

THE ROLE OF FLEXIBILITY IN SUSTAINABLE PROTOTYPE UNIT DESIGN: RIYADH COMMERCIAL HOUSING DEVELOPMENTS, RCHD, CASE STUDY

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Up to four decades ago Saudi traditional housing units were designed and built with local materials and expertise that corresponded with cultural values and fitted well with the local environment and climate. Local materials and technology were affordable to the majority of the population due mainly to the environmental sustainability of construction practices and building materials at the time. The boom of the mid-1970 witnessed the opening of local markets to a variety of building materials and technologies from all over the world. These materials and technologies were used to construct housing units in massive numbers without substantial research to test their compatibility with local culture and environment.

One of the important factors contributing to the sustainability and life cycle cost of current housing units is design flexibility and the prediction and planning of unit future expansion, modifications and alterations. Modifications to the housing unit are normal phenomenon's that accompany the household life cycle changes. For every stage of the families life has a different type of requirements dealing with play, study, storage and outdoor areas. Providing pre-designed alternatives for additions to existing housing units is beneficial in terms of the unit's life cycle cost and in maintaining healthy, diverse stable and sustainable communities.

In the city of Riyadh, Saudi Arabia, the recent trend of building large number of units in commercial housing developments was perceived to decrease the flexibility of individual units. This study documented a representative sample of prototype units built recently in commercial housing developments in the city of Riyadh (RCHD). According to survey participants, RCHD units were moderate to highly flexible. The study identified three main categories of flexibility options with subcategories as significant predictors of overall flexibility namely functional flexibility (including ability to interchange and exchange spaces), structural flexibility (ability to extend the unit vertically or horizontally, and apply a system of standardized modularization), and cultural flexibility (ability to personalize the space). The last category of predictors was the only one that was negatively rated by RCHD survey participants. The study

concludes with suggestions and recommendations to improve the flexibility options of RCHD units.

KEY WORDS: *Functional, structural and cultural flexible unit design; sustainable dwelling design, Riyadh commercial housing developments.*

1. INTRODUCTION

Buildings alone do not make sustainable communities. It is rather a partnership between many contributors including government bodies, design professionals, commercial developers, and community activists that share in the local accountability to essential decisions concerning issues at the macro and micro level; these issues include appropriate housing design, density levels, social mix, employment opportunities, location of transportation nodes, and so on.

Dwelling design is one of the key elements leading to sustainable communities at the micro level. Sustainable dwelling design guidelines include the efficient initial and ongoing use of energy, water, and building materials; use of appropriate technologies that correspond with local climate and depend on natural systems with little or no pollutants or emitants; and culturally appropriate flexible designs that promote efficient spatial multiuse and end users participation in the design process.

Healthy sustainable communities are lasting stable communities that project inhabitants' well being, comfort, flexibility of use, and enhanced asset value; and encourage family's stability through long-term investment in neighborhood growth and transformation. Designers can promote this sense of stability through several avenues including *unit flexibility*. They need to make a good fit between the unit features and the household changing life cycle needs in order to deter constant movement and to simplify anticipated future additions or modifications (Edwards, 1999).

2. PROBLEM STATEMENT

In the last decade, new commercial housing development companies have emerged to address the current and anticipated housing demand in the city of Riyadh and to meet the needs and aspirations of the new young Saudi households. However, the community has not regulated these companies properly and their developments have not been assessed in terms of correspondence with essential principles of sustainable neighborhood and unit design.

One of the key elements for establishing and encouraging sustainable stable communities is flexible unit designs that anticipate and encourage future unit additions and modifications and correspond with household life cycle

changing needs. The notion of flexibility and choice should be at the heart of any sustainable design concept.

This research will not address the other components of sustainable community design. It will concentrate on *identifying* appropriate *unit flexibility* options to Saudi households namely functional, structural, and cultural flexibility options and to *evaluate* Riyadh commercially developed prototype (RCHD) units in terms of these options. This evaluation will be an important tool for developers and regulatory bodies to assess the success of these developments and to establish guidelines to fine-tune existing housing units and to design and develop new prototype units (figure 1).

