FITTING MORE INTO VOLUME
–AN AFFORDABLE HOUSING INITIATIVE

PRODUCT DESIGN PROJECT II

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Fitting more into volume

- An affordable housing initiative

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Approval sheet

The project titled as " Fitting more into volume - An affordable housing initiative " by Manu Revi Poovakkat is approved in partial fulfilment of the requirement for the degree of "Master of Design" in Industrial Design.

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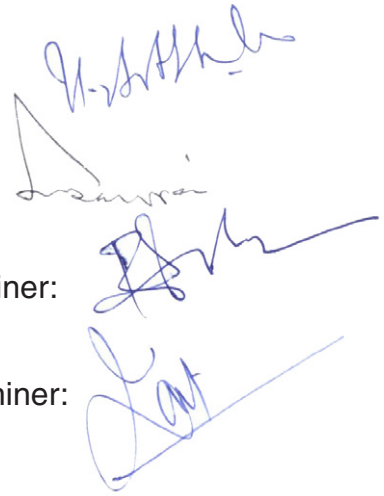

Declaration

I hereby declare that this written submission represents my idea in my own words and where others' ideas have been included; it has been adequately cited and referenced the original source. I declare that I have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any data/idea/facts/sources in my submission. I understand that any violation of the above entitles the institute to take disciplinary action against me to which I shall be answerable to.

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Abstract

The title of the project is Affordable housing for the bottom of the pyramid. The land cost in the Urban cities is shooting up day by day as the availability of living space is becoming scarce. This forces the immigrants or the bottom of the pyramid people to force themselves into temporary living setup, which in turn increase the slums in the cities. This project is trying to provide a housing option for these people who have very low income and are mostly migrants. Various slums were studied for understanding the lifestyle of migrants belonging to various categories like Hedonist, Settlers, Risers, etc. Based on these studies , the minimum space required for a family of 6 members was calculated and different layouts were made for the same. Out of these, three layouts were selected as the final layouts of the house and a working model of one among these layouts were made to get the feedback of the users. Throughout the project we followed the approach of experiential learning where we made the life size mockup of the house in the initial stage itself and then based on our own experience inside the house, we modified it to suit the needs of the actual user category. The main focus throughout the project was to efficiently use each and every cubic volume present inside the house. For this, various spaces which can be of multiple use were identified and designed according to the incremental needs of the user. The outcome of this project

is the prefabricated DIY units, which actually makes the user the creator of his space. Provisions were also provided for the user to bring in his own furnitures or equipments and place it effectively in the house in such a way it does not eat up much space.

Contents

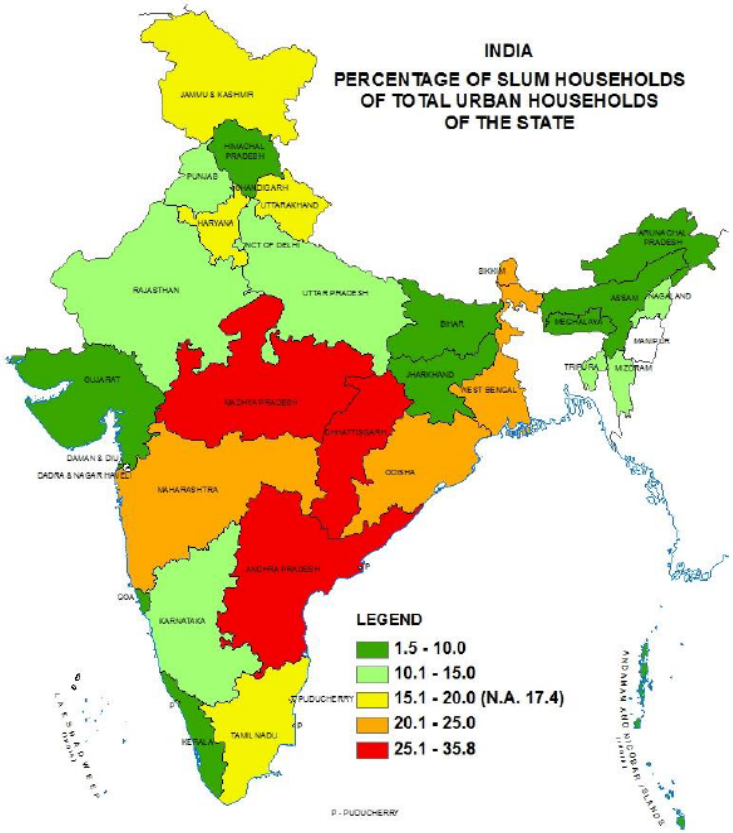


Fig 1. *Percentage of slum households of total urban households*

Introduction

In the present day scenario, growth of cities is succumbed by growth of slums. Cities, very often, provide ample opportunities of employment, good education, health facilities as well as better standards of living. People from the rural areas migrate to the cities just because the very facilities are not provided or available in the rural side. When these people, who cannot afford a better living immediately after migrating end up in a degraded living area or condition, what we call as 'slums' or 'squatters'. The problem rises when most of them are not able to climb up the social ladder for years, at the same time the flow of migrants keep rising.

Urban agglomeration happens when more and more people migrate to the cities. These are not the people who come from nowhere. These are the people who live in the rural areas/ people from other states/ international migration. Why do they come to the cities? Two factors, basically;

1. *Push factors from the rural:* Unemployment, lack of basic amenities, drought, crop failure, poverty etc.

2. *Pull factors of the urban:* Potential for employment, better service provisions, greater wealth, health facilities, educational facilities, social security etc.

Proportion of slum households in Metros - 2011

Million Plus Cities	Proportion of Slum HHs to Total Urban HHs (%)
Greater Mumbai (M Corp.)	41.3
Kolkata (M Corp.)	29.6
Chennai (M Corp.)	28.5
Delhi Municipal Corp (U)	14.6
BBMP (M Corp.)	8.5

Source: Census 2011

1. Why this project/ context.

The table on the left shows the proportion of slums households with respect to the urban households. From the table it is clear that almost half the urban population in Mumbai is living in slums and are forbidden from a better standard of living. The condition in the other metropolitan cities is not very much different. The cities themselves seem saturated and not capable to hold the in-house population. The migrants, in that manner, are an additional pressure, but at the same time a very valuable labour force demanded by the city, together making a vicious cycle. The authorities fail continuously to provide the housing and living needs of these migrants.In this light, it is important for us to look into the matter very seriously and urgently.

This project takes the present circumstances into consideration and attempts to give out a solution with an industrial design approach.

2. Summary of the report

This report delineates the need and purpose of the project as well as the approach taken for this project**. The report gives a brief idea as how the challenge of affordable housing was dealt with.

***This report can be divided into two halves. The first half deals with the housing unit as a whole, whereas, the second half focuses on a particular furniture within the housing unit.*

3. Initial brief

Design an affordable do-it-yourself furniture system for bottom of the pyramid houses in Urban Slums. It assumes that enclosure of certain specs are ready.

The system of furniture should be:

- *Growing according to the sequential user needs.*
- *Floor supported and self standing.*
- *Pluggable pre-fabricated furniture modules.*
- *Capable of easy dismantling.*
- *Compatible for elderly.*
- *Frugal in nature and appearance.*
- *Able to accommodate the time based changes in needs of the user.*
- *May use existing joints and mechanisms.*

Regarding slums

1. Context

1.1. Current Scenario

The cost of land, especially in the urban realm is ever increasing. When a person migrates to a city in search of employment, education and other facilities, it is difficult for him to find an affordable place to live. Without the surety of a permanent wage, that too lower than the average wage, it will be almost impossible to rent a place in the city. As a result, slums start to develop in the city centres, where the job opportunities are higher.

It is likely that a person who have migrated and is settled would bring his brother or a friend from the rural area. Thus, in such a manner, the slums start growing and when they grow, there would be space constraints. According to the census 2011, there is a shortfall of about 25 million houses in Urban India.

The people living in the slums can be categorised into four types: *Transients*, *Settlers*, *Hedonists* and *Risers*. The people who just migrated to the city and are doing temporary jobs while in search of a good job, come under transient category. Settlers are those who have found a reasonable permanant job that pays enough to sustain their

Fig 2. *Current interior scenario*

livelihood. They would not spend much on things or artifacts that are permanent, for example, a concrete staircase or permanent tile flooring. Hedonists, on the other hand, would spend money on comfort. They would be generally bachelors who have low-end jobs. Risers are people with education and tend to climb up the social ladder as well as in employment.

There is a large requirement of urgent action from the governing authorities and urban planners.

1.2. Current Interior Scenario

At present, the houses built in slums are not strong enough structurally. A catastrophe could happen anytime anywhere. There is only limited privacy inside the house and all they have is just a single room which is used as a living, dining as well as bedroom. There is hardly any proper ventilation and natural lighting. They would not have or rather prefer to have furnitures in their homes. Many houses don't have toilets and even if they have, there is lack of proper sanitation and hygiene because of which they are more prone to diseases. The daily activities in the slum household tend to spill over from their boundaries into the public space. This is quite natural since, the space the family have inside the home is very small and limited and all the activities such as washing utensils, water storage bins are done outside.

Exterior access to houses inside the slums are limited. If there is any fire hazard or health emergency, it is impossible for the brigade/ ambulance to reach the interiors of the slums.

These are based on earlier studies by IDC over a period of 3 years, though yet to be published.

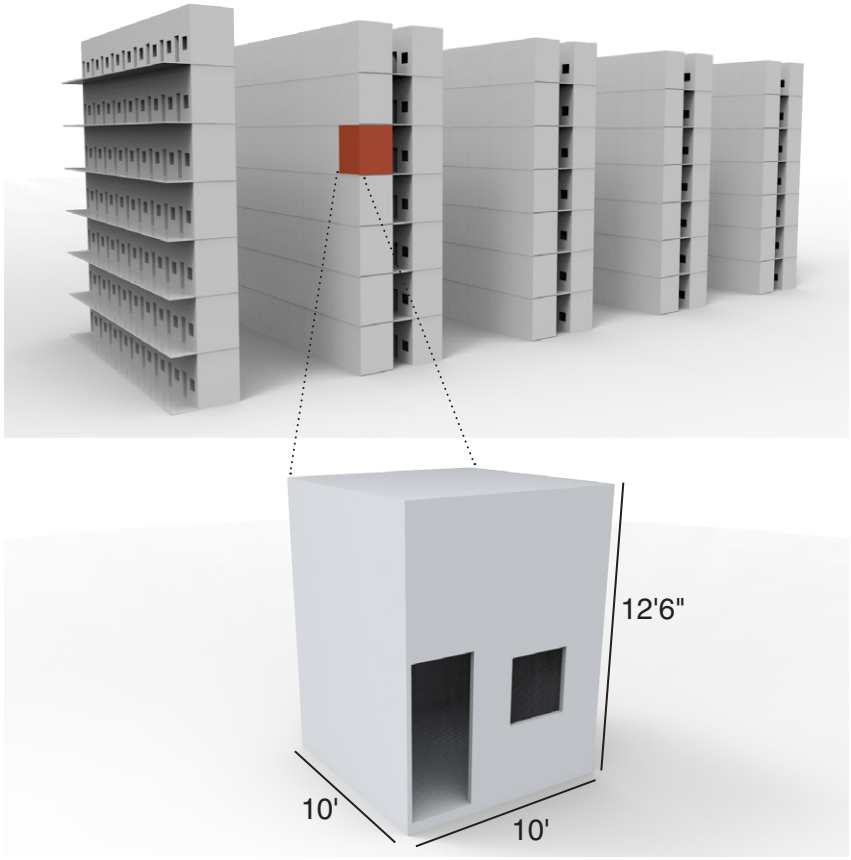


Fig 3. *Multi-storied concept(Top); Individual block(Bottom)*

Project assumptions

The space to be designed is already available as multi-storey building having modules of size 10’x10’x12.5’. All the walls are assumed to be made of brick and concrete. The rooms have one exterior wall which contains windows and all the plumbing connections. Every building has a passage of six feet (6’) between the two opposite facing modules. The distance between each consecutive building would be around hundred feet (100').

Data Collection

1. Already researched data

1.1. User studies

The user data available at IDC which was collected over a three years of time was used as a backdrop for this project. The available data defines the user category. It also elaborated the occupation, their annual wage and also about their lifestyle.

Apart from this data, field trips were conducted to get a first hand experience of the life in slums. Through this field visit it was possible to see , socialize and learn about the people living in slums and who will be the major user category for this project.

1.2. Activity Analysis (in reference to available data)

A brainstorming was done apart from available data to understand time slice of a family of 4 members. Probable activities undertaken by each member were identified to get an idea of the time based usage of space. This analysis was further used to identify spaces that could be exploited to bring about versatility in its usage.

Fig 4. *Roof top view of dharavi(Top); Inside an embroidery unit at dharavi(Bottom)*

2. Secondary and Primary research

2.1. A visit to Dharavi

A visit to Dharavi was undertaken in order to get a feel of life in slums and their utilization of space. Our expectations of an underdeveloped space in the heart of Mumbai was met with an extremely contrasting picture of a multi billion dollar self sustained industry.

The main industries at Dharavi are leather, pottery, textiles and recycling industries. The district has an estimated 5000 businesses and 15000 single room factories. Dharavi exports goods around the world with a turnover estimated to US$500 million per year.

What we saw at Dharavi

1. The life

- Working women population at dharavi consist of mainly house maids and also people working in papad making units and local industries (embroidery works, pottery etc).
- Dharavi has local schools numbering to around 60 (govt. and subsidised private) which look after the education of the children over there. In addition to this, there are children who go to near by schools outside dharavi as well.
- People receive post through local post office, and normally the postman himself knows most households. There are people who even go for online shopping that are delivered at their household or delivered at a particular delivery point. In most of the cases, they receive their electricity bills via post. Dharavi consists of

Fig 5. *Space constrains (Top) ; Usage of recycled materials in construction (Bottom)*

various sectors and lanes and house numbers(for some houses) which are used in identifying the household units.

- Some households had goats, hens and other pets. (closed cages could also be seen at some households.)
- There are some households that run small businesses like grocery shops, which forms a part of their house.
- Local industry units are used as sleeping spaces, mostly by their workers, which frees the them of their rent.
- Dharavi has many recycling units that recycles plastic, aluminium, tin cans of paint and chemical cans etc.
- Machine industries could be seen which manufactured machines to support the local recycling industries.
- Certain industries and houses were constructed at a lower level from the ground which mostly get flooded in the rainy season.

2. Living space and furniture.

- The access to the houses were through ladders made by local welders, mostly with scrap metal or sometimes with new ones. The welders go on-site carrying the welding machines to build the window extensions, doors and stairs. The steel steps were of mostly 1.5’ to 2’ in width. The landing area ranged from 1.5’x2’ to 2’x2’, which were just enough for a person to stand.
- In certain houses there were obstructions at the entrance (mainly because of stairs).
- Clothes drying and footwear storage were mainly done on the window extensions built through local welder.
- Recycled parts or scraps, sacks and sheets and wood

Fig 6. *Drainage system at Dharavi*

parts were used in the construction of walls and roofs.

- Less ventilation in case of most industry units (mostly use only one exhaust fan), but many industries have ceiling fans (clear height of 10’ to 12’).
- There were certain cases of bathrooms constructed under stairs. Most bathroom units were located on the front side which give direct access to the drainage system that runs through the front of each houses or industry unit.
- Most households have water storing barrels, which are used chemical barrels.
- Most houses had appliances like Fridge, TV, washing machine etc.

3. The drainage system

- Drainage systems run along the front side of housing and industry units with concrete slabs over them (this helps in saving space, as they don't need to invest in separate space for drainage).
- In some areas like Nayivasthi, houses were constructed on both sides of the sewage(some sunken and some raised and some at ground level). The lanes were just enough for a person to walk.
- Most of the times these partly covered drainage system acts as the access lanes to the houses within the slums.

