UNLEASHING THE POTENTIAL OF TRADITIONAL CONSTRUCTION TECHNIQUE IN THE DEVELOPMENT OF MODERN URBAN MASS HOUSING

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Abstract
The provision of adequate quality housing for the mass population has always been the major challenge for a rapidly developing country like Malaysia. As the country heads towards higher level of urbanization, it is expected to face accelerated demand on housing and the associated environmental impacts. Only by encouraging the development of more efficient buildings or through implementing a holistic construction approach that addressed right from the onset of the design stage, harmful environmental impact to the surroundings can be mitigated. This paper highlights the potential of applying flexibility – a design approach which has been widely adopted in the traditional construction – as an inherent design strategy for the modern urban mass housing. The proposed design strategy entails open plan that enable retrofit and reconfiguration to be made quickly, economically, and repeatedly, without involving excessive site labour, time, and cost; as compared to the currently adopted design strategy which is associated with rigid structure, interlocking plan, and predetermined function. It makes possible the creation of dwellings which may grow old yet without becoming obsolete; incorporating the latest design ideas and technologies, yet have a sense of history on the Malaysian housing design (the *rumah kampung* design); allowing the communities to live for generations, yet incorporating the potential of adaptation. By examining the background research and the fundamental design principles, the paper suggests that only dwellings with high degree of flexibility may enable the integration of dual aims and principles of affordability and sustainability in mass housing, thereby facilitating the movement of the country's construction industry towards mechanization, industrialization, and standardization.

Keywords: *Divergent dwelling deign, sustainable, affordable, housing, flexibility, tropical country*

INTRODUCTION

Housing industry today are overshadowed by two major problems: (i) short supply of adequate housing to mass population as a result of increasing demographics, and (ii) significantly contributing to CO_2 emission, caused not only by activities during the construction period but also after housing is completed and being occupied. While moving towards higher level of urbanization, Malaysia is of no exception in facing mass housing problems that require a solution with the integration dual aims and principles of affordability and sustainability. Keen architects, urban planners, and engineers might have achieved advances in generating single meaningful buildings, but most of them fail to come up with effective sustainable mass housing design when dealing with concentrated urban populations (Gan, 2013). Among the identified major impediments are the lack of research in the field of sustainable mass housing and the challenges of meeting public's affordability level with the fast rising construction cost (Zaid and Graham, 2011; Gan et al., 2013[a]). Based on the Real Estate and Housing Developers' Association's (REHDA) estimation, the price of an eco-friendly house is about 15% higher than the conventional one (REHDA, 2013). Given that the profit hovers around 5% to 10%, coupled with the nature of construction industry which

is rather competitive and with extremely high risk, incorporating sustainable or green features into mass housing development is thought of as not cost-effective (Gan et al, 2013[b]). Hence, sustainability features were rarely seen as a mean of achieving affordability. Any movement towards embracing the green cause or promoting a wider notion of sustainability in mass housing is not in the preferable mode of housing design and construction, not to mention the adoption of an unfamiliar system or design principle that requires a major change to the existing housing construction process.

As the era of sustainability is taking its stand, unsustainable construction practices in the building industry are getting increasing attention from the public (Gan, 2013). Issues such as excessive energy and electricity consumption, consuming more raw materials than other industrial sector, generating large amounts of wastes, using heavy materials subject to wear and tear, disruption to nature etc. have become the main topic of public concern. Questions also arise whether mass population is being accommodated in suitable dwellings, and are homes now being developed capable of adapting to occupant's ever-changing requirements. Studies show that residents of mass housing in Malaysia are generally not satisfied with their housing conditions, in terms of construction activities, materials used, aesthetic value, amenities etc. (Karim, 2012; Isnin et al., 2012). Most of them end up renovating houses to tailor-suit their needs before occupancy (Rostam et al., 2012; Nurdalila, 2012; Erdayu et al., 2010). This is largely due to the nature of the current mass housing architectural strategy, namely the convergent design system (Figure 1), which is a "one fits all" design initiative where housing is likely to be designed around the capability of a given product, instead of around the end-user. Thus, houses designed for the average family are deficient in meeting the mass housing sustainability objectives as they are leading to further compromise the occupant's needs.

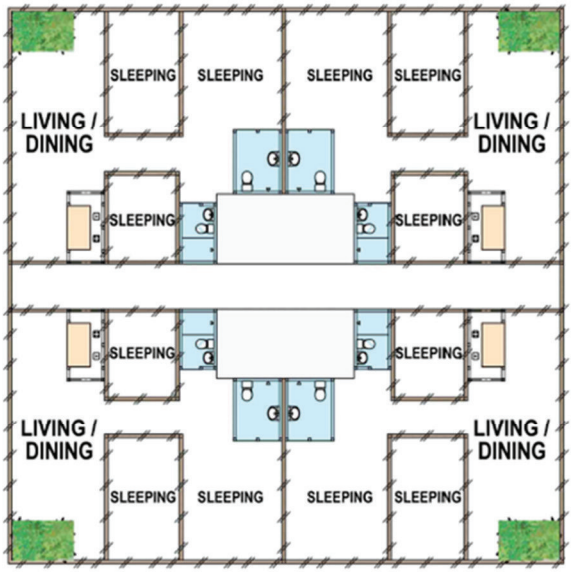


Figure 1. Typical layout of convergent design system

Besides, convergent design system implies to extreme compartmentalization and dissociation of internal elements, where service spaces such as kitchen, bathroom, etc. are built internally by interlocking with space, making the said service spaces difficult to interchange.

