traditional households. Providing occupants with forms and means to facilitate a fit between their space needs and the constraints of their homes either before or after occupancy increases the value of the time and protects it from becoming obsolete in an ever-changing society. Ease of interior modifications, therefore, extends the life of the townhouse, increases affordability, reduces waste and unnecessary moves.

The concept of flexibility is especially suited to the townhouse typology due to its compact form and limited area and structural system. As noted above, the interior can be freed from load bearing walls or columns (shown in Figure 7) and the subdivision of spaces, therefore, can depend solely on functional requirements.

By freeing spaces of supporting features, interior changes can be made without concern for
To keep costs low, homes can be constructed and sold with certain unpartitioned and unfinished spaces. This permits add-in growth, a flexible design strategy that allows occupants to customize their house progressively according to their needs and budgets. At a later date, homeowners can add walls and finishings to suit new requirements, budget and aesthetic preferences. As a family grows and changes, additional partitioning may become necessary. Contemporary construction methods and products have simplified inclusion of design strategies, which permits adaptability.

Prefabricated, demountable walls can be used to enclose rooms with more permanent use. As a system of joined parts, the walls can be assembled, disassembled and repositioned according to the need of the occupant. For example, two smaller bedrooms separated by demountable wall will allow two children to each have their own room. When the older child matures and moves out, the wall can be removed to make a larger bedroom, displayed in Figure 8. Flexible partitioning methods ensure that a dwelling reflects the needs and lifestyles of its occupants. Rather than anticipate potential program requirements, designers can offer a basic framework, which can be easily retrofitted to suit diverse contemporary families.

When privacy requirements call for a traditional room division, dimension and partitioning methods can be employed to maintain flexibility.
The common floor area for bedrooms, living rooms and home offices typically varies between 130 sq. ft. to 170 sq. ft. (12 m² to 16 m²) each (Pfeifer and Braunek 2008). Using similar room dimensions and proportions throughout, allows for the various functions to be rearranged in the post-occupancy phase. A ground floor home office, for instance, can be relocated to an upper storey without concerns for lack of space. A room can initially have two doors and later be partitioned to create two smaller rooms.

In some cases, when the original structural framing of the townhouse is designed to support future building loads, a concept called add-on growth can be used. Opposite to add-in growth, add-on growth is the construction of an entirely new addition to increase the total floor space of a home to accommodate new functions. Depending on the structure, rooms can be added in any direction to comply with new needs (Conrad 2007).

Since space in townhouse units is limited, expansion typically takes place at the rear or, alternatively, a storey will be added. When conventional construction is used, the new section can be structurally independent or it can use the existing structure as part of its support. In the former case, a prefabricated system can be employed. The addition could be made of a factory-built model that would be brought to the site and placed on a perimeter foundation wall or piers. When the expansion uses the existing house as part of its structure, beams or columns need to be affixed to it. Provisions for connecting the old structure to the new would include the extension of re-bars from the frame or pockets of soft filling at the edges of beams so that when new structure is added, it can be done easily.

**LINKING INTERIOR TO EXTERIOR**

A direct access to the outdoors is essential if a townhouse is to offer the same advantages of a single-family dwelling. Not only does it reinforce a territorial feeling of homeownership, but it also expands the floor area and makes the interior seem bigger through a dynamic visual relationship that exists between the interior and exterior spaces. While the front yard has a more formal, public character, the backyard is a private space that can become an extension of the house’s floor plan.

Porches and gardens enhance the attachment between homeowners and their places of living. During warmer months, an enclosed exterior area can become an outdoor room with seating arrangement. Large glass doors facing the backyard, a deck which resembles the interior floor pattern and overhead protection from the sun all contribute to blurring the distinction between the indoors and outdoors. In Shim-Sutcliffe Architects’ Laneway House in Toronto, Canada, the interior and exterior gardens and courts blur the relationship between inside and out as shown in Figure 9. The configuration of the interior layout will also influence the functioning of the exterior. If a kitchen is placed at the rear of a townhouse, the backyard can easily accommodate an outdoor eating space. When connected to the living room, comfortable seating can create an area for quiet activity and relaxation.

While decks and patios are typically built on the ground level, upper floors can reap the benefits of exterior space through balconies, loggias, and roof terraces. The roof garden terrace can offer a pleasant view that justifies additional costs associated with construction of a flat roof.

**Figure 9.** Laneway House in Toronto, Canada by Shim-Sutcliffe Architects. The exterior, indicated in the darker tones, is an extension of the interior and is used to increase liveable floor area in the home (Source: Shim-Sutcliffe Architects).
CONCLUSION

Townhouses build in a row have a simple geometry that also contribute to affordability. In addition, as the density of a development increases, the cost per unit decreases. The small footprint reduces waste and maximizes space usage. It is these advantages that are likely to make a dwelling attractive to contemporary households.

The interior design of townhouses requires using design principles that ensure waste reduction, maximum space efficiency and creating a space that appears larger. According to Kottas (2008), this can be achieved through using furniture, light, colour, and materials. Reducing and simplifying circulation, allowing ample natural light in, and taking advantage of the exterior surrounding the home are key strategies in the architect’s approach. Attention to detail is imperative and, with success, can give a townhouse most of the benefits as a detached dwelling. Designers need to consider every small area in their layout. Whether it is under the stairs or in the backyard, every part of the home can be used for a specific function. What it all comes down to, is definition and spatial efficiency; ensuring that the interior can adapt to the needs of the occupants.

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**Authors’ address:**

**Avi Friedman, Ph.D.**
McGill University  
School of Architecture  
Macdonald-Harrington Building  
815 Sherbrooke Street West  
Montreal, Quebec, Canada  
H3A 2K6  
Tel. (514) 398-4923  
E-mail: avi.friedman@mcgill.ca

**Robyn Whitwham**
McGill University  
School of Architecture  
Macdonald-Harrington Building  
815 Sherbrooke Street West  
Montreal, Quebec, Canada  
H3A 2K6
The increasing environmental concerns in the 21st century require the building industry to adopt environmentally friendly approaches and promote long-lasting buildings. The flexible building idea has gained attention again because it has the potential to extend the functional life span of buildings and respond to users’ various needs. (Jia, 2001: 27,32) The associated concepts of standardization of building elements may reduce energy and material consumption by enhancing productivity and reuse of building materials.

After WWII, mass housing was driven by several prototypes of functional plans and the standardization of building technology to minimize the cost and increase construction speed. These prototypes and the standardization proved incapable of adapting to the diversity and constant changes of the residents’ needs. In the 1960s, N. John Habraken demonstrated a new concept that divides a building into two levels: support, which involves building structure, common circulation, and service cores, and infill, which involves all detachable building elements. The inhabitants were the ones responsible for controlling the application of the infill. Since then, many architects, engineers, and building researchers in Europe, the US, Japan, and China have engaged in implementing the theory in a variety of cultural, economic, and technological contexts, developing a common movement called Open Building Implementation (Jiang and Jia, 2011: 7). Recently, architectural academics have become increasingly concerned about the fundamental problem of architectural theory and history right at the center of the discipline: featuring the monumental buildings in the history of Europe and ignoring the ordinary buildings in the diverse civilizations in the world (Habraken, 2006:13-14). Ordinary buildings form cities, settlements, and the essential parts of the world’s cultural civilization. More importantly, they closely respond to the people and changes over time. Thus, the history of architecture should be reviewed based on a new dimension of understanding of the built environment represented by the people, time, and diversity of regional culture. Therefore, a study on traditional Korean architecture, which is accomplished...
through flexibility and adaptability because of its unique types of structures, infill elements, layout of buildings, and construction system, cannot be ignored.

Korea is in the middle of China’s continental culture and environment and Japan’s oceanic culture and environment. The Joseon Dynasty (July 1392–August 1910; also includes Choson, Choson, and Chosun) founded by Taejo Yi Seonggye lasted for approximately five centuries as a Korean sovereign. Joseon was also the last royal and latest imperial dynasty in Korean history that had a strong influence on the buildings existing today. It was the longest ruling Confucian dynasty; therefore, the quantity and quality of its records are comprehensive. The current paper analyzes the existing buildings and archives from this dynasty. The ancient paintings, historical records, and literature are used for analysis. Most of the examples in this paper were taken from Dolgwoldo or “Painting of the Eastern Palace,” which is cited by Uigwe, and Joseonwangjo-silok or “Historical Documents.” Donggwoldo is representative of Korean paintings in the early 19th century. It depicts the two royal palaces, Changdeokgung and Changgyeonggung, during the Joseon Dynasty. Uigwe is a collection of royal protocols of the Joseon Dynasty that records and describes the important ceremonies of the royal family. Joseonwangjo-silok is the annual records of the Joseon Dynasty kept from 1413 to 1865.

Unlike conventional discourses of traditional architecture, which may be confined by the evolution of building styles, construction technology, implicit or explicit cultural and social metaphors, this research investigates the flexibility of the structure, and interactions between buildings and life supported by structure flexibility. The following paper analyzes the support systems, infill systems, functional adaptability, the organization of construction, building regulation and standardization in traditional Korean architecture.

Understanding any building works as a united system, the analysis of these aspects of the flexibility revealed the knowledge, material, techniques and beliefs that the building is living process, rather than a static object. Of course, the most flexible structure type is the temporary structure, which is found widely used in the palatial quarters to cater a diversity of events.

2. TEMPORARY STRUCTURES IN PERMENENET SETTINGS

The usage of exterior space for ceremonies, such as marriages and banquets, through movable partitions and screens in palaces is described in the Dolgwoldo (Painting of the Eastern Palace). Movable objects, including Panjang, Hwijang (curtain), Chayang, and Gatoi, described in the Dolgwoldo are located in the central part of Changdeokgung and Changgyeonggung palaces, where important people such as the king, queen, or prince lived. Figure 1 shows how Panjang was used for multiple purposes, including division of space, obscuring sight, and separation of circulation, specifically the space of Huieongdang Hall (Park, 2000:247)
Fig. 2 shows how another type of temporary structure, Cha-il, was attached to buildings and independently installed. Cha-il was used in important ritual events and was especially designed for royal banquets (HAN S., 2000:6). The functions of Cha-il were to protect space from sunlight and rain, and to extend and reorganize the ritual space (CHOI J. & HAN D., 2009:186).

These variable devices were used for the following purposes. 1) To pursue efficiency and economy of palace usage, variable devices were set up, dismantled, modified, and set up again instead of building a permanent building. 2) Owing to the wide scope of a palace’s domain and the numerous users, several variable devices were used to accommodate various classes of users and dwellers, as well as to separate public from private spaces and inside from outside. 3) Each variable device was used for residence, daily activities, and special events in palaces. These devices were used for artistic effect as well for fitting variable characteristics of space and intended usage.

3. SUPPORT IS AN ASSEMBLED STRUCTURE

The traditional Korean building structure is similar to that of the Chinese; that is, the structure can be divided into two parts: large timberwork (Figure 4) and small timberwork (JIA 2011:22). Large timberwork is the main structure composed of beams, columns, and roofs connected in various joint and splice methods without nails (Figure 5). Figure 5 shows the joint and splice methods between pillars and tie beams (Changbang), which perform the important function of transmitting vertical and horizontal load. Small timberwork includes manufacturing and installing infill and fit-out. Small timberwork will be discussed in detail in spatial flexibility.

The framework structure bears the force transmitted from the rafters, Tōri (crossbeam running the length of the house from side to side), and pos (cross beams running from the front of the building to the back) to the column and supports.
the weight of the roof. If the scale of the building is larger, and the beam length becomes longer, Koju (extra tall pillar) should be used to narrow the distance between beams. The number of Tori also increases. This wooden framework structure eventually enables buildings to have the possibility of structural extension. Examples are an extension of Yeongnyeongjeon (Confucian shrine) and that of Guksajeon in Songgwansa temple. The number of Kan (a unit of measurement, referring to the size of a square space created by four pillars set roughly at a distance of one-Kan, which is about seven to eight feet) in the Yeongnyeongjeon’s front facade was originally 10 but became 12 in 1667 (Kim, 1993:207).

The majority of buildings for religious activities have an odd number of Kans in the front façade. However, the Guksajeon had a four-Kan front façade, different from the usual cases (Figure 6). The Kans in Guksajeon’s front façade were originally three in number. The number later became four Kans to contain an additional portrait of the national monk (Nam, 2006:173-180). The structural flexibility enables spatial change to serve the users’ changing purposes and needs over time.
4. THE INFILL

During the Joseon Dynasty, according to the Confucian principles, men and women were placed in separate quarters: Anchae (women’s quarters) and Sarangchae (men’s quarters). However, the Anchae and Sarangchae were connected by a bridging passageway (Maru) and a middle gate B (Figure 7) between them for functional efficiency. At first sight, the Anchae and Sarangchae look structurally separate, but through Maru, the gate and entrance, two quarters remain joined.

In terms of arrangement and plane levels, the houses of the Joseon Dynasty Era were various, depending on weather and social status. However, the houses with the floor heating system, which were developed in the northern region, and the wood-floored halls, which were developed in the southern region, co-exist in the Hanoak (traditional Korean house). The floor heating system and the bridging passageway (Maru) are placed in a single indoor space with rooms that can be separated or integrated by opening or closing the sliding doors.

Spaces were used for multiple purposes by sitting on the floor, similar to the Japanese lifestyle. In houses where the upper class lives, the Anchae (women’s quarters) was comprised of a kitchen, Anbang, Daecheong (wood-floored main hall), and rooms on the opposite side and over the front door. The kitchen and the main room were connected.

The main room served as the everyday quarters of the housewives. It was used as the “living room” or greeting room for the female guests during daytime and was converted into the bedroom at nighttime. The room over the front door was located in the upper part of the main room. The clothes and closet were located in this room (Joo, 2006:412).

The Sarangchae (men’s quarters) was comprised of the man’s study or drawing room, bedroom, upper floor room, and bridging passageway (Maru). The man’s study or drawing room served as the living room of the owner during daytime, where guests were entertained. The bedroom served as the owner’s bedroom. According to the etiquette between men and women, the husband and wife were supposed to sleep in different rooms and sleep together only on specific dates (Joo 2006:412). Daecheong, without the heating system, served as the place for various domestic activities, particularly during summer.

Festivities, such as weddings and ancestral worship ceremonies, were conducted in Daecheong (figure 8). Spaces could be opened and closed with various hanging doors. These doors remained open on all four sides of a building in the summer months, enabling ventilation and open views of the surroundings of the house. When opened, the Dloyulgaemun or hanging door panels were folded up and hooked on the ceiling by rings (Figure 9).

Figure 7. (a) A ground floor plan showing the relations of male and female quarters. (b) A typical plan house plan (Redrawn by the authors according to Sin, 2000b:50, and Choi, et.al. 1999:62)
Figure 10 presents the operation of the hanging doors. Figure 10 (a) shows the lifting of the door in between the main room and the wood-floored hall. Originally, there were four pieces, but later on, three out of the four doors were made into one for the convenience of easy lifting. When they function as a wall, with one piece lifted up, the hanging doors can open up the entire space at once. Figure 10 (b) shows the condition when the door in between the main room and wood-floored hall is closed and when the door between two neighboring wood-floored halls is lifted. Figure 10 (c) shows the partial closing of the door between the two wood-floored halls.

Korean houses feature a layout of rooms that enable a high degree of movement from one room to another. The use of removable room dividers and doors made various areas accessible
to different members of the family, as well as visitors, at numerous times throughout the day. Inside the rooms, the walls were lightweight partitions operable like doors or windows. These walls played an important role in accommodating the changes in use in everyday life. The anbang, tarch’ong, and other rooms could remain individual areas or be combined in different ways to accommodate each household activity. Each room had a separate exit outside, which could be used as an independent space. It could also be integrated into the neighboring rooms by opening up, taking out, or lifting up the pieces of partitions. There were many different types of openings, such as sliding room divider door, paneled removable door, pocket sliding door, plain board door, framed board door, non-transparent window or door, fancy and decorated door, and latticed door, among others (Figure 11).

5. FUNCTIONAL ADAPTABILITY

Functional adaptability means several functions overlapping on a given space and/or one function replacing another (Kim S., 2000:50). An example is the use conversion of Buddhist temples in the Goryo Dynasty to places of worship or prayer for private ancestors and royalty. This conversion was caused by the change in political ideal and religion. Goryo’s ethical and philosophical system was Buddhist, and Joseon Dynasty’s was Confucianism. This shift caused temples to be converted to other purposes. Although the Joseon Dynasty’s belief was different from that of the Goryo Dynasty, temples of the Goryo Dynasty were reused without deconstruction.

Use conversion of the municipal building in the Goryo Dynasty to accommodation for Chinese envoys is another example. The record of the Taejo-silok states that the municipal building called Jeongdonghangseong, which was built in the Goryo Dynasty, was remodeled in this month. It was renamed Taepyoung-gwan and used for the accommodation of foreign envoys. Taepyoung-gwan was located in Gaeseoung City, which was the capital city of the Goryo Dynasty. (Taejo-silok Vol.3, 1393, 29th Dec, 6th article)

After the capital city of the Joseon Dynasty was moved to Hanyang (old name of Seoul), the newly built Taepyoung-gwan was used as the accommodation facility of Chinese envoys. It also became the venue for royal ceremonies, including royal weddings (Yoryosilikisul, cited by Seo and Han, 2007:595), national examination, ceremonies or rituals of the Joseon Dynasty to be learned by the princes (Jungjong-silok Vol.8, 1536, 12th Dec, 1st article), and accommodation of foreign non-Chinese envoys (Saejo-silok Vol.43, 1467, 14th Aug, 2nd article).

Jeongjo-silok (Vol.11, 1781, 10th March, 6th article) documented another use conversion. Docheongbu, which was in charge of the royal security, moved to Changgyeonggung, and the place was used as an office of scholars called Inumwon. Docheongbu was originally located near the main gate of the palace and the king’s office. However, King Jeongjo wanted an office for scholars to be located near his quarters so he could exchange opinions with them and have them work in one place. According to the record of the Jeongjo-silok, Jeongjo enjoyed talking about academics as well as political and administrative affairs of the Joseon Dynasty with the scholars who worked for Inumwon even late at night.

No room in Korean houses served only one purpose, such as sleeping or eating. The same area used as the living room also served as the dining

Figure 11. Various kinds of partitions and doors for the interior spaces (illustrations from Choi, et.al., 1999)
room at mealtimes, and it was turned into a bedroom at night. In the houses of the upper class, sarangbang was not only a man’s bedroom but also a reading room, a place for meditation, an area for receiving guests, and a place for relaxation and artistic endeavors. To accommodate the multiple uses of a small room, the furniture and decoration in sarangbang were minimized; they fulfilled simple functions while exhibiting a modest yet elegant appearance (Choi et al. 1999: 164, 212).

As restricted by Confucian teachings, the anbang in the women’s quarters were not used for learning and artistic endeavors, but they functioned as a multi-purpose area. They were especially small for serving a considerable number of functions: as a bedroom, dining room, living room, storage of the entire family’s clothes and bedding, and special events room for the delivery of babies, attending to a deathbed, or the reception of a bride. The special space required small and portable furniture, and the placement of only a few essential pieces of furniture that occupied space along walls, leaving the middle of the room free for conducting various activities (Choi et al., 1999: 159-161).