Insights from dharavi visit

The innovative utilization of space, as far as the people in Dharavi are concerned, is not a new thing. They have been doing so from the time they occupied the space. We could observe and learn how they have utilized their available space and customise it to

suit their needs. They even found multiple uses of the same object in their home. This forced us to think about their necessities and desirables considering their daily life. Some of these necessities or desirables are common to all the people but it is important for us to have the flexibility to customise the living space depending on the requirement of the dwellers.

We could learn how the daily life of a person goes in Dharavi. This data was very much important to figure out the time based activities. We could also learn how a typical manufacturing/repair/ maintenance happens inside the slum. This information gave us the idea of how we should go about making the components DIY.

2.2. Parallel Projects

Different similar projects across the globe were studied to learn and understand what is the current scenario in affordable housing as well as compact housing units. From these projects, the efficient methods of space utilisation were understood. Most of the houses that were studied had a small footprint of comparable size, hence studying the vertical space utilisation in these cases were critical. The case studies also gave an insight about the new technological developments in the housing sector which helps increasing the efficiency of space.

We, the tiny house people - documentary

When we were searching for inspirations and to get an insight of minimal living, we stumbled upon this documentary “We the tiny house people” by TV producer and Internet-video personality Kirsten Dirksen. It is a compilation of her best contents with regards to tiny houses (Fig.7), which gives us an insiders view of how people manage to live in small spaces. Kirsten takes us through a journey around the world of tiny houses of people


Fig 7. *Tiny house movement*

Fig 8. *Cube project*


Fig 9. *Caged homes in Hong Kong*

searching for simplicity, self-sufficiency, minimalism and happiness creating shelter in caves, converted garages, trailers, tool sheds, river boats and former pigeon coops. This became the source of inspiration and a peek into creative ideas which people employ to save space.

Cube Project

The Cube Project (Fig.8) is a low-energy micro-home project taken up and designed by Dr. Mike Page at the University of Hertfordshire. Built under the name, QB and QB-2, the micro-home takes up very little carbon footprint and can accommodate a single person or even a couple. QB has a footprint of 3mx3m, whereas in the extended edition, QB-2 has a footprint of 3mx3m and a clear height of 3m. Even though, this is compact in size, it accommodates a fully functional kitchen (with hob, oven and fridge), a 4m long galley bathroom, a living space with a two-seater sofa and two ottomans which can be converted to a dining when needed, a fully-sized double bed and ample storage space.

QB-2 ensures a highly insulated construction, low energy lighting and appliances. It is a post and beam structure, which can be assembled and made water-proof in around 4 hours and the entire structure can be completed in 3-4 days. QB-2, once constructed can easily be transported and fixed wherever a static caravan is permitted.

The most important aspect of QB-2 is that it is available as a do-it-yourself kit as well as a complete building at various stages.

Market study/ Asian Scenario

The Asian scenario was a bit different from the other case studies. These were slums, though vertically. A new idea of cage housing (Fig.9) was seen in the case studies of Hong Kong urban slums. Since the land prices were extremely high (similar to

Fig 10. *Convertible furniture.*

Mumbai), they don't have much option other than share a particular small space among five or six separated by individual cages made of metal. Another idea of rooftop housing was also seen in the Hong Kong scenario. Though the name 'rooftop housing' sounds fashionable, it is literally a slums on the roof of an existing building. Efficiency of space is critical in such areas and this was well understood through the case studies.

Convertible Furniture

Spatial constraints pushed us to employ the same space for multiple use, based on the time-based usage analysis. Temporary spatial occupancy of furniture thus plays a crucial role in minimizing the space and changing the utility of space. If the same space can be utilised in multiple ways , why can't we use same furniture that occupies minimum space for different purposes?

The idea of convertible furnitures came from this point of view. Various convertible furnitures which were already present in the market were studied through internet and other references.

Insights from parallel projects

From the secondary research, it was possible to study how people all over the world have negotiated with the problem of having less space. Many a times, people used convertible or foldable furniture as a solution to tackle the space issue. Multi-purpose furniture systems were another facet by which the efficiency of utilisation of space was increased. From the case studies it was also possible to understand how the furniture can be changed to manipulate the space it creates.

From the 'Cube Project', the idea of constraining the space was taken. A thorough study on how the limited space of 10ft x10ft

x10ft was utilised to its very bit was done and this was benefitted later in the project.

Convertible furniture, as said earlier, increase the efficiency of space usage. It has the capability to make its related spaces multi-purpose. Therefore, these kind of furnitures were given a serious thought and the intricacies were thoroughly learnt to adapt and suit the concept in our context.

Design Brief

Design an efficient space division for the bottom of the pyramid houses in Urban slums, visualized as post constructed furniture like system.

The design should satisfy the following requirements:

– *Efficient usage of volumetric space (considering the least FSI) according to time based user needs.*

– *The furniture system should be incremental assisting the dynamics of the space according to the growing user life cycle and their needs.*

– *User should be able to employ himself as the creator of the furniture with minimal external help.*

– *The furniture should consume minimal volumetric space at the same time scaling down the compromises associated with the current scenario.*

– *The design should ensure ease of availability of materials and components, should reduce the learning curve in building and maintenance.*

– *The furniture system should be pluggable, ready to assemble modules which could be assembled and disassembled with locally available tools and skills.*

Note:

Compromises are acceptable (1) in case of space utilisation, since, the project is aiming at a gradual improvement from the present living scenario. For example, making the person comfortable inside a washroom is less important when compared to making him comfortable in living room or kitchen. (2) depending on the usage time-span of the spaces.

Compromises can be made in case of overhead clearance while accessing higher levels (higher levels are planned so that requirements of elderly are catered to in the main floor).

Provisions can be given to add fans, TV etc as a part of the furniture and fixture.

Upgrading scenarios and requirements

The sequential up-gradation map was done to analyse the upgradation pattern followed by the people in slums. This also helps to differentiate between various necessities and desirables for the people. Various upgradation phases are shown in the image provided in the following page (Fig.11).

(A1) Scenario 1 : When the migrant comes to the city

In this phase the user would be a single person who migrates to city in search of a better living option. A living space with a toilet, bathroom and water storage would be the necessities. The other furnitures like kitchen unit or couch/ seating could also be bought depending on the users choice.

(A2) Scenario 2 : Sharing the space

When the user gets kind of settled in the new place, there are certain possibilities like the room could be shared with any of the friends or any of the relatives can come and join. In such cases few furnitures gets upgraded or added. One more single bed gets added to the living space to accommodate the next person. The water storage capacity will increase and a television could be bought by the two as its the

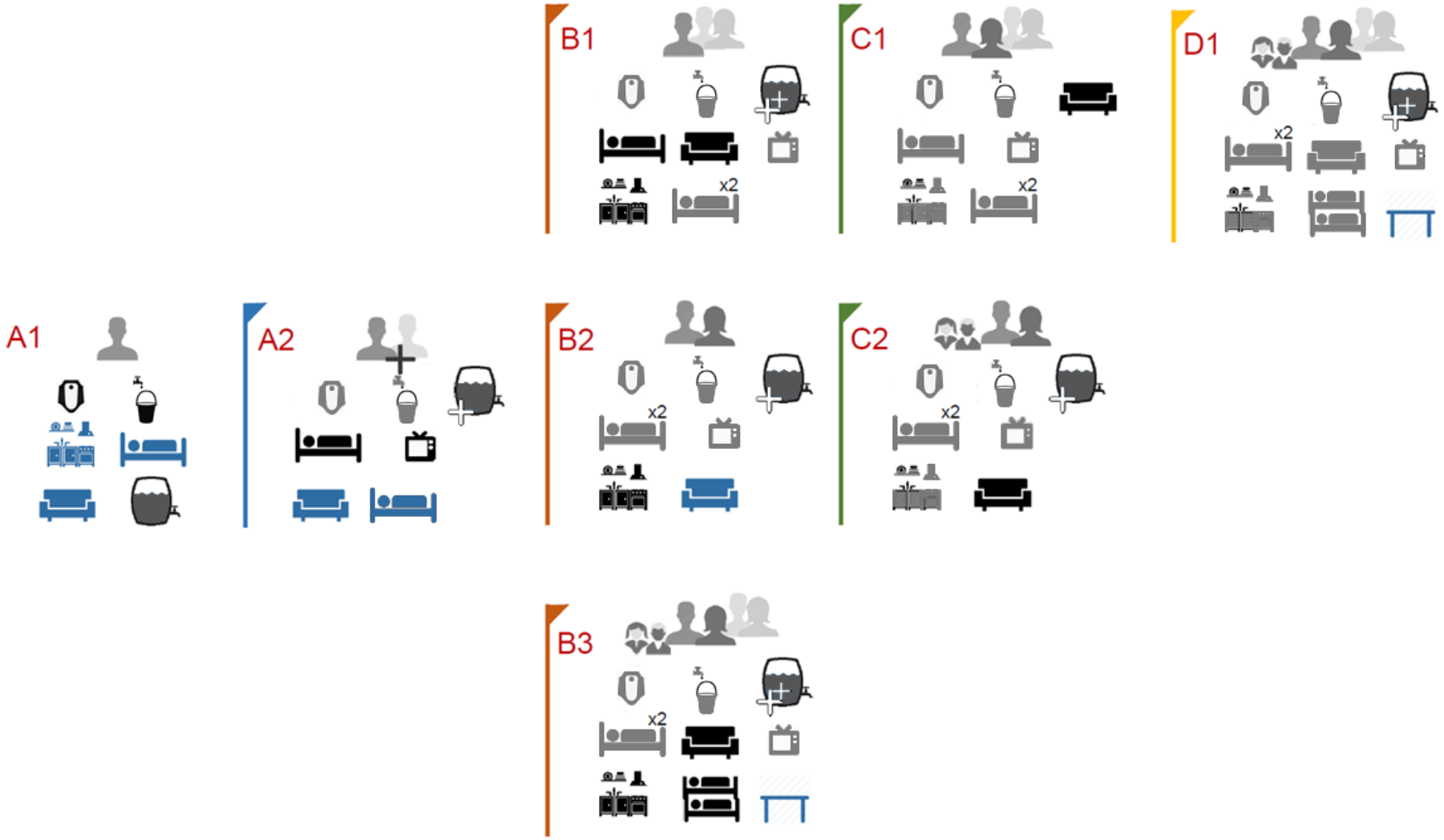


Fig 11. *Sequential upgradation during different stages of a persons life.*

only means of entertainment for the people living in this context.

When the user/migrant gets financially settled, any of the below 3 scenarios (B1,B2 & B3) can occur which demands few changes in the furniture and the spaces required.

(B1) Scenario 3 : Parents joins

When the parents join the user in his house, a need for separate bed space for the parents arises. Also the kitchen unit comes in place as the parents would be in the house during daytimes and frequent cooking would be expected. The water storage also increase to suit three persons. For the daytime activities of the parents, a seating space would also be needed.

(B2) Scenario 4 : When getting married/ Wife joins

When the wife joins, the first thing to get upgraded would be the single bed. A double bed would replace the single bed and rest everything remains the same as the scenario (A2). A proper kitchen unit would be bought according to the wife's preference.

(B3) Scenario 5 : When whole family (parents, wife and children) joins

This the scenario in which the house has to accommodate maximum number of people and so occupies the maximum of the space available in the 10'x10'x12.5' space. There are two double beds for the young couple and the elder parents and two single bed/ bunk bed for the children. The water storage is in the maximum. For the children dedicated study space s also a desirable in this phase.

From the scenario 4 (B2) there are chances of forming two

more scenarios when

– *The couple has children.*

– *When the parents visit or stay.*

(C1) Scenario 6 : Couple with parents

The layout is almost same as scenario 4 , the things that would increase would be the bed space for elderly parents and water storage. Special care needs to be taken for the privacy of the couples.

(C2) Scenario 7 : Couple with children

The incremental furniture here would be the study space for the children. Privacy for the couple should be taken care. Water storage also increases.

(D1) Scenario 8 : When whole family (parents, wife and children) joins

This scenario 8 is similar to scenario 5.

Misc scenarios

– Tenants coming and joining

– Growing children + Grownup children (off-shoot of the above ones)

1.1. Insights

From the sequential upgradation map, we figured out some furnitures which stay static throughout the stages and few others which were added up. The added-up furnitures were Bedspace, Kitchen, Storage (water storage including), Level and Living space furnitures. The static furnitures throughout the stages are toilet, stairs and TV.

Few furnitures were identified such that they could be added in any of the incremental stage. They are puja, Dining space and washing space.

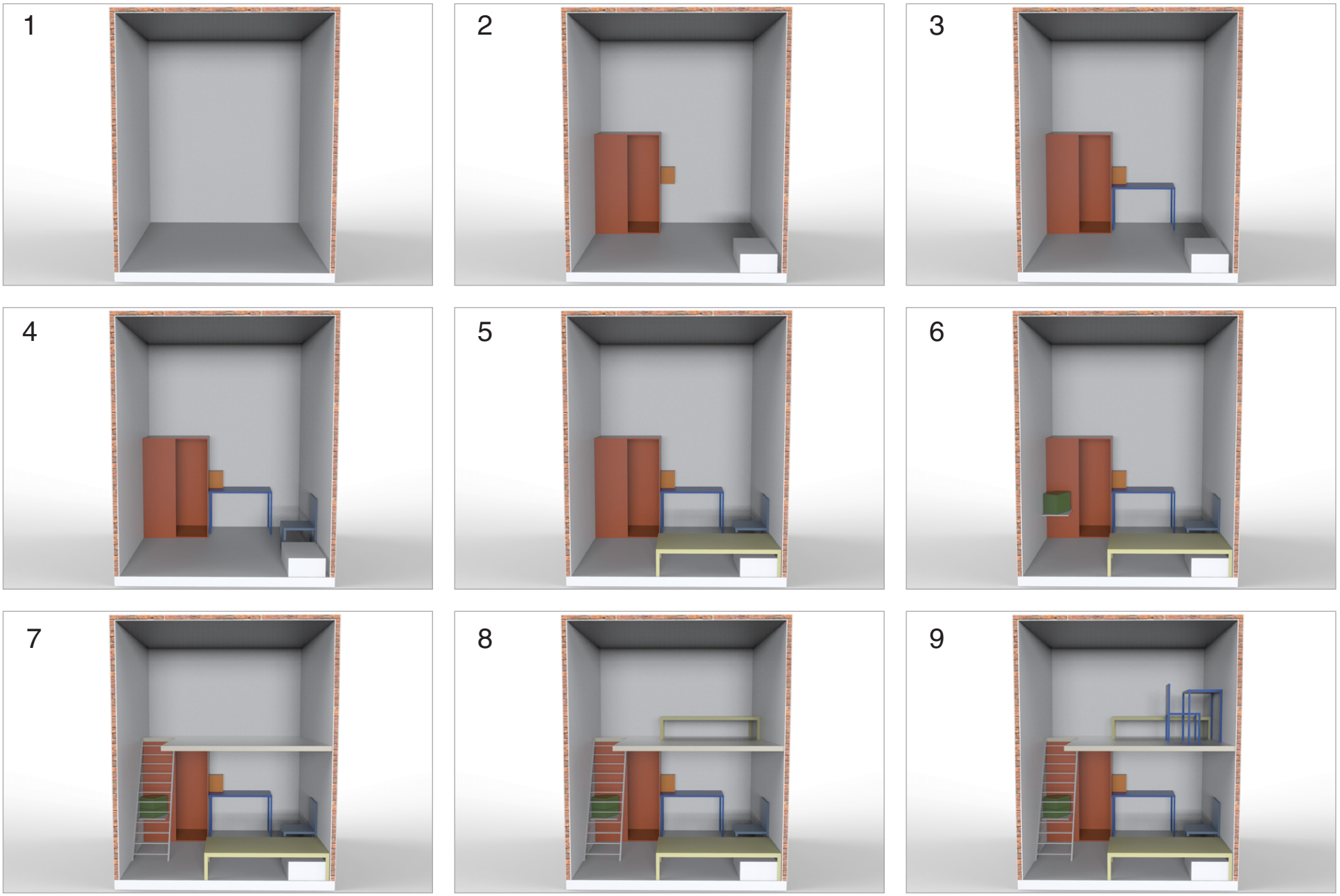


Fig 12. *Conceptual sequential upgradation of space during different stages.*

Scope of the project

This project aims at the housing needs of people at the bottom of the pyramid, whose annual average salary is below Rs.90,000 at the 'start' level, where he has a small family (or him being single), which can increment slowly. Considering the already existing space constraints in the cities, the project looks at utilising the available space in the most efficient way.