Houses designed and built with this system are solely based on the economic concepts of housing that only measure affordability, ignoring the potential of sustainable housing design that offers social and environmental benefits. The design features can be characterized as rigid structure, interlocking plan, and predetermined function, where very few of them are open plan that enable retrofit and reconfiguration to be made quickly, economically, and repeatedly (Gan, 2013). Even though the convergent dwelling design offers a reasonable alternative of housing needs for the general population, it is found to consider more on the physical development of housing rather than on the sustainable inhabitation. If Malaysia is to negate itself from locking in for an unsustainable future with detrimental construction that disregards environmental issues, a housing design approach that can create greater impact of sustainability to the dwellers, while improving the overall environmental performance is essentially needed. As such, how will the dwelling adapt to changes of a household over its lifecycle, and how can it adapt to suit different households or changes in external social and physical context becomes a tough challenge waiting for a holistic solution.

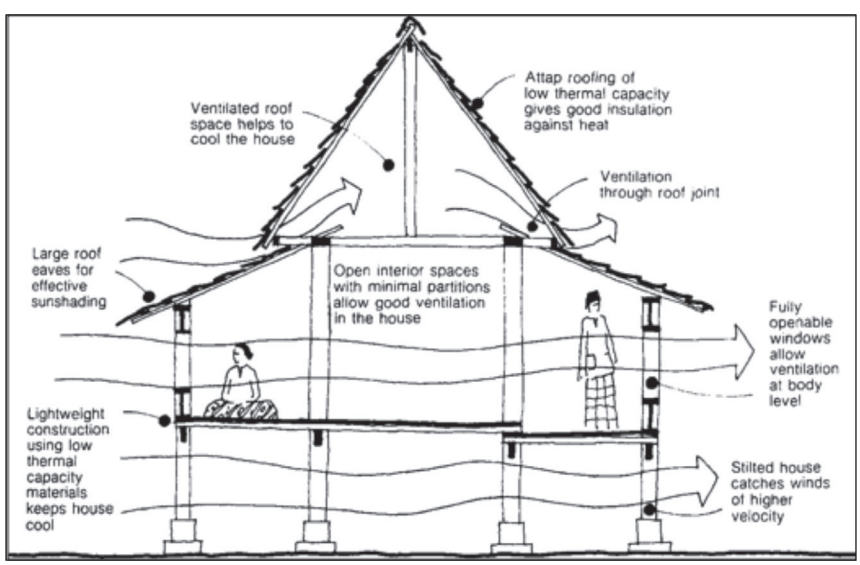
In this paper, the potential of applying flexibility – a design approach which has been widely adopted in the vernacular architecture – is proposed as an inherent design strategy for the modern urban mass housing. The aim of this paper is to explore how vernacular architecture grant insights to produce flexible mass housing design that will respond to changing demands of the users during occupancy. Within this framework, the paper focuses on the following topics of discussion: (i) what are the features of flexibility offered by the vernacular architecture; (ii) what is the scope of flexible housing in Malaysia; and (iii) how does the proposed design system address the issues of affordability and sustainability within the context of modern mass housing?

DESIGN FOR FLEXIBILITY – INSIGHT FROM THE VERNACULAR ARCHITECTURE

Flexibility refers to the idea of accommodating changes over time (Siddharth and Ashok, 2012). It is an innovative approach to architectural design that enables facilities to be retrofitted quickly, economically, and repeatedly. The concept of flexibility has long been a hallmark of the office and commercial spaces design. In-line with the new trend of residential housing design, the concept of flexibility is further intensified in the design of housing, as housing in the present day required to consider not only about housing one family or group of occupants over their lifecycle, but also allowing new residents to adapt the dwelling to their needs, or to allow a suitable mix of dwelling exists in an ever-changing environment. Flexibility, in the context of housing represents a comprehensive research on cases in the European context beginning from the early twentieth century (Siddharth and Ashok, 2012). According to Schneider and Till (2007), who introduce "flexible housing" by providing a criticism on the current condition of housing in the UK, housing flexibility addresses a number of issues related to the current and future needs of the users as it: (i) offers variety in the architectural layout of the units; (ii) includes adjustability and adaptability of housing units over time; and (iii) allows buildings to accommodate new functions.

In Malaysia, the idea of flexibility has long been the key feature of design in the vernacular architecture. This is well reflected in the traditional Malay house, where the residential

environment is not only designed to respond to the occupant's living demands, but also fully integrated with the tropical climate and the uses of local resource (Figure 2). The traditional Malay house is constructed by employing sophisticated architectural processes that has been proven to be harmony and successfully maintaining the capacity of the rainforest ecosystem (Che Amat et al., 2009; Nordin et al., 2005). Its design approach is ideally established based on the accumulated local knowledge, way of life, culture, and the deep understanding of natural environment. Apart from being the richest component of the country's cultural heritage, traditional Malay house is also recognized as the most sustainable building in the past, even until today, due to its design and construction process that takes into account energy efficiency, indoor environmental qualities, sustainable site planning, and the uses of local materials and resources. Typical example can be seen from the house orientation, where high-pitched roof not only encourages stack effect function but also acts as solar shading devices (Ramli, 2012). Besides, building on stilts allows cross-ventilating breezes beneath the dwelling to cool the house whilst also mitigating the effects of occasional flood as well as ensuring safety from possible attack by wild animals (Amad et al, 2007). Plenty of windows and openings allow more natural lighting while capturing high-velocity of air movement (Ramli, 2012). All these features have been proven to be the most effective passive design for a tropical building, as it increases the overall building's thermal comfort and energy efficiency. The application of Malay house's features into the design of low energy building can be seen from the Ministry of Energy, Green Technology & Water (MEGTW) Building, where among the features to be re-adapted are such as the consideration of building orientation, fenestration design, the application of natural lighting system, natural air ventilation system, and the arrangement of interior spaces (Ramli, 2012).