3. LITERATURE REVIEW

3.1 Sustainable Housing Design

The objective of sound housing policy should be to enable people to have control over the way they live and to give them the opportunity to create a good home that promotes social cohesion, well being, and self-dependence. Furthermore, several scholars argue that a critical indicator of housing policy success is the level of its sustainability. They argue that the aim of sustainable housing is to insure a better quality of life for current and future generations while balancing appropriate use of natural resources, protection of the environment, economic growth, and social progress. At the macro level, essential components such as selection of appropriate location, better integration with transport, and sense of belonging and ownership by residents all contribute to a stable sustainable community. While at the micro level, sustainable housing is the product of culturally sensitive flexible unit design, efficient use of energy, water, and natural resources, reduction of pollutants and emitants; and an increase in the building life expectancy (Edwards, 2000).

According to Rodberg (1996) sustainability strategies should be focused at the micro level. He argues that it is more difficult to change at the macro level because the existing urban structures are permanent, while at the micro level, housing clusters and units are easier to alter through design improvements. User participation at all stages, especially during the design stage, is essential for preserving and lengthening the life of the units and stability of the neighborhood.

Sustainable housing design requires a new integrated holistic approach to unit design with greater cooperation between designers, developers, and end users. Along with standard design guidelines to help designers set appropriate goals and make the right decisions. *Unit flexibility* enables household lifecycle to conform more closely to neighborhood life cycle and therefore its vitality. To avoid forced movement of households and to meet their changing needs, *unit flexibility* should allow for a more easily adaptable home. Thus, diverse flexible

housing alternatives especially those corresponding and accommodating cultural and social changes are essential components of stable sustainable communities.



Figure (1) several examples of RCHD prototypes

3.2 Flexibility in sustainable housing design.

There are two usual methods to deal with unit household changing needs. The first is to move from one unit and neighborhood to another. Although there is very little research, documenting the movement patterns of Saudi families, few studies report that it is much less than among U.S. families. The second approach, dealing with household changing needs, is unit design flexibility to provide for ease of modifications and additions. The preplanned flexibility approach gives families the opportunity to invest financially and spiritually in the unit and allows them to establish roots in the neighborhood. Therefore, in order to achieve the goals of social sustainability and establish stable communities that belong to the area, *unit flexibility* must be considered a priority at the design stage (Rudin & Falk, 1999).

Unit Flexibility can be defined as the units' ability to correspond to the changing needs or wants of households over time through expansion, modifications, or additions. It can be incorporated at the design or construction stage. Further, it means that the design process does not stop at the construction stage but rather continues over the life of the building through planned additions, and modifications. This dynamic process gives the dwelling the quality of balance throughout, and unlike static dwellings that deteriorate drastically with any alterations, units with flexibility options or attributes last longer and improve over time (D'Souza, 1991).

To achieve *unit flexibility* a clear working plan should be implemented through detailed architectural programming that fits well with the household life cycle changes. The working plan should provide a detailed database of different types of households that will allow the designer the chance to design a good fit with the type of household. *Unit flexibility* at the design, construction, and finishing stage gives the household a good short- and long-term investment that makes a good fit with their financial situation, and special needs (Hershberger, 1999).

The dynamic interactive relationship between the sustainable housing design, on the one hand, and the changing needs of the household and time and place in the life cycle, on the other, are essential components of housing design that can be sustained for the upcoming generations. For instance, a traditional household with a newly married couple have limited needs. But once the family grows and children come into place, the household needs will change to include play and storage spaces. As the children move from childhood to adolescence and onto adulthood their needs will change accordingly. When the children become independent and move out of the household and the parents move to the retirement stage, the household needs will shrink demanding modifications for fewer and smaller spaces. Hence, the importance of the programming stage becomes apparent where the changing household needs are anticipated and monitored; and the needs and aspirations of the different life cycle stage for each household type is documented chronologically to plan for smooth modifications and additions to the unit as the household grows or changes (Teasdale, 1993).

Designers can provide flexibility in housing unit design through several methods including the following:

I. Conversion of space in the design phase: This method concentrates on providing multiuse interior spaces that are readily and easily modified without any structural obstacles. Some designers proposed a one space unit without any structural obstacles where spaces are formed through movable closets and partitions. The best example of the conversion of space in current Saudi society is the two story detached unit design. Where the traditional household resides on the ground floor during the first stages of the life cycle and they supplement their income by renting the first floor. When the household grows and more

members demand more space, they utilize the whole unit. After the children move out and the parents reach the retirement stage, the upper floor is rented to pay for the costly maintenance and upkeep of the unit and at the same time to enjoy the secure, cozy and easily operated and maintained environment of a small unit (Aldakheel, 1995).