The project looks into the possibilities of sustaining better, healthy and hygienic living conditions for the slum dwellers.Keeping the rising cost of materials in mind, care has been taken to make the whole housing solution affordable for the bottom of the pyramid.

1. User profile

The user segment for whom the furniture system is being designed is the current dwellers in the slums with an average annual income ranging from ₹90,000 to ₹2 Lakhs (incremental). The project also takes into consideration the immigrant population. During initial years, rather than buying a house permanently, the immigrants prefer to rent the space till they get a proper foothold in the city. They move to different locations in search of job or contract work. Generally, the

migrants tend not to rent the space all at once. They rent out the space and incrementally buy space saving furniture as the family grows. In any case, as per the regulations, a person who has migrated, after the year 2000, is not entitled for Government funding under Slum Redevelopment Authority. So, the authorities cannot provide housing and provide for living needs of these migrants. This forces the poor immigrants, into informal and temporary living setup, which in turn grows as the slums in the cities.

Slums in different cities were studied for understanding the lifestyle of migrants. The data threw up four personas, namely Transients, Settlers, Hedonist and Risers. The current project cater to groups like Transients and the tenured residents of the space.

2. Limitations

The project takes a certain amount of freedom from the Development Control Rules and Byelaws; this is not uncommon in affordable housing but at the same time care has been taken to reduce the impact on living conditions.

3. Deliverables

This project contains a collective part as well as an individual part. The collective part was done by a group of three. The work in this category was shared among the three and each of them had their own inputs in building up the foundation of the concept.

3.1. Proposed solutions (Collective)

– Full size working model (integrating all the individual units)

– Mock-ups

– Range of furniture systems

In the individual category, each person focused on a certain area to work out and detail a portion of the housing unit.

3.2. Proposed solutions (Individual)

– Prefabricated plug-in super compact do-it-yourself bathroom units

– Prefabricated plug-in super compact do-it-yourself kitchen units (movable/ convertible)

– Prefabricated structural units

Design Approach

1. An Industrial Design Approach

The project follows an industrial design approach to this problem. [1] Instead of going by the conventional method of building the outer structure and designing the space inside, the project explores the space required for each activity and starts the design from inside to outside. Through this project, the team tried to utilise each and every unit cubic volume inside the given space and tried to utilise it in the best possible way. The space utilisation for each activity was brought down by considerable amount, so that the dwellers can live inside instead of surviving.

2. Agile Methodology

2.1. What is agile process?

Agile process, when put in product design context, will be a movement from the conventional design process. Agile is a movement away from the typical 'waterfall' method, which

[1][Assumption that the building shell is constructed as per the standard requirements of the interior]

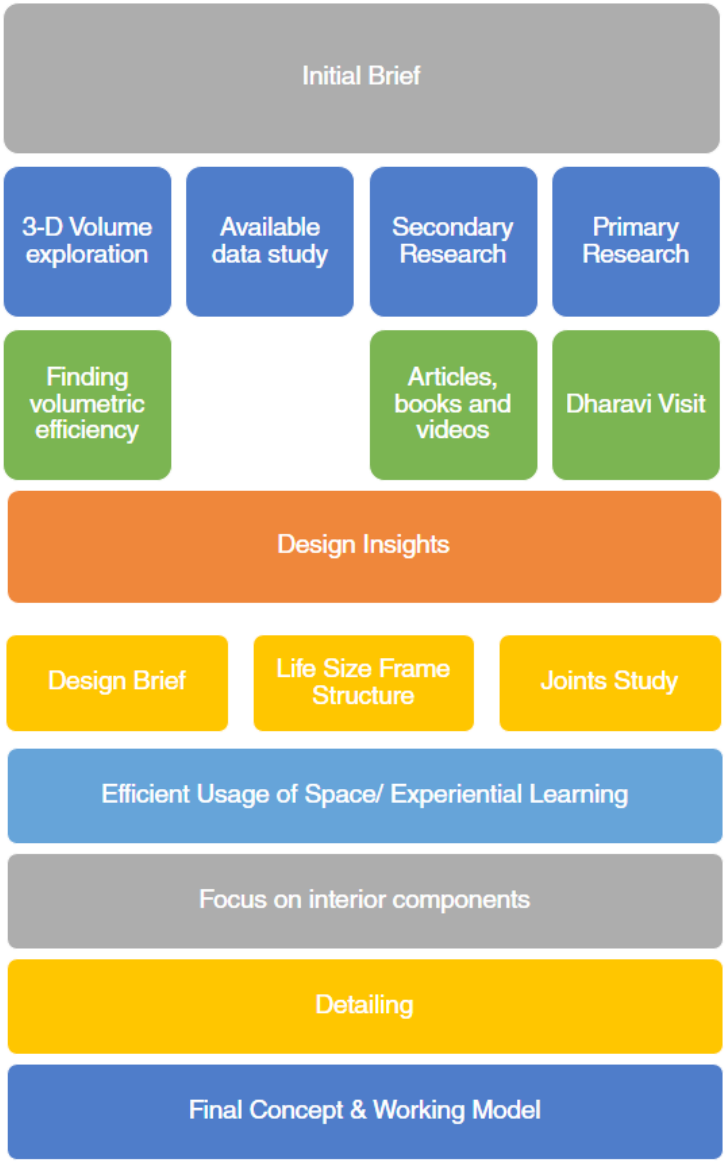


Fig 13. *Design approach*

brings a bulk product only at the very end of the process. In such cases the developments can be delayed, become over the expected budget or become irrelevant by the time product is out and running.

Agile development takes place through defined iteration cycles that are 1-2 weeks long. At the end of each iteration, a certain outcome is taken as a deliverable. The use of such a method is that, changes can be fitted into the design process from time to time based on the need.

2.2. Applying the agile methodology in Product design

Since agile process deals with continuous deliverables in a certain period of time, scaled mock-ups, which are three dimensional, was the best way to take the process ahead. Such mock-ups have the capability to transform easily according to the altering requirements from time to time. It also lets out a wide spectrum of ways, may be intentional or by accident, by which the product could harness the change for its competitive advantage. Mock-ups and at a later stage, a prototype could become a measure of progress of the project.

The deliverables can be regular with a short span of time in between so that each minor change or improvement is noticed and hence, taken care of. That would give other designers also to review the design and make new improvements based on what is existing.

Input from the user's side is very important and this was done on a regular basis, majorly during the initial and middle stages of design. The designers, developers, management personnel and users should maintain a constant pace throughout the project and beyond. Agility is enhanced through continuous attention to technical excellence and good design.

2.3. Initial Exploration

Step 1 - Remodelling cube project 10'x10'x10'

The project began with the idea of inhabiting the cubical space, taking the constraint of 10’x10’x10’. Various explorations were done to accommodate a six member family in the given volume, with minimum compromises.

Step 2 - 10’x10’x18’

In a volume of 10’ x 10’ x 10’, it was only possible to look into the basic necessities for the living conditions of a family of 6 members. The height of the structure was then taken to 18’. Now it was possible to find a lot of space which was extra. More planning came into the scene with respect to placing different space modules like Kitchen, toilet and bed space. Learning was now to efficiently utilize the vertical space. This helped us understand how volume can be used.

Step 3 - 10'x10'x14' and 10'x10'x12.5'

The height was further reduced to 12.5’ clear, above which the area to be computed would be 1.5 times the FSI. The objective here was to accommodate all the things that have taken up space in the previous volumes into this constrained volume.

Step 4 - Vanishing Spaces

The task of vanishing spaces was done to get a hand on convertible/ foldable furniture, so that it would become multi-purpose or occupy very little space. It also helped in visualising time-based activities and its relation to the furniture or space.

Step 5 - Spaces Underneath

It has been noticed that a lot of space is getting wasted

underneath objects or furniture. The task here was to find out and utilise such wasted spaces and put them into productive use.

The next section shows these explorations. In the initial exploration, different contexts were taken such as

- 4 members (Elderly parents + Children)
- 4 members (Couple + Children)
- 2 members (Couple)

Fig 14. *Foam board mockup (in clock-wise from top-left)1.Full model; 2.Stairs; 3.Couple sleeping space; 4. Parents sleeping space.*

Concept 1 - 10'x10'x10'

(Elderly parents + Children)

– The main focus went to giving the basic necessities inside the house, as the space was very limited.

– The kitchen and Toilet were assumed to be shared by 2 houses, hence not included in the cube.

– More open multi utility area were given inside the house to accommodate various usage profile of the elder parents who spent more time inside the house in the day time.

– The sleeping space were given such that it provides enough privacy for both the young and elderly couple.

– A small kitchen space is also given considering the immediate needs of the elderly people (Like, drinking water at night)

– The stairs were divided into two parts with upper part fixed to the house and the bottom part, which serves multiple use like a table for adult and kids as well as serving the purpose of stairs and these were stackable.

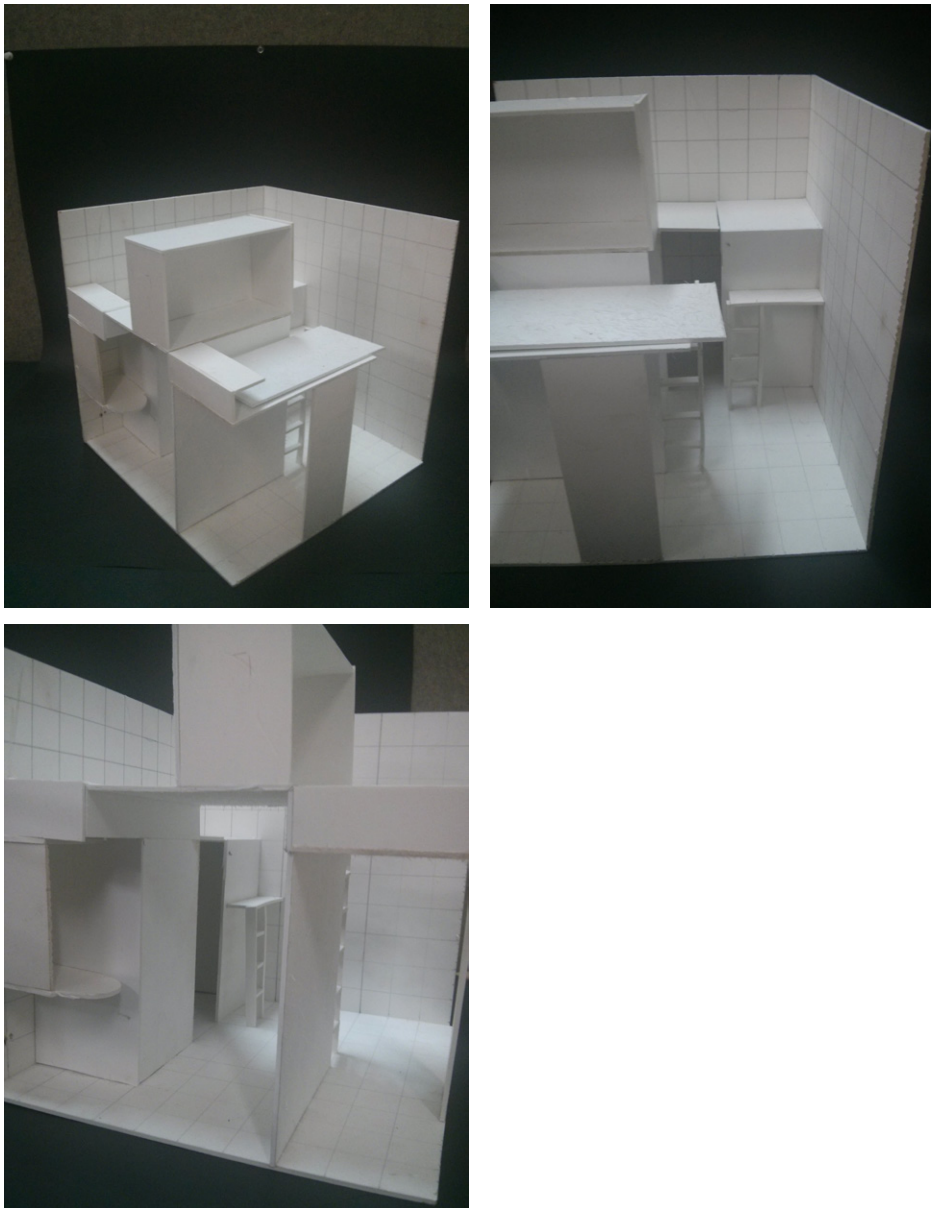


Fig 15. *Foam board mockup (in clock-wise from top-left)1.Full model; 2.Access to higher levels; 3.Kitchen space*

Concept 2 - 10'x10'x10'
(Couple + Children)

– In this particular layout, enough space was left out near the entrance which could be used for storage as well as for business needs that need direct exterior access(eg: running a shop)

– The activity analysis showed usage of bathroom being maximum in the mornings. The toilet space and bathroom space was separated into two 3'x3' modules for separate access to both.

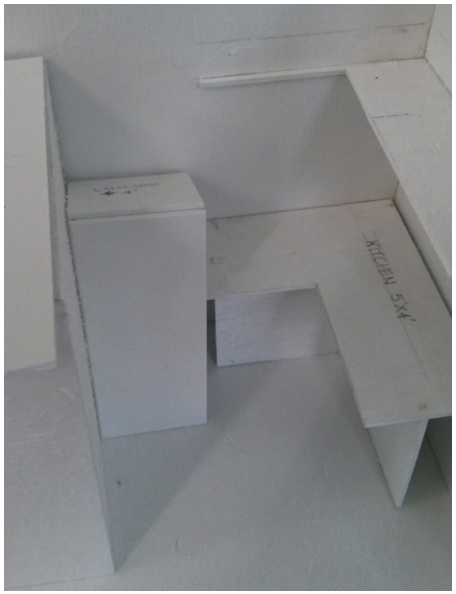
– The sleeping space was accommodated in the upper level for both parents and children, with storage options.

– Ladders could be used to access higher levels with a ledge option at the parents side to aid in easier access.

– Enough clearance was given at the upper level while sitting (4 ft).

– Kitchen space accounted for 4'x5' with an additional 2'x3' for sink + storage option.

– Living space has been kept to the side of kitchen considering the position of the TV.