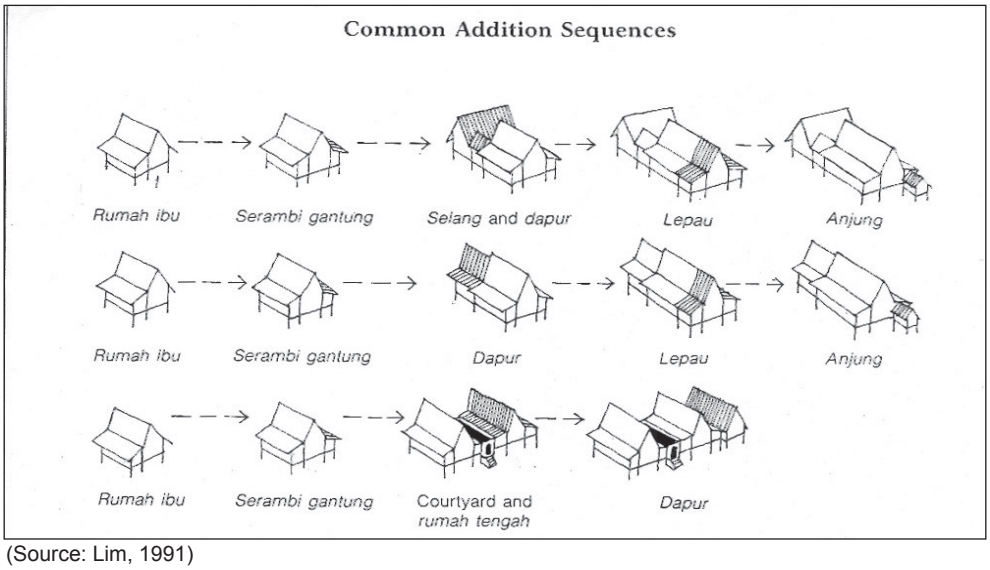


(Source: Lim, 1991)

Figure 2. Climatic design of the traditional Malay house

In terms of construction, the Malay traditional house utilizes the technique of housing components prefabrication, which has permitted flexibility in the development of the house form. All the components that make up the structural framework, roof trusses, stairs, wall and

floor panels, and roof surfaces, are made before erection of the house begins (Hassan, 2001). Structural framework such as columns (*tiang*), beams (*rasuk*), secondary beam (*gelegar*), primary roof beam (*alang panjang*) and secondary roof beam (*alang pendek*) are assembled on site to form the primary framework. Through this flexible housing construction approach, the traditional Malay house is capable of expanding from time to time, based on the occupant's affordability level and demographic concerns. With the basic type (i.e. *rumah ibu*) forms the 'core house', the house size is changeable along with the occupant's future requirement. Whenever additional finance is available or as the family grows larger, the house is capable to evolve, not only in terms of configuration and appearance, but also in respond to the explicit need through accommodating a wide diversity of users and household types (Figure 3).



(Source: Lim, 1991)

Figure 3. Possibility of expansion – the flexibility of traditional Malay house.

SCOPE OF FLEXIBILITY IN RESIDENTIAL HOUSING

Today's Malaysian residential housing does not incorporate the concept of flexibility in its design. The present mass housing design is said to have lost its build form identity in terms of rainforest and tropical landscape. This is largely due to the country's planning pattern and construction system, which adopt planning laws, building codes, and regulations borrowed from the West that promoting heavy weight construction using bricks and reinforced concrete as the main materials, has forbidden housing development based on traditional concepts (Hassan, 2001). Besides, the practicing housing construction method which is derived from system used since 1700s (the period of Industrial Revolution in Europe) is outdated. It is unlikely taking environmental concern as a primary consideration. What makes the condition even worse is that almost all housing programmes that initially aimed to tackle the country's housing shortage, is simply to augment the housing supply with minimum concern for social tradition issues (Hassan, 2001). For example, the housing industry is required to construct at least 100,000 affordable housing units per year (or 274 units per day) following the launching of 1 Malaysia People's Housing Scheme (PR1MA). Question arises concerning how far these programmes have succeeded in providing physical and social wellbeing of the population,

considering the country's current housing design strategies are unable to cope with the incredible demands on such massive scale in sustainable manner.

For mass housing to be an attractive option for the average family, the provision of architectural flexibility is essential (Singh et al., 1999). Since each dwelling unit is a primary structure that would contribute to the quality of life through its flexible organization, and the root causes leading to housing quality problem are identified as issues related to housing layout and design, surrounding environment, maintenance, location, amenities, and building material (Živković and Jovanović, 2012), flexibility should be reflected, as much as possible, within all aspects of the housing type. According to Friedman and Krawitz (1998), elements to be considered for a flexible housing should include: (i) the composition of the varied households within the single structure; (ii) the choice of components that are available; and (iii) the ability to make future modifications with minimal inconvenience. In other words, each dwelling unit should be designed, in such a way that it is economically and easily adjustable, while adheres to the context of contemporary technology, tropical adaptation, and cultural responses. The key design element is the realization that lifestyle – as one of the defining characteristics of peoples' lives as citizens, consumers, and householders – is a feature that shifts in accordance with a dynamic lifecycle process. A home that can be altered with minimum effort and expense at a time of change in the lives of its owners, whether through such a minor intervention as the rearrangement of furniture in a non-restrictive space or through more vigorous modification such as the relocation of living or storage spaces, is a home that evolves with the lifecycles of its household rather than becoming rigidly obsolete in the conventional manner (Friedman and Krawitz, 1998).

DIVERGENT DWELLING DESIGN (D3) – PROPOSED MASS HOUSING SYSTEM FOR TODAY AND TOMORROW

The proposed mass housing design system – Divergent Dwelling Design (D3) – is an inherent design strategy of sustainable development that fully utilized the idea of flexibility. It is inspired by the traditional Malay house design approach that accommodates freedom for change of preference even after the structure is built. Each function unit (*rumah ibu, dapur, serambi, anjung* etc.) combines divergently to reduce the immense intricacy of architectural phenomenon to simple constant units and bring about an effective formation of a flexible dwelling system (Figure 4). By having the same models, structures, and constructions, D3 can produce millions of combinations, where each of which is of high level of flexible form and function in architectural organization with sustainable manner – capable of continuous modification, renewal, and redesign (Figure 5).