6. ORGANIZATION OF BUILDERS

Although the organization of builders differed according to the different sizes of constructions, in the Joseon Dynasty, it was largely divided into three: the official manager, supervisors, and builders.

The organization of Nambyeoljeon reconstruction (1677) (Figure 12) was composed of the official management (from Nangcheong to Sujikgunsa), positions that supervised the builders in the construction (Gamyeokgwan), and the workers including craftsmen and laborers. Craftsmen for each process belonged to each work team. Work team 1 carried out woodwork, mostly consisting of craftsmen working on 16 areas. Work team 2 carried out masonry and roofing tile work, and it included craftsmen working on two areas. Work team 3 was responsible for the decorative painting of the wooden structures and artifacts. In the work of “cinnabar and blue-green,” the craftsmen working on six areas participated in six stages in the processes. The roles and responsibilities of each craftsman were clearly defined. Subdivision of roles and responsibilities for the same job was also defined. A working process was specialized and systematized according to the kind of work.

Dangsang (positions which generally supervised or managed construction)
Nangcheong (person in charge of construction work by each work team)
Seori (person in charge of record keeping and communication)
Gojik (warehouse keeper)
Saryeong (person in charge of running errands)
Sujikgunsa (person in charge of surveillance within the supervising office who safeguards the goods)
Sanwon (inventory identification and management)
The process of building in the Joseon Dynasty was not clearly divided into design and construction. A master builder called Daemok, who was the head builder in first half of the Joseon Dynasty, took on the design and supervised the construction work in the field. In the construction of palaces or important ancestral shrines, many people, including the king, the subjects (e.g., feng shui experts), and the master builders would take part in the decision-making process of design and construction.

In the early Joseon Dynasty, Daemok, as the head craftsmen, gained high positions. However, after the 16th century, as the number of positions for craftsmen declined and as the craftsmen were not under the government anymore, the position of Daemok disappeared in official constructions after the 17th century. Builders with the title Pyunsoo replaced the Daemok. Pyunsoo were workers who possessed more specialization. This shift specialized and standardized the building system of the Joseon Dynasty (Kim, 1993:209–211).

The position of Yeongyeok-boojang was responsible for primary executions. It was the lowest management or supervisory post along with the head craftsmen. Yeongyeok-boojang was being in charge of various execution works. Those in this position supervised and commanded the craftsmen and inexperienced laborers. The position of Yeongyeok-boojang disappeared in the late 1800s, and it was replaced by the term Paejang (Seo, 2009:215). When the title of the manager’s position changed from Yeongyeok-boojang to Paejang, most of the works were completed under the Paejang’s supervision. Each group took responsibility for its own work. Work units (Pae) enabled the measurement of the amount of work and the calculation of construction cost.

Construction work based on unitization and quantification of workload and costs indicates that planning construction based on exact estimates of material requirement is possible. This method enhances the effectiveness of construction and promotes productivity, eventually leading to the reinforcement of the specialization of each work. In the construction process, the diversification and specialization of jobs required tend to increase the efficiency as well as accelerate the assembly of parts and specification of parts. This specialization facilitates countermeasuring the changes taking place in the future and the renovation of buildings. Moreover, it facilitates the assembly and disassembly of parts, enabling re-use.

7. BUILDING REGULATIONS

The Joseon Dynasty regulated the size of the land as well as the house itself according to the ranking of royalty or government position. Certain rules were applied on the types of decorations and accessories as well. Sejong, the fourth King of the Joseon Dynasty, imposed limitations on the number of Kans, controlling the practical sizes of homes in 1431:

It was 60 Kans for the Taegun (rank of princes by the king’s first wife), 50 Kans for the ranks of kun (princes by the king’s secondary wives) and Ongju (princes by the king’s secondary wives), 40 Kans for the chongcho’in (king’s relatives) of Class Level Two or above, 30 Kans for Class Three and lower, and 10 Kans for Sohins (non-titled citizens). (Sejong-silok Vol.51, 1431, 12th Jan, 3rd article)

People strictly observed the regulations on the sizes of homes. However, the rules became increasingly lax. The government amended the rules to regulate both the sizes of homes and the size of materials in 1440. The Joseon Dynasty revised the regulations four times.

The concept of modularity was defined based on the regulations of the class system. The primary unit of modularity was “Kan” which represents the space between columns. The unit length of “Kan” in buildings differed, even in buildings in the same Kan. As the unit length of “Kan” was not fixed, the regulations on the hierarchy of residents were not strictly implemented. Therefore, in 1440, King Sejong imposed the sizes of elements, including length of beams and Toris, and height of columns. The following record shows how the sizes of components were controlled:

The Ceremony board reported that the Joseon citizens from upper and lower classes had begun exhibiting extravagance in the size and decoration of their homes, and there were no class distinctions. As such, the government formalized the regulations. However, the people did not comply with this requirement and exceeded the limits. Therefore, beam length and column height (the
number of ch’ok=a unit of measurement equivalent to 30 cm for beam and column), as well as the number of Kan for pavilions and general buildings, were settled by law according to classes and people who complied. (Sejong-silok Vol.90, 1440, 27th July, 2nd article)

The regulations of the Joseon Dynasty were written not only in Joseonwango-silok and but also in Kyeongguk daejeon. The Kyongguktaejon, a book on the principles of the government, was published in 1419 A.D. The section on the requirements for the sizes of homes specified only the square footage.

8. PREFABRICATION AND RECYCLING

By trimming timber with specific measurements and forms, timber frame post and lintel structure were completed by a prefabrication method, that is, erecting columns and T oris to the rafters. This prefabrication method facilitates the replacement of elements and enables the recycling of materials.

In the era of the Joseon Dynasty, the shortage of timber supply intensified further as the demand increased for reconstruction after the Japanese invasion in 1592. Owing to the shortage of timber, the recycling of the timber increased, and planning for prefabricated component parts was encouraged to prevent possible wastage of timber.

Figure 13 shows that the Marus system (floors finished with wooden boards) was easily repaired by replacing the deteriorated components with new ones. It was built by setting up wooden boards without any nails. Short boards were fitted into longer framing boards by a tongue-and-groove method. The Changguitul (long framing boards) and Tongguitul (short framing boards) formed the frame, and Chongpan (filler boards) filled out the Maru space inside the frame.

The prefabrication and standardization of component parts encouraged the recycling of materials. The following are the historical records of Joseonwango-silok depicting the reuse of materials:

In the early Joseon Dynasty, the residence of Min, Mugu and Min, the Mugil brothers, was disassembled. Using separate wooden elements and roof tiles, the accommodation facility for envoys called Dongpyoung-gwan was constructed. (Taejong-silok Vol.17, 1409, 26th Feb, 1st article)

Many Buddhist temples went into disuse because of the change in religion. Some Buddhist temples were made obsolete, and their materials were recycled only after disassembly or remained disused. Others were converted (transformed) to (into) to be used for other functions. (Saejong-silok Vol.45, 1429, 10th Aug, 2nd article)

Early in the Joseon Dynasty, many Buddhist temples were abandoned, as Buddhism was suppressed. The building materials for Buddhist temples were used for repairs of administrative buildings.

The head of two provincial agencies asked the superior officers for permission for the following. They wanted the wood and roof tiles of abandoned Buddhist temples to be used for repairing administrative buildings and construction elements in a new municipal building. The superior officers allowed it.

It was reported to the king that a building of the Heungcheonsa (Heungcheon temple) has been abandoned and that the structure of the building was dangerous. The king ordered for repairs. However, the technical officers revealed that even if it was repaired, it would still be dangerous. It would be better for the materials from the building to be reused rather than removed because the building was constructed by the previous king, and it was a part of the dynasty’s heritage. The three-storey building was disassembled, and a one-storey building was reconstructed using recycling materials. (Saejong-silok Vol.68, 1435, 12th May, 1st article)
As indicated previously, specialization of work reinforced the specialty of each job and enhanced the productivity of architecture. Ancient Korean architecture already accomplished modularity and standardization of elements based on the records of this regulation. The specialization of construction systems and standardization of materials contributed to the improvement of constructive productivity by enhancing the efficiency of works. Furthermore, the prefabrication method based on standardization and modularization of component parts preserved the limited materials and enhanced the possibility of recycling materials.

5. CONCLUSION
An alternative approach to analyzing traditional Korean architecture is to focus on the spatial and structural flexibility, and the interactions between building technology and people, including the users and builders. First, temporary structures, which were equally magnificent as permanent structures, were used in palaces to accommodate temporary activities. These structures could be easily assembled and disassembled or reused in other events. Second, in permanent structures, the support and infill system were separate. The infill elements, especially the hanging doors and sliding partitions, created endless spatial changes, whether to accommodate the different needs for privacy and communication or the different occasions in the same building. Third, the construction of the main structure was based on the assembly of elements. Part of the structural elements could be replaced or modified while the entire structure remained unchanged. A structure could withstand high demanded and long-lasting service by constantly changing its components. This structural characteristic enables the changes in use, from serving as an area for sleeping or meeting guests to an area for holding religious activities or accommodating guests. Fourth, there was no clear distinction between designers and builders. They were usually the same person, but they were highly specialized, with a focus on a particular area of design and construction. Similar to a building structure, a construction team was also made up of sub-teams responsible for and skillful in specific parts of the structure. The team could be broken up based on the process of construction and needs of a particular time through the duration of the structure. Finally, there was consistency between the development of standardization and the saving of materials by recycling them in the traditional Korean architecture.

In Korea today, the sustainable building concept, including green architecture and environmentally responsive architecture, is being advocated. However, the practices of sustainability have been accomplished already in ancient Korean architecture and moved with the times. The current research is significant in that it presents the useful experiences and methods from ancient times that make the traditional Korean building last longer, accommodate changes in needs better, and use less resources than most contemporary buildings.

ACKNOWLEDGMENTS
The current paper was written based on the research project “Architectural Identity in Asian Cities: A Comparative Study on Housing Morphology” funded by the Conference and Research Grant Committee of the University of Hong Kong 2010. The authors would like to express their gratitude to the University of Hong Kong for allowing Dr. Kim Sungwha to be involved in the project by providing a position for him as a Visiting Research Associate from July 2009 to June 2010.

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Authors’ address:

Kim Sung-Hwa
Instructor (or Lecturer)
Department of Architecture
Kyungpook National University
Deagu, Korea

JIA Beisi
Department of Architecture
The University of Hong Kong
Hong Kong


URBAN SQUATTING IN LATIN AMERICA: RELEVANCE OF ‘GUIDED OCCUPANCY’

Belén Gesto, Guillermo Gómez, Julián Salas

Abstract
While the illegal occupation of land by families lacking the means to acquire housing on the market is hardly front page news in Latin America, it may not merit the silence to which it has been relegated of late. The authors, who formed part of a research team on the subject, conclude that urban squatting is still very common today. The team found that most Latin American countries are amending their municipal, provincial and national legislation in this regard and backing programmes for consolidation and improvement. In a nutshell, they are adopting a more tolerant attitude toward squatting. The authors believe that the Guided Occupancy Programme successfully implemented by the city of Trujillo, Peru, for over a decade, constitutes an exemplary approach to the problem. While not necessarily constituting a universal solution, it can be viewed as a viable and reproducible alternative in situations of widespread poverty.

Keywords: urban squatting, Latin America, guided occupancy, urban planning, basic habitability.

INTRODUCTION TO THE ONGOING DEBATE ON URBAN SQUATTING

In the framework of the Polytechnic University of Madrid’s UNESCO Chair on Basic Habitability, the authors conducted a study published under the title: Las tomas de tierras urbanas en Latinoamérica hoy: problema o solución (Urban squatting in Latin America today: problem or solution). The preliminary conclusion drawn was that the diversity and complexity prevailing in Latin America, with over 16,000 towns and cities, rule out any single answer to the paradox: problem or solution?

Urban squatting or “invading” land that belongs to someone else is usually the initial stage of what, over time, become slums, variously termed callampas in Chile, favelas in Brazil, limonás in Guatemala, ranchos in Venezuela, villas miseria in Argentina, pueblos jóvenes in Peru, ciudades paracaidistas in Mexico or tugurios in El Salvador. Such communities house 23.5% of the urban population in Latin America (UN-HABITAT, 2008).

Squatting and slums (the latter defined here as in the United Nations publication UN-HABITAT (2003a)), are closely related, for they can be seen as two consecutive periods or stages of the same process: squatting as the starting point, and slums as the long-term result. The ultimate aspiration is to convert such communities into consolidated neighbourhoods in the shortest possible time. Not all slums can trace their origin to squatting, however.

Slums are the result of processes that graphically reveal the absence of urban planning in cities in Latin America and in fact nearly all developing countries. Squatting is the outcome of the pursuit by the less advantaged, nearly always domestic migrants, of employment and the health and education services lacking in their places of origin (Davis, 2003).

Squatting is an obvious matter of concern in Latin America and its existence may well account for the very high response rate (80.85%; 38 of 47 questionnaires)¹ and quality of the meticulously documented replies to a survey recently conducted on the subject. This invaluable material furnished an updated view of squatting in Latin American countries and provided quantitative evidence for the fact that it constitutes a current and widespread occurrence.

The very high rate of response to the aforementioned survey, with replies from all Latin American countries, is indicative of the acute awareness on the part of some architects, engineers and institutions of the problem posed by squatting
and slums. It also denotes the potential contribution that sharing local experience can make to expertise and productive capacity, as well as the advantages of networking in a situation that affects all Latin American countries in one way or another.

HUMAN DEVELOPMENT INDEX (HDI) AND SLUMS

As Figure 1 shows, according to the present country classification based on the human development index (PNUD, 2011), two of the 19 Latin American countries, Chile and Argentina, are in the very high human development bracket (HDI > 0.900), ranked 44th and 45th, respectively of the 187 countries classified. Nine are in the high human development bracket (HDI < 0.900 and > 0.800), with Uruguay in 48th and Colombia in 87th place, and seven are in the medium human development bracket (HDI < 0.800 and > 0.500), ranging from the Dominican Republic’s 98th place to Guatemala’s 131st. Haiti, ranked 158th, is the sole Latin American and Caribbean country in the low human development bracket.

According to United Nations data for 2010 (UN-HABITAT, 2008), over 110 million people or 23.5% of the total urban population live in “precarious housing” in Latin American and the Caribbean. In 10 of the 20 countries (Argentina, Bolivia, Brazil, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Peru and Venezuela) analysed, the percentage was higher than the mean. Surprisingly, countries such as Argentina, Venezuela, Brazil and Peru, which have high or very high HDIs, had high slum rates. Nonetheless, in five of the seven countries with the highest regional HDIs (Cuba, Uruguay, Chile, Costa Rica and...
Mexico), slum dwellers accounted for a smaller percentage of the population than the regional mean.

Graphs such as depicted in Figure 3 that plot countries’ HDI ranking versus the percentage of their population living in slums show that a country’s development is inversely related to its poverty levels and the precarious nature of its settlements, as the United Nations pointed out in 2003. In fact, the higher the percentage of the population that lives in slums, the lower the HDI and conversely, the higher the human development index, the lower is the percentage of slum dwellers (UN-HABITAT, 2003b). The HDI comprises three development indicators, GDP per capita, life expectancy and the literacy rate, from which it may be deduced that these three factors are also related to a country’s habitability. Figure 3.2

SQUATTING: A CURRENT AND WIDESPREAD PRACTICE IN LATIN AMERICA

Government attitudes toward squatting and informal settlements have changed visibly over the last five years. Eviction rates are declining. Present policy increasingly leans toward the acknowledgement and consolidation of informal settlements, according to the results of the surveys conducted (Salas et al., 2010). This change of attitude has only exceptionally carried over to engineering and architectural circles, however. The perception is that architects, urban planners and civil engineers continue to view the development of the urban fabric and city building as areas of their exclusive competence. Concepts such as participatory design, organic growth, self-building, interdisciplinarity, process/product and many others are excluded from the training delivered in their schools and faculties, even in the Third World. These institutions still maintain the eighteenth century idealist vision of city building in which dweller participation is limited to the passive acceptance of the products generated by architects and engineers and private or public developers.

The perception of their countries’ attitude toward and policies on squatting expressed by the Latin American specialists surveyed is illustrated in the percentage results given in Figure 4 (Salas et al., 2010). Eviction is the option least frequently adopted by Latin American authorities, some of whom reject the possibility even vehemently: only 13% of the respondents, all in Brazil, Colombia, Panama or Uruguay, defined it as a “current policy”. Consolidation, by contrast, i.e., policies that seek integration, legalisation and improvement of the outcome of squatting, is the majority option, accounting for 62% of the responses. That finding clearly ratifies the scant belligerence of Latin American society and institutions toward squatting.

Figure 3. Country HDI versus percentage of slum dwellers in Latin America. Source: UN-HABITAT, 2003b and UNDP 2007 data, author configuration.

2 The values shown in the figure are for the year 2007; more updated data by country on the percentage of the urban population living in slums were not available (UN-HABITAT, 2003b and PNUD, 2007).
Further to the study discussed (Salas et al., 2010), across nearly all of Latin America, three levels of government action can be identified: national, provincial and municipal. While municipal governments are not generally empowered to legalise informal human settlements, they cooperate with the provincial or national authorities by both establishing direct contact with the persons concerned and handling the administrative proceedings. Intense activity funded by outside resources, primarily from the Inter-American Development Bank (IDB), was also identified. The study likewise revealed that the right to decent housing, here interpreted to mean the right to basic habitability, is included in the constitutions of 16 of the 19 countries analysed.

The consolidation of slums via improvement programmes is one of the most active housing policies (in the broadest sense of the term) in Latin America today and one to which sizeable resources are being allocated. This would help to explain that, except where located in vulnerable areas, the results of squatting are more a solution than a problem in response to “housing hunger” (Salas, 1998). These are, however, “palliative” policies that address the existing housing problems. A more desirable solution would be to deploy forward-looking, “preventive” policies that anticipate slum creation or at least seek solutions that will not compromise the future of these settlements. The value of the Guided Occupancy Programme implemented in Alto Trujillo, Peru, lies in its ability to anticipate the solution that the squatters themselves would otherwise adopt (Smolka, 2007).

THE ALTO TRUJILLO GUIDED OCCUPATION PROGRAMME IN PERU

The Guided Occupancy Programme described in this section is a municipal scheme that the authors believe merits acknowledgement and dissemination, in light of its practical contribution to citizens’ right to basic habitability which ensures them land at least apt for human habitation and future development.

Trujillo, a city on the northern coast of Peru and capital of the Department of La Libertad, stands on the right bank of the River Moche, just a few kilometres inland from the Pacific Ocean (Trujillo, 2002). It is presently the third largest metropolitan area in Peru by both physical dimensions and population and home to over 792,355 residents whose average age is 29.4 (INEI, 2007). According to a 1995 urban growth forecast, on the order of 120 gross hectares/year would be needed to house approximately 4,000 new families, an estimated 50% of whom were expected to have scant resources (Trujillo, 1995).