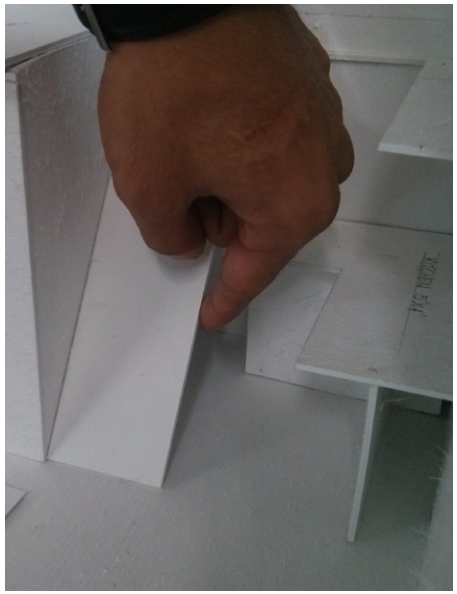


Fig 16. *Foam board mockup (in clock-wise from top-left)1.Stairs folded in ; 2.Stairs in original position; 3.Full model*

Concept 3 - 10'x10'x10'

(Couple)

– In this particular layout, a flexible open space of 4' x4' is given to accommodate the spillover activities. This would make the indoor living space in 'L' shape, so that the space in itself would work efficiently.

– This open space, during the final stages of incremental growth, can be re-fixed in such a way that the 16sqft is taken indoors, into the living space.

– A bathroom block of 4' x 3' was considered so that a bed space can be accommodated on top of it.

– A kitchen block of 5' x 4' was given with a ledge on top.

– The ledge can be converted to a bed space later.

– Both the beds are designed at a certain height that they are accessible from the landing of a common staircase.

– The staircase can be folded when not in use, thereby, allowing other use of space.

– A drying area was also considered behind the staircase.

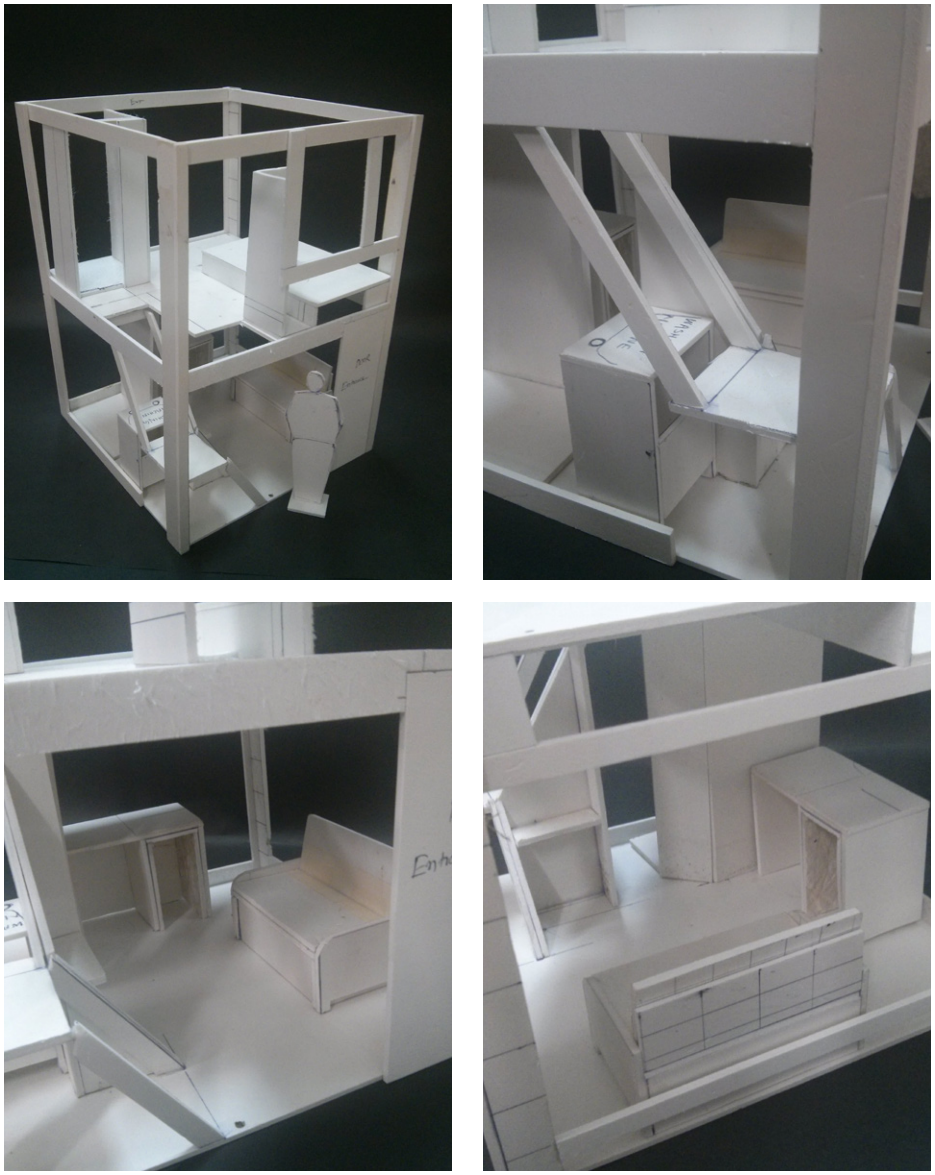


Fig 17. *Foam board mockup (in clock-wise from top-left)1.Full model ; 2.Sink under stairs; 3.Kitchen and living space; 4.TV area*

Concept 4 - 10'x10'x18'

(Elderly parents + Children)

– As the vertical space was increased to 18ft, we got little relaxation from the space constraint. This helped to have little bit planning and add various desirable spaces into the house.

– The bathroom and kitchen came inside the house. An additional bathroom on the first floor was also thought about.

– The bedding, living space, kitchen and the toilet space were given in the first floor itself.

– Even after adding the desirable spaces, we could identify spaces which were not used. This helped to add more things into the house.

– Convertible furniture idea came into the scene, so that same space could be used in multiple ways.

– Separate washing sink was given, which comes below the first landing space of the stairs, the sink could be pulled out like a drawer.

– The first floor was given majorly for the younger couple for their bedding and work space. considering the privacy they need.

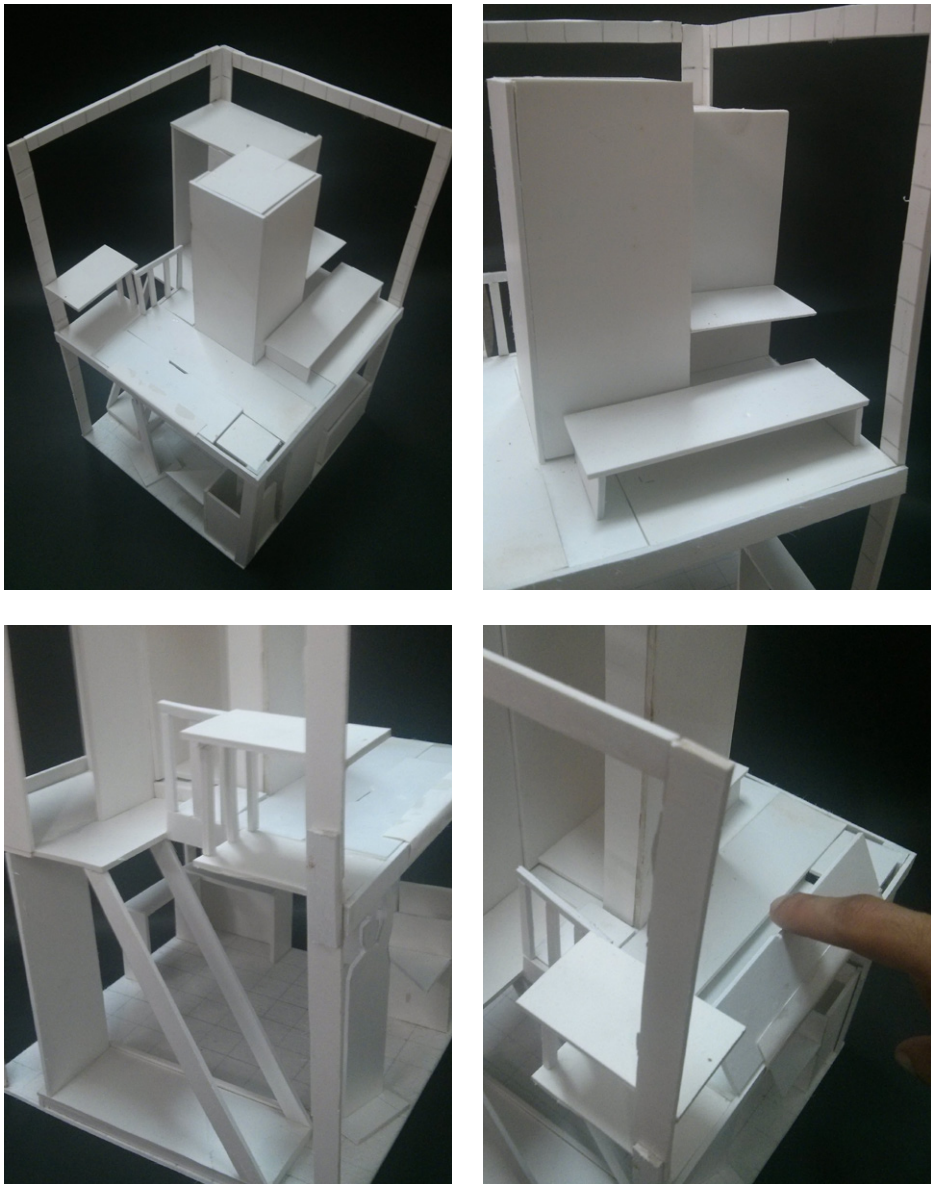


Fig 18. *Foam board mockup (in clock-wise from top-left)1.Full model ; 2.Study and sleeping space 3.Parents sleep area under stairs; 4.Flip open sleep area.*

Concept 5 - 10'x10'x18'

(Couple + Children)

– Taking the height to 18' gave more volume to explore and more emphasis was given to planning of the space.

– Sleeping and study area for children could be separated from other spaces.

– Bathing (3'x4') and toilet space (3'x3') was again separated and shifted to upper level as these were spaces that had an occupancy time less than 4 hours a day.

– The space under stairs was converted into sleep area for parents.

– TV kept in such a way that it could be viewed from kitchen as well as living space and sleeping space.

– Flip open bed space was added, so that the same space could be used for additional activities when not in use.

Fig 19. *Foam board mockup (in clock-wise from top-left)1.Full model ; 2.Toilet space at level 1; 3.Kitchen space at level 0; 4.Height clearance.*

Concept 6 - 10'x10'x18'

(Couple)

– An exploration in the vertical axis was really possible when the height was extended to 18ft.

– More levels came into play with each of them having its own specific functional aspect.

– It was more free to play with intermediate levels, which would increase the efficiency in a certain way.

– More activities could be taken into consideration.

– The levels were designed in such a fashion that each level is needed only when there is a growth in the family or when the family felt the need of it.

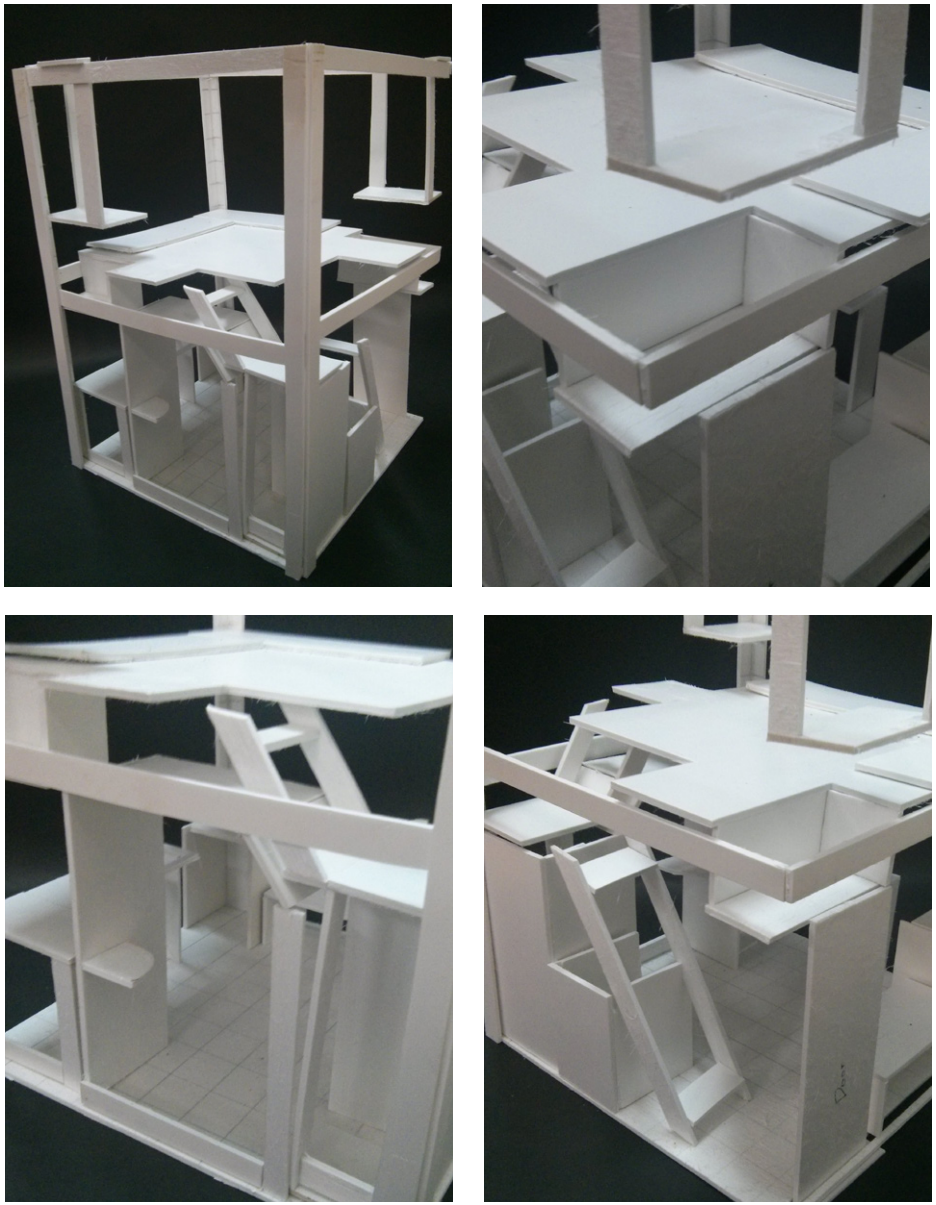


Fig 20. *Foam board mockup (in clock-wise from top-left)1.Full model ; 2.Study space; 3.Toilet space under stairs; 4.Washing area under stairs*

Concept 7 - 10'x10'x14'

(Couple + Children)

– By taking the clearance down from 18' to 14 ', care was given to contain all the activities in the reduced volume.

– Sleeping and study area for children could be separated from other spaces. Study space was done in such a way that the floor itself could be utilized as the seating space.

– Bathing (3'x4') and toilet space (3'x3') was combined together and kept under the stairs.

– The leftover space under stairs was used to contain the washing machine.

– Positioning of staircase directly in front of the entrance gave possibilities of giving the upper space for rentals(a practise often followed to get additional income).

Fig 21. *Foam board mockup (in clock-wise from top-left)1.Full model ; 2.Toilet space; 3. Open area; 4. Ledge sleeping space*

Concept 8 - 10'x10'x13'

(Couple)

– The exploration did with levels in the 18ft height layout was helpful in the case of 10’ x 10’ x 13’.

– The clear ceiling height for the ground floor was more wherever there was a bed. This vertical space was used to accommodate the fan.

– To accommodate 6 members in this volume, a bed space was given on a ledge at the extreme top, which is accessible through a small ladder.

– The flexible open space was given as it is.

– Enough storage space and a proper study area were also considered in this particular unit.