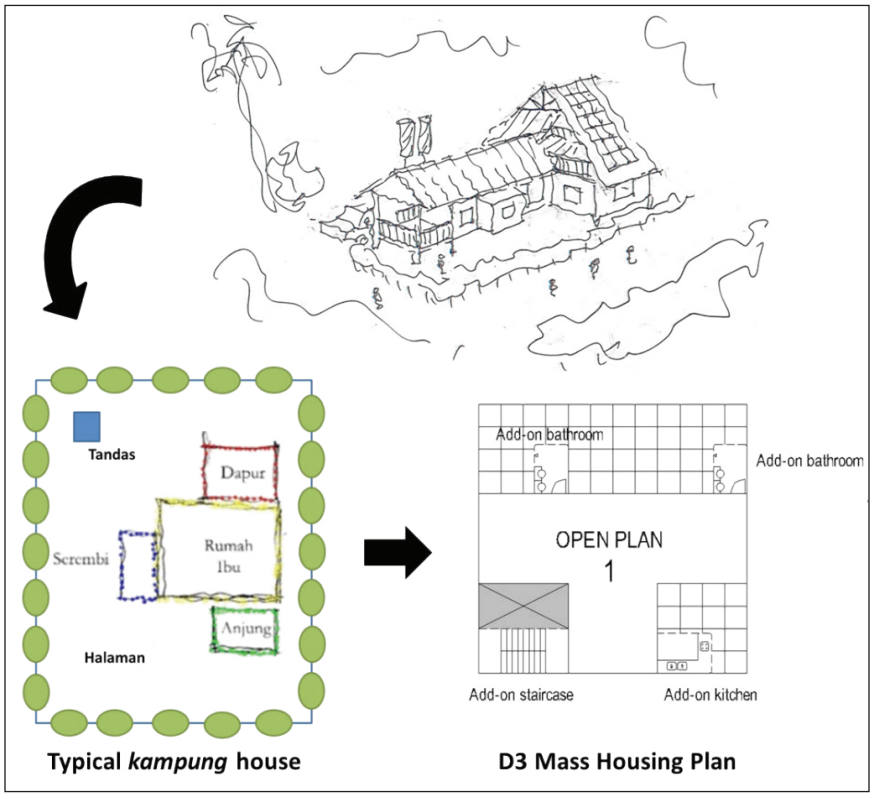


Figure 4. D3 design process

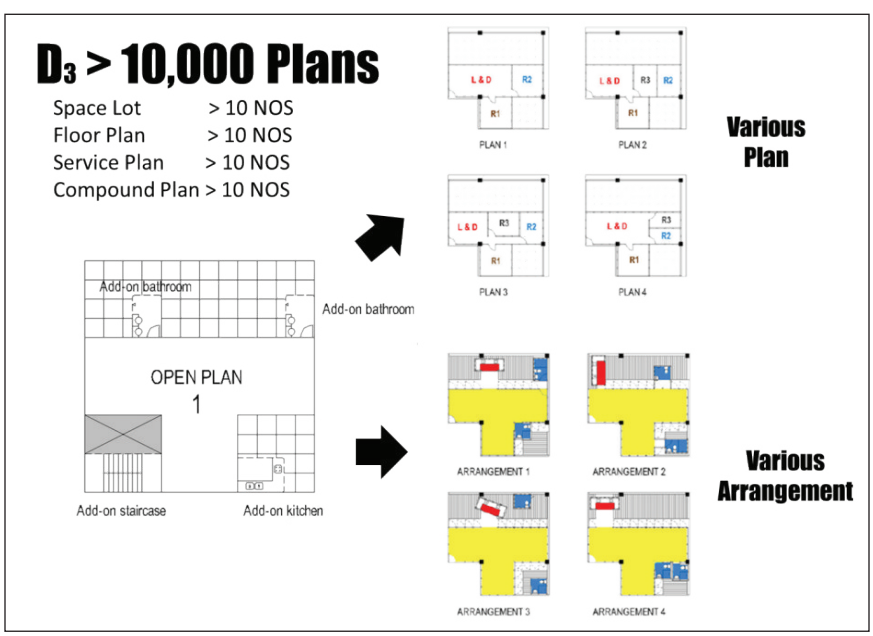


Figure 5. Possible combination of D3

In layman terms, D3 is an architecture where service spaces are attached externally to form dwelling of which the service spaces can be changed to accommodate different functions with minimum or no disturbance to the core structure (COR) (Figure 6). The concept is similar to the other existing facilities in modern industry (automotive innovations, electrical appliances, furniture, etc.) where each individual functional unit is freely bonded with the COR to serve different occupants' requirement. The COR, as a module, houses every independent functional unit of the dwelling and also forms the space for further expansion. The sustainability focuses on providing spaces to be used for a variety of purposes over time, be it the changes of household demography or the changes of resident's living satisfaction. Since this kind of functional change can be done by merely switching of the independent units within the configuration through a simple process, the function of the dwelling unit can be cultivated and adapted to the occupant's need whenever it is required. For example, a residential space can be converted into a café by just incorporating a larger kitchen and more toilets; a laboratory or playroom or computer room when added with a unit space for teaching can be used as an educational institution. So similarly the kind of unit space or constant space can change its function from residential to commercial, without ever needing to change the basic unit. As such, D3 system makes possible the creation of dwellings which may grow old yet without becoming obsolete; incorporating the latest design ideas and technologies, yet have a sense of history on the Malaysian housing design (the *rumah kampung* design); allowing the communities to live for generations, yet incorporating the potential of adaptation.