II. (Staggered) staged construction method in the construction phase: This method relays on implementing the unit at stages either in the construction of spaces or in their finishing through the adjustment of the implementation schedule to correspond with the household finances. For instance, the interior and exterior cladding as well as floor finishing and lighting fixtures and plumbing accessories could all be delayed to after occupancy. Furthermore, design and implementation of the unit could be scheduled to make a good fit with the household life cycle. Hence, at each stage of change or growth, the housing unit grows with the household to make room for children sleep and play area, to minimize waste in the initial and life cycle cost and allows the newly formed family the opportunity to own a unit they can afford (Teasdale, 1993).

3-3 Sustainability and housing development in the city Riyadh

Sustainability is not a new approach. It has always been an important part of vernacular architecture and urban form of traditional societies. Arab cities embody the concept of sustainability through two main strategies namely protection and adaptability. In terms of protection, sustainability has traditionally been achieved through the reduction of climatic effects and through a comfortable holistic urban fabric that mixes land use and increases densities. On the other hand adaptability was achieved through a locally developed unit design that utilizes local renewable resources and that transforms problems and obstacles into opportunities to develop unique culturally appropriate designs.

The city of Riyadh was a good example of a traditional Arab city that was built on sustainability principles both at the housing unit and urban scale. However, the economic boom of the last four decades has affected this approach substantially. At the urban scale, the city has expanded with great speed and has transformed the new suburbs into low density neighborhoods with little support for social networks and almost total dependence on the automobile. At the unit scale, dwellings are much larger than actual household needs (almost four-fold the traditional units) and totally dependent on transported global construction materials and mechanical systems for climatic comfort (Bahammam, 1998).

In the last decade, the city of Riyadh has witnessed dramatic increases in plot area prices while household income has stagnated. The rising ratio of capital to income required to purchase and develop a new parcel of land has

decreased significantly, while, the incremental cost of modification or addition to an existing dwelling are still marginal compared to developing new units (AHA, 2001).

Commercial housing developments are on the rise in the city of Riyadh. A growing number of these commercial housing developers emerged in the market and began creating different sized neighborhoods through the repetition of several unit prototypes. These companies range in size and in type of services provided. They hold approximately 6% of the market currently and are projected to expand drastically in the next decade. These companies developed a number of prototypes through several generations of design revisions to provide for the needs of the average young nuclear traditional Saudi family. However, the efficient uniformity of mass housing production utilized by these companies limits the end-users participation in the design phase and to a very small role in the construction phase. Only a small number of these companies allowed the end-users involvement in the selection of some finishing material. Thus, the weakness of these housing developments lies in the limited role they give to end users input. To make these communities more stable and prototype housing units more sustainable, designers need to offer an acceptable degree of end-users participation and *unit flexibility* to allow for adaptation and adjustments to personalize the dwelling and to make them more compatible with the end users needs.

3.4 The role of *unit flexibility* in contemporary Saudi housing design.

The principle means of accommodating changing housing needs for most Saudi families is not through mobility, but rather through dwelling additions and modifications Saudi households move less than western households but make modifications or additions to their dwelling more often (four out of five households make modifications or additions within the first two years of occupancy and a similar number declare their intentions to do more modifications within the first five years of occupancy)(Aldakheel, 1995).

These modifications include changing the function of spaces especially in guest reception areas, adding new spaces in the sleeping and service zones, personalizing the unit through the replacement or repainting of finishing materials in the main facade and guest area, improving the security and maintenance attributes of the unit through adding steel bars on windows and changing plumbing and electrical fixtures (Khan & Zain Ul Abdein, 2004; Aldakheel, 1995)

The notion of flexibility and choice should be at the heart of any sustainable design concept. Diverse groups of users with individualized space requirements demand an approach which allows for separate arrangements according to the spatial needs of each end-user at all the different stages of his/her life cycle.

There are many reasons for instigating strategies of unit modifications and additions. In summary, these reasons are changing lifecycle (functional), changing lifestyle (cultural), personalization of dwelling (cultural), and updating unit to new trends in maintenance and automation (technical). Recent studies also indicate that unit design flexibility can be provided through many strategies. They stress two main approaches to modifications either add in or add on. Each of these approaches follows different strategies and use different application methods:

- The add in approach is usually carried out through the unit layout and furniture. It takes the form of modification and alterations of space and it follows the strategies of either separating the unit into two units by exchanging spatial components, or through a strategy of versatility by converting or interchanging spaces to achieve functional flexibility (Brand, 1994).
- The add on approach is usually carried out either in the site, unit structure, or unit skin (cladding). It takes the form of expansion or addition and it follows the popular strategy of vertical or horizontal expandability by adding spaces either horizontally in the site attached to the original building or by adding spaces vertically on extra floors. The method of application for this approach requires a high level of structural flexibility, flexible zoning requirements, built in standardization and pre-designed staged construction planning.