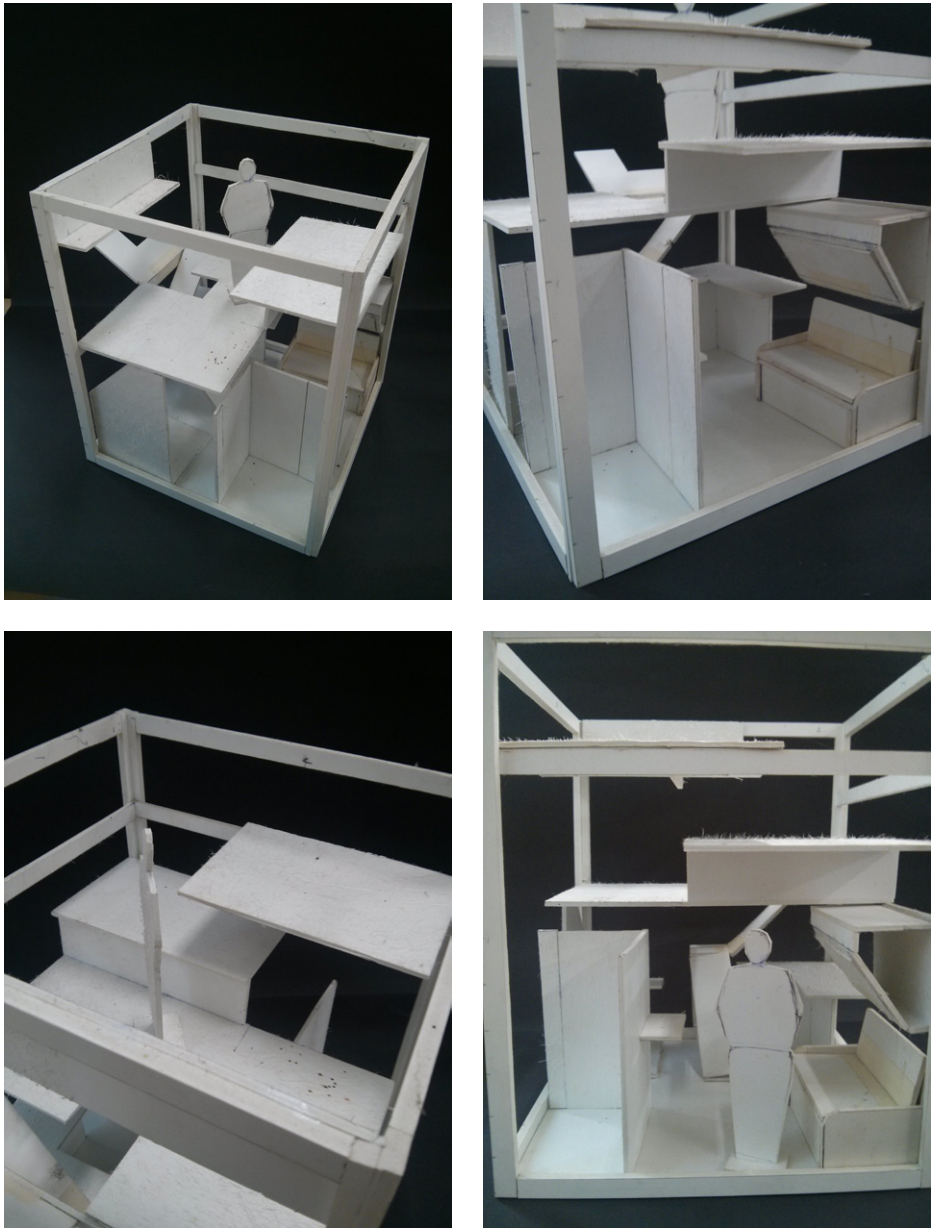


Fig 22. *Foam board mockup (in clock-wise from top-left)1.Full model ; 2.Open area; 3. Ledge sleeping space; 4. Living space*

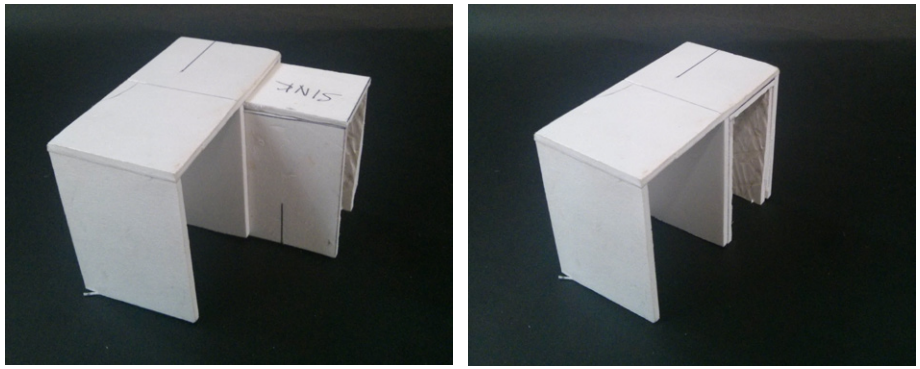
Concept 11 - 10'x10'x12.5'

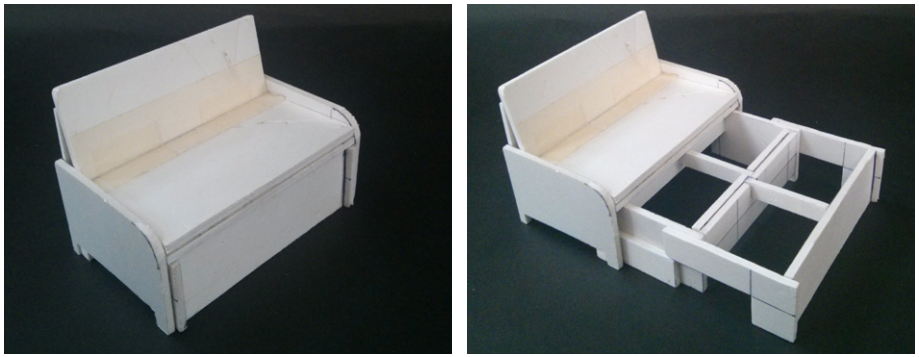
(Couple)

– The open space given came very handy and spacious when two mirrored units were combined.

– This layout is a culmination of what was done in the previous layouts.

– The layout has the incremental capability and could accommodate all the 6 members of the family.





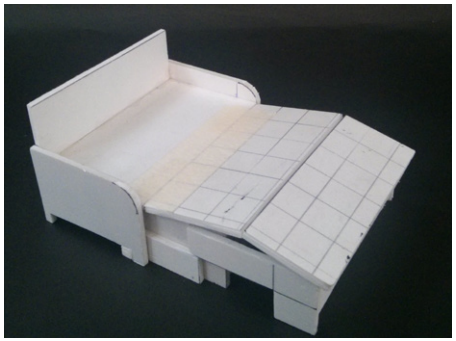


Fig 23. *Kitchen sink (Top 2); Seating space to bed space concept1 (bottom 3)*

Further to the exploration of space, various options were looked up on for multiple usage of the same space through:

- Convertible furniture
- Vanishing spaces
- Spaces underneath furniture
- Movement of furniture

Convertible furniture

Several options for having convertible furnitures were thought of, which could be easily manufactured. Some of the ideas were to have:

The kitchen unit

Initial ideas of the kitchen unit was to have a mobile kitchen table unit including the wash sink. The wash sink comes as a separate unit which could be purchased independently and attached to the kitchen unit such a way that it could be pulled out from below the countertop

Seating space to Bed space - concept 1

A sofa of 4ft width which could be converted to a 4'x6' bed. The idea was to combine and utilise the same living space as a bed space for the elderly. The legs of the sofa could be pulled out and the seating pad along with the backrest could be unfolded to make a bed. The idea was to make all moving parts with normal hinges and the drawer slider.

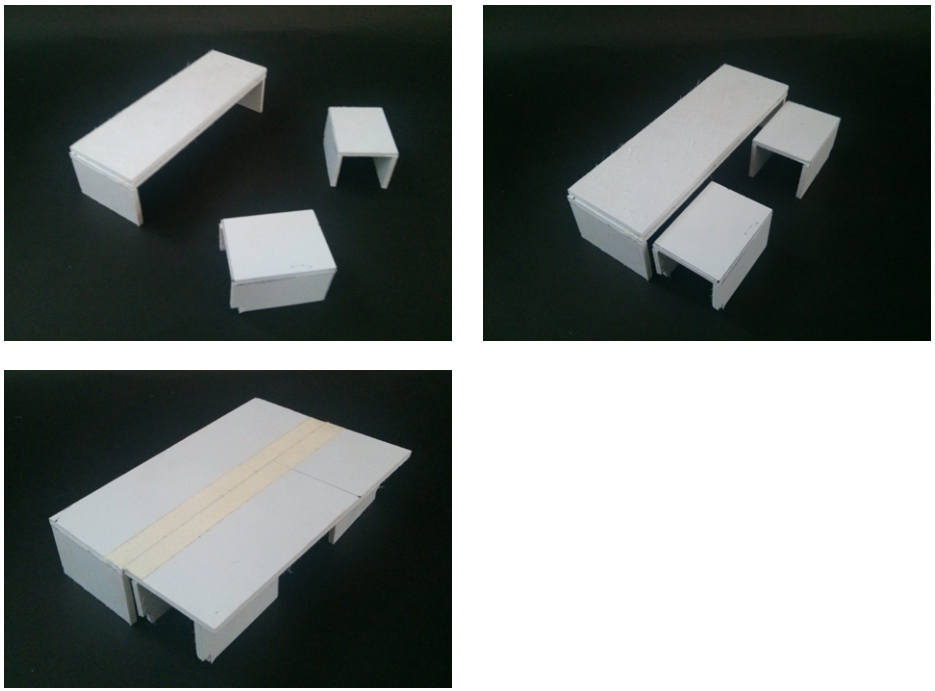


Fig 24. *Sofa to bed convertible*

Seating space to bed space - concept 2

Here a 6ft sofa along with two single 2ft chairs could be arranged in certain way to form a bed. The two single sofa could be stacked below the main sofa when not in use, which helps to reduce the space usage. one of the main advantage of this was that, the same furniture could be used as a Single bed, Double bed and a living space sofa set.

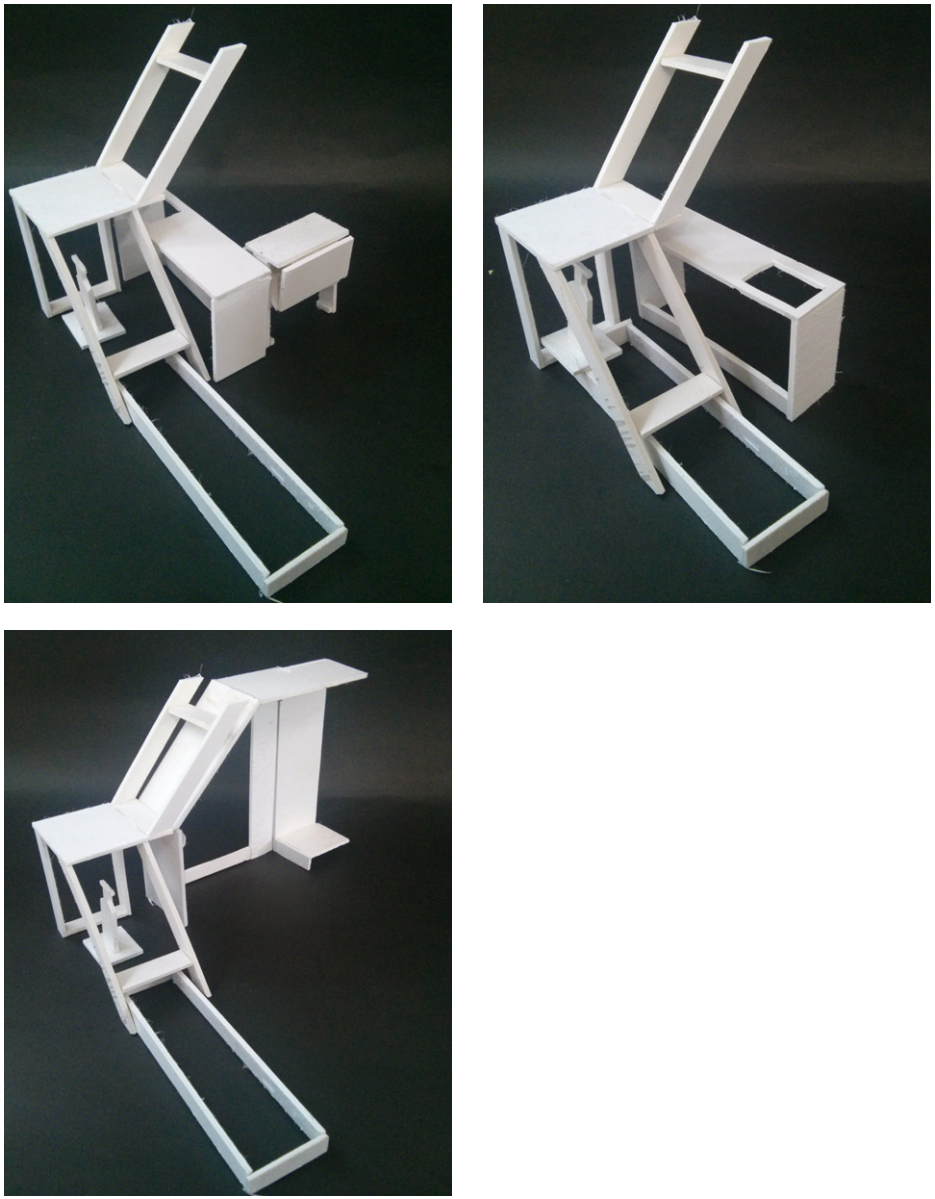


Fig 25. *Usage of space underneath stairs (Clockwise from top-left)1&2. Kitchen and gas cylinder; 3.Toilet space*

Spaces underneath

An exploration was done to utilize spaces that were left unused underneath furniture. This led to identifying possibilities of using space underneath stairs for various activities:

– Gas cylinder is one object that needs replacement once in a month, and thus need not have frequent access to it. This also enabled putting the kitchen space under stairs.

– Sleeping space, when constructed in a pull out form could also be accommodated under the stairs.

– Considering the minimal time spent in bathroom space in comparison to other spaces, it could also be positioned under stairs.

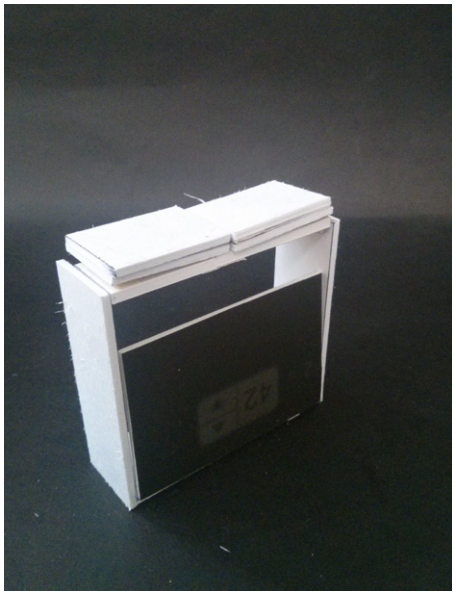


Fig 26. *Bathroom in a suitcase*

Bathroom in a suitcase

– The idea of ‘bathroom in a suitcase’ came through this task.

– ‘Bathroom in a suitcase’- A 3’ x3’ bathroom space which can be knocked-down to fit in a 3’x1’ box.

– Even though the total volume is 3’x3’x6’4”, it can accommodate a toilet, bathing space, a washbasin and even a cupboard space.