Another feature of D3 is that the system utilizes amply science, technology and industrialization in the formation of a unit. For example, bathroom and kitchen dimensions are fixed for mass production. The occupant has wide spectrum of choice with regards to products in the market. Since each unit is independently constructed by machine production, the development entails the use of technology and innovation, without the involvement of excessive site labour, time, and cost. In this sense, divergent design concept comprehends the advances of science and technology over time, thereby resulting in faster production at economical rates. More crucially, it helps to boost a greater productivity, better quality, and an assurance of a growing and interested housing market in the 21st century. Once the design system is in tandem with serial production and standardization, there will be no bounds for the development of sustainable community (Figure 7). It is because every detail can be perfected – just like the automobile and telecommunications industry, has seen continued advancement in technological innovations that have benefited consumers in the long run.

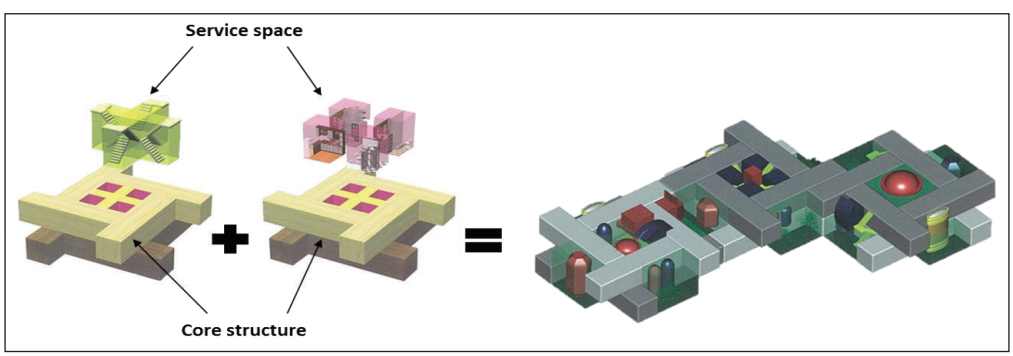


Figure 6. The concept of Divergent Dwelling Design (D3)

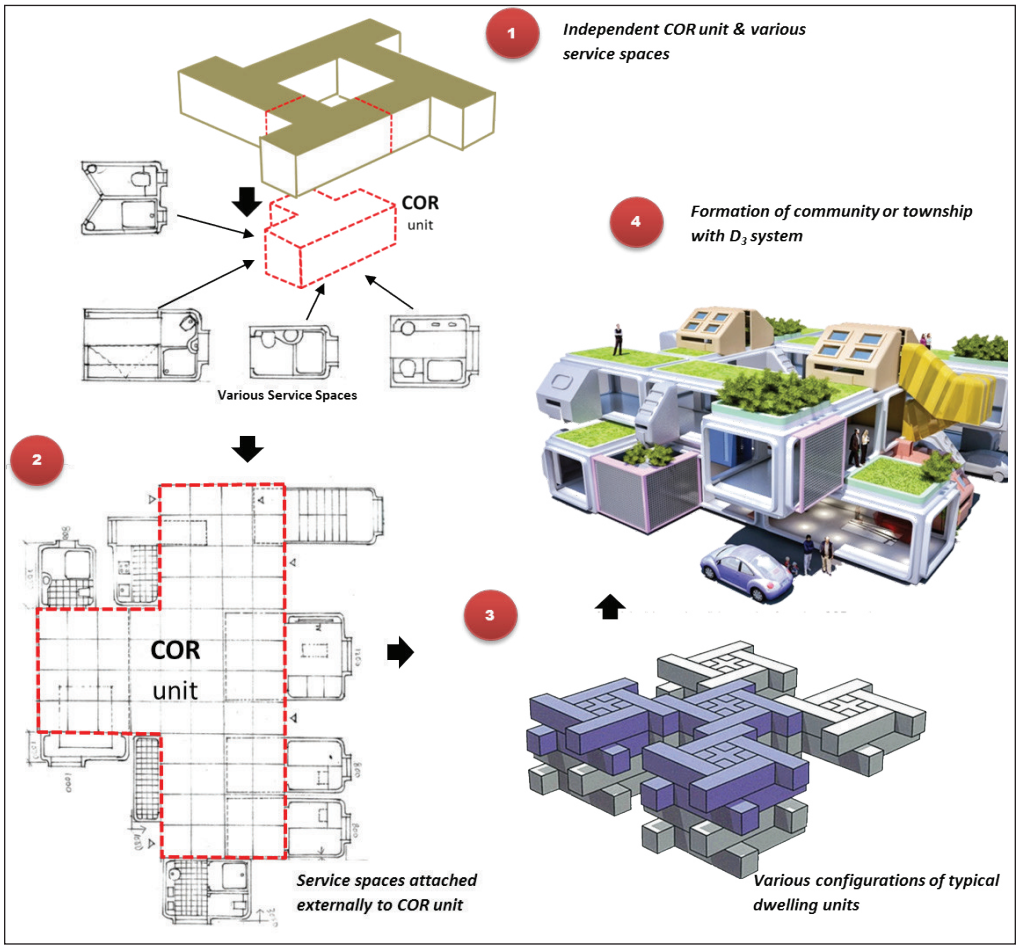


Figure 7. The application and evolution of Divergent Dwelling Design (D3) system

DESIGN PRINCIPLES OF D3

D3 directly responds to the fundamental demographic and economic pressure that have recently heightened the need for a new housing alternative that appropriately integrates affordability and sustainability. To ensure mass housing populations could enjoy eco-housing with affordable price, affordability is designed in at the beginning by adopting a simple design layout. This is to avoid the use of unnecessary technology which is costly to buy or repair, so that the house is easy for maintenance in the future. Besides, defining affordability in relation to housing within the ambit of sustainability broadens its scope by involving the social and environmental perspectives. The element of sustainability in D3 is ensured through a flexible design prototype that suits to the climatic condition in Malaysia, using environmental friendly method, contribute to the sustainable development of the construction industry, offers what people demand from a house and that they can live how they want to within it, by taking into account (i) the spatial and functional arrangement, (ii) the potential to expand spaces for increased occupant's usage, (iii) maximizing natural lighting and ventilation, (iv) the continuity of the traditional housing concepts into a modern contemporary residential development.