Greater Trujillo has two chief areas of economic activity: agro-industry and the manufacture of footwear and other leather goods. One of its most prominent farm products is asparagus. The area’s output has made Peru a world class exporter, providing jobs for a large share of the city’s population under the “Special Chavimochic Project”, which includes irrigation for several local valleys. This, in turn, has favoured the export of other farm and agroindustrial products. The city has also encouraged the establishment of a footwear cluster at El Porvenir, one of its poorest districts; 53% of the city’s small and medium-sized enterprises are now located in that district, where the Guided

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3 For the authors (Colavidas and Salas, 2006), basic habitability means conditions that “...meet the essential need for shelter common to all human beings. Satisfying that need entails covering residential urgencies, but not as regards habitation alone, but also to public space, infrastructure and the elementary services that together constitute a settlement that favours population growth. Basic habitability therefore includes a supply of potable water, wastewater collection, elimination of solid waste, basic social assistance, transport and communications services, low-cost roads, energy, health care and emergency services, schools, public safety, spaces for leisure, seed housing...”

4 By “improvement” the authors mean both legalization and improvement per se, understood to mean works and intervention affecting the physical space where informal settlements are established, and PNUD, 2007).
Occupancy Programme studied here was implemented.

In its Metropolitan Plan for Trujillo 2010 (Trujillo, 1995), which preceded the launch of the Guided Occupancy Programme, the city expressed its alarm over the growth of informal and unplanned urban development in the area and its expected magnification. Inherent in the problem was the insufficient urban development of human settlements due to the high social and economic cost of intervention, which also met with other difficulties such as the uncertainty around land ownership and the scant accessibility of basic services. Squatters were observed to usually choose the wrong areas, areas that might be vulnerable, earmarked for intensive farming or protected as natural or landscape reserves (Trujillo, 1995).

The high demand for housing generated by the less advantaged part of the population, accentuated by heavy migration flows from the department’s inland areas and other regions in northern Peru, was going unmet in Trujillo. The scant supply of housing for this population and the lack of sufficient economic resources to meet demand at the local level intensified urban squatting. Municipal planners therefore established strategies to anticipate the growth of slums on the outskirts of the city, characterised at the time by a total lack of planning and limited or nil access to infrastructure and services. These strategies had at the same time to be compatible with the shortcomings with which local government had to deal. The response was the implementation of a municipal Guided Occupancy Programme (Amemiya, 2006) (see Figure 5).

The programme, largely propelled by architect Amemiya, was launched under the Metropolitan Development Plan for Trujillo 2010 (Trujillo, 1995), primarily to halt the spontaneous installation of slums in unsuitable areas and hence to favour the orderly growth of human settlements. The specific objectives included reducing the degree of informal housing, providing readier access to urban land, promoting the rational use of land for urban purposes (increasing density to raise efficiency), ensuring access to basic municipal services and facilities in the shortest possible time, and furthering co-management by encouraging citizens’ and local organisations’ participation in urban development planning, management and control.

Figure 5. Aerial photo of Alto Trujillo showing the urban structure around which the settlement is organised. From 1995 to 2006, 14 neighbourhoods were progressively occupied. Source: Google Earth photograph, 2006

The programme was implemented in an area known as Alto Trujillo, in the district of El Porvenir, whose location just 7 kilometres from the centre of the city guaranteed accessibility and connectivity. Although characterised by certain limitations, such as 3 to 8% grades and a soil with a low carrying capacity (estimated to be around 0.8 kg/cm²), it was chosen in light of the limited availability of other residential land. Special measures were adopted to ensure building stability and occupant safety, including restricted occupancy on grades of over 10%, a ban on buildings of over two storeys without a geotechnical survey and a requirement to build over continuous foundations. In addition, education campaigns were conducted and prevention, improvement and furtherance of safe housing programmes implemented.

Time has shown that urban planning prior to occupancy and urban growth, in which land was set aside for facilities and services, guaranteed efficiency, reduced costs and waiting periods for access to municipal services and facilities (Amemiya and Rodríguez, 2008). To that end, the urban model divided the district into three urban planning sectors. Each sector, in turn, consisted of from six to eight neighbourhoods, where provision was made for community facilities. Zoning was primarily residential, but allowed for productive activities in the form of mixed home-workshops to accommodate small-scale productive and industrial activities. The land set aside for parks was sited in areas at risk of flooding.
The basic unit in the model, then, was the neighbourhood, a group of around 800 families occupying some 20 hectares (see Figure 6). This modulated model favoured territorial organisation as well as inhabitants’ identification with and integration in the neighbourhood, while facilitating the technical implementation of municipal service designs. The programme, in pursuit of greater land use efficiency, allocated 58% of the total area for private use, 30% for roads and the remaining 12% for facilities. Density was 200-250 inhabitants per hectare, greater than the average for the area, to minimise infrastructure costs, while the mean plot size was 140 m². Larger plots, measuring 300 m², were allowed where housing was also used for running a business (home-workshop). In this context, the aim to increase density did not clash with the requirement to build only single family housing units. The single family dwelling is not merely traditional: it is in keeping with the socio-economic realities prevailing in the area. Collective housing was not feasible in this context, for it would have entailed foregoing self-building and called for larger family investments, which neither the families concerned nor the city could afford.

The success of the Guided Occupancy Programme depended on guaranteeing plot occupancy, in addition to providing access to the land. For that reason, plot ownership was made subject to living permanently in the neighbourhood and committing to take part in its consolidation, which included building a home. The indispensable requirements to qualify for access to the programme was to be registered as a resident, constitute a family unit and not own any other land. Once plots were awarded to eligible families, the population was organised to build priority structures, stake out the plots, condition roads, build latrines and dig wells. Families settled precariously on what were initially “their” plots, with no need to pay for the land, but committing to live on it (otherwise, the land was awarded to another family under the provisions of the Abandoned Plot Reversion Act). From that moment on, the neighbourhood and its homes gradually developed. Title to the property was delivered after a one- to three-year monitoring and assessment procedure. Thereafter, in a process whose duration depended on each family’s economy and the financial contribution available from the city government at any given time, infrastructure was laid and housing and facilities were built (Figures 7 to 10).
From 1995 to 2006, 14 neighbourhoods, now home to 50,000 people, were gradually occupied. In Trujillo, guided occupancy, as a model for gradually fitting occupied land with facilities, became a feasible land management strategy able to fuel urban development in the settlements by promoting joint action between the population concerned and the municipal and national governments. Active and organised community participation ensured financial as well as social and cultural sustainability. The resumption of squatting in 2006 when the programme was discontinued in the wake of a change in the municipal government (Figure 11) stands as proof that it achieved its objectives.

GUIDED OCCUPANCY: AN ALTERNATIVE TO SQUATTING

In the face of actual circumstance that corroborates basic habitability theory (Colavidas and Salas, 2006), the question posed is whether the Guided Occupancy Programme can be regarded as a generally applicable solution to one of the most pressing problems confronting humanity: an overwhelming housing deficit and new urban growth in the least developed countries.

The present authors share the view that basic habitability can be divided into four stages: choice of land apt for human habitation, rational plot division, gradual urban planning and phased building, all of which can be readily identified in the practical implementation of the Guided Occupancy Programme. The first stage, the choice of the site, was wisely undertaken by the city government. Bearing in mind connectivity, the new district was sited just 7 kilometres from the centre of Trujillo to guarantee future dwellers access to their places of work. At the same time, measures were taken to mitigate site limitations. By not allowing land to be spontaneously chosen, the city ensured settlement on suitable soil where the likelihood of natural catastrophes such as flooding was low (Fernandes, 2002).

The city also assumed responsibility for the second stage: rational plot division. It determined the size of the plots to control densities and reserve public space for facilities, parks and roads, while affording legal certainty in the form of property titles. The city of Trujillo in fact handles and controls the first three stages, for it also attends to the most basic and indispensable urban planning, in a clear commitment to public over private management. It nonetheless leaves gradual or “incremental” (to use a term coined by Cilento (1998)) housing construction in the hands of the dwellers themselves. The city also allocates some rather limited resources to the stages that lie outside the scope of the community.

A study of the underlying principles and drawing from what they learnt in situ from the Guided Occupancy Programme, the authors of this paper defined what in their unanimous opinion is the programme’s core idea: urban planning must
pre-date, must be able to anticipate, even spontaneous construction. A comprehensive instrument that covers the entire process in a context in which the population is expected to grow by 25% (from 800,000 to 1,000,000), the programme is deemed to be a suitable model on a scale able to deal with the squatting problem. The three conditions that must be met for its reproducibility in other places are: the existence of available land, a context of clear growth in the demand for unskilled labour and a local government with competence and determination to confront the squatting problem. Guided Occupancy can be seen to be a smaller scale version of the site and service schemes which, under World Bank sponsorship, were implemented around the developing world in the nineteen seventies (Clichevsky, 1990).

BY WAY OF CONCLUSION

Urban squatting continues to exist in Latin America as a solution to their dwellers’ “housing hunger” problem. But comparing spontaneous settlement resulting from unplanned invasion to the outcome of a municipal programme such as Guided Occupancy (Amemiya and Rodríguez, 2008) reveals visible differences, inasmuch as the latter:

guarantees land ownership, which is transferred from the city to the new dwellers
involves rational land selection and plot division that does not compromise families’ future, for any subsequent intervention for improvement or growth will be less expensive, easier and faster than in unplanned squatting
reserves public space that would otherwise be impossible to provide, and favours subsequent installation of infrastructure.

As a strategy for access to land and urban development, municipal guided occupancy programmes may be a feasible, reproducible and urgent alternative to squatting, providing for comprehensive and sustainable land development in lieu of what Matos Mar (Mar, 2004) describes as “population overflow” and urban growth under conditions of poverty. Guided occupancy programmes such as Trujillo’s may prove to be exemplary if they address the housing needs of the future population in the framework of basic habitability, subject to certain conditions such as local government leadership, land availability for urban expansion and residents’ participation in the process (Riofrío, 1986).

Viewed from the sound fundamentals afforded by the large scale of their implementation, these schemes may be expected to operate well when the city in question is willing to assume at least the first two stages of basic habitability (choice of soil apt for human habitation and rational plot division). These two stages, while not involving a particularly large investment, ensure that the future of the settlement will not be compromised, but can expect to acquire access to the economic support...
needed to continue to progress toward the attainment of decent housing.

Even so, the city of Trujillo, and on its behalf professor Amemiya, the driving force behind programme principles and ongoing implementation, question its cosmopolitan and general applicability to other contexts where circumstances may differ from the situation that prevailed in Trujillo. They conclude that guided occupancy “...is valid only under the present conditions of poverty and limited resources found in Peru”.

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**Authors’ address:**

**Belén Gesto**
Cátedra UNESCO de Habitabilidad Básica
Escuela Técnica Superior de Arquitectura
Avenida Juan de Herrera, 4, 28040 Madrid (España)
Email: belengesto@ichab.es;

**Guillermo Gómez,**
Cátedra UNESCO de Habitabilidad Básica
Escuela Técnica Superior de Arquitectura
Avenida Juan de Herrera, 4, 28040 Madrid (España)
Email:guillermogomez@ichab.es;

**Julián Salas,**
Instituto E. Torroja (CSIC)
Serrano Galvache, 4 28033 Madrid
Email: julian.salas@ietcc.csic.es
The process of architectural design is known for its complex and ill-structured nature. For this reason the process normally involves various stages of decision making, each requiring discrete inquiries into issues at varying levels of complexity and abstraction. The complex and ill-structured nature of the process is often due to ambiguities surrounding not only the definition of procedures and the flow of the entire process but also the nature of the information to be processed as part of the problem solving process. Overall, the architect is relied on to resolve information conflicts and differences of opinion and to integrate the knowledge held by the various design participants in a way that leads to a design solution (Maver 1970; Zunde & Boughdah 2006). In light of current architectural practice, the ambiguities warrant consideration at two levels: professional practice and information analysis. Uncertainties at professional practice level primarily deals with the coordination of input of many collaborators in the design process (Cuff 1992). To Cuff, ambiguities concerning “professional uncertainty” occur in four primary areas: expertise or knowledge of the design team members; authority and responsibility of building team members; allegiances of consultants and clients; and procedures (the actions taken during the course of a project) (Cuff 1992).

The second level of ambiguities mainly deals with what is usually called “architectural data,” for example, spatial dimensions, qualities or relationships of spaces. There may also be contradictions, unclear information and inconsistencies in the program requirements, project objectives or design criteria for satisfying users’ requirements (Chermayeff & Alexander 1963; Alexander 1964). It is assumed in this regard that those pieces of information obtained about the attitudes of prospective users of the project in question are “soft facts” and not usually fully verifiable (Cherry 1999). Another set of conflicts involve technical information and criteria that seem to exist in professional handbooks, tips and timesavers, the literature of the trades and many other sources cover a wide range of topics concerning the building process, construction elements and technical equipment.
Today it is generally accepted that the complex and ill-structured nature of the problem-solving activity in architecture requires creative thinking to generate novel ideas for solving complex problems (Franken 2001; Casakin 2008). The concept of creativity is today typically explained on the basis of novelty, utility and surprise. But as long as the existing literature on the concept is concerned creativity is not a unitary concept and needy of multidimensional treatment. One of the aspects of the problem is related to the supplies of evidence for claiming that the product deserves to be assessed as creative, mainly because the problem requires testing whether the creativity lies in the design or in the assessor (Gero 2011). Considering complexity of a design problem and difficulties in producing a universally agreed definition of creativity, there is a need to reconsider creativity in relation to some of the underlying aspects of the architectural design process. The present paper is an attempt to re-examine the underlying structure of the process of architectural design and the concept of creativity from the points of view of multi-sensory perception of an architectural design product, user needs, a designer’s theoretical orientation toward creativity and incremental steps of problem solving.

STRUCTURE OF ARCHITECTURAL DESIGN PROCESS

The architectural design process is often explained in terms of a decision sequence that involves analysis, synthesis, appraisal and decision at increasingly detailed levels of the design process (Lang 1987 & 1991; Moore 1997; Maver 1970; Lawson 2008). It seems, however, that the true meaning and importance of the decision levels in design are literally embedded in the levels of ambiguity and abstractness of the information itself. It is generally assumed that architectural design process mainly consists of two categories of activity: conceptualization and realization. The term “conceptualization” is often used to mean activities related to the schematic development of the design solution. “Realization” has to do with the communication, documentation and construction of that solution. Conceptualization is meant to encompass two successive phases of work: first, schematics as a way of exploring preliminary decisions for the requirements of the project; and second, preliminary design development. The first phase, schematics, generally consists of collecting, analyzing, synthesizing and evaluating preliminary information for the project, and two of its major elements are design concepts and formal explorations (Figure 1). Development of a design concept invariably requires that the designer recollect, review and evaluate solutions found in previous projects and consider their value as prototypes for the current project.

Formal explorations, on the other hand, would take place at a relatively more advanced stage of schematics. Such explorations essentially deal with the transformation of spatial and functional arrangements into two- or three-dimensional artifacts, structures, structural elements, spaces and environments. A preliminary design, based on the study of the schematics, is typically developed through the collective participation of the project owner, consulting engineers, resources for information on regulatory matters, representatives of building equipment and supply manufacturers and other groups. During the second phase of creative design solving (realization), the final version of the preliminary project plan may be improved by fine-tuning the contributions of the design participants. Realization may be achieved in two phases: development of the engineering project and construction drawings and finalization of the working drawings and specifications (Shoskes 1989; Mitchell 2002; Cherry 1999).

CREATIVITY FOR A MULTIDIMENSIONAL VIEW OF ARCHITECTURAL DESIGN

It has been stated by Gero that there are inadequate measures of design creativity and that it is appropriate to consider the measurement of design creativity from a multidimensional view, since design creativity is a multidimensional set of concepts (Gero 2011). With regard to the existing architectural literature, concern with design creativity must take into account a multidimensional view of an architectural design product concerning the following factors:
• A multi-sensory perception in architecture;
• Concern with human needs;
• Conceptual orientation for creative design; and
• Incremental steps of creative design problem-solving process.

A Multi-sensory Perception in Architecture:

Architects are generally known for their practice of communicating concerns about buildings by emphasizing visual as well as virtual images and visual techniques, while suppressing techniques that call for subtle and often difficult decisions concerning the people’s perception of and usefulness or functionality of spaces, buildings and consumer products. Norberg-Schulz states that a place cannot be considered by its visual appearance alone (Norberg-Schulz 1996). It has been claimed that a constructive view on how humans perceive architecture may be explained on the basis of the following concepts: hapticity, kinesthesia and synaesthesia (Schaap 2010). Hapticity refers to the haptic experience of people through touch. However, an experience of touch is often explained on the basis of its two-dimensional character, haptic experience, on the other hand, is assumed to be a three-dimensional one.

Kinestesia is the exploration of our environment through movement in which our eyes or body play a primary role. Diana Agrest is one of the researchers who explains kinesthesia as follows: “Other senses beyond the limits of the visual and spatial, such as audition and metonymically the entire body through time, rhythm, movement, and speed becomes relevant as part of representation”
(Agrest 2000). Active exploration of the environment may be achieved with touch and movement and also with hapticity as well. Such experience is important for architecture, because moving through space with body, or just moving with the eyes makes us experience architecture in less static way.

Syneastesia is defined as a phenomenon that transfers sensory information from one sense to the other. Aristotle saw syneastesia as the device connecting all senses together, to create a coherent representation (Aristotle 1999). Normally each of the concepts hapticity, kinesthesia and syneastesia is considered to explain a certain area of theories about sensory perception. But combination of the senses associated by each of these concepts is the embodiment of a person’s perception what is human in his/her surroundings. According to Gibson “the eyes and ears are not fixed capacity instruments, like cameras and microphones, with which the brain can see and hear. Looking and listening continue to improve with experience. Higher-order variables can still be discovered, even in old age” (Gibson 1968).

**Concern with Human Needs:**

Information about user needs for a design problem is considered to be important for the usefulness or functionality of the final product. Normally the needs of people may vary according to both circumstances of the environment in which they live and the lifestyles or living standards of the people. Abraham Maslow is one of the psychologists who attempted to synthesize a large body of research related to human motivation (Maslow 1943 & 1954). In his early work Maslow identified five basic human needs on the basis of a hierarchical order: physiological needs, safety/security needs, belongingness and love, esteem and self-actualization. But seventeen years later, Maslow modified his early theory of hierarchy of needs by adding 3 more levels to his early list of levels of basic human needs (Maslow 1971; Maslow & Lowery 1998). Maslow’s modified list of the levels of human needs in hierarchical order consists of the following:

1) physiological: hunger, thirst, bodily comforts, etc.; 2) safety/security: out of danger; 3) belongingness and love: affiliate with others, be accepted; 4) esteem: to achieve, be competent, gain approval and recognition; 5) cognitive: to know, to understand and explore; 6) aesthetic: symmetry, order and beauty; 7) self-actualization: to find self-fulfillment and realize one’s potential; 8) self transcendence: to connect to something beyond the ego or to help others to find self-fulfillment and realize their potential (Maslow 1971).