There are many other modification approaches mentioned by the literature involving building technology and materials. These approaches include transferability where the whole or part of the unit is transported to another location or retractability, a strategy in which the materials and technologies selected for the unit hold the capacity to shrink the size of the unit in accordance with household needs.

4. RESEARCH DESIGN

This study created a database of most of the projects built by commercial housing developers in the city of Riyadh, and the prototypes used in these projects. Seventy-two prototypes were selected from the database according to several criteria including size and number of units constructed. The sample can be deemed representative of all prototype units with less than 400 m² of built area implemented by commercial developers in the city of Riyadh between the year 2000 and 2003.

A review of literature has revealed a wide range of approaches, strategies, and methods for providing *unit flexibility* throughout the life expectancy of the dwelling. At this stage, the research documented some of these tested methods. Next, it evaluated their socio-cultural appropriateness to Saudi households and then it ranked them according to importance. An evaluation instrument was

designed through a review of locally applied modifications and additions research, as well as in-depth interviews with a number of housing design experts to document and evaluate appropriate flexibility options in Riyadh commercial housing prototype developments (RCHD). After reviewing the different design flexibility approaches, strategies, and methods identified by the literature and interviews, a list of these options were compiled and reviewed by design professionals. Designers were asked to prioritize the list according to the needs and aspirations of the average traditional young Saudi household. The opinions of the design professionals were checked against several local studies identifying local patterns of housing modifications and additions. A short list of ten flexibility options was then selected and included in the survey. The list can be divided into three main categories of flexibility options with a number of sub-categories. (Table 1)

After compiling the list of appropriate flexibility options to Saudi households, the 72 selected prototypes were evaluated by 17 design professionals involved in the housing industry. They assessed the anticipated performance of these units in the long-term according to the level of flexibility they offer to potential traditional young Saudi households. Each participant was given site and floor plans of each of the 72 prototypes. They were asked to evaluate each prototype according to the ten appropriate flexibility option measures. Participants evaluated each flexibility measure through a 5 level scale ranging from high to low flexibility.

From the data analysis, an overall flexibility measure of these prototype units was created and a priority list and design guidelines were developed to rank flexibility options that are appropriate for Saudi households.

5. RESEARCH RESULTS

Data Analysis indicated that over two thirds (69%) of RCHD units commercially built in Riyadh were detached and the rest were semi-detached units. The plot area ranged from 350m² to 400 m² with a median area of 362 m². The total built area ranged from 310m² to 520 m² with a median of 417 m². The average built area of the prototype layout was divided into 29% sleeping quarters, 21% guest area, 11% family living area, and 15% for services, and 24% for circulation and non-functional areas.

According to survey participants, the overall flexibility index (combining the weighted average score of several flexibility measures including the variables measuring the units degree of convertibility, extendibility, ability to separate unit, standardized modularization, and ability to personalize unite) has shown that the majority of commercially built Riyadh prototype (RCHD) units (53%) had moderate to high design flexibility attributes. A third of these units were rated as moderately flexible, and only one in six of the units were evaluated as having low to moderate flexibility attributes.

Table 1: Saudi Household Appropriate *Unit Flexibility* Options

Functional	Versatility (layout permits spatial multiuse with minor structural modifications, Figure 2).
	Convertibility (ability to interchange spaces without any structural modifications, Figure 3).
	Ability to separate unit into two units and the ability to rejoin it at a latter stage, (Figure 4).
	Pre designed service and utility zones for plumbing and electric works.
Structural	Extendibility (the ability to add spaces vertical or horizontal through prior planning, Figure 5).
	Standardized Modularization (to apply a holistic integrated module system that ties the unit structure with the other building systems and components, Figure 6).
	Open plan free structural system to alleviate structural obstacles for future modifications (Figure 7).
Cultural	Ability to personalize unit (to add the end-users personal taste and to project their identity on the dwelling, Figure, 8).
	Ability to improve exterior privacy (especially between semi public and semi private areas; as well as, the relationship with immediate neighbors).
	Ability to improve interior privacy (Through the improvement of privacy standards that are consistent with current and anticipated Saudi household needs, especially the critical boundaries between guest, family, and sleeping zones).