In general, D3 system utilizes four level of housing design principles: (i) the design of unit plan; (ii) the design of unit configurations; (iii) the design of sustainable strategies; and (iv) the design of structure and construction.

The Design of Unit Plan

In D3 system, the unit plan is designed to respond to the demand for more space and the changing circumstances of the occupants. It allows the flexibility in forming the basic unit configuration which then responds to the nature of the site conditions as well as the improvement of living environment quality (Figure 8). Internal space is adjustable according to the requirement of the user through adopting an open plan design. The dwellers are able to choose the interior components to tailor the design to their individual lifestyles and budgets, and can easily modify these initial parameters as the need arises. By enabling the floor plan to be adapted to the future users and the changing needs of families, D3 unit plan is also said to take into account different family types: (i) dynamic family which is likely to have more children in future, and is thus requires a high degree of space flexibility to cater for continuously changing and increasing needs; (ii) stable family which is not going to have any more children (either the children have left home or are too small to leave home) and thus requires a relatively lower degree of space flexibility; (iii) stagnant family which is expected to live in the same dwelling for a long time and thus has sufficient opportunity to benefit from flexible building elements, which provides for lower life-cycle cost of such elements. With dwelling unit built according to this flexible design principle, users are not only given the chance to choose the floor plan they want to live before moving in, but are also able to achieve harmony between the basic structure and the various sizes of dwellings in the long term, in accordance with rising space standards and the possibility of new family members in the future.

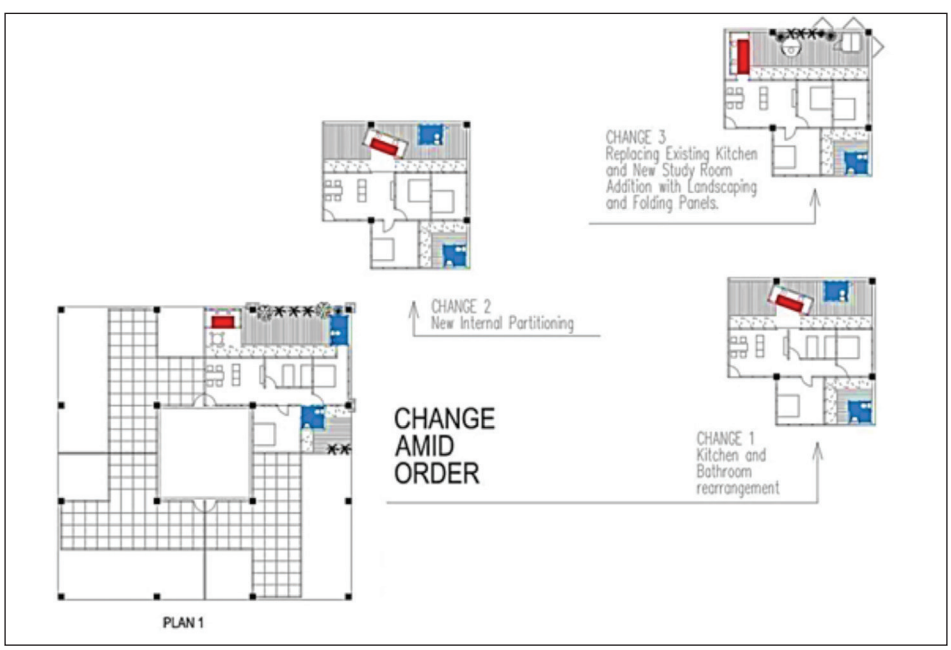
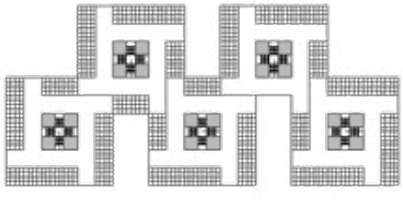
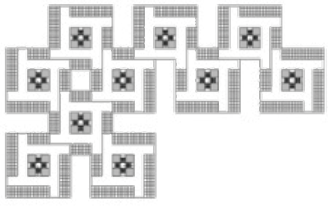


Figure 8. The design unit plan with D3 system

Unit Configurations Design

According to the Construction Industry Master Plan (CIMP, 2006 – 2015), the quality in construction industry encompasses more than contractors alone. Architects and engineers may have to be involved as well since they are the contributing factor to quality failures (material faults, construction faults, and design faults), where 50% of the failures can be attributed to design faults, while the remaining 40% and 10% are due to the construction and material faults, respectively. Since the formulation of the National Urban Policy is to the provision of adequate, affordable and quality housing for all Malaysians, it is essential to include environmental clause in every project development as to strengthen environmental control and preventive measures. A flexible design can respond to events, even when they unfold in unpredictable ways. On a much larger scale, there is current interest in the adaptation of the built environment for climate change. Because the rate and severity of future climate change is unpredictable, design for adaptation is best achieved by providing lifecycle options that will allow future decision makers to respond appropriately to the trajectory of climate change that actually occurs. D3 will sure to put sustainable architecture along the curve followed by science, technology and industrialization, and facilitates a shift towards higher quality housing development that eventually creating sustainable community for everyone in anywhere in the country.

Figure 9 shows some possible formations that can be achieved with D3 system. By combining each and every sustainable individual dwelling, a greater sustainable community or township is formed. No part of it needs ever be obsolete. One does not have to determine in advance the overall makeup of the group of units, for the whole community may just be cultivated or generated in a naturally evolving manner. This programmable dwelling pattern will enable a variety of dwellings to be processed, to constantly renew themselves owing to industrialization and with rational rearrangement of all available habitual spaces and incorporation of machine production resulting in the community that has no slum, and where no redevelopment is necessary. Fundamentally, the evolutionary nature of the D3 – the notion that housing to be designed to evolve not only in configuration and appearance but also in use – responds to an explicit need to accommodate a wide diversity of users and household types.