After the introduction of the revised version of Maslow’s theory, some alternative theories have been introduced by different researchers. The theory introduced by Alderfer in 1972 is claimed to be supportive of the works of William James, an American psychologist and philosopher who lived between the years of 1842 and 1910. James hypothesized the levels of material (physiological, safety), social (belongingness, esteem), and spiritual (James 1892/1962). Alderfer developed a comparable hierarchy with his ERG (existence, relatedness & growth) theory (Alderfer 1972). He categorized the physiological and safety needs into the Existence, love and esteem into Relatedness, and self-actualization needs into the Growth category. It has been argued that Alderfer’s approach modified Maslow’s theory based on the work of Gordon Allport who incorporated concepts from systems theory into his work on personality (Allport 1960 & 1961).

A theory of Fundamental Human Needs developed by Manfred Max-Neef and his colleagues Elizalde & Hopenhayn was introduced in 1991 (Max-Neef et al 1991). This theory is known for its radically different view about human needs than the ones developed by the theories of James, Maslow and Alderfer. According to this theory there are 9 fundamental needs which both interrelated and interactive with no hierarchies existing among themselves. The fundamental needs introduced by Max-Neef and his colleagues consist of the following: subsistence, protection, affection, understanding, participation, leisure, creation, identity and freedom.

Considering the implications of the human needs established by each theory for the wellbeing of an individual, it seems possible to relate those
items of human needs proposed by each theory on the basis of three levels: physical survival, sense of belongingness or social relationship and sense of self. Within the framework of this understanding the four theories of human needs introduced above (Maslow’s hierarchy of needs, ERG theory, the theory by William James and Max-Neef et al’s Fundamental Human Needs) can be incorporated into a common matrix as shown in Table 1.

Table 1. Synthesis of Human Needs

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<tr>
<th>Theory</th>
<th>Maslow</th>
<th>ERG</th>
<th>James</th>
<th>Max-Neef et al</th>
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<td>Freedom</td>
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The Conceptual Orientation for Creative Design:

Although it has been argued that creative process could be learned through examination of the logic of people who are exceptionally creative, it is posited that creative behavior is not monopolized by the gifted (Guilford 1950). It is generally asserted that creative thinking is not only constructive, it is sometimes destructive in the sense that you have to break out patterns, routines, and rules, establish ideas, organizations and systems to discover or create something new (Vidal 2007). Conceptual orientation of the designer toward the use of cognitive processes that are believed to involve creative thinking is considered to be the key for success in the search for creative ideas. Those cognitive processes are identified here briefly.

Metaphors: The basic of metaphor is generally considered to be similar to the term analogy in literature, but metaphor itself is assumed to be more powerful and assertive than analogy itself (Antoniades 1992). Normally this grammatical term has the relation between the source and the target. Source means the thing or object which sends the message or the impulse and target the recipient of the impulse itself. Theodore Lewis, argues that metaphors involve transferring elements of a particular state or context to another, from a source domain to a target domain. Lewis also states that by facilitating description of new situations through reference to familiar ones, metaphors allow conceptual leaps (Lewis 2005).

Analogy: Analogy is considered to be a cognitive process of transferring information or meaning from a particular subject (analogue or source) to another particular subject (target). Drawing analogies or analogical reasoning is therefore a comparison of two things that are essentially dissimilar but area shown through the analogy to have some similarity. People normally look at two unrelated things (one thing from the problem and something from an unrelated world). They find the relation between them and tease from the comparison a new idea. It is argued that creativity tools move people to fresh perspectives that provide new connections for new ideas.

It is generally assumed that metaphors are used more frequently during the early, problem framing, stages of the design process and analogies are used later in the concept generation phase.

Deconstruction/Reconstruction: The processes of deconstruction and reconstruction are related to turning a problem into a creative challenge by deconstructing and reappraising the problem so that its causes and consequences can be identified. The deconstructed parts of the problem are combined together in new ways to infer innovative and novel solutions through the reconstruction process. According to Rene Victor Valqui Vidal “all theories of organization and management are based on implicit similes or metaphors that lead us to see, understand and manage organizations in distinctive
yet partial ways” (Vidal 2007). Vidal also argues that creative thinking is sometimes a destructive process and that often the problem solver has to break out the existing patterns, routines and rules, establish ideas, organizations and systems to discover or create something new. He thinks that to change the existing conditions, the problem solver has to destruct first, and then he/she can reconstruct or redesign.

Incremental Steps of Creative Design Problem-solving Process:

It has usually been the case in design practice that those procedures of problem solving to be employed invariably involve definition and subdivision of larger problems into more sub problems and seeking guidance in applying specific strategies and procedures, as discrete inquiries on different issues are carried out simultaneously. In this way, nearly all aspects of the final product are covered within the framework of the problem at hand, but there is an ongoing difficulty in making all the inquiries and the related findings work together. Certainly, inquiry into different aspects of the design problem calls for review of discrete information on each aspect of the problem in question in recurrent manner. The review of information about each aspect of the design problem must essentially be carried out in connection with procedures of creative design solving activity. This process is necessary not only for each different aspect of the design problem at hand, but also for integrating or interlinking different parts of the solution for different aspects of the problem.

As far as the existing literature is concerned creative design solving process invariably involves both divergent and convergent thinking (Guilford 1967; Tversky & Chou 2011). Divergent thinking is needed to produce as many ideas as possible. Divergent thinking is also necessary to develop original and unique ideas and then come up with a problem solution or achieve an objective. The purpose of the action in this respect is defined to aim at “discovering problems and solving them by means of branching out, making unexpected associations, applying the known in unusual ways, seeing unexpected implications” (Cropley & Cropley 2007). According to Guilford (1967) divergent thinking is composed of four factors: fluency (ability to produce many ideas); flexibility (producing a wide variety of ideas); originality (producing novel ideas); and elaboration (adding value to existing ideas) (Guilford 1967).

Convergent thinking, on the other hand, is considered to provide coherence and viability to the range of ideas under consideration. Convergence is commonly defined as “the ability to use logical and evaluative thinking to critique and narrow ideas to ones best suited for given situations or set criteria” (Gardner 1999). By definition, to converge means to approach the same point from different directions. In other words, convergent thinking directs one’s efforts toward the key opportunities and challenges to be explored (Gardner 1999; Guilford 1967). In the whole process of problem solving convergent thinking yields fully determined conclusions drawn from given information.

Distinct aspects of a design problem that are subject to both divergent and convergent thinking, are often associated with the core issues of an architectural design product, each requiring discrete inquiries in recurrent fashion. Therefore, a general view of the major realms of inquiry in architectural design process would help the designer comprehend the scope of the total problem he is dealing with. Concern with the major realms of inquiry in the design process is generally known to be the central issue in curriculum planning for professional degree programs in architecture. Thus an inquiry into the specifications of study areas in professional degree programs in architecture, developed by the major educational and professional organizations, will be helpful for the identification of the major realms of inquiry in this field.

The student performance criteria developed by both the National Architectural Accrediting Board (NAAB, 2004) and the Association of Collegiate Schools of Architecture (ACSA, 2008) in the U.S., and the basic capabilities of professional school graduates developed by the International Union of Architects (UIA, 2002) have been surveyed within the framework of the current study to achieve the above stated purpose. Clearly the review results are conducive to generalizations about the treatment of both core professional values and issues and the primary realms of inquiry.
For this study, the primary realms of inquiry for the design process were established with a conscious concern for the consistency and homogeneity of the items selected, so as to constitute reliable content for each realm (Table 2). The primary realms of inquiry are identified in terms of their relative importance for each level of decision making in Figure 2. The importance of the primary realms of inquiry for each level of decision making are basically determined on the basis of the literal meanings of the items listed under each realm of inquiry, for the decision making level in question.

**CONCLUSION**

Architectural design is known for its complex and ill-structured nature. Its complexity and ill-structured
nature is mainly due to the ambiguities involving both professional practice and information analysis. Because of the ambiguities or uncertainties that exist in it, the problem-solving process in architecture essentially requires creative thinking to generate innovative solutions for the design problem in question. Creative solutions are sought not only for solving various aspects of the design problem at creative problem solving normally involve divergent and convergent thinking. Meanwhile, because of the complexity of the design problem the notion of creativity for architectural design is expected to encompass the following factors: multisensory perception of an architectural design product, concern with the totality of human needs, conceptual orientation of the designer for creativity, and procedural aspects of creative design problem-solving process.

Multisensory perception of an architectural design includes people's multiplicity of sensory experiences concerning both the characteristic features of spaces which the design includes and formal expression of the overall design. The multisensory perception of architecture in general has been introduced by the present study based on the concepts of hapticity, kinesthesia and synaestesia. Concern with totality of the needs of users is gener-
ally found necessary for the users to satisfy not only their physical needs but also their other needs. It has been revealed that sense of belongingness or social relations and sense of self are as much important as those items required for an individual’s physical survival. Concerning the conceptual orientation of the designer in the design process, metaphors, analogies and the processes of both deconstruction and reconstruction are generally considered to be effective tools of creative thinking. It is stated that both metaphors and analogies are considered to be cognitive processes of transferring information or meaning from a particular subject to another one. The processes of deconstruction and reconstruction basically involve both the deconstruction of the design problem into parts, and then combining together the parts in new ways to infer innovative and novel solutions through reconstructing the deconstructed parts.

The procedural steps of creative design-solving process would normally consist of both divergent and convergent thinking. But these steps are generally considered to be necessary not only for solving different aspects of the design problem at hand but also for integrating or interlinking different parts of the solution. It is argued that the whole process would invariably involve five levels of decision making, design concept development, formal explorations, preliminary design development, engineering projects and construction drawings development and working drawings development. The varying aspects of a design problem normally relate to the primary realms of inquiry, which are invariably associated with discrete study areas included in professional degree programs in architecture. These realms of inquiry are related by this study to the five levels of decision making, on the basis of their relative importance for each of the levels cited. The design model shown in Figure 2 also denotes the relative strength of the relations between the levels of decision making and the primary realms of inquiry in architecture. It is expected that the model would help designer make inferences for interlinking different parts of the solution in consonance with the major goals of the problem.

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**Author’s address:**

Saim Naikaya,  
Alaybey, 1672 Sokak,  
No: 45 Daire: 1 (Mahmut Bey Apt),  
Karşıyaka | İzmir  
Turkey  
Email:saimnalkaya@gmail.com
FLEXIBILITY IN HONG KONG PRIVATE HOUSING

T. H. Khan, and T. K. Dhar

Abstract
This paper investigates the private housing in Hong Kong in terms of flexibility. Since the last few decades Hong Kong Government is steadily endeavoring to achieve a sustained and healthy development of private housing property market. With Hong Kong’s economy on the rise, and its fertility rate being one of the lowest in the world, more people are looking for increased space standards even for higher price. Currently, around two-third of the population of Hong Kong lives in private flats. However, it is observed that these flats, especially the highrise housing estates do not come as open shell like the public housing estates do. This paper at first identifies the major prototypes of contemporary private housing built in the past few decades. Then it compares the flexibility of different prototypes in four sequential levels of construction i.e. structure, envelop, building services and infill. Flexibility is measured by means of potential layout options that the users practice inside these prototypes. It finds that some prototypes offer more flexibility than the others. It concludes that flexibility in recent private flats is gradually reducing. But on a positive note, they are offering more varieties in size and layout design in order to meet the increasing demand in spatial standards.

Keywords: Hong Kong, Private Housing, Flexibility, Support, Infill.

INTRODUCTION
Hong Kong has an extensive Public Housing scheme. At some point in history, more than fifty percent people used to live in public housings. However, the balance is gradually shifting. Today almost two-third of Hong Kong’s residents live in private housing. This number is continuously increasing during the last three decades as government is steadily maintaining a policy to reduce its responsibility in the provision of public housing, and to enable a sustained and healthy development of private property market (Fung 2010). Therefore, there is a rising private property market, which is currently supplying more housing stocks than the government.

However, there are some basic differences between the layouts of public and private housing flats. Hong Kong public housing flats are extremely small compared to those from any other country. For example, Research and Library Services Division of the Hong Kong Legislative Council Secretariat in 1999 estimated that average living space per person in Hong Kong was only 15.6 m² (Hui et. Al. 2004). These tiny-sized flats were stacked into high rise blocks, a phenomenon that has always been directly linked to extremely high residential densities caused by limited availability of land for urban development. These flats came in the form of tenant fit-out i.e. tenants constructing the internal partitions or ‘infill’s. They showed that a great variety of family types can live in the same shell or one family can also change layouts of the same shell according to their changing needs. Therefore Sullivan (1997) concluded that though the ‘support’s i.e. the structures, are rigid, there is flexibility at infill-level in public housing. But it was not the same scenario in the contemporary Private Housing Estates. In terms of size, they were comparable, but it is observed that flats in Private Housings do not come as open shell.

A flat which is not an open shell does not necessarily mean it is not flexible. In fact, flexibility is a term which has never been exactly specified (Gijsbers 2006). However, it is understandable that an open shell might offer a greater degree of flexibility. But the question is, why would private flats in HK suddenly need to be more flexible? The answer can be given from different perspectives. Hong Kong economy had been quite steadily on the rise
during the last few decades, and its fertility rate had become one of the lowest in the world (Fosh et al. 2000, HKCSD 2011). The average household size has also been declining over the last two decades (Wadu and Lau 2008). That means in terms of the number of housing stock, supply may become more than demand in near future. But that does not necessarily mean that older and tinier flats remain attractive if they cannot offer flexibility to transform to improved space standards. A rising number of comparatively richer people with a smaller household size are now in need for improved space standards (Lee 2010). Tearing down old buildings to meet demands of new generation users have been practised quite extensively in Hong Kong. But when it comes to such numerous gigantic highrise blocks, may be demolition is not be the only cure. This study, which is an attempt to investigate the flexibility of private housings in Hong Kong, can be regarded as one of the first steps towards developing that awareness.

A preliminary investigation was conducted to develop prototypes in private flat designs with the help of statistical tools. Then the different options in layout practiced by the users inside these prototypes were surveyed. Highrise Private Housing Estates (minimum 10 storey high) are chosen instead of Highrise Courts (i.e. single highrise buildings), as the impact of the former is more in the supply market. 108 such Private Housing Estates were surveyed. Secondary data was collected from Centadata (Centadata 2011) in order to get the original plans. Primary data was collected through interviews with users and property agents, who gave access to visit different selected flats. Existing literature has been studied to document the space dimensions, and structural systems of these buildings. Flexibility is measured by the number of potential layouts, a method of comparative analysis used by Sullivan (1997). The results were interpreted through analyzing the determining elements of flexibility in the four levels of construction identified by Slimbouwen (Slimbouwen 2011) i.e. structure, envelope, building service, and infill.

FLEXIBILITY AND HOUSING IN HONG KONG

Users’ spatial needs change with time. Residential spaces are no exception. Families grow, their demography change, their affordability change, their aspirations change (Tipple 1999). All these together puts pressure on the household to look for different options of space layouts in the house they live. The pressure may reach a critical point when the household needs to make a decision between moving or improving. If they have the authority, they can decide to improve by transforming the layout. Otherwise they need to move to another house which can suit their new needs (Seek 1983). However, it is often seen that moving may not be the best option because of the hazards related to it (Carmon 2002). Therefore, transformation can be a useful method to adjust the spaces according to the changing needs. A house that can offer options to be transformed whenever a household decides, can be regarded to have flexibility, and hence it proves to be more capable of extending its economic life span. As mentioned, flexibility can be achieved during different sequential processes of construction such as structure, envelope, building service, and infill. It is obvious that there is more sensibility to implement flexibility from the very first step (Slimbouwen 2011). However each step can offer its own degree of flexibility. The parameters in each level that determine the flexibility is as follows:

1. Support Level: The location or construction method of the columns or structural shear wall determines the possibility to expand spaces inside. In Hong Kong, structural elements are still considered rigid.

2. Envelop Level: Façade Envelop has window zones and windowless zones, which can limit the possibility of re-arranging layouts in case of transformation. It is important if pre-fabricated facades are widely used, which the case in Hong Kong is.

3. Building Services Level: The location of building services is important as they can be considered as non-flexible spaces. There are examples of movable system of building services, but it is not yet widely popular in Hong Kong housing.
4. Infill Level: Though appears to be the most flexible level among these, the method of constructing internal partition walls (i.e. the infills) is very important as different methods can have different boundary conditions.

The prototype layouts in public housing of Hong Kong have gone through changes because of changes in housing needs, construction methods, or other case-specific requirements. These prototypes are often called as ‘generations’, a term that implies that once a new prototype is evolved, the old ones were not practiced any more. The generations existed so far are Mark, Old Slab, Single Tower, Twin Tower, H-block Series, Trident Series, Harmony Series, Cruciform, New Cruciform, and Concord series. The flats came with an empty shell that had a fixed service zone (kitchen and toilet). Sullivan (1997) studied that users came up with immense possible layouts even though the shell had a fix boundary condition regarding the structure, the envelope and the building services. In that sense, these shells had been proved to be potentially flexible at the infill level. However, flexibility of shells was gradually reduced in later generations, especially those in the Harmony blocks. Structural walls invaded the freedom at infill level. Prefabricated façade and standardization were also often blamed for bringing in rigidity in layout, even though those methods reduced construction time, construction hazards, and overall cost (Chiang et al. 2006).

Private flats usually did not come as empty shells. The internal partitions were always there from the beginning. Therefore, these housing units were assumed to be less flexible than those of public housings. Government’s Joint Practice Note 2 (JPN2 2002), where private developers were also encouraged to use standardized and prefabricated facades, is also often blamed to have impact on the rigidity in private housing design. However, private housing offered variety in sizes or in details. Therefore, prior to the investigation of the phenomenon of flexibility in private housing in Hong Kong, it was necessary to categorize the prototypes in private housings as there is no comprehensive study on that.

**Generations in Hong Kong Private Housing**

The study shows that private housing estates, though were not obligated, adapted the strategy of using limited number of design prototypes. However, unlike the public housing, all prototypes of private housing cannot be termed as ‘generations’. ‘Generation’, as in public housings, showed the end of an era and the beginning of another. In private housings, there are several prototypes which appear to be discontinued at some point, which can be termed as ‘generations’, while there are prototypes which continued even though a newer one had been introduced. Some of the generations are non-existent at this moment while some others still exist. In this study, we did not investigate the generations, as they are considered to have little or no impact on current prototypes. However, a brief discussion on the existing generations would be useful to give the platform for discussion on the later prototypes.

**Walk-up Tenement Housing**

The first generation of currently existing private housing in Hong Kong is the walk-up tenement houses. They usually follow the existing urban street pattern constructed on individual lots. Usually two units are paired around a staircase by sharing a longer wall, while each pair is attached with the immediate next one by sharing one relatively shorter wall, consequently creating a courtyard in the middle of each pair. For building regulations, they usually have an extra staircase at the back as fire escape and the service zone are located near the fire escape (figure 1a). However, previous studies show transformations can occur freely. Toilets or kitchen can be placed virtually at any location inside the flats (Khan et al. 2009). It is worthy to mention that highrise apartments are still being built on individual lots, which are usually known as ‘Highrise Courts’. However, for the aforementioned reason, they are not considered as ‘generation’.
The practice of housing estates i.e. apartment building(s) constructed by a group of owner or developer on an accumulation of lots (instead of building on individual lots) became popular with the introduction of elevators in large scale residential buildings during the late sixties (HKHA 2011). It is a step forward to the previous generations as comparatively more units could be delivered in one building. However, this first generation of private housing estates still followed the urban street patterns. Long corridors were also a significant feature in these buildings (figure 2a).