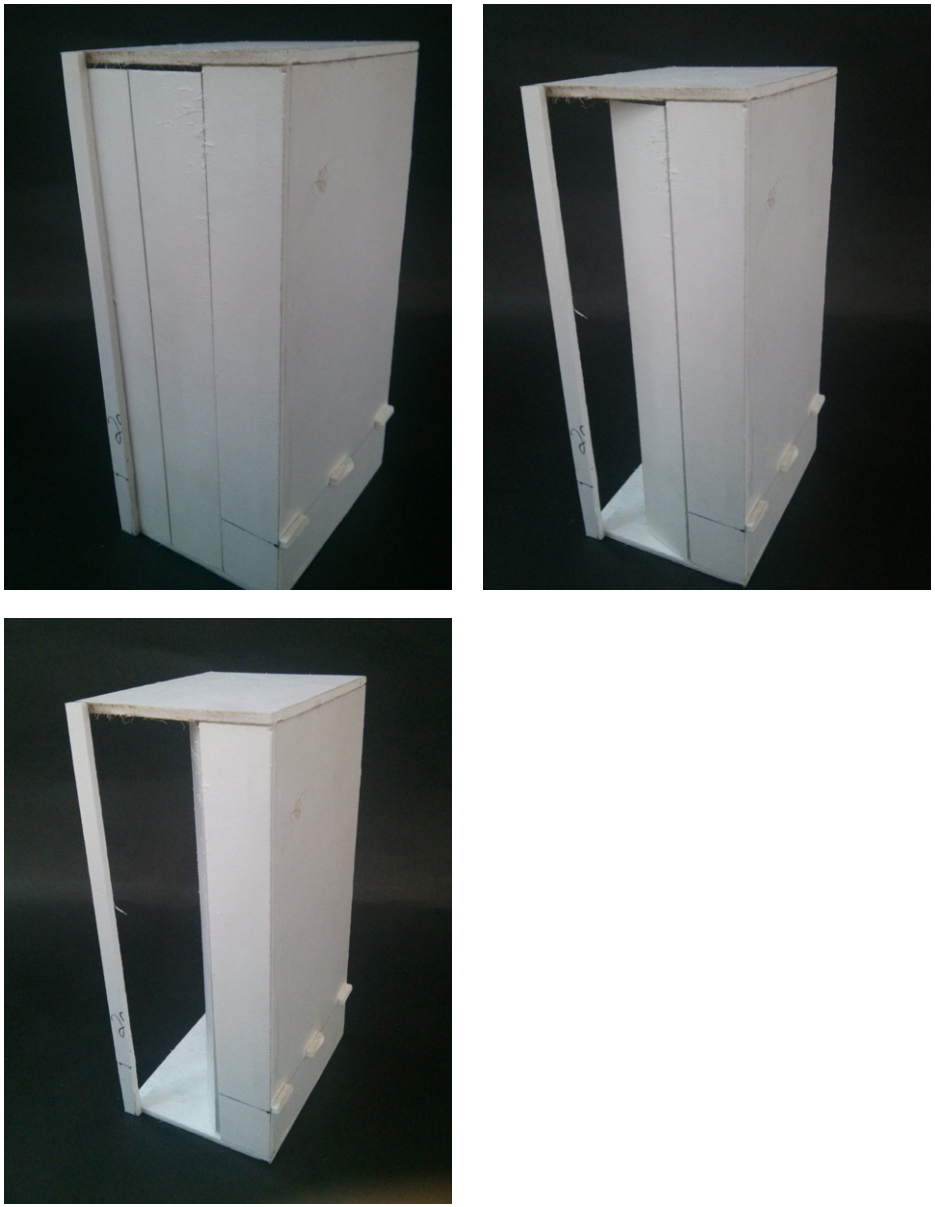


Fig 27. *Door closing*

Door movement

As the toilet space is very limited, the doors were given special consideration to make it space efficient. The doors were initially considered having double hinge. One at the wall and the other at the middle of the door. So the door folds twice, reducing the span of rotation, which gives enough space for the user to go inside and close it.

Extended exploration

1. Layout Drawings

Detailed drawings of the various layouts of the house were made to explore and find out unused spaces and figure out better alternatives. With the proper dimensions in place, it was easier to visualise the space occupied by each unit.

Drawings were made for each incremental stage, therefore, it was possible to forecast how the internal developments would happen.Each layout was evaluated and compared against each other.

Changes were made after initial discussions within the team based on which the life size structure was made.