Types of Formation	Description
	**Linear Formation** Like a straight line that stretches from one point to another, positive and negative COR units are configured to extend in a single path to form a straight row of units.
	**Branching Formation** In each unit there are four possible corners that can have connection. The combination of positive and negative units can stretch in any or all of the four directions.

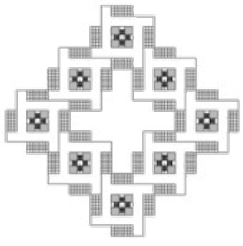
	**Ring Formation** When the arrangement of units stretches to eventually be joined back to the original unit it started from the combination produces an overall "closed" structure.
	**Cellular Formation** Except for the peripheral units in a network combination, each unit is joined on every one of its four corners by other units.

Figure 9. Types of formation in D3 system

Sustainable Strategies Design

In D3 system, flexibility and adaptability are key strategies for sustainable design. The use of concrete construction ensures many of the qualities that aid flexibility in housing design. Concrete is an inert material, with no harmful off-gassing emissions. Coupled with its structural form, concrete is the construction material most commonly associated with building designed with enhanced natural ventilation and daylighting. Concrete construction presents great opportunities to meet the needs of the users by helping to improve the function, value, and whole life performance of the house. With its high thermal mass, concrete construction can reduce energy requirements during the operation of the building by moderating energy demands in cooling and beating buildings, thereby adding to the value in use of a school building. Besides, concrete contributes to the range of other inherent benefits at no extra cost, such as its proven integral fire resistance, high levels of sound insulation, and robust finishes. Through its very nature, concrete provides robust surfaces for walls, partitions, columns, soffits and cladding that are easily sealed and free of ledges or joint details. All these may finally lead to the lower maintenance costs of the building while set in motion an efficient, cost effective and practical method for solving housing needs and overcrowding concerns in urban areas.

The use of a reinforced concrete skeleton structure which allows the design of floor plans that are variable to accommodate different family structures, coupled with the constant improvement in structural design and technology supported by the incorporation of lightweight, durable, smooth edged, space efficient and universally adopted specifications ensure that mass housings remain affordable and sustainable for the long term. The overall result/outcome of the sustainable strategies design can be seen by observing how the dwelling units encourage maximum cross ventilation, minimizing heat island effect, facilitating new technology installation, and promoting green architecture (Figure 10).

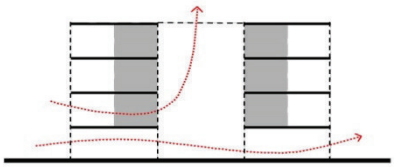
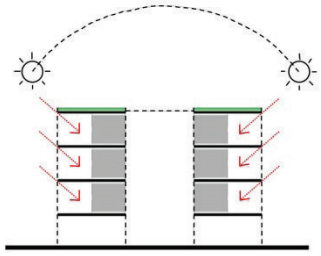
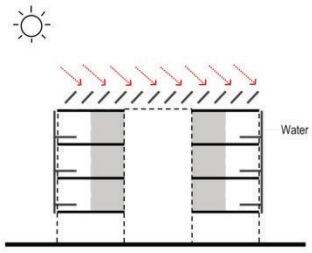
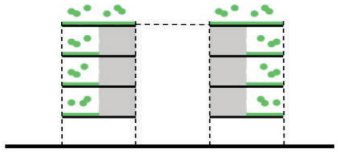
Sustainable Living System	Description
	**Cross Ventilation** Open plan allows easy passage of air and good ventilation.
	**Heat Island Effect** Reduction of 85% heat island effect on wall surfaces
	**Sustainable/Green Technology Installation** Photovoltaic panels and rain harvesting can be incorporated easily.
	**View and Vegetation** Vegetation helps to cool down overall environmental temperature.

Figure 10. Achievable sustainable living system through D3 sustainable strategies

Structure and Construction Design

There is usually a cost with the provision of a structure that allows the most flexibility and adaptability. However, with early consideration of the benefits of using concrete during the design phase, flexibility of the dwelling can be optimized at little or no extra expenses. It is because the use of concrete is compatible with fast housing construction, in part due to its easy mobilisation at the start of a project. In a departure from the conventional mass housing design, D3 system generates a better and cheaper habitat option through the application of existing science, technology and machine production capability. By incorporating IBS and industrialization into the construction process, a compressed construction schedule is not only

cost-saving in and of itself, getting the building into productive use sooner and reducing finance periods, but, especially in times of significant inflation, compressed construction schedules save additional significant sums. It is because the use of modern methods of construction, including sophisticated formwork systems, posttensioning, prefabricated roll out reinforcement and precast elements can all save time.

In D3 system, modular construction concept is widely adopted, where pre-fabricated elements or existing structures are used as the basic structure while additional natural materials are used to add insulation or to adjust the aesthetics. This allows for the construction of various building types, be it the low-rise low-density configuration, vertical tower configuration, low-rise high density pyramid configuration, or the high-rise high density configuration (Figure 11). Short term flexibility can be achieved by movable partitions. Since common walls between the dwelling units are non-load-bearing walls, the dwelling unit floor areas can be arranged independent from boundaries, thereby providing an entirely flexible arrangement of living room and wet room locations in the plan layouts. Partition walls in D3 system that enabling flexible planning will encompass the following features: (i) easily applicable; (ii) produced in standardized dimensions and not require base coat; (iii) easy to remove any traces left by demounted partition elements on the adjoining elements, such as floors, ceiling, face walls, and fixed partition walls; and (iv) possible to coat them with different materials and to change colour and texture of their surfaces in accordance with the requirements of the space and the individual taste of the users.

In the longer term, adaptability is needed over the life of the dwelling unit to allow internal walls to be moved, to change the size or use of spaces or suites of spaces. As such, flexibility is achieved through both the arrangement of columns and load-bearing walls and the possible clear span. Steel or pre-stressed reinforced concrete floor systems and components are used to obtain maximum clear space in the plan layout. The ceiling surfaces are clear, and beams are hidden in the exterior wall axes or fixed infill wall axes. All structural elements are located at the exterior of the layout to allow for unlimited unobstructed clear spaces that can be freely arranged over the life of the dwelling unit.