Things began to change with the introduction of trident blocks in the ‘80s. Several reasons can be identified for these. Firstly, there was the emergence of corporate private developers who were encouraged by the government to occupy bigger lots to build housing estates instead of courts. Secondly, the introduction of revised density control act (Allarakhia 1985), which led the way to a new type of housing estates where slimmer tower blocks had to be more sparsely arranged in a relatively bigger lot due to new Floor Area Ratio (FAR) calculation. The developer (be it government or private) now had the freedom to introduce internal road network, as there was no necessity to follow the existing road to place the buildings. Thirdly, the concept of re-entrance was introduced after trident series. Not only it could hide the service units (toilets and kitchens), but also it can group them in one zone which are efficient to reduce the cost of piping considerably. Individual towers, each one with a number of flats around a central core sparsely located along a big site, proved to be a successful trend for private housing estates, similar to that of public housing estates. So we notice a gradual lack of practice of long-corridor housing existence, and the emergence of slimmer tower blocks with re-entrances.

**Long-Corridor Housing Estates**

The currently practiced prototypes in private housing started around the early ‘80s. In search for prot...
prototypes, stratified sampling method was adapted. From four distinct areas in Hong Kong namely HK island, Kowloon peninsula, New Territories (East) and New Territories (West), same number of samples were chosen randomly using Centadata website (Centadata 2011). As a result the sample was evenly spread all over Hong Kong. In total there were 108 housing estates all of them being constructed after 1980. Therefore, the older generations are excluded from the sample.

Obviously there are no such definitive prototypes in private housing as in public housing. Private housing estates vary in detail from each other. However, several parameters were chosen in an attempt to develop prototypes. Adjusted $R^2$ value, T-test and a p-value with a 5% level of significance were applied accordingly to choose the significant parameters as well as their particular characteristic. Size and shape of units are obviously the major two parameters. However, the arrangement of units in a typical floor was the first concern. It is found that two units are paired and such four pairs are arranged in each typical floor of a single tower in a way that they are separated by re-entrance.

The next step was to hypothesize the shapes of the units, hence of the block. Consequently, several more distinctive parameters were characterized and were correlated with the shapes using similar statistical tools. The followings are the parameters those were investigated:

1) The shape of individual unit,
2) The range of sizes for different shaped units,
3) The location of service units inside the unit,
4) External openings in the service core,
5) The number of slabs defined by beams inside the units,
6) The number of storey in the block,
7) Construction commencement (decade). Their significance is described below:

1. The shape of individual unit: For simplicity, walls were considered straight though they might have some details at the facade. The objective was to derive the simplest possible ‘polygonal shape’ of each unit. In each pair, it has been hypothesized that the pattern of the wall shared between the two units helps generate the shape of the units. Three such patterns were identified i.e. an L-shaped wall, a short diagonal wall, or a long diagonal wall. By using the adjusted $R^2$ value at 5% significance level, the data failed to reject the null hypothesis. Therefore, three shapes of units, hence pairs, were correlated with the three different patterns of sharing walls. Eight such units arranged in one typical floor eventually derived the shape of the three prototypes. They are named as Cruciform, New Cruciform, and Diamond shaped blocks. The
names of the first two are drawn from their similarities with that of public housing blocks. The final one, which takes roughly a quadrangular shape, is named as ‘diamond’. The number of arms and the way they are attached were also statistically tested in order to determine a simplistic shape of each unit, hence of a typical floor in a block (figure 3).

2. The size of units: The objective was to associate a certain ‘range of sizes of units in each prototype. At first it was observed that the units in one particular floor vary in size. The available options of arranging the flats in a typical floor are as follows. The two flats in one pair may or may not be mirrored. If mirrored, different pairs may contain units of different sizes. However, it is found that they come in just two available sizes in a particular block. If not mirrored, they create a pattern with one big and one small unit. This pattern may be replicated around the whole floor, or again patterns can vary in size. Again, it is found that they come in only two particular sizes in one particular block, though for simplicity, this variation is not shown in figures. A typical floor irrespective of any prototype contains four pairs separated by re-entrances, and whether mirrored or not, they come in just two different sizes of pairs in one particular block. The cruciform blocks were correlated with non-mirrored pairs, the diamond blocks were correlated with mirrored pairs, while the new cruciform blocks did not show significant correlation with any. The floor areas were not found significantly correlated with shape, as many different sizes were available for each type of blocks. However, though statistically insignificant, there are instances that two pairs from diamond or new cruciform shaped prototype are associated with two pairs from cruciform shaped prototype in one particular block (figure 4). These hybrid blocks were not considered as separate prototypes in this study.
3. The location of the service units: The re-entrance is obviously the major location for service units. However, three situations were identified: i) the service zone can be continuous; ii) it can have a break in the middle so that the dining space can get an external wall to provide openings, and iii) extra toilet(s) can be located outside re-entrance. The bigger unit in cruciform blocks has been correlated with option one, but the smaller units in that pair is correlated with option two. All other units in other prototype blocks were correlated with option two, and option three was not significantly correlated to any prototype.

4. External openings in service core: The cores can be totally blocked by service units along re-entrance, they may be partially blocked, or they may be moderately open. The objective was to characterize ‘the way the service areas cover the core’. Diamond blocks were found to have moderately open cores, while cruciform and non-cruciform blocks have closed cores.

5. The number of slabs in individual units: The slabs give an idea about the space underneath, because column, shear walls, and beams (i.e. the ‘support’ elements) may limit the options to transform internal spaces. The objective was to characterize the ‘number’ of slabs. Small units in cruciform blocks were found to have only one slab, while the large units have two. In New cruciform blocks there are two slabs for small units, and two or three for large units. In Diamond blocks, smaller units have two, while large units have two, three or more slabs.

6. The height of the blocks: The objective was to correlate a certain ‘range of number of storey’ for each prototype. The correlation between prototypes and building height was not found to be significant enough.

7. Construction commencement (decade): The three prototypes were found to be significantly correlated with a particular decade. The cruciform blocks are with the ‘80s, though the earliest of private housings is in Mei Foo in 1979 (HKHA 2011). The new cruciform blocks are correlated with the ‘90s and the diamond blocks are with the ‘00s. Following the statistical analysis, the range of sizes, and the height of blocks were not considered as a parameter. The rest were used to describe the parameters of a prototype with their particular characteristic.

FLEXIBILITY MEASUREMENT

Potential Layouts in Prototype A (Cruciform Blocks)

Prototype A is the most used prototype mainly because it started earlier than the other two. Usually they have one slab in the smaller unit, and two in the larger. However, sometimes an extra cantilever part is also added. One unit in a pair invariably gets a direct entrance to living room while the other has an entrance through a vestibule. The service zone is continuous in the smaller unit, but not continuous in the larger unit as it gives way to the openings at dining spaces. However, in recent trend, examples show smaller ones also have discontinued service zones. Considering that window zones are available almost all around the unit, smaller units offer only two options i.e. one bigger bedroom or two smaller bedrooms. The larger units offer four options. However, keeping the Master-bed big at the end is a popular choice.

Figure 5: Potential layouts in Cruciform Blocks

Potential Layouts in Prototype B (New Cruciform Blocks)

Prototype B can be regarded as an improvement from Prototype A in several ways. In terms of shape, it offers either symmetrical units in one pair (figure 6a) or two different sized units in one pair, though only the latter is shown in figure. In terms of advantages, it gives similar view for both units in one pair. In terms of flexibility at infill level, they provide more choices as well. Probably learnt from Prototype A, the Master-bed is invariably occupies the end of the circulation route with no practice to subdivide. However, we find that the toilet zone can be moved along the re-entrance line to accommodate one extra bed (Marked with a cross), creating a double loaded corridor. The rest of the space usually can provide just one bedroom for smaller units, and at most two for the larger units, though sizes can be adjusted. See Figure 6: Potential layouts in New Cruciform Blocks
Table 1. Results showing three distinct prototypes

<table>
<thead>
<tr>
<th>Number of flats per floor</th>
<th>Shape of sharing wall between flats in one pair</th>
<th>Construction Commencement (decade)</th>
<th>Shape (1)</th>
<th>Range of floor areas (sq. m)</th>
<th>Service Zone (3)</th>
<th>Core blocked by re-entrace (4)</th>
<th>Slabs in flats (5)</th>
<th>Average number of floors (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>L-shape wall</td>
<td>’80s</td>
<td>Cruciform</td>
<td>552</td>
<td>1129</td>
<td>Broken for larger, unbroken for smaller flats</td>
<td>Fully blocked</td>
<td>1, 2, or 3</td>
</tr>
<tr>
<td></td>
<td>Shorter diagonal wall</td>
<td>’90s</td>
<td>New Cruciform</td>
<td>635</td>
<td>1163</td>
<td>Broken</td>
<td>Fully blocked</td>
<td>2, 2 or 3</td>
</tr>
<tr>
<td></td>
<td>Longer diagonal wall</td>
<td>’00s</td>
<td>Diamond</td>
<td>680</td>
<td>1348</td>
<td>Broken</td>
<td>Moderately open</td>
<td>2, 3, or more</td>
</tr>
</tbody>
</table>

Prototype C in general provides bigger size units. However, the major change in shape is that all the rooms are now positioned in a way that not only
each of them get a window, but also each of them get the same view as the living room (figure 7a). So, we see a continuous exterior wall with a series of windows. In the previous two prototypes, the re-entrance provided opening for dining space. But, that trend is changed as dining spaces do not have separate openings any more due to structural system and prefabricated envelope. Therefore we get a windowless (β) zone in the dining. Considering the Master-bed occupying the final slab with usually no practice to be subdivided, the rest of the habitable space can only have two options under the middle slab, offering either one big room or two small rooms. One thing to note is that prototypes have steadily moved from ‘one-toilet’ culture to ‘two-(or more) toilet’ culture as there are no units with only one toilet any more in prototype C. Thus extra bedroom interrupting the re-entrance is no longer an option. From the study it is also found that size and shape of the core, and the way the flats are arranged around it, are changing. As a result the internal layouts are changing. It is likely that new hybrid prototypes will generate very soon.

Figure 7: Potential Layouts in Diamond Shaped Blocks

Comparison

From Sullivan (1997)’s study, we can find that flexibility inside a unit is related to its adaptation with many possibilities of space allocation patterns. Therefore studying the potential layout can be a good way to find out its flexibility. Let us first look at public housing. At support level, the size and shape of units in public housing is fixed, so is the major circulation route inside units (from entrance to the toilets and kitchen). At envelop level, there are fixed window zones and windowless zones. So, there can be a limited number of possible space allocation patterns. At building service level, service zone is fixed, so not much flexibility is available there. At infill level, the open shell gives more choices of potential layouts. In private housing, firstly at support level, the units can have variety in sizes. Therefore they have more potential for flexibility in one single block. However, there is limited number of patterns in layouts; hence the circulation routes inside flats remain limited. That results in similar potential layouts even though sizes are different. At envelop level, windowless zones are negligible (as we can see in figure 5a, 6a, and 7a), which offers more options in terms of flexible arrangements. At
building service level, the service zone along the re-
entrance remains as a rigid element. And finally at
infill level, units in private housing do not offer ten-
ant fitout (empty shell), which means users are pro-
vided with the partition walls. Moreover, these par-
tition walls, though not structural but are equipped
with different concealed wiring and piping; there-
fore it makes difficult for users to make changes in
layout that subsequently reduces flexibility

Comparing the number of potential lay-
outs, it is found that flexibility have increased from
Prototype A towards B. Though prototype C is pro-
viding bigger flats and better views for all rooms,
flexibility has been decreased from B to C.
Moreover, the way the partition walls or the infill are
constructed in-situ, later transformations increase
construction hazards, therefore they limit flexibility
(Lee et al 2004). The core shapes have more exper-
imentation though. As a result, new patterns in lay-
outs are evolving, which obviously give more choic-
es to users.figure 8: Different core size/shape and
variety in layout are evolving as a continuation of
prototype C

On the positive note, it is observed that
developers often offer bigger units as penthouses
on the top floors. In those cases the sharing wall
between two adjacent units in one pair, are
removed. The absence of shear wall or column on
the sharing wall is therefore an advantage for that
kind of transformation. In some cases, duplex is
another option to connect two vertical units togeth-
er. Even more, combining both units in one pair,
and connecting two such bigger units vertically, can

Figure 7. : Potential Layouts in Diamond Shaped Blocks

Figure 8. Different core size/shape and variety in layout are evolving as a continuation of prototype C
result in almost a four-time bigger duplex unit. It can be a great way to meet users’ increasing spatial needs (figure 9). However, there might remain legal or structural restrictions whether owners, who are able to buy two adjacent units, or two vertical ones, can transform them into one by themselves or not. In Figure 9 though not many in numbers, but there are attempts to transform smaller units into bigger units.

CONCLUSION

The experiments in recent private housing blocks especially in the last decade are encouraging. It shows that there is more concern over the growing demand for bigger size units and more variety in design instead of fixed prototypes. The increased rigidity in layouts can be compensated by the variety offered in sizes. When a choice over moving or improving has to be made, and if the users are tenants, it is probably easier to decide to move. The efficient moving companies in Hong Kong can also offer an advantage for that. However, if the users are owners, they may not have that luxury to move frequently. In that case, and with Prototype B offering more options, and prototype C offering bigger sizes, the question only remains how to keep the smaller units in prototype A attractive. A further study on clients’ requirements on flexibility might complement this study. For example, studying only the practiced layouts is a good start, but studying all possible layouts by investigating furniture usage would give more in-depth look on their flexibility. And moreover, with the combination of those studies, proposing more flexible future layout designs of private housings can also be a decent continuation of this research.

ACKNOWLEDGEMENT

The authors sincerely acknowledge The University of Hong Kong for the funding of the survey, and RMC, Universiti Teknologi Malaysia, and Ministry of Higher Education (MoHE), Malaysia for Logistic support.

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Authors’ address:

T. H. Khan,
Department of Architecture,
Universiti Teknologi Malaysia,
Malaysia, e-mail: tareef@utm.my

T. K. Dhar
Department of Architecture,
Khulna University,
Khulna, Bangladesh
Abstract
Integrated design is a strategy to develop sustainable architecture projects incorporating multidisciplinary work and environmental performance assessment, which has provided significant advancement to public buildings in developed countries. This paper presents a review of some aspects of integrated design for the planning and construction of energy-efficient housing in the south of Chile, as part of the reconstruction process following the earthquake on 27th February 2010. Firstly, a synthesis is made of the characteristics, implicit conditions, participants, steps, resources and expected results of an integrated design approach according to existing references. This is then contrasted with normal housing design practice in Chile according to current building regulations and interviews with professionals in the field. The design processes of experimental houses and housing projects that place specific focus on energy performance are then analysed, with follow-ups and interviews to review significant aspects. After examining those experiences, the authors identify some particular features and resources of integrated design that promote environmental improvements.

Keywords: Integrated Design, Energy-efficiency, Sustainable Architecture, Housing, Chile.

1. INTRODUCTION

Sustainable development makes it necessary to tackle new aspects of housing design, particularly regarding reductions in energy demands, since residential housing is one of the sectors with the highest energy consumption (in comparison to public buildings, industrial facilities and transport). For example, in Chile the housing sector absorbs more than 20% of total energy consumption (Rozas and Bardi 2010), from largely non-renewable and externally-sourced resources. At the same time as the country faces the need for a better quality of environment, population increase and natural catastrophes demand constant growth and renewal of housing stock. The earthquake in the south of the country on 27th February 2010 damaged about 30% of the existing housing stock in the three affected regions (Maule, Bio-Bio and Araucanía), which have a current population of approximately 4,000,000 inhabitants (Minvu 2010). On this account, this work aims to study adequate procedures for residential reconstruction incorporating enhanced energy performance. It takes into consideration both the diverse public programmes for housing construction and improvement, and private individual and collective housing initiatives that deal with house building and rehabilitation. These adopt conditions and architectural typologies similar to existing housing, mainly consisting of single or two-storey detached houses, built on the urban periphery of cities from 5,000 to 300,000 inhabitants. Most of houses are erected in last thirty years by public programmes or private investors in groups from 30 to 300 units. Houses are around 50 to 120 square meters, in regular sites of 300 square meters, like detached volume of reinforced brickwork with timber roof structure (fig.1). Typical houses have an average energy demand of 150 to 200 kwh/m² (Rozas and Bardi 2010). In this zone, with its cold-temperate climate and high levels of humidity in coastal zones, heating is required in the winter period to achieve adequate environmental comfort.

Sustainable housing design implies to review different construction features, from the use of more renewal materials and passive heating-ventilation-air conditioning (HVAC) strategies, to establishing housing settlements with lower environmental impact. Emphasis is placed on the need to
adapt solutions to local conditions, and to regard integral cultural and environmental relationships (Hernandez 2007). In the studies on housing construction in Chile (like Bustamante 2009) the need to improve the thermal comfort performance of the envelope has been recognised (which has been partially included in the current building regulations), as well as volumetric and material considerations. This demands a full assessment of building conditions and subsequent modification in design practice. To this end, it has been proposed that architectural projects include sustainability aspects in their development from the outset through an integrated design process (Löhnert et al 2003; Zimmerman 2004). This approach has demonstrated notable contributions to improve energy performance of buildings. However, there are no specific experiences with this approach for housing, especially in Latin America.

For this reason, this research proposes to determine significant aspects of integrated design that can be applied to housing reconstruction in the south of Chile to reduce energy demand. Characteristics and conditions suggested for the integrated design process are reviewed in relation to regular housing design practice in the country and the more advanced practices of some case studies. This has been achieved through interviews with professionals, and document and design analyses, as well as follow-up of design activities for a couple of high-standard residential building projects in the zone. Some considerations and relevant resources are identified that achieve environmental improvements.

2. CHARACTERISTICS OF INTEGRATED DESIGN

Integrated design is a working strategy that arose recently in the construction industry of developed countries, and has been put to a variety of uses, especially in public buildings (Löhnert et al 2003; Zimmerman 2004; Moe 2008; 7Group and Reed 2009; CMHC 2009; Keeler and Burke 2009; Yudelson 2009, Kowk and Grondzik 2011), and reviewed in some Latin American cases (Treblilcock 2009; Figuereido and Silva 2010). This strategy intends to promote more sustainable architecture through multidisciplinary collaboration from an early stage in the design. This approach can regard benchmark procedures for the design; in particular BREAM or LEED certifications, as well as quality assessment tools in construction (Abdulaziz and Tawfiq 1999, Wentzel 2010). But they are focused in final results and regular activities, and integrated design is a change in the work process in order to regard specific conditions for each project. That aim is based on the idea that substantial aspects of improved environmental performance in a building must be defined in the outset of design. It has achieved up to 80% reductions in building operation costs (according to EC 2009). The integrated design process (according to Löhnert et al 2003; 7Group and Reed 2009; Keeler and Burke 2009; Yudelson 2009) includes the following general characteristics:

1. Motivation: the participants are committed to creating a building project that contributes to sustainable development.
2. Goals-oriented: global objectives and measurable requisites are established in the design that foster low impact design and high environmental quality.