Concept 1

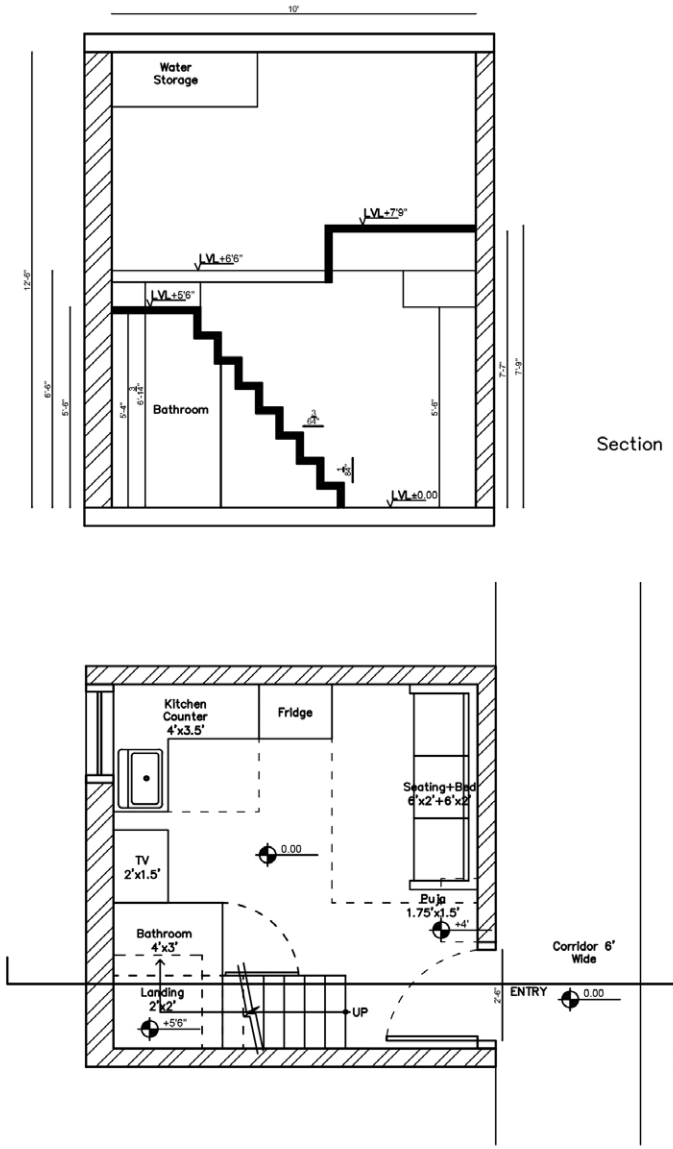


Fig 28. *Layout - Concept 1 (6 members)*

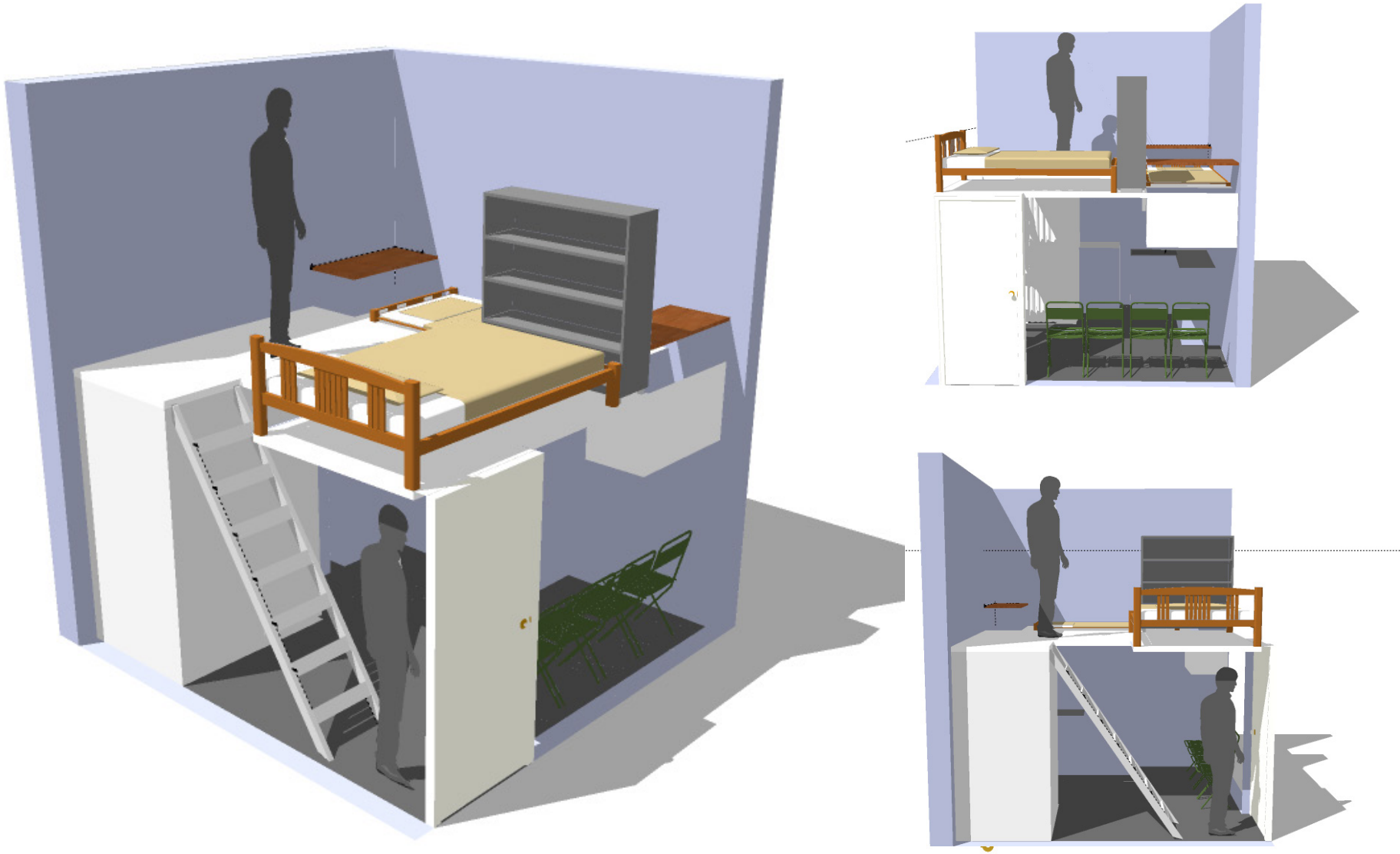


Fig 29. *Visualization of Concept 1*

Concept 2

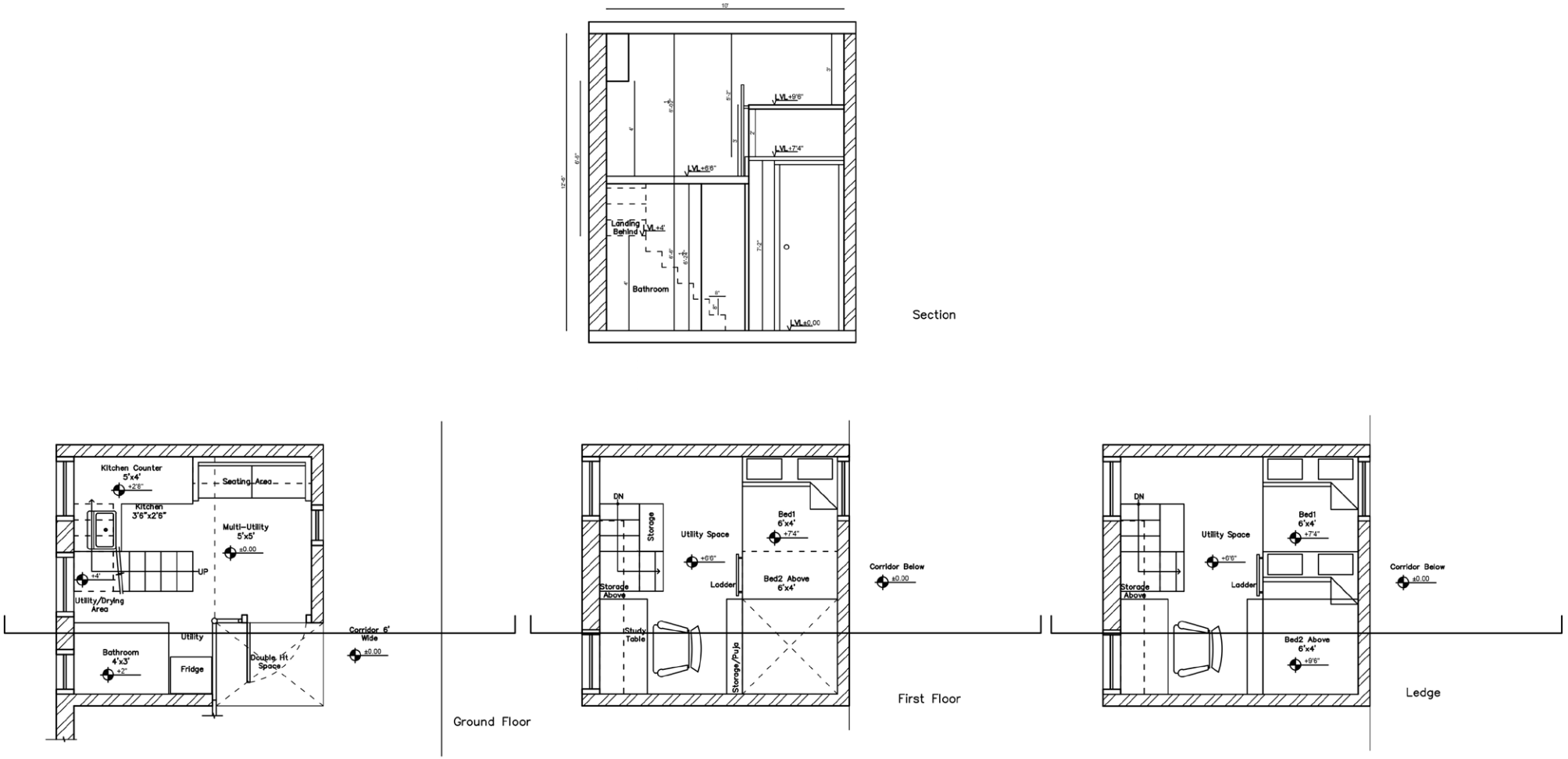


Fig 30. *Layout - Concept 2 (6 members)*

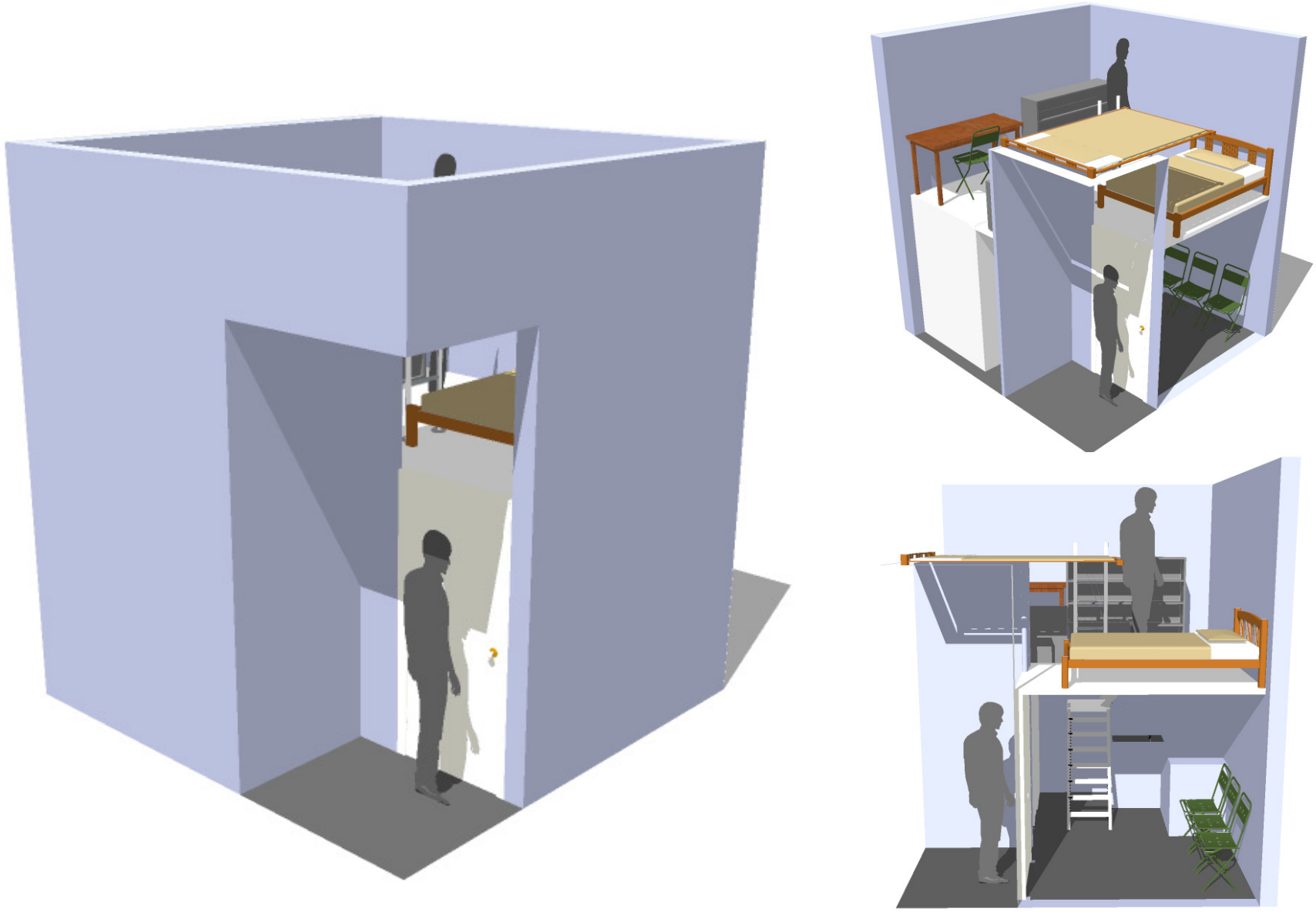
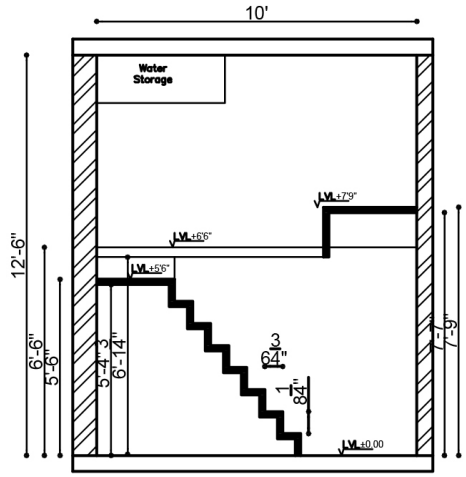
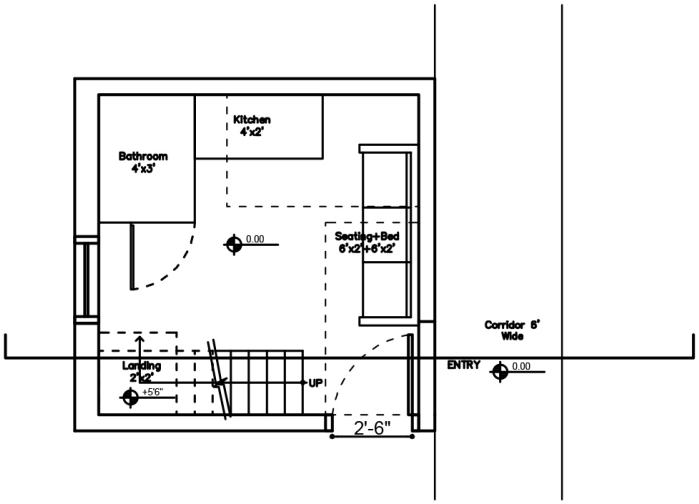


Fig 31. *Visualization of Concept 2*

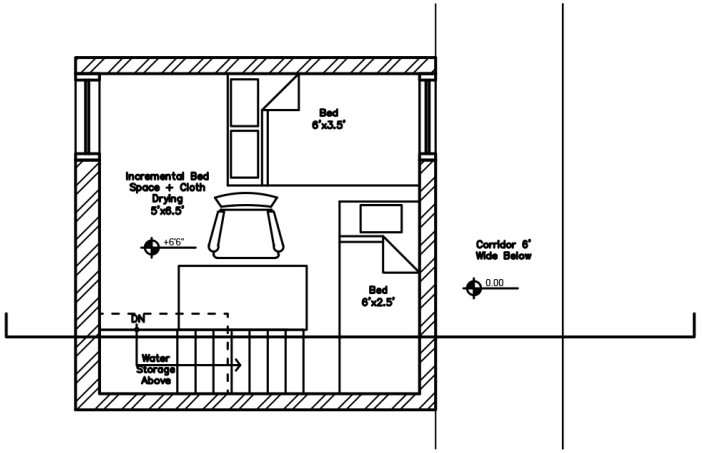
Concept 3



Section



Ground Floor



First Floor

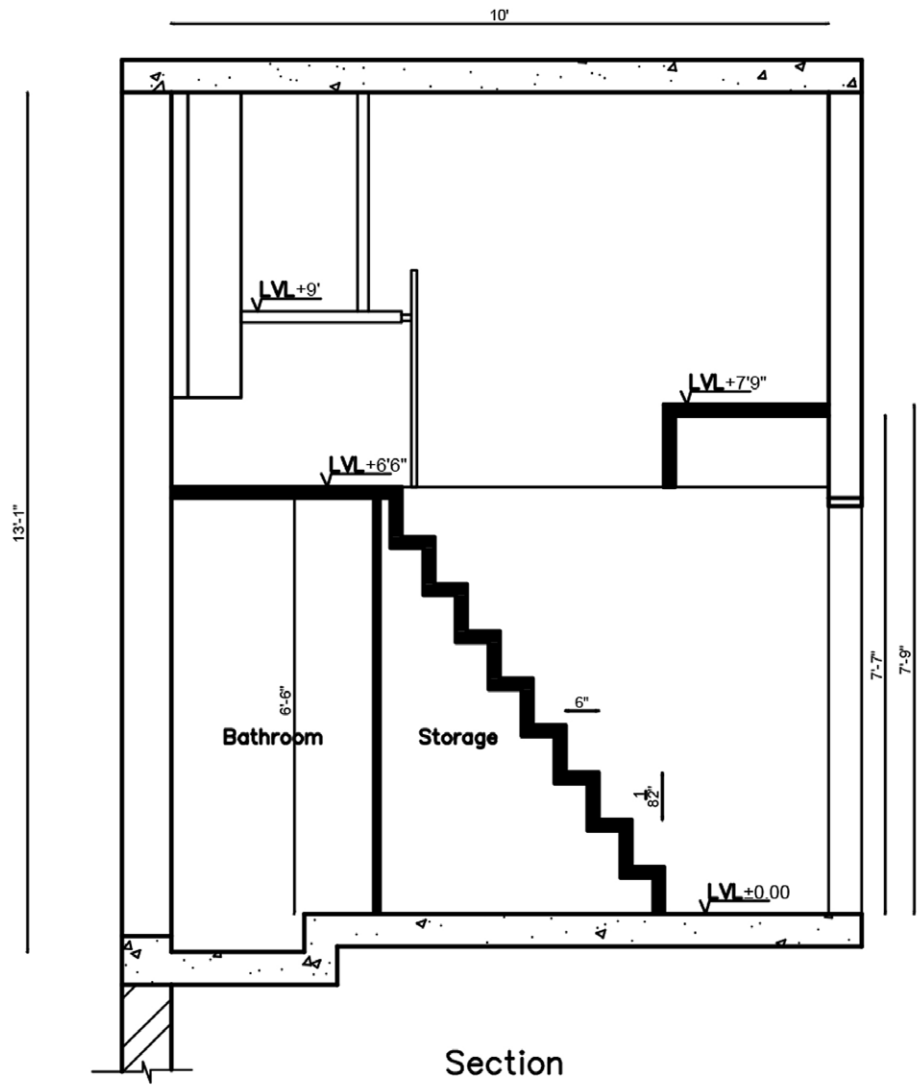
Fig 32. *Layout - Concept 3 (6 members)*

Fig 33. *Visualization of Concept 3*

Life size model

In order to understand and experience the volumetric constraints, a life-size model of the housing unit was built. With the completion of the built model, it was possible to explore and find each and every un-utilised space. The possibilities of further increasing the space efficiency and also figure out ways and methods to negotiate within this constrained volume was analysed.

While building with one of the layouts in mind, new opportunities of effective space utilisation were discovered and they were taken ahead to form a new layout altogether. The new layout (Fig.34) is as follows.



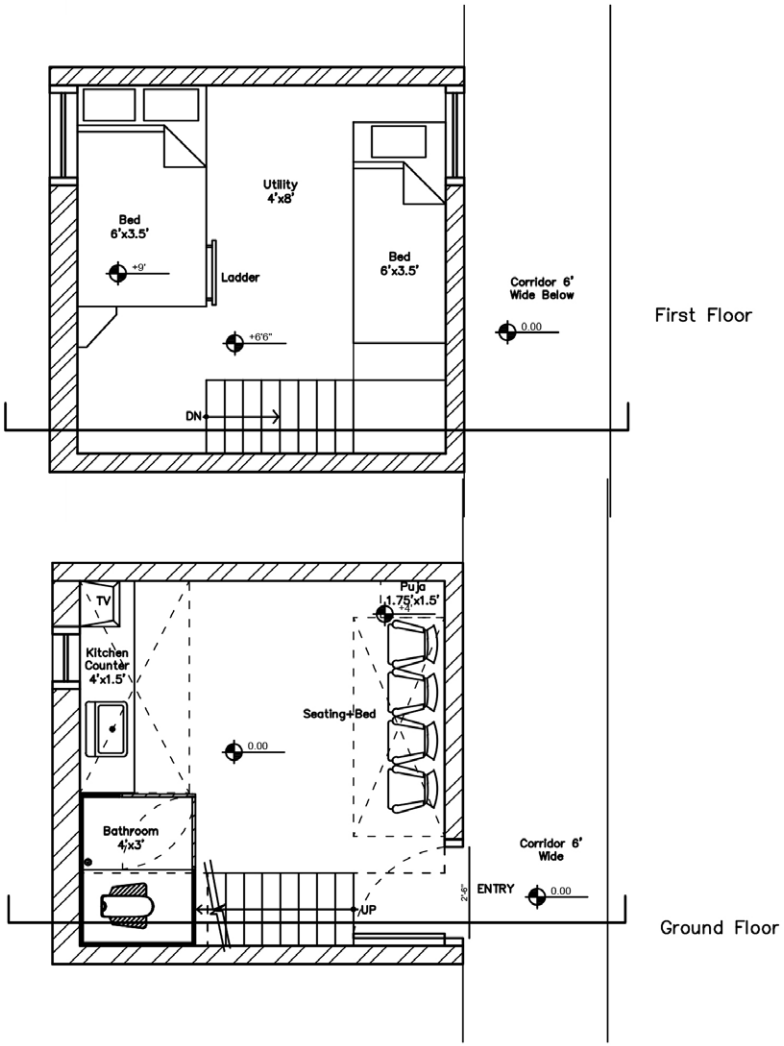


Fig 34. *Modified Concept 1 layout chosen for life size simulation*

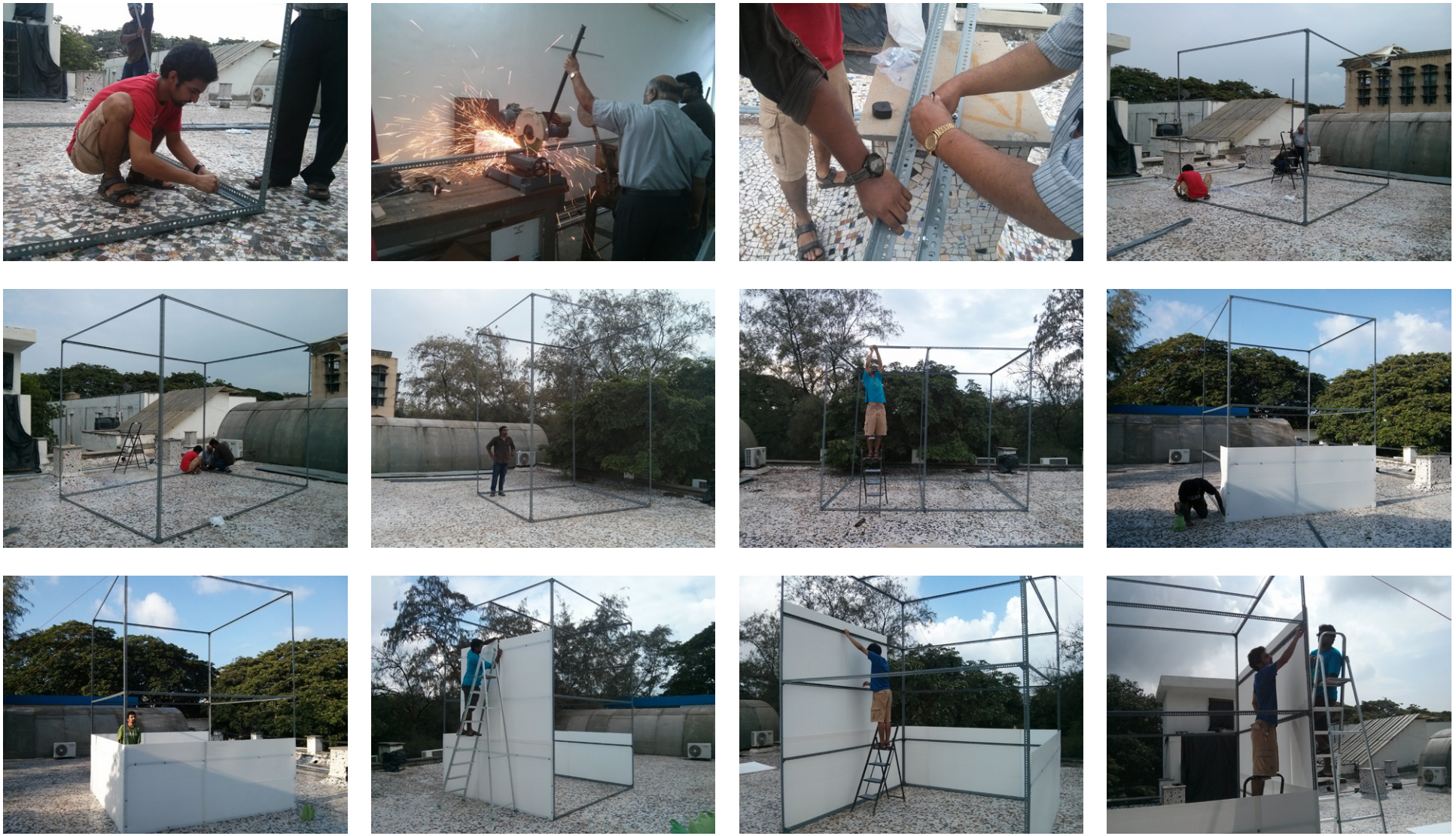


Fig 35. *Building life-size model frame*

Fig 36. *Building life-size model frame (contd.)*

Fig 37. *Building life-size model frame (contd.) - construction of upper level*

Populating the space

The life of the people living in was simulated in the life size structure. The space within was populated with artefacts and materials to simulate the daily life. This helped in calculating the volume taken by actual home appliances, utensils and other articles. It was now easier to visualise how much space is occupied by the articles and how much space is left out for people to live. The living inside the space was also simulated using 6 occupants to understand the usage of space during maximum occupancy.