There is also the bonus of a gain in flexibility in the process of designing the primary-use spaces. Architects and planners have more time to work with clients, medical consultants, and others to plan these spaces more effectively. Additional costs may be saved by increasing the number of contractors who can bid on a single job that can now be divided into several jobs. Smaller, more competitive firms, whose bond limitations might have precluded their undertaking a project as costly as an entire hospital, can bid on individual aspects of the project – say, the M/E core alone.

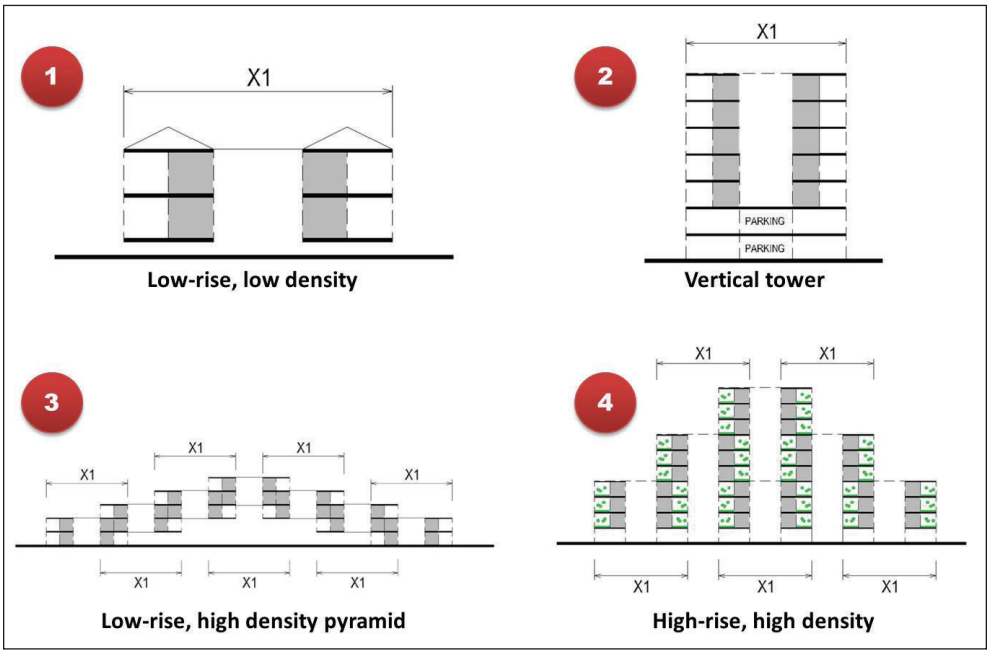


Figure 11. Possible building types with D3 system

CONCLUSION

Affordable housing in the past has never been designed to last. It was aimed to provide a short-term solution – maximum number of houses in the shortest possible time – to meet the urgent housing demand as if poverty and lack of affordable housing is a short-term problem. Although it is a government effort in providing adequate and affordable housing for the general population, the new contemporary household with its diversity of interior design needs in their consideration of future housing prototypes can no longer be ignored. Moreover, in the realm of the current architecture and urban planning, affordable housing development is acquired to last into the future without becoming obsolete, as sustainability is increasingly embedded into building regulations and is no longer perceived as a novel idea pertinent to only certain locations, populations, or building typologies. Realizing that past trends of energy and resource consumption for constructing and operating the built environment are no longer feasible to continue environmentally or economically, how architects design affordable housing that is intrinsically sustainable becomes the most essential. Many people think that sustainability is about planting more trees. Yet even more people believe that sustainability is about producing green energy with more solar panels. But very few realize that sustainability is all about ensuring dynamic balance of environment through the regulatory mechanism of divergent design process.

This paper suggests that the incorporation of flexibility in architecture is essential for the design of affordable housing that is environmentally, economically, and socially sustainable. D3 – a new design approach to the sustainable living system that derived from the tropical vernacular architecture – has lots to offer towards sustainable construction solutions in the development of affordable housing, as it is not only able to reduce both the initial build cost

and running expenses of housing construction, but also balance affordability, durability, and adaptability in designing sustainable solutions that are resistant to obsolescence. Due to its consideration in addressing the shortcomings in the current housing development, as well as taking into account the beginning of the design process for the dwelling unit, the construction process, and the flexibility in future development, D3 is capable to redefine tropical housing as adaptable and resilient, and shows promise for the creation of more environmentally and economically sustainable architecture and infrastructure.

Malaysian demographics are changing rapidly, with average households becoming smaller as an increasing number of people live independently in their later years. Prefabrication and modular construction are believed to be the solution for constructing houses that meet the vast number of demands in urban areas. Yet, as a housing strategy it is still considered unresponsive to local climates and conditions with low acceptance rate. One of the problems that Malaysian prefab housing industry does not perform as well as other countries (i.e. US, Japan) may likely be due to the lack of variability and an individual identified design. At this juncture, how prefab housing design can be evolved from mass repetitive production level to mass customization level that account for flexibility and variability is the primary issue to be explored. D3 system discussed in this paper is deemed to bring improvement to the country's prefab housing industry with respect to time, cost, and quality, through the design of adaptability of individual residential units, the buildings that contain those units, and the surrounding site. On a much larger scale, there is current interest in the adaptation of the built environment for climate change. Because the rate and severity of future climate change is unpredictable, design for adaptation is best achieved by providing lifecycle options that will allow future decision makers to respond appropriately to the trajectory of climate change that actually occurs. D3 will sure to put sustainable architecture along the curve followed by science, technology and industrialization, and facilitates a shift towards higher quality housing development that eventually creating sustainable dwellings for everyone in anywhere in the country.

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