3. Holistic: a wide range of information is reviewed for the project (particularly regarding site, climate and local culture, materials and systems, user behaviour, etc.).

4. Coordinated: a central project management and support structure is established that distributes and connects the different activities.

5. Multidisciplinary: a variety of professionals and other interested or involved persons participate in the project.

6. Extensive: the process develops from the outset of the project and accompanies it in all its phases including construction and occupation.

7. Analytical: design decisions are reviewed in a reiterative sequence that increases the achievements of the proposed requisites.

8. Assessed: specific preliminary quantifications are made (particularly energy demand/consumption and construction/operation costs).

9. Innovative: the project incorporates novel conditions regarding general aspects of the designs, such as recuperating vernacular features.

10. Verified: some proof is established of fulfilment of the initial requisites considered in the design during construction and/or occupation of building.

Although some of these characteristics can be recognised in many architectural projects, the difference lies in their clear fulfilment. The aspects of professional participation and achievement of sustainable improvements are particularly emphasised. Although it seems certain conditions must also be assumed in order to develop this strategy, for example: the project must be a building with relevant environmental requirement; some participants need specialised formation in sustainable construction; the group must possess organisational capacities; a level of expertise is needed in environmental performance assessment and verification tools; and specific information on the site, products and performance must be available. The building must be of a medium-big size in order to permit a multidisciplinary approach with the associated improvements, particularly with regard to the assignment or transfer of higher project and construction costs and longer project time frames. The existence of certifications, regulations or sustainability references (mainly LEED: Leadership in Energy & Environmental Design from U.S. Green Building Council) are also considered, along with the adoption of design characteristics in the construction and occupancy phases of the building, the resolution of shared responsibilities and risks associated with the multi-disciplinary design and the compatibility of sustainability improvements with aesthetic, cultural, functional and budgetary expectations of the project.

The following participants are normally included in a project:

1. Coordinator; a specialist consultant, facilitator or leader who tends to be the project manager, linked to the property development operation.
2. Architect
3. Structural engineer
4. Sanitary engineer
5. Electrical engineer or technician
6. HVAC engineer or technician (sometimes a specialist in energy simulation)
7. Building engineer or representative from the building contractors
8. Client or representative of the building owners
9. Building users or representative of building occupants
10. Public agent or representative of the building regulations

However, the final three participants (8, 9 and 10) are barely mentioned. Fundamentally, professionals with different mentalities must participate simultaneously in all the diverse design decisions, in accordance with the principle of the 4Es: “Engage Everyone Early in Each Issue”. This principle is applied to all stages of the project: review of background information; preliminary or schematic design; architectural development or project; construction decisions and/or specialist projects, build-
ing execution and occupancy. Some common resources or media used in the process are listed below:

1. Architecture and engineering plans.
2. 3D design software or BIM (Building Information Modelling)
3. Software to analyse energy flow, lighting, ventilation and/or acoustics
4. Collective work days (eco-charrettes)
5. Chronogram of meetings
6. Chart of participants
7. Performance standards or specific sustainability certifications.
8. Volumetric isometrics with solar exposure at different dates and times
9. Sections showing airflow and daylighting at different times of the year
10. Building skin construction details with energy transmission calculations
11. Economic assessment of construction costs and investment return
12. SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats)
13. Exterior renders to check final design
14. Graphs of annual energy demand/consumption

Lastly, the integrated design leads to certain results, primarily those true to all building projects: a functional distribution, construction solutions and global costing (verifiable according to specifically expressed regulations or demands). It also provides the project with an interior and exterior appearance acceptable to both the occupants and society in general. With regard to environmental conditions, these tend to obey standards or certifications: specific performance requirements for annual energy demand/consumption per unit of surface area (sometimes expressed in construction conditions or systems); temperature, humidity or interior air renewal measurements; thermal comfort performance, air permeability, waterproofing and acoustic insulation of the building skin; amount of CO₂ generated, life cycle of materials used, water consumption, waste generated, etc.

3. APPLICATION OF INTEGRATED DESIGN IN CHILE

In order to review the possibilities of implementing integrated design in the construction of energy efficient housing in Chile, the first task was to contrast this method with regular practices in the country. Later, a more exhaustive review of some more advanced practices was necessary in order to ultimately detect which specific aspects significantly improved energy performance.

In regular practice, the residential building regulations were reviewed, followed by semi-structured interviews with professionals with extensive experience in housing design in the zone. This information was compiled into an evaluation of the different identified aspects of integrated design (characteristics, conditions, participants, stages, resources and results).

According to the current building regulation in Chile (Ordenanza General de Construcciones y Urbanización), a single residential construction requires a general project stage prior to construction in which only the architect is obliged to participate, while the client must sign the final documents and architect and client both sign the final certificate of execution along with due provision of sanitary and electrical services. Large-scale housing developments require design of public roads and urban services by specialist professionals and high-rise buildings require structural studies (but these are rarely used for residential projects). Some formal constraints are placed regarding volume and openings for daylighting and ventilation (although these are independent of site and layout). There are also regulations concerning building structure and construction quality control. In year 2000, standards for thermal performance of the building skin (roof, walls and floors) were also included (only for housing), with moderate levels of application. A more global energy performance certification was promised for 2010 but this has been delayed.

A group of professionals were interviewed to verify regular practice of housing design in Chile, from the bigger city in the zone affected by earthquake. The subjects consulted were all architects with private independent offices and an average of fifty residential projects done, located in the larger
cities in the area. The procedure included two-step interviews, to collect some documents and to complete a scale of frequency for each feature of integrated design. In the interviews these architects described following a fairly autonomous design process, reviewing the progressive stages to ensure concordance mostly with programme requirements and cost-related and aesthetic criteria. This process includes site visits and observation of occupancy of users. Most design work is carried on by architect, with minor participation of structural engineer and client representative, instead of multidisciplinary development suggested by integrated design process (fig.2). Occasionally sanitary or electrical specialists participated later in the building process, in a partial way and only when the projects showed a greater degree of complexity. Services or construction specialists were rarely consulted. The construction process presented frequent design modifications, agreed between client, building contractor and architect, with occasional participation from those installing specific systems.

Since the regulatory implementation of thermal standards, insulation levels in the building envelope have increased (thickness of material is prescribed according to the geographical zone or certified construction solutions), but there is neither verification of compliance nor assessment of performance.

With regard to more advanced practices, some case studies with special aims of building quality and environmental performance were chosen, in order to review a variety of local experiences in that way (fig.3). The cases were selected asking to researchers in the local university for recent exemplary housing cases related to sustainable issues, and contact them to verify availability. The project designs, processes and execution were analysed through interviews, document review and site visits and in some cases with follow-up and participation in design meetings. The first two cases studies are two individual houses by architects with relevant professional standing who took on the projects with specific environmental intentions (“Casa Arco” by Pezo Von Ellrichausen in Concepción and “Casa Martí” by Pablo Sills in Villarica). Both houses have been built, so the effective performance of each could be assessed. Another case study is a housing development on the outskirts of the city (“Aconcagua”), where a housing developer with widespread national and local experience promoted a new design seeking enhanced levels of building quality, energy performance and functionality. A further two case studies involve experimental projects (one housing group and one detached house) with the involvement of the university and other
organisations developing solutions with high environmental performance using multidisciplinary design strategies and allowing a direct and ongoing review of the process. The first is a group of eight units of social housing (approximately 55m² each) in a suburb of the city of Temuco, a collaborative project between the building contractors’ union of the Araucanía region, the public agency for financing social housing and professionals from a local research centre working from design stages to completed buildings. The second is a private house of about 140m² sited on a hillside close to the city of Concepción, in the district of San Pedro de la Paz. It was built by a private client with collaboration from university professionals involved in a research project on solid timber construction systems, applying German standards for passive housing.

Interviews with professionals of the projects, as well as clients or other technicians related, asking about process carried on, documents and details of housing design. Visit to the cases and to complete assessment of features were done also. The first advanced houses revealed a fairly autonomous but particularly motivated and innovative architectural process, fed by advanced levels of design formation and specific studies, although with variable performance levels and scarce multidisciplinary participation. The housing development expresses a fairly close relationship between the architectural project, the building process and occupancy, but without any professional collaborative organisation or specific environmental assessments. Improvements in energy use and materials are achieved nonetheless, with verification from occupants. In the experimental initiatives the process was organized in accordance with anticipated results, especially regarding building quality and energy efficiency, with a multidisciplinary participation, although the professionals involved had little prior experience in such an integration and performance achievements. Computer systems were used to simulate energy flow and 3D design along with wide-reaching debate in the early design stages. Some modifications and difficulties were faced, arising from the project requirements and multidisciplinary participation as well as the technical decisions. However, the projects reached completion with their expected improvements in environmental performance and relevant professional recognition.

**4. ANALYSIS OF DESIGN PROCESSES**

The evaluation of each feature suggested by references on integrated design was carried on about frequency expressed in each interview or documentation, in a scale from 0 (nothing) to 5 (full). It regards the local regulation of building and synthesis of literature like main references, and two groups; the interview to professionals like regular practice and the case studied like advanced practice. The analysis (fig.4) reveals that housing regulations and regular practice in the country are fairly far removed from the integrated design consideration.

<table>
<thead>
<tr>
<th>N°</th>
<th>Case</th>
<th>Surface</th>
<th>Units</th>
<th>Designer</th>
<th>Energy performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Casa Arco</td>
<td>100 m²</td>
<td>1</td>
<td>Architect</td>
<td>120 kwh/m²</td>
</tr>
<tr>
<td>2</td>
<td>Casa Marti</td>
<td>140 m²</td>
<td>1</td>
<td>Architect-energy consultant</td>
<td>90 kwh/m²</td>
</tr>
<tr>
<td>3</td>
<td>Aconcagua</td>
<td>80 m²</td>
<td>50</td>
<td>Architect-builder</td>
<td>120 kwh/m²</td>
</tr>
<tr>
<td>4</td>
<td>Temuco</td>
<td>55 m²</td>
<td>8</td>
<td>Team</td>
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</tr>
<tr>
<td>5</td>
<td>San Pedro</td>
<td>240 m²</td>
<td>1</td>
<td>Team</td>
<td>15 kwh/m²</td>
</tr>
</tbody>
</table>

Table 1. Cases of Advanced Practice.
ations suggested by the references. This is particularly true for relevant aspects such as multidisciplinary participation, length of process and design assessment, although there is some evidence of an integrated approach with development of capacities and incorporation of thermal regulations. Project development is the responsibility of the architect with some participation from the clients and building contractors and scarce participation from other specialists limited to developing construction solutions, mainly using building plans. This process achieves adequate architectural results but with no follow-up information on environmental performance.

The more advanced design practices examined present a closer connection with integrated design strategies, particularly regarding the goals and innovations sought, but with weaknesses in multidisciplinary participation and assessment. The adoption of capacities and development commitments should be acknowledged, but the scale of the projects is reduced. The collaboration includes a wide diversity of professionals, although with scarce representation from clients, users and executors. The process also concentrates on the project development but most important decisions are made at its initial phases. Resources used include management procedures, analysis and diverse graphic media. These projects enjoy better expected results for energy performance compatible with the architectural design but with little improvement in other environmental aspects.

In the review and follow-up of the advanced case studies with specific focus on energy efficiency (Social Housing in Temuco and Solid Timber Passive House in San Pedro), some particularly significant characteristics of integrated design and actions of compatibility between the architec-

Figure 4. Comparative graphs of integrated design features according building regulations, regular practice and advanced practice in Chile (by authors).
tural proposal and energy efficiency were identified. Although it should be recognised that both initiatives were motivated by technological advances requiring professionals with specialised training and additional resources, other professionals, involved parties and clients participated in similar conditions to the regular housing projects in the area. Both experiences establish strict energy performance goals (in Temuco, less than 48kwh/m², in San Pedro, 15kwh/m²), equivalent to 10-30% of a regular house, as well as other environmental conditions expressed in a performance table in the first case or in the Passive House standard in the second.

The working procedure was distributed and structured with hierarchies for different professionals, with architects in different roles and engineers from different specialist areas and occasionally with the clients and building contractors. Several professionals held postgraduate degrees in the field, but those responsible for the design and execution were mostly regular professionals. Diverse collective work meetings were held from the outset (fig.5), in which design decisions were discussed using quantified assessment results (energy simulations and budgetary calculations). Innovative design proposals were developed and techniques of verifying performance during occupancy were included. In both case studies additional financing was provided for the projects, which needed a longer time span for design development, but regular housing budget allowances were met in the execution phase despite explicit commitments to carry out the developments proposed.

Studies and documents undertaken included: schematic and detailed architecture plans, volumetric isometric views showing daylighting on chosen days in an average year (fig.6), energy simulations, budgetary estimates, thermal transmission calculations, constructive sections with airflow patterns, natural and solar illumination, realistic visualisations with 3D digital modelling (fig.7 and 8), vapour pressure versus saturation pressure charts to determine condensation risks, monthly energy demand graphs, air admission and extraction
charts for each living space and air leakage studies for different window types.

During both processes some conventional developments of architectural design (representing brief-related, constructive or cultural requirements) had to be made compatible to specific improvements for energy performance. These “conflicts” reveal actions that must be taken in order to adjust the traditional design process to expected environmental advances, thus expressing significant aspects for the integrated development of a sustainable architecture (fig.9). For example, in both cases a new location had to be chosen to make better use of sunlight in the volume (to increase the accumulation of solar radiation) in accordance with site access, surrounding views and site dimensions. It was also necessary to adjust the volumes to provide greater compactness (a smaller perimeter reduces surface area of building skin and hence thermal loss), thus implying changes to exterior appearance, dimensions and space distributions. The servicing requirements of bathrooms/kitchens, HVAC installations and ducts also demanded adjustments to interior layouts to ensure sound functional connections and capacities. The definition of the building skin to improve transmittance, ventilation and waterproofing had to be made compatible with its expressive treatment, global costs and possibilities for prefabrication. In particular, the definition of window openings implied budget and performance reviews with subsequent adjustments to dimensions and finishing.

In both cases, these definitions took place in meetings mainly between the architect-designer and professionals responsible for assessing energy efficiency but also with representatives for the clients and the building contractors involved, with a series of consecutive discussions using schematic plans and sections over which new options and possibilities could be sketched. Information was supplied regarding results of different energy simulations and budgetary estimates for construction costs. Between each meeting, the transfer of documents (plans, calculations and product brochures) between the participants also played an important part in the process. Decisions were made as a group in order to keep architectural design decisions compatible with energy efficiency goals, thus demonstrating the application of some aspects of the integrated architecture.
design strategy (Löhnert et al 2003; 7Group and Reed 2009; Keeler and Burke 2009; Yudelson 2009).

5. CONCLUSIONS AND SUGGESTIONS

The integrated design process is an approach proposed to foster the development of a more sustainable architecture which has demonstrated its use in diverse public buildings in the developed world. This paper presents a review of its possibilities of implementation to improve energy efficiency in housing in the south of Chile, specifically in terms of reducing energy consumption (a quarter or less of regular consume according cases studied). Its relevant characteristics were analysed in relation to current building regulations, regular building practice and a number of specific advanced case studies in the area. This analysis reveals substantial differences in traditional housing design processes compared with conditions suggested by integrated design. However, the experimental initiatives reviewed express a certain convergence with this strategy, probably due to the advanced formation of the specialists involved, thus pointing to specific achievements in energy efficiency in housing projects. These actions demonstrate the potential of the integrated design process to improve the energy performance of housing projects in the area, by verifying the application of a large part of the conditions and defining designs with relevant reductions in energy consumption. In these cases, some particularly significant characteristics to achieve these advances were defined, such as: the participation of an energy efficiency specialist, the client and the building contractor alongside the architect in relevant design decisions; collective availability of documentation, the use of basic graphic information on the project and energy consumption tables and global cost estimates; the consecutive and collective review of decisions made, especially those involving location, spatial distribution, orientation, volume, building skin, openings, budget, prefabrication and visual appearance of the project in order to achieve energy consumption of less than a quarter of equivalent regular constructions in the area while still preserving a configuration suited to housing.

To generalise this approach it would be necessary to consolidate a process suited to local conditions and disseminate this in the professional and social spheres in order to fully appreciate its benefits and requirements. It would probably be necessary to establish regulations or instruments to facilitate its use, as well as demonstrations of its achievements. It might prove particularly effective to verify and disseminate some processes and results to provide quantifiable and proven examples, particularly regarding the morphological and constructive adjustments required for better energy performance. These experiences could also be linked to other building contexts and types, and some effective means of distance consultancy could be implemented that integrates design conditions and energy and
financial studies in order to facilitate the process. The integrated design strategy can require more time and economic resources, especially for individual houses, for example due to the specialised formation of some professionals and the higher costs of design process as well as construction improvements, hence these aspects must be made evident and transferred to the clients. Careful watch must be made of the balance of interests and organisation of the project team to achieve the environmental and architectural goals in an integral way. Some considerations and resources will probably naturally be dropped at different stages, thus progressively alleviating the necessary process to concentrate on the design and ways of strengthening its results. The energy requirements that demand the integration of new aspects in the architectural design imply a relevant review of its activities and conditions. But these processes and experiences are demonstrating significant possibilities to improve the integral environmental quality of housing.

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ACKNOWLEDGMENT:

Research Project MEL 81100003 from CONICYT, Chile, and assistant arch. Gerth Wandersleben.

Authors’ address:

Rodrigo Garcia Alvarado,
Dept. Design and Theory of Architecture,
Universidad del Bio-Bio, Chile.
Email rgarcia@ubiobio.cl

Underlea Miotto Bruscati
School of Architecture and Urbanisme,
Unisinos, Brasil.

Flavio Celis D’Amico
Department of Architecture,
U. Alcala de Henares, Spain.

Olavo Escorcia Oyola
Faculty of Architecture and Arts,
U. Nacional de Colombia, Colombia

Maureen Trebilcock Kelly
Dept. Design and Theory of Architecture,
Universidad del Bio-Bio, Chile.
ABANDONED HOUSING PROJECT: ASSESSMENT ON RESIDENT SATISFACTION TOWARD BUILDING QUALITY

Zamharira Sulaiman, Azlan Shah Ali, Faizah Ahmad

Abstract
Abandoned buildings which are exposed to weather and human threat may lead to deterioration in building quality. Indirectly, the buyer is not satisfied when the abandoned buildings is completed and occupied. This study seeks to assess residents’ satisfaction towards residential building quality which was abandoned. This research combined quantitative and qualitative methods. Respondents are randomly selected based on reports and information obtained through the Ministry Housing and Local Government (MHLG) and Local Authority (LA). Subsequently thirty (30) housing projects were selected to answer the questionnaires. Based on thirty (30) housing projects which have been completed, only three (3) housing projects ranged between six (6) months to two (2) years and have been occupied by the buyers. A total of ten (10) developers were interviewed with respect to rehabilitation of abandoned projects. Thus 194 respondents were randomly selected to achieve the objective of the study. The data was analysed through descriptive statistical analysis and inferential statistics. This research demonstrated that abandoned housing project can lead to residents’ satisfaction towards building quality. In order to rehabilitate abandoned housing, the study subsequently suggested build then sell approach towards achieving better housing quality.