The analysis also revealed that relative to explained variance, the set of variables comprising *functional flexibility* (the ability to exchange or interchange space function and the ability to separate the unit) ranked first among predictors of overall RCHD units flexibility, explaining more than half of the variance in overall flexibility. The *structural flexibility* index ranked second explaining 36% of the variance of overall flexibility. It included the ability to extend the unit vertically and horizontally, as well as, the variable measuring standardized modularization. The last category of predictors was the *cultural flexibility* index combining the ability to personalize the dwelling as well as the ability to improve privacy components. This category accounted for 17% of the variance.

The preceding significant predictors of *unit flexibility* were treated as single variables and entered simultaneously in a single regression analysis. Combined they explained 67 % of variability in overall *unit flexibility*.

Following is a discussion of each of the 5 significant predictors of RCHD *unit flexibility*.

- **Convertibility** (a *functional flexibility measure*) was ranked as the most important variable contributing to overall *unit flexibility* by survey participants. With a mean score of 3.4 out of 5, respondents rated the majority of RCHD units as being highly to moderately functionally flexible. This variable can be defined as the household ability to convert space from one

function to another or the ability to exchange or interchange space functions or building components to compensate for an incompatible relationship between units' layout and household changing needs. Most of the conversions usually involve children sleep and play area. As well as study and storage spaces.

- **Extendibility** (*a structural flexibility measure*) measuring the units pre planned vertical or horizontal extensions or additions was ranked second in RCHD units overall flexibility. The mean score for this variable was 3.5 out of 5 which reflects that the majority of RCHD units can be extended easily. It can simply be defined as the preplanned design options to accommodate for household changing lifecycle needs through the addition of extra spaces horizontally in the front- or backyard or by enclosing terraces and balconies or vertically by adding an extra partial or full level to the unit. It can be done through a preplanned efficient layout constructed at several stages. RCHD households were expected to add a male reception room, driver room, and outside kitchen in the lot as well as additional extra sleeping, play, and storage area on the roof deck.
- **Ability to Separate unit** (*a functional flexibility measure*). This variable ranked third in predicting overall flexibility. Its mean score was 3.3 out of 5 which indicates that most of RCHD units allow for each unit to be separated into two. This choice offers the end-users the ability to adapt to changing circumstances. Young couples can separate units and use the rental income of the second unit to help with the unit finances. As their income and family grow, they can rejoin the separated unit and use all available space. When the children leave, they can reestablish the separation for retirement income. This arrangement is widely used for Saudi households and gives a good margin of flexibility for financing.
- **Standardized Modularization** (*a structural flexibility measure*). This variable ranked fourth in predicting overall flexibility. The mean score was 3.2 out of 5 which indicates that a significant number of RCHD units used modularization to allow for flexibility. This variable can be defined as open-ended unobstructed modularized structural design which allow for vertical or horizontal additions or modifications through the free placement of services. Another method of application of structural flexibility is through prior grouping and placement of services in specific zones and the freeing of the rest of the dwelling for end-users spatial definition. In RCHD unit design the latter is more efficient, since most of them use cast in place skeleton structures which allows for a good margin of flexibility for future modifications and additions. The choice of the modular system that correspond with pre-fabricated building materials and components such as doors, windows, structural components, and building systems, technologies, and appliances, along with the proper placement of services (especially kitchens and bathrooms) allow for the freedom to change and re-change unit

layout. Standardized modularization was described by the literature as well as by study participants as the combination of three main principles namely simplification, unification, and specification.



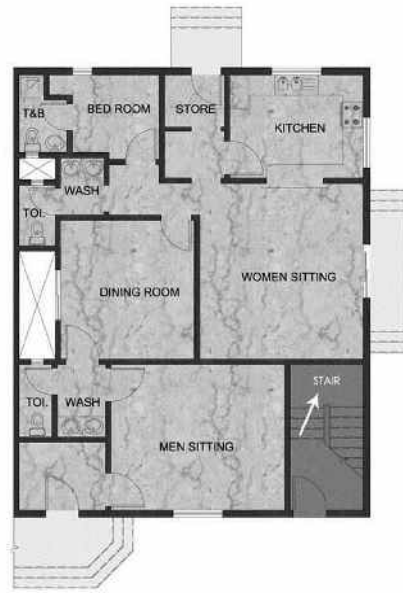
FIGURE - (2) FUNCTIONAL FLEXIBILITY (VERSATILITY) LAYOUT PERMITS SPATIAL MULTI-USE



FIGURE - (3) FUNCTIONAL FLEXIBILITY (CONVERTABILITY)



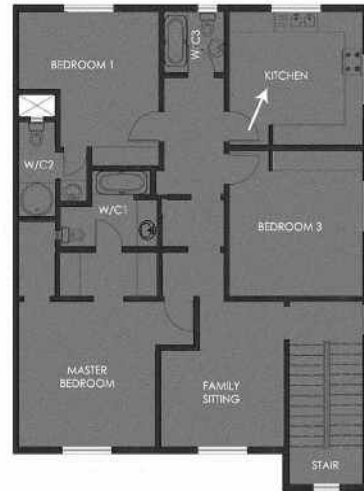
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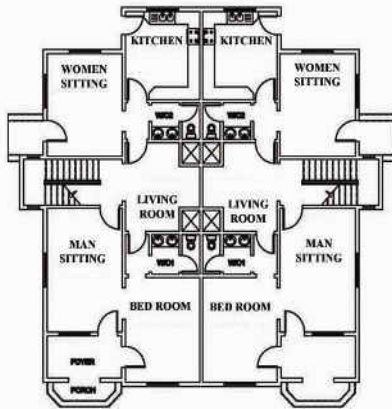


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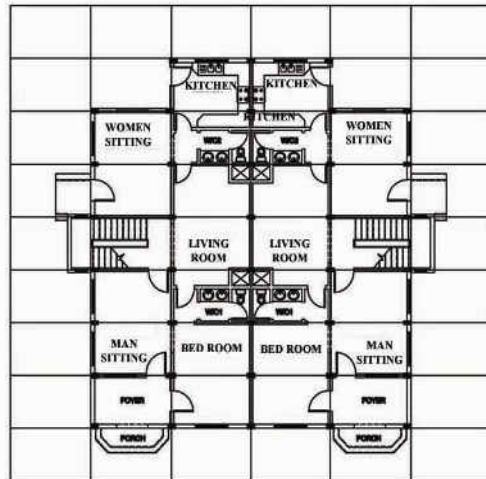
FIGURE - (4) ABILITY TO SEPARATE UNITS



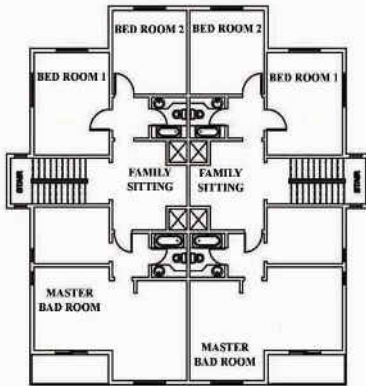
FIGURE - (5) STRUCTURAL FLEXIBILITY (EXTENDABILITY)



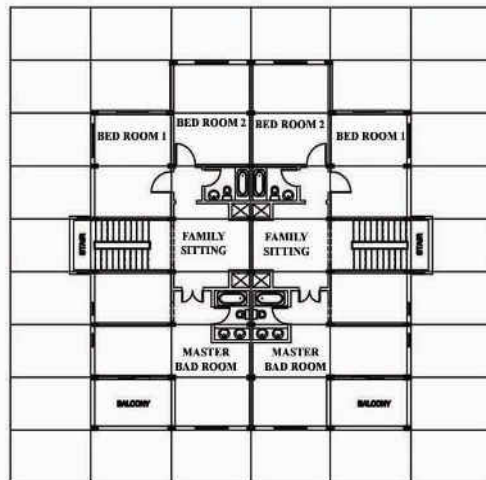
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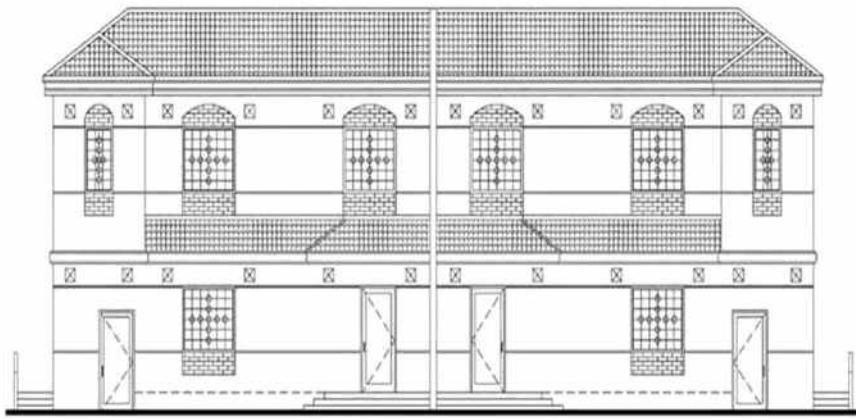