Keywords: Building Quality, Customer Satisfaction, abandoned project.

INTRODUCTION
The failure of a project or project being abandoned is a serious issue in the construction industry (Abdullah & Zailan 2007). The highest factor that causes an abandoned projects are largely due to financial problems caused by economic recession in 1997 (Hamzah 2009). The New Street Times (2006, p.16) revealed problems other than financial difficulties faced by developers, among which are the weaknesses of management, marketing, technical problems encountered during construction, as well as compensation to squatters, in addition to problems with land owners. Azlinor (2007) argues in the case of abandoned housing projects, there is a drop in the quality of work or specifications that are not adhered, to the extent that the Local Authority (PBT) refuses to issue Certificate of Fitness (CoF). As a result, the impact of an abandoned projects as described by Setterfield (1997) and Scafidi et. al (1998) will propagate social problems, slow local economic and pose various dangers, such as fires. Even the exposure of construction materials to the environment such as rain can cause weaknesses in the wall structure with the weakening of the cement mortar bonding the bricks (Smith, 1994; Dunstan & Swenson 1999). Holler (1972) writes about the dangers of an abandoned building with holes in walls, floors, utility systems and others. Subsequently, the quality of a building will deteriorate and cause the buyer to be discontent or dissatisfied with the building (Aziam & Maznah, 2009). In the context of the construction, Auchterliounie (2009) argued that each developer has an effective level of control to determine the quality of a building to be free from defects. This clearly shows that defects in buildings affect the quality and indirectly on customer satisfaction (Anderson 1994; Auchterliounie 2009). There are five factors which influence the satisfaction of the quality, mainly, building structures, building materials, stability of the building, construction works and environmental quality (Hamzah et. al 1999). Auchterliounie (2009) also noted that customer satisfaction is related to quality, thus, the measuring of this quali-
ty must first be known. Nurizan (1998), Dwijendra (2004), and Aziam & Maznah (2009), outline the product and the quality of service, price, location, delivery systems and the character of the buyer, as the influential factor to the buyer’s satisfaction. This is further supported by Hamzah et. al (1999) in terms of customer personal opinion and also the final opinion of the customer on the products and services, will determine whether the product meet their expectation or otherwise.

2.0 OBJECTIVE AND AIM OF RESEARCH

The objective of this study is to assess the level of customer satisfaction towards the quality of buildings that had been abandoned and is now completed by the original developer and are being occupied by residents. Therefore, to meet the objective of the study, an assessment of the types of defects that affect the quality of the previously abandoned houses and level of satisfaction of the buyers of the house will be conducted.

3.0 DEFECTS ON BUILDING AFFECTING THE QUALITY AND CUSTOMER SATISFACTION

CIB W86 (1993) explains that defects is a condition in which one or more elements that are not conducted in accordance with the functions of each of the specified elements. In the context of physical disability of a building, it can be explained that the physical of buildings being build or that have been completed, there are lacking or imperfection that is detrimental to the situation, nature or elements of buildings (houses, schools, factories, offices, etc.). Addleson (1997) argued that the defect caused by the environment a result of moisture caused by the hot weather and rain. According to a study conducted by Richardson (1991), the defects that occur are caused by weather pressure, environmental conditions, land pressure, weakness in the design, chemical attack, structural movement which are caused by the weakness of the structural design, installation methods, construction works, maintenance issues and working conditions on site. Wai and Sui (2006) outline the defects into five (5) categories which include:

i. Elements
There are eleven (11) elements comprise of floor, external walls, internal walls, doors, windows, mechanical and electrical systems, plumbing and sanitary systems, roof, ceiling and external works.

ii. Materials of construction
Materials which impairs the elements of a building.

iii. Explanation on discrepancy
Uniformity of defects and defects that were confirmed by the Building Surveyor, where the inspection team should accurately describe the defects so that the defects do not re-occur.

iv. Causes of the discrepancy
The causes of defects can be observed by the parties involved in addressing the problem of defects in the building, like the designers, contractors, material suppliers and maintenance contractors. Causes of these defects are due to:
- Design:
Defects caused by the weakness in making decisions, where the outcome includes material specifications, layout and integration of building materials and systems.
- Construction
Defects caused by weaknesses in assembly techniques, including mixtures of materials, weakness in handling material, weakness in the planning done by the contractor who affected the quality of the building, failure in providing the right connections, gaps or materials to avoid defects and so on.
- Construction materials
Defects arising from poor quality materials. These materials should be in accordance with required standards. If it is too exposed to the surrounding conditions that might have a high impact or effect, it will be considered as low quality. When there are defects of this construction material, it is often attributed to the design and construction work.
- Maintenance
Defects arising from either building materials or poor maintenance of the system.
v. Design strategy.  
There are five (5) strategies to the design importance, namely:  
- Aligning performance significantly against bad weather.  
- Prevention of occupant and load effects.  
- Prevention of water leaks that cause defects in other elements.  
- Improved specifications  
- Improve the clarity of the design.

4.0 QUALITY ASSESSMENT OF AN ABANDONED HOUSE  
Most of the complaints about the problems of building are related to serious aesthetic defects involving major structural failure of buildings (JSCQB 2002). Tam & Tong (1996) found that the construction industry in Hong Kong have always been linked to unsatisfactory quality. Therefore, Tam & Deng (2000) argued that the approach adopted by the Government of Hong Kong by introducing the Performance Assessment Scoring Scheme (PASS) is a measure used to evaluate a building for the purpose of improving the quality of buildings in the country.  
This system is also applied in Singapore, known as the Construction Quality Assessment System (CONQUAS) that was introduced in 1989 (Low et al 1999). This system involves a method of valuation and the value that was set in accordance with aspects of the evaluation set. Table I show the components to be evaluated to determine the quality of construction which includes:  
Each of these aspects will be assessed through the specified points. Thus, to focus on quality of construction, Malaysia have an organization body that is Quality Assessment System in Construction (QLASSIC) under the auspices of the Construction Industrial Development Board (CIDB) in accordance with the specifications and standards set to achieve an effective level of quality (QLASSIC 2008).

5.0 CUSTOMER SATISFACTIONS  
The study of customer satisfaction should be enhanced by discovering the factors necessary to achieve customer satisfaction. In addition, it can also provide an assessment of the quality of the building, market, sales planning the future and so on, to increase the performance of a company or organization. Customer satisfaction will also shows the actions of a customer’s acceptance of the products offered can be evaluated, where the comparison between the products shown and the standards set forth (RB Woodruff 1996). However, according to a review by Perry (2007) on the customers in the housing construction industry, generally are satisfied with the comparison on the expectations described between customer’s (Oliver 1983) pre-purchase (pre-purchase expectations) and post-purchase (post-purchase perception). This is to determine how the customer can evaluate their level of satisfaction of which it is difficult to draw conclusions as a whole. Therefore, to determine the products or services produced, customers will have the final say whether the product or service meets their needs and requirements. (Hamzah et al. 1999).

6.0 BUILDING QUALITY INFLUENCING THE CUSTOMER SATISFACTIONS  
Roodman and Lenssen (1995) argued that buyers rarely know what they want, so that buyers will focus on price, location, size, durability, amenities and some related matters. This is evidenced by a study conducted by Hamzah, Kwan and Wood (1999), which demonstrated twelve factors which influence the quality of the building as illustrated by the purchaser. These factors are characteristics of the structure, building materials, construction works, surrounding environment, moni-
toring and home security in an emergency, home size, basic amenities, maintenance works, residential layout and condition of the building. These factors will affect customer satisfaction whether they are satisfied or dissatisfied with the result of construction work done. However, the results of their study also demonstrated five other factors that influence satisfaction with the quality, which are the structural elements, building materials, stability of the building, construction works and environmental quality. Overall, the stability of the building was rated the highest compared to the materials, repair works, design of structural elements and the least is the quality of the environment. This is supported by the Low SP and Daren (2001) in which all structures or building components must meet the needs of clients stated in the contract. If it does not meet the client’s requirements, then the building designer or contractor would have failed to provide the necessary quality required by the building. Indirectly, the defects in the building will increase. These factors are arranged according to levels which are considered important for the purchaser as shown in Table II.

### Table 2. Building quality factors affecting the customer's satisfaction

<table>
<thead>
<tr>
<th>Level</th>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Structural Benefit</td>
<td>These factors influence the quality of housing. Thus it is important for the understanding of a customer. Structural elements such as base, beams, columns, roof floor and walls. Defects such as cracks, leaks, seepages of water through the floor and walls are matters that will be look by customers.</td>
</tr>
<tr>
<td>2</td>
<td>Building Materials</td>
<td>The materials used to make the walls, roof, flooring, doors and windows should be durable. This is because the materials are not durable, it will cause problems for the building.</td>
</tr>
<tr>
<td>3</td>
<td>Construction Works</td>
<td>Construction works or installation such as installing ceiling, doors, windows, floor tiles, plastering, plumbing works and mechanical and electrical systems, will also affect the quality of a building.</td>
</tr>
<tr>
<td>4</td>
<td>Environmental Condition</td>
<td>Environmental conditions such as air quality, noise and traffic also affect the quality of the building. Dissatisfaction of customers arises when the air quality and noise occurs in the area around them.</td>
</tr>
</tbody>
</table>

Source: derived from Rodman and Lenssen (1995) and Harzallah, Kwan & Peter (1999)

7.0 RESEARCH METHODOLOGY

In this study, the research method is a combination of quantitative and qualitative research. A quantitative study was developed in the social sciences to study natural phenomena. Among the methods of observation are testing or laboratory experiments and studies involving numbers and mathematics (Dennis 2005). The function of quantitative research is to create descriptive, inferential, to forecast and testing statistically (Palaniappan 2009). In descriptive research, data collected from the entire population and basic statistics such as frequency, percentage, minimum, standard deviation and distribution of the scores are reported (Chua 2006). Whereas, with the inferential study, a sample of subjects randomly selected from population of numerical data studies, collected from a sample to be tested using statistical tests. The study is based on a few selected samples to be used as a test and will be displayed in graph or statistic (Dennis et. al 2005). Meanwhile, the qualitative research undertaken in the social sciences is to understand the phenomenon and culture (Myers 1997). Dennis et. al (2005) also stated that qualitative methods are used to assist researchers in understanding the study, social and cultural environment.
Research module was divided into four stages, of which the first stage involves the statement of the problem, determining the topics and literature. The second stage includes technical research, formulation of questionnaires and sample selection, based on objective and doing field work by distributing questionnaires related to the respondent. The third stage is data collection and processing and the final stage is writing a report on its findings and recommendations of the study.

7.1 PROCEDURES

For this study, three (3) housing projects were selected ranging between six (6) months to two (2) years that had been completed and occupied. The case study is randomly selected at Selangor state area, the state with the highest ranking case of abandoned housing project in Peninsular Malaysia (MHLG 2010). Table III shown the number of respondent at each of housing area. The questionnaire is distributed to the respondent based on the population calculation. Hence, a total of 154 respondents were randomly selected and are required to do the assessment. Questionnaires were given to the respondent to be filled up immediately. This method is used for respondents that are not from a construction background and are uncertain of the terminologies used in the questionnaires given.

7.2 SUBJECTIVE MEASUREMENT

The questions were divided into three (3) main sections, namely section A: general information on selected respondent. These consists mainly on the status of a building and whether the respondent is a tenant or owner, number of years the house was abandoned between six (6) months to three (3) years and occupancy period ranging between less than six (6) months to two (2) years. Meanwhile, in section B: type of defects affecting to the building quality. Likert scale is being used at this section, where the respondents are required to do an assessment by using the 5-point Likert scale (1= None, 2= Some, 3= Neutral, 4= Many & 5= Too many). The last section is section C: an assessment on customer satisfaction level for housing was abandoned. In this part respondents are required to do an assessment base on the point given. As in section B, the Likert scale is used from point 1 to 5 (1= Very unsatisfied, 2= Unsatisfied, 3= Natural, 4= Satisfied & 5= Very satisfied). All this Likert scale is measured through frequency analysis and average index analysis. These scales will be classified...
according to the significant of each factor: Not Important from 1.00 < average index < 1.50; Less Important 1.50 < average index < 2.50; Moderate Important 2.50 < average index < 3.50; Important 3.50 average index < 4.50 and Very Important 4.50 < average index < 5.00.

### 8.0 FINDINGS

Objective assessment on the level of customer satisfaction towards the quality of buildings that had been abandoned and now completed and occupied by residents were successfully conducted.

All factors is analysed by using SPSS to identify the level of customer satisfaction on the housing previously abandoned. Of the 154 respondents whose questionnaire were analysed, 75.97% of the respondents (117 people) are the original owners of residential units and 24.3% of respondents (37 people) are tenant living in the units. During questionnaire being distributed, most of the respondents are not certain on the year of housing were abandoned.

Quality of building is assessed by the respondents according to the common defects that occur on housing project. Most of common defects are crack on wall (mean score 2.90), uneven surface of wall (mean score 2.73) and floor (mean score 2.64) and floor finishes not properly done (mean score 2.63). Table IV highlights the common defects affecting quality of building. This assessment will determine the level of customer satisfaction on the end product.

Table V shows the frequency distribution obtained through questionnaires on customer satisfaction. There were four (4) factors for building quality affecting the customer’s satisfaction as per Table II. Based on these figures it can be concluded that most respondents are not satisfied with the construction works (workmanship) which has the lowest minimum score of 2.40 compared with building materials and structural advantages, each has a minimum score of 2.46 and 2.78.

The above findings indicate that the respondents are not satisfied with the final product produced by the developer. Therefore, the study demonstrated that the construction work and building materials will affect the quality of the building, thus affecting customer satisfaction.

Hamzah et. al (1999) argued that the satisfactions of those occupying the low-cost housing are related to the impact of the environmental and

<table>
<thead>
<tr>
<th>Table 4. Common defects affecting quality of building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defects</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Crack on wall</td>
</tr>
<tr>
<td>Uneven surface of wall</td>
</tr>
<tr>
<td>Uneven floor</td>
</tr>
<tr>
<td>Uneven wall</td>
</tr>
<tr>
<td>Uneven surface of wall</td>
</tr>
<tr>
<td>Uneven floor finish</td>
</tr>
<tr>
<td>Uneven floor finish</td>
</tr>
<tr>
<td>Uneven wall</td>
</tr>
<tr>
<td>Uneven floor finish</td>
</tr>
<tr>
<td>Uneven wall</td>
</tr>
<tr>
<td>Uneven floor finish</td>
</tr>
</tbody>
</table>
the construction works. According to the research carried out, most of the respondents are not satisfied with building materials and construction works for houses that used to be abandoned.

8.1 RELATIONSHIP BETWEEN LEVELS OF SATISFACTION AMONG RESIDENTS LIVING IN PREVIOUSLY ABANDONED HOUSES

Based on the following Table VI, it can be concluded that there was a significant linear relationship between the structural benefit, building materials, construction works and environmental conditions. Low correlation coefficient ($r = 0.348$) and positive shows that there is a positive linear relationship for the low level of satisfaction residents who lived in the house that was once abandoned. This means that the satisfaction level of residents who lived in the houses that had been

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**Table 5. Percentage base on the scale of the level of customer satisfaction.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Scale Value</th>
<th>Very Unsatisfied (1)</th>
<th>Unsatisfied (2)</th>
<th>Neutral (3)</th>
<th>Satisfied (4)</th>
<th>Very Satisfied (5)</th>
<th>Total</th>
<th>Min Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Structural Benefit</td>
<td>1</td>
<td>66</td>
<td>47</td>
<td>50.5</td>
<td>92</td>
<td>59.2</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>Building Materials</td>
<td>7</td>
<td>42</td>
<td>77</td>
<td>58.0</td>
<td>65</td>
<td>40.9</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Construction Works</td>
<td>7</td>
<td>45</td>
<td>84</td>
<td>54.5</td>
<td>58</td>
<td>33.7</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Environmental Condition</td>
<td>1</td>
<td>0.6</td>
<td>11</td>
<td>7.3</td>
<td>60</td>
<td>39.9</td>
<td>75</td>
</tr>
</tbody>
</table>

**Table 6. Correlation Schedule of Level of Satisfaction among Residents Living in Previously Abandoned Houses.**

---

Based on the following Table VI, it can be concluded that there was a significant linear relationship between the structural benefit, building materials, construction works and environmental conditions. Low correlation coefficient ($r = 0.348$) and positive shows that there is a positive linear relationship for the low level of satisfaction residents who lived in the house that was once abandoned. This means that the satisfaction level of residents who lived in the houses that had been
abandoned, have a mixed relationship from low to high. The study demonstrated the relationship between building materials and structural benefit. Similarly, the construction works are connected to the building materials. However, the correlation coefficient for the environment shows a high positive linear relationship with the construction works ($r = 0.84$).

9.0 CONCLUSION

The buildings are more vulnerable to weather and human vandalism that causes a lot of damages and defects to buildings that was previously abandoned. Even though the developer sought to revive the project by resuming the construction project, the duration to solve the problem of the abandoned projects caused the buyer or customer to grumble. Consequently, the developer continued with the job irrespective of building quality which affected the customer satisfaction.

An index analysis by a descriptive statistic of common defects affecting to customer satisfaction demonstrated that most of common defect occurred in the building involving elements like floors, walls, doors and windows, ceilings, plumbing and sanitary and roof. Common defects found on the wall elements are wall cracks, breaks, uneven walls and unsatisfactory finishing. The second element of common defects in the building is the uneven floor. Defects of this building will indirectly affect customer satisfaction. This is evidenced by the findings of the study which demonstrated that most buyers are not satisfied with the construction works (workmanship) and construction materials. This is evidenced by the defects caused by the construction works and the use of low quality building materials. The findings based on Pearson correlation study illustrated that environmental conditions have a relationship with the construction works that will satisfy the satisfaction levels of residents who lived in the house who had been abandoned.

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Authors’ address:

Zamharira Sulaiman,
Faculty of Built Environment
University of Malaya, 50603 Kuala Lumpur

Azlan Shah Ali
Faculty of Built Environment
University of Malaya, 50603 Kuala Lumpur

Faizah Ahmad
Faculty of Built Environment
University of Malaya, 50603 Kuala Lumpur
THE IMPACT OF PASSIVE DESIGN ON BUILDING THERMAL PERFORMANCE IN HOT AND DRY CLIMATE

Emad S. Mushtaha, Taro Mori, Enai Masamichi

Abstract
Several calls have been everywhere asking for proper use of passive design tools like shading devices, insulation, natural ventilation and solar panels in building architecture of hot-dry area in order to improve the thermal performance of indoor spaces. This paper examines the effect of these passive tools on indoor thermal performance which in turn helps arrange thermal priorities properly. Herein, basic principles of Successive Integration Method (SIM) have been utilized for an integrated design of two floors with small openings integrated with floor cooling, solar panels, natural ventilation, shading devices, and insulation. As a result, create priorities of passive tools that are structured consequently for ventilation, insulation, solar panels, and shading devices. This structure could guide designers and builders to set their priorities for the new development of building construction.

Keywords: Passive Design, Natural Ventilation, Insulation, Shading devices, Hot and Dry climate.

INTRODUCTION
It has been known across the world in the construction industry that “higher level of insulation, passive solar, passive cooling, and day lighting, all increase the survivability of a building” (Lechner 2009). Principles of passive cooling are set as: shading, reflection, insulation, reduction of internal gains, ventilation, fans, and tightness of buildings (Rosenlund 2000). Herein, passive design and its tools are of great importance guiding design towards sustainability. There have been several calls asking for proper use of passive design tools like shading devices, insulation, natural ventilation and solar panels in building industry in order to improve the thermal performance of indoor spaces. Many researchers concentrated on reducing energy consumption using natural resources and providing comfortable, healthier and sustainable living spaces (G. Manioglu 2007). Researchers like Guangyu C. 2011, Kristina O. 2011, and Dilia A.S. 2011 have been looking forward to achieving and reaching a climatically responsive design. “If we wish to exist in harmony with our environment, we must do by choice what our ancestors did out of necessity, ‘design with the climate and with a sense of place’.” If we ignore this, we miss out on many sustaining qualities of the context of site and surroundings” (Derya O. 2001). Therefore, testing and evaluating the impact of passive design on indoor temperature is a good approach towards achieving low-energy and comfortable houses. Kumar, Garg and Kaushik evaluated the performance of solar passive cooling techniques such as solar shading, insulation of building components and air exchange rate. In their study they found that a decrease in the indoor temperature by about 2.5°C to 4.5°C is noticed for solar shading. The analysis suggested that solar shading is quite useful to development of passive cooling system to maintain indoor room air temperature lower than the conventional building without shade (M.A.Kamal 2010). Herein, this study focuses on evaluating some common passive parameters such as shading devices, natural ventilation, solar radiation, wind velocity, etc., it is not possible to design a building that is energy efficient without being wasteful of resources” (Hui scm 2000). This will guide designers to consider climate in their design. Understanding vernacular architecture could also help find main elements needed for having a climatically responsive design.

Hui SCM in his online website mentioned one of the most important things in building energy efficiency is the climate you are designing in. Without knowing the temperature, solar radiation, wind velocity, etc., it is not possible to design a building that is energy efficient without being wasteful of resources” (Hui scm 2000). This will guide designers to consider climate in their design. Understanding vernacular architecture could also help find main elements needed for having a climatically responsive design. “If we wish to exist in harmony with our environment, we must do by choice what our ancestors did out of necessity, ‘design with the climate and with a sense of place’.” If we ignore this, we miss out on many sustaining qualities of the context of site and surroundings” (Derya O. 2001). Therefore, testing and evaluating the impact of passive design on indoor temperature is a good approach towards achieving low-energy and comfortable houses. Kumar, Garg and Kaushik evaluated the performance of solar passive cooling techniques such as solar shading, insulation of building components and air exchange rate. In their study they found that a decrease in the indoor temperature by about 2.5°C to 4.5°C is noticed for solar shading. The analysis suggested that solar shading is quite useful to development of passive cooling system to maintain indoor room air temperature lower than the conventional building without shade (M.A.Kamal 2010). Herein, this study focuses on evaluating some common passive parameters such as shading devices, natural ventilation,
and insulation in addition to solar panels. This study is to be the second part of the paper which has been published at JAABE, 2005 by the main author where it focused on Gaza city representing Temperate Climates (Mushtaha et al. 2005). In this study the same model and simulation have been applied to Jericho city in Palestinian Territories representing hot and dry climates. Jericho is located in Jordan Valley, and is characterized by a hot-dry summer and a warm winter (Haj hussein 2010) so that the simulation of this study will deal with problems of summer rather than those of winter. The city of Jericho has been chosen just for the validity of the climatic data of the hottest and coldest days over the year. The climate of Jericho like other hot-dry areas in the world has been faced with temperature variation through the year where the monthly mean high air temperature reaches up to about $(46^\circ C)$ in a typical summer and the monthly mean low air temperature drops down to about $(6^\circ C)$ in winter. Minimum and maximum relative humidity in both summer and winter are respectively arranged for $(10-30)$ % and $(23-72)$ % as shown in the appendix. This proves the difficulties of the climate of the area, which affects people inside houses. In recent architecture, simple construction materials, poor techniques, absence of insulation for walls and roofs and lack of shading devices are a common phenomenon in most of the developing countries. Accordingly, buildings have become a source of discomfort through certain times of the year. The impact of the passive design on room temperature has been studied to improve indoor spaces. Herein, achieving environmentally friendly housing designs within the most modest means in a sound environment is urgently needed. To solve such problems, a proposal has been adopted for passive mobile strategies that consider the relation of the human, the building and the climate. Four parameters: shading devices, ventilation, insulation for walls and roofs and floor’s cooling were conducted in the study in order to obtain effective solution for indoor environment. Herein, the calculation analyses will focus on summer rather winter for its obvious problem “ Temperature and Heat”. This will help future design listing priorities, tools, and materials towards sustainability. So, the main objective of this study is to show the impact of passive tools on building thermal performance in hot and dry areas. This would help people set their priorities on the use of passive tools to achieve the thermal human comfort zone, which is defined as “the range of climatic conditions within which the majority of persons would not feel thermally discomfort either heat or cold” (Sayigh 2003). The comfort zone will be arranged at $21-29^\circ C$ in both winter and summer. This objective will help drive the way towards understanding sustainable buildings through the use of passive design.

2. RESEARCH METHODOLOGY

This paper has used the Visual Basic Program in developing and adopting some calculative equations, in addition to Successive Integration Method (SIM) (Aratani 1983) to evaluate the thermal environment of the structure. The Successive Integration Method (SIM) was defined as “a tool used to predict transient heat-transfer in a building by assuming a quasi-steady state between the building members and the room air temperature” (Masamichi 1997). Herein, the accuracy of simulations has been positively confirmed by SIM and compared with the first part of the study published at JAABE. Figure (1) illustrates the concept of Successive Integration Method, which is any unit step function of temperature $\theta_u(t)$ has an initial heat flow response $h(t)$ then; the heat flow response consequent on arbitrary temperature excitation $\theta(t)$ produces heat.

![Figure 1. Conceptual Diagram of SIM](image)

3. PROPOSAL’S DESCRIPTIONS

A model consists of two floors, a penthouse and a 6 m chimney with gross area $(134m^2)$ (Fig.2 and Fig.3) has been proposed to investigate and improve the thermal environment of indoor spaces in hot and dry climates. An integrated design with natural ventilation, southern solar panels $(40m^2)$, and a floor radiant cooling system, in which pipes
of hot and cold water are embedded inside the concrete floor slabs have been implemented.

3.1 Performance of Passive design
Passive design concepts are set for enhancing indoor thermal environment. Natural and passive cooling uses non-mechanical methods to maintain a comfortable indoor temperature. Shading is a simple method to block the sun before it can get into the building. Shading minimizes the incident solar radiation and cool the building effectively and hence dramatically affect building energy performance.

The processes of enhancement are discussed and described below.

3.1.1 Natural Ventilation
The main route of natural ventilation has been conducted with the “Wind-Catcher” concept (Figure 3). The main route provides several zones of spaces with fresh air. Airflow in each route can be induced by utilizing the tendency for warm air to rise and be displaced by the cooler air. In summer nights, the floor’s wind-catcher is closed and then the route of ventilation goes down from its openings to the indoor spaces. This occurs due to the outdoor air being denser than the indoor air, which in turn encourages driving the force of the flowing air from more dense to less. Accordingly, the main route R1 blows fresh air into indoor spaces to get circulated within indoor spaces throughout some inlet and outlet openings within 5 routes (R2&R3 in the first floor, R4&R5 in Second floor, and R6 in the penthouse floor). This cools internal surfaces of construction and help be cooled for the next day (Figure 3).

3.1.2 Solar Panels
Active solar tools for heating and cooling in the proposal used built collecting panels, pipe, an automatic pump and a sensor for controlling the movement of shutters. This system mainly works at summer nights when outside temperature is low which cools down the temperature of water in pipes. This cooled water will cool down the construction elements and store it in the building body. If this system works to warm water in winter, then it collects, stores, and distributes the collected solar energy inside spaces and this depends on the solar energy and radiation. In the proposal, panels are supported by water as a means of heat transfer and directed south to collect as much heat as possible.
for winter problems but in summer where it is the case in Middle East the proposal focuses on summer problem “overheat” which needs cooling strategies. This passive concept is created throughout this active system to compose an approach of sustainability.

3.2 Terms in Simulations
In the simulation, different heat resources were studied for estimating the heat balance of rooms’ temperature. The resources were considered as follows:

3.2.1 Internal resources
The internal thermal resources from lighting, the human body, and equipment with a dimensional unit (Wh/ day) are considered. The heat are emitted from the human body is approximated by 25 (W/m²) and the average area of the human body’s is approximated by 2 m². Totally emitted energy of the human body is calculated to 50 W, while five people were considered in the study. The life pattern of those people was different from time to time. Occupying times from (4pm till 7am) was considered. The heat from lighting, other internal resources and equipments are added to the human body’s energy to accumulate 12050 Wh/day.

3.2.2 Construction Material
External walls with/without insulation, windows,
roofs, and floors with pipes transfer heat energy from side to side by the processes of conduction and convection. The process of calculations has considered the characteristics of all materials’ layers and sub-layers (Table 2). The thermal conductivity and transmittance, diffusivity of each layer, hourly outdoor temperature, and the net of long and short wave radiation were considered. Respectively with applying SIM, temperatures of solids’ surfaces and layers were estimated. “When a surface temperature is finally known, then most of the heat will be exchanged between the air of the room and the solid surface such as a wall by convection heat-transfer” (Masamichi 1987).

3.2.3 Passive technique
a) Solar panels shown in case 6 (Table 2) are conducted to the study. Some terms were used in the calculations for measuring panels’ area. The calculations were dependant on the material’s characteristics such as walls, roof and window conductance, required ventilation for occupants, difference of temperatures between average outdoor temperature and human comfort zone, internal heat resources and long wave radiations from the roof to the sky. To evaluate the heating and cooling effect of the solar panels’ system on the rooms’ temperature, common equations and definitions were used for this purpose, such as Reynolds, Prandtl and Nussenl Numbers. Pipe diameter of the solar panel and the floor were calculated for 1.20 cm.
b) Natural ventilation has been conducted to the

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<td>Reinf. Concrete Rock Wool</td>
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<td>Foam Concrete</td>
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<td>Wall-B Cement Mortar</td>
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model. Fluctuation of temperatures, difference of pressure, and air leakage has been studied. Fresh air flow is simulated according to the difference of temperatures between wind-catcher’s indoor and outdoor temperatures. Orifices of the wind-catcher are contributed ventilating spaces through different levels of openings (Figure.3). The location of the natural pressure level at which indoor and outdoor pressures are equal is controlled by the size and the location of leakage openings.

4. ANALYSIS AND RESULTS OF SIMULATIONS

The list of conducted conditions for simulation is shown in (Tables 1&2). The processes of executing the simulations have undergone many procedures. Each case tests one or more parameters’ effect on rooms’ air temperature. The hottest and coldest day of the year were used for the numerical simulations Table (5) in the appendix. As mentioned earlier, this study focuses on summer problem rather than winter one. Gradually, these analytical processes will achieve the most valuable parameters for summer by the end of this study.

Case (1)
The first case represents most of houses in developing countries where shading devices, insulation, ventilation, and solar panels are absent in their buildings architecture. Each zone of indoor spaces was simulated and represented individually as shown in (Figure 4A). In order to simplify reading the analysis, average of outdoor temperature and average of calculated indoor spaces were shown as two straight lines. It was recorded that the temperature of indoor spaces has an increased average of about (+2.90) °C to reach (37.6) °C, while the average outdoor temperature was (34.70) °C. Moreover, it is being laid outside the thermal comfort zones where it is considered between 21 and 29 °C. A difference of average temperature between the basement and outdoor spaces showed an improvement of (-1.40) °C; while about (5.4) °C between the penthouse and the outdoor spaces (Fig 4.A,B). Therefore, it is noticed that, the temperature has accumulated gradually from the lower degree of the basement floor to the higher degree at the upper floors, which in turn compels one to examine some natural tools to evaluate the temperature.

Case (2)
It is seen that the accumulated heat inside the living spaces is being decreased during nighttime with a difference of up (-1.2) °C while in the penthouse it showed an increased improvement of (-2.50) °C (Figure.5A,5B).Herein, utilizing ventilation only during nighttimes obviously affected and activated the air to lessen a gradient of temperature.

Case (3b1) in summer
This practice has been compared to the original one, base line case, to examine shading devices. A significant difference of temperature of up (-2.60) °C showed an improvement in the upper floors (Figure. 6A), while (-0.60) °C in living spaces as illustrated in figure (Figure.6B). On the other hand,
in winter there will be almost no difference due to the altitude angle, which causes sun penetrates indoor spaces easily.

**Case (3b2) in summer**
This practice is compared to case.1 and it is noticed that the temperature has been reduced to (-1.6) °C in living spaces, (-0.5) °C in the basement and (-3.70) °C in the penthouse Fig (7.A, B). Moreover, shading devices prevent the solar radiation from penetrating into the buildings while ventilation improves the thermal environment during the night. Generally, temperature is reduced inside the model’s spaces to (-1.80) °C.

**Case (4) in summer**
Comparing this practice to the original case, a gradient temperature is improved of up (-2.85) °C in living spaces and (-6.10) °C in the penthouse’s space Figure (8A,B) due to the efficiency of insulation and the shading devices, which are reducing...
An improvement of temperature about (-2.50) °C was shown in living spaces, (-0.7) °C in the basement spaces, while about (- 4.75) °C in the penthouse. The temperature reached an average of (35.15) °C in living spaces while (32.9) °C in the basement spaces and (35.50) °C in the penthouse. Generally, the average indoor temperature reached about (34.80) °C. Temperature is decreased due to the smaller openings dimensions with the shading devices, ventilation and massive walls, which in turn reduced the indoor temperature. Herein, case (4) without ventilation has more accepted results than case (5).

Case (6)
The previous case 5 is integrated with solar panels of (40 m²), floor pipes on the first and the second floor, an automatic pump and shutters. Water flows into floors through embedded pipes. This system is supported by an automatic pump, which works during the summer’s nighttimes. Moreover, a sensor is used for controlling movement of shutters, which are shutting the panels during the daytime and opening them during the nighttime. Comparing this case to the original one, it has been noticed that an improvement in temperature of (-3.15) °C in living spaces to reach an average of (34.5) °C and about (-5.40) °C in upper spaces to reach an average of (34.80) °C figure (10A, B). It is reasonable to implement the solar panels to reduce the gradient temperature by convection.
For achieving the thermal comfort zone of the original case, it was noticed that the needed temperature to cool living spaces is about (8.6) °C. In the case (5) which is consisted of (shading devices, insulation, ventilation and small openings with double glass panes), it is noticed that (6.2) °C was required for cooling, but in case (6) less than (5) °C for cooling is required (Table.4). The model has succeeded to some extent in reducing indoor temperature and showing the impact of each parameter on thermal performance of indoor spaces. Although thermal comfort was not achieved but this study inevitably helps assemble the most effective tools and parameters lessen energy consumption. Accordingly case (5, 6) could achieve high thermal performance with its positive impact in terms of sustainability, applicability and reliability. From the study, it is gradually seen that the most valuable parameters in summer are managed to

Insulation, Ventilation, Shading for -2.35, 1.75, -0.5 °C respectively. When combing all cases with solar panels the thermal performance of indoor spaces gets improved between (-3.2 and - 5.5) °C. Therefore, thermal comfort if considered between (21 and 29) °C would be achieved easily if other passive techniques were used. It is recommended to adopt these green tools into current design processes. As a rule of thumb, passive design has many other ways to reduce indoor spaces such as evaporative cooling in hot and dry climates which help reduce dramatically the indoor temperature and increase humidity ration in air. The authors also recommend case.4, just using small openings with insulation and shading devices, for any future renovation or planning and designing of social housing environment as it improved the average indoor spaces by -3.40 °C. For more clarification on the simulation results, tables (3 and 4) illustrate the conclusive values of all cases including the main three cases: the original case, case (5) and (6). To improve the quality of the paper, part of the conclusion section has been restructured. From the previous cases the effect of the most effective parameters on room’s air temperature are gradually assembled as herewith. As a result, the authors would suggest the following recommendations for future building design.

1. Thermal Massive Walls
   It was recorded that massive walls with small external openings of hot and dry climate decreased heat losses and improved the thermal environment of inner zones by (-3.40) °C while of temperate climate improved living spaces positively by (-1.20) °C (Mushtaha 2005). This comparison validates the importance of using insulation in hot and dry climate and recommends utilizing insulated walls with small external outside openings to balance heat-transfer processes. The authors recommend using small to medium openings of about (20–40) % of an elevation to work properly.

2. Ventilation
   Ventilation should be considered into architectural design processes. From the previous simulation, it was shown that ventilation could improve both living spaces of both climates: hot dry and temperate by (-2.70) °C (Mushtaha 2005). This verifies the
importance of having all indoor spaces ventilated to improve indoor temperature. In temperate climate the ventilation was more effective than that case of hot climate because in hot-dry climates not only is the problem related to the increase of temperature but also to the humidity percentage. If all indoor spaces were humidified and well ventilated, then the case would be more effective. Therefore, humidifying and ventilating spaces in hot and dry climate is a good approach for passive cooling system to reduce cooling loads.

3. Shading devices
The utilization of shading devices is to decrease penetrated sunrays and heat gains during summer. Architects have to reconsider the way they design devices attractively. The effect of those devices on living spaces has positively shown improvements of indoor spaces by about -0.50 to -1°C.

4. Solar Panels
Active solar tools for heating and cooling in the model used built collecting panels, pipe, an auto-

Table 3. Difference of Temperature Average between Outdoor and Indoor Zone

Table 4. The Conclusive Values Of Model Study

Table 5. The Hottest and Coldest Days considered in the simulation for Jericho
matic pump and a sensor for controlling movement of shutters. From the simulation it was shown that the system improved the indoor spaces of hot-dry climate of about (-3.20 to -5.45) °C while of temperate climate of (-2.40) °C (Mushtaha 2005). This enhances the idea of applying these valuable tools into future design of hot-dry climate for its huge diurnal temperature which makes the panels of high importance.

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Authors’ address:

Emads. Mushtaha,
Department of Architecture, College of Engineering
Ajman University of Science and Technology Network (AUSTN) P.O.B. 346-Ajman City, UAE
Tel (Office): +971 6 705 6721
Mob: +971 50 1710 359
E-mail: e.mushtaha@ajman.ac.ae or emad27270@hotmail.com

Taro Mori,
Division of Urban & Environmental Engineering
Hokkaido
Japan

Enai Masamichi,
Division of Urban & Environmental Engineering
Hokkaido
Japan
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