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FIGURE - (6) STANDARD MODULARIZATION

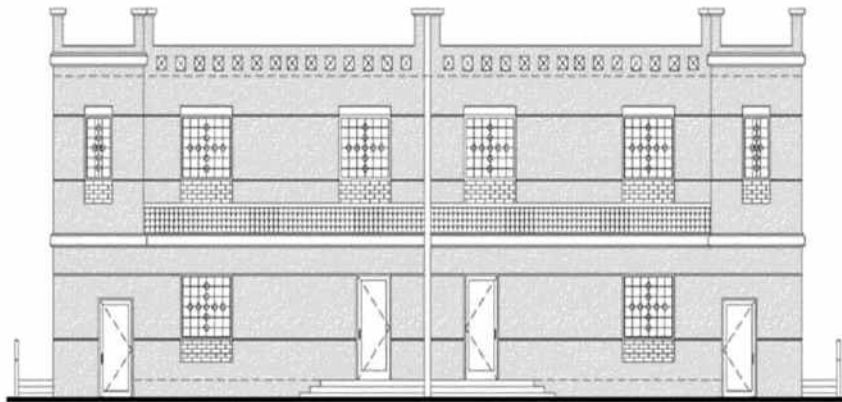


FIGURE - (7) STRUCTURAL FLEXIBILITY (OPEN PLAN)



FRONT ELEVATION

OPTION - 3



FRONT ELEVATION
PROTOTYPE 9

OPTION - 1

FIGURE - (8) ABILITY TO PERSONALIZE
ADD ENDUSERS PERSONAL TASTE AND INDENTITY

• **Personalization.** (*a cultural flexibility measure*) The ability to personalize the dwelling ranked fifth among the significant predictors of *unit flexibility* the mean score of this variable was 2.1 out of 5 which indicates that the majority of RCHD units give little room for personalization. The mass production of housing creates repetitive units that lack identity. The home is a status simple that directly reflects the personality and status of the occupant. Most of the Saudi households have a real need for projecting their identity on their homes. This is usually done through the partial finishing of the units main facade, entrances, outside parapet wall, and guest area. Most of the RCHD units included in the study were completely finished and did not allow for any personalization. The few that did, only offered pre-selected finishing material alternatives, which to a great extent limited the amount of personalization the household can project on the unit.

Several variables had little if any contribution to overall unit flexibility, especially ones dealing with privacy and unit characteristics. This can be attributed to the instrument utilized in assessing these measures. Survey participants evaluated the prototypes flexibility options through site and floor plans. This instrument is not efficient in measuring social factors such as privacy. They are better assessed through indirect measures related to the end-users personal characteristics, standards of comparison, and relationship with neighbors. On the other hand, the weak correlation between unit characteristics measures and the overall flexibility index can be attributed to the level of development and cultural sensitivity of the prototype designs.

The study also identified several limitations to the ability of designers to provide for *unit flexibility*. The most visible of these obstacles can be summarized as follows:

- Developers' resistance to the short-term increase in dwelling initial cost especially in design consultation fee.
- Current economic and cultural conditions demand single function space efficiency.
- Staged implementation requires several construction disruptions, which is inconvenient to households.

6. CONCLUSIONS

With the growing demand for housing units in the city of Riyadh, and the emerging new phenomenon of commercial prototype housing developments, the evaluation and fine-tuning of existing prototypes especially their flexibility attributes is critical to the long term neighborhood stability and community sustainability. *Unit flexibility* as a component of unit design is an important ingredient of stable sustainable communities. Mobility should be discouraged and a high degree of *unit flexibility* that allows for additions and modifications

and accommodate the changing housing needs of households should be encouraged.

This study reviewed the flexibility options identified by the literature, and prioritized them according to the needs and aspirations of young traditional Saudi households. Design professionals were asked to evaluate each of the RCHD units according to the flexibility options list. The survey data clearly indicates that RCHD units have a high degree of flexibility. The overwhelming majority of respondents rated these units as being flexible. They identified and ranked five signification predictors of flexibility. Four of them were positive contributors to overall flexibility. They were in order of importance:

- Convertibility (a functional flexibility measure)
- Extendibility(a structural flexibility measure)
- Ability to separate unit(a functional flexibility measure)
- Standardized Modularization. (a structural flexibility measure)

The only significant contributor to overall flexibility that was negatively rated by RCHD respondents was a cultural flexibility measure that measured the end-user ability to personalize the dwelling which was clearly lacking in RCHD units. Designers and developers should encourage building housing units with no or partial finish which will allow each household to personalize and schedule the finishing according to their finances and taste. It will allow more affordable flexible units that are more in tune with the needs of the household with less finance to perspective homeowners. It will also cut down on waste for removing and applying new finishing materials that fits better with household taste (a wide spread costly phenomenon that usually happens at two different stage within the first five years of occupancy with Saudi households). Many commercial housing developers perceive that a completely finished unit will increase the price and therefore improve profitability. However, this perception has contributed to the excessive use of expensive and sometimes extravagant finishing materials that excluded a substantial number of households from ownership status and created dissatisfaction with the available finishing selection. The importance of personalization of finishing materials and its direct connection to the end-users background and personal taste makes their involvement in the selection essential and cost effective in the long run. Although it cost more initially to allow for end users participation in the selection of finishing materials, it is usually cost effective when modifications and changes at latter stages are accounted for. The end-users background and personal taste makes their involvement in the selection of finishing materials essential and cost effective in the long run.

7. RECOMMENDATIONS

Local traditional and vernacular architecture and urban form are important lessons in housing sustainability. These approaches and techniques should be studied, analyzed, and utilized for current projects.

To improve the quality of life for current and future generations, an integrated holistic approach to housing unit design with special attention to allow for flexibility options is an essential ingredient to community sustainability. Even though the study has indicated that RCHD units allow for a high degree of flexibility, designers, and developers should continue to consider all five significant contributors to overall flexibility when designing a new prototype or fine-tuning an existing one.

The efficient uniformity of mass housing production limits the end-users participation in the design process and gives end-users little to no room for personalization. Designers and Developers should give end-users the opportunity to personalize the dwelling through partial or no finishing especially in the main facade, entrance, and guest area.

8. SUGGESTIONS FOR FUTURE RESEARCH

Saudi society is going through major social changes. Future studies should consider changes in life style for non traditional families and in demographic trends to support a diversity of housing alternatives that correspond and accommodate cultural and social change.

The instruments utilized in assessing the *unit flexibility* options should not be used to measure social factors such as privacy attributes. Other indirect measures should be utilized to assess these options.

RCHD units were evaluated by design professionals and not end-users. It is anticipated that there is a discrepancy between the two groups. Future research should consider end-users perspective through extensive post occupancy evaluation at several stages of the household life.

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المرونة التصميمية واستدامة الوحدات السكنية النموذجية (حالة دراسية: المجمعات السكنية الاستثمارية في مدينة الرياض)

المرونة التصميمية أو إمكانية تغيير وتوسيع وتعديل الوحدة السكنية هي أحد العوامل المهمة التي لها أثر ملموس في استدامة الوحدة. فتعديل الوحدة السكنية عادة ما يتبع التغييرات التي تحصل في المراحل المختلفة التي تمر بها الأسرة , فكل مرحلة في حياة الأسرة لها احتياجات مختلفة عن المراحل الأخرى من مناطق للدراسة واللعب والتخزين. توفير خيارات تعديل وإضافة مصممه مسبقاً للوحدات النموذجية المتكررة له عدة آثار إيجابية مثل السيطرة على تكلفة الوحدة السكنية وتوفير مجمعات سكنية صحية ومستقرة.

البعض من المماريين المحليين تحفظ على مستوى المرونة التصميمية التي توفرها الوحدات المتكررة المطبقة حالياً في المجمعات السكنية الاستثمارية في مدينة الرياض. هذه الدراسة وثقت وقيمت المرونة التصميمية للوحدات السكنية لهذه المجمعات المشيدة في الفترة ما بين عام 2000م وعام 2003م. ووضحت الدراسة أن هذه الوحدات توفر مرونة تصميمية متوسطة إلى عالية. وكشفت الدراسة أن بالإمكان تقسيم المرونة التصميمية إلى ثلاث مجموعات رئيسية هي : المرونة الوظيفية (إمكانية استبدال أو تغيير وظيفة الفراغات) ومرونة التشييد (إمكانية إضافة فراغات جديدة) والمرونة في القيم الجمالية (إمكانية وضع اللمسات الشخصية على الوحدة).

أبدئ المشاركون في الدراسة عدم رضاهم عن المجموعة الأخيرة أو مرونة القيم الجمالية. وقد ختمت الدراسة ببعض التوصيات لتوفير المرونة التصميمية المناسبة للوحدات المتكررة في المجمعات السكنية الاستثمارية.