Fig 38. *Populating the space with furniture.*

Fig 39. *Simulating living inside the space.*

Kitchen space

Exploration of kitchen spaces started during the exploration of vanishing space, concentrating on kitchen sink as a unit that could be manipulated based on time based usage.Activity analysis also indicated regular usage of the kitchen space, and its importance in the incremental stages of a persons life. The importance increases as soon as the person gets married or he brings his parents to the living place.

During the initial explorations using mock up models, it occurred that kitchen coming in close proximity of toilet+bathroom space had added advantages in case of plumbing system. This could be optimised further if the same kitchen sink could be used in both spaces according to time based usage. Further to these, existing kitchen spaces were studied to identify problems in current usage of space and how the space could be designed in such a way that it would cater to both working women and housewives. These were the ideas behind the initial concepts, which are explained in the next section.

1. Design brief for Kitchen space

To design a prefabricated do-it-yourself kitchen space for the affordable housing unit. The design should cater to the following features.

– Easy to assemble and disassemble onsite with easily available tools.

– It should utilize both vertical and horizontal space in the maximum efficient way.

– The space should be incremental in nature.

– It should provide room for user to populate the space their own way, scaling down the compromises in the current scenario.

– It should provide provision for utilizing the floor whenever needed for preparation of food.

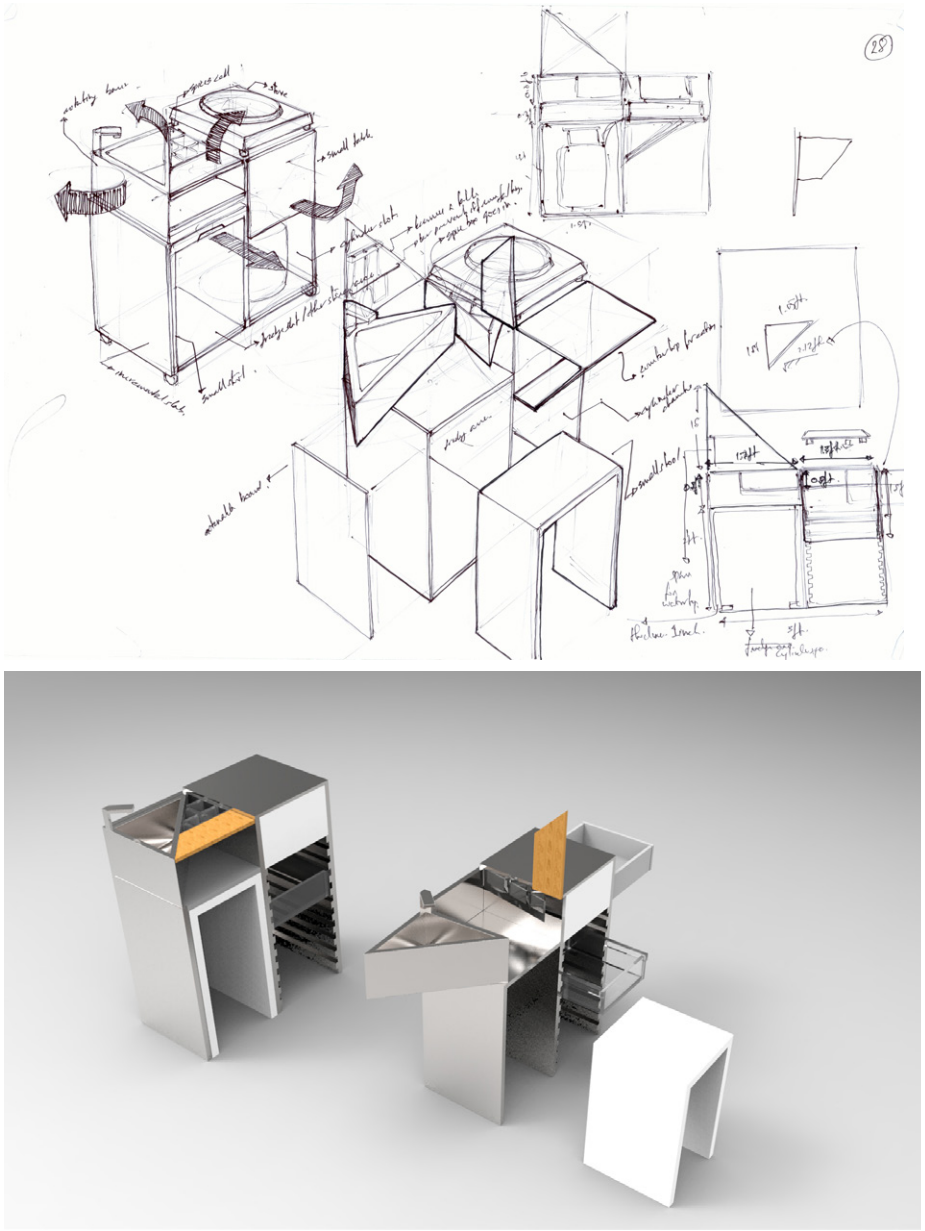


Fig 40. *Concept 1 sketch(Top);Concept 1 render (Bottom)*

1. Concepts

1.1. Concept 1

The focus here was to use minimum space to contain the accessories needed for cooking. The design ideas came as an offshoot of various micro kitchen cabinets that were used when kitchen spaces were minimum, especially in micro apartments and trailers. The space was designed considering the accessories that could be used in Indian scenario

– A space of 1.5'x3' was used to contain washing space, cooking space and storage space. The height of the furniture was kept at 2'8".

– The sink could be rotated to the bathroom side as and when needed.

– The shape of the sink was kept triangular as it use the minimum area, providing for usage of rest of the spaces for storage and preparation.

– Dedicated space was given for cooking gas and storage of utensils.

– The countertop was designed to accommodate a single burner stove.

– Provision was given for a pull out stool or a pull out countertop extension.

Feedback

– Complex movements
– Less usage of vertical space
– No space for double burner stove
– A non-affordable solution

Fig 41. *Concept 2 sketch(Top); Concept 2 render (Bottom)*

1.2. Concept 2

The focus was to minimize the space further, but still having enough space for containing the accessories. Various possibilities of storage of utensils were considered in this concept.

– The space utilization was minimized to 1.5'x1.5'(keeping the height at 2'8") to contain the washing space, cooking space and storage space.

– Rotating portion of sink was maintained, with an added flap that could cover the sink. This enables usage of the full space when kitchen sink is not in use.

– The single burner was kept in a slide out rack that could be brought out when needed.

– Dedicated space for the gas cylinder was maintained and the stool was accommodated in the same space.

Feedback

– No space to accommodate Kerosene stove

– Slide out options can complicate the things

– The triangular part is an obstruction for easy movement

– Complex in terms of storage options

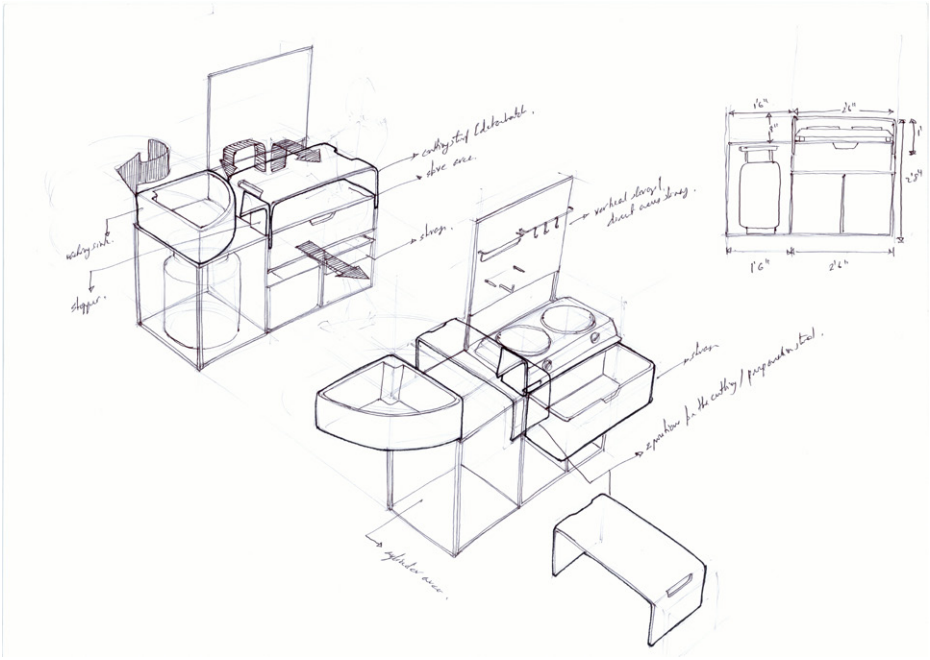


Fig 42. *Concept 3 sketch(Top); Concept 3 render (Bottom)*

1.3. Concept 3

Based on the earlier feedbacks and discussions with the affordable housing team, the focus was shifted to enable the usage of kitchen space and floor space alike for cooking/preparation. It was noticed that using floor space while cooking, especially in case of time consuming works, was a regular practise among women.

– The kitchen floor space was increased to 1.5'x4'(height kept at 2'8"), to provide for a bigger countertop that can accommodate a double burner stove.

– Kitchen sink was provided a curved contour, so that it could be rotated without obstructing other spaces.

– A pull out countertop cover that could also function as a stool, when utilizing the floor space for cooking.

– Vertical storage of utensils.

Feedback

– Rotation option can become boring on frequent use.

– Vertical space could be used more

– Necessity of a countertop in all scenarios

Fig 43. *Concept 4 sketch(Top); Sink and countertop render (Bottom)*

1.4. Concept 4

The focus was shifted to simplify the design and provide minimum space that is needed, beyond which they could populate the space themselves. The spaces were also split based on necessities and desirables. Usage of vertical space was considered rather than restricting the design to horizontal space.

– The space was split into Kitchen sink part(necessary) and counter top part(add-on).

– A 1.5'x2' was used for the sink part and a 2'x2' space was used for the countertop (.5' added for safety purpose).

– The sink part was cantilevered so that it becomes a static entity and the countertop becomes a movable entity.

– Left out spaces after occupancy of the sink was used for easy access storage options.

– Trap position in sink shifted to leave out maximum area for storage.

– Water storage can and plate racks positioned above the sink to account for dripping water.

– Vertical rods to hang utensils.

– Space left out for the people to populate.

Feedback

– The countertop could be a knockdown one than a welded piece

– Access to vertical storage above the kitchen space.

– Provision for user to populate the space.

2. Evaluation criteria

Concepts were evaluated based on the following criteria:

- *efficient usage of space(vertical and horizontal)*
- *Ease of access*
- *simple and efficient in terms of components*
- *Options for storage*
- *Options for the user to populate the space*
- *Ease of assembly and disassembly*
- *Easy to manufacture.*

Based on the evaluation criteria, all the alternatives were analysed and concept 4 was taken further ahead for refinement, mainly because of its simplicity in terms of components, efficient usage of vertical space and ease of manufacturability.

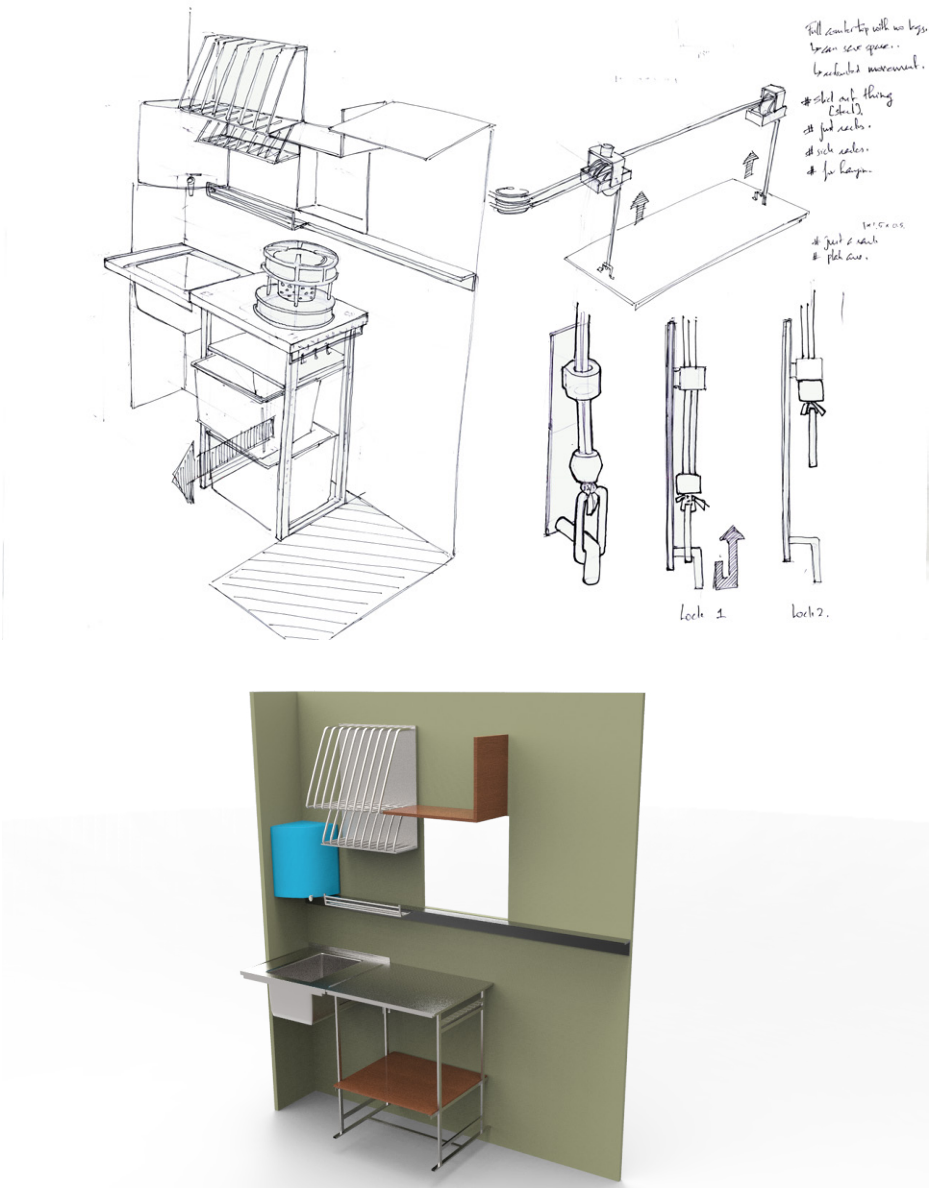


Fig 44. *Concept 4 refined sketch(Top); concept 4 render (Bottom)*

3. Concept refinement

The concept 4 was further refined to better the utilization of vertical space and possibilities of converting the countertop into a knock down furniture was considered.

– Sink space and countertop space extended to 1’8”x2’.

– Mesh(static or pulley functioned) positioned above the kitchen space so as to increase the storage options.

– Other storage options like rack and water storage was incorporated into the horizontal structural member.

– Space left out for people to populate themselves and provisions were also given to accomodate TV near by the kitchen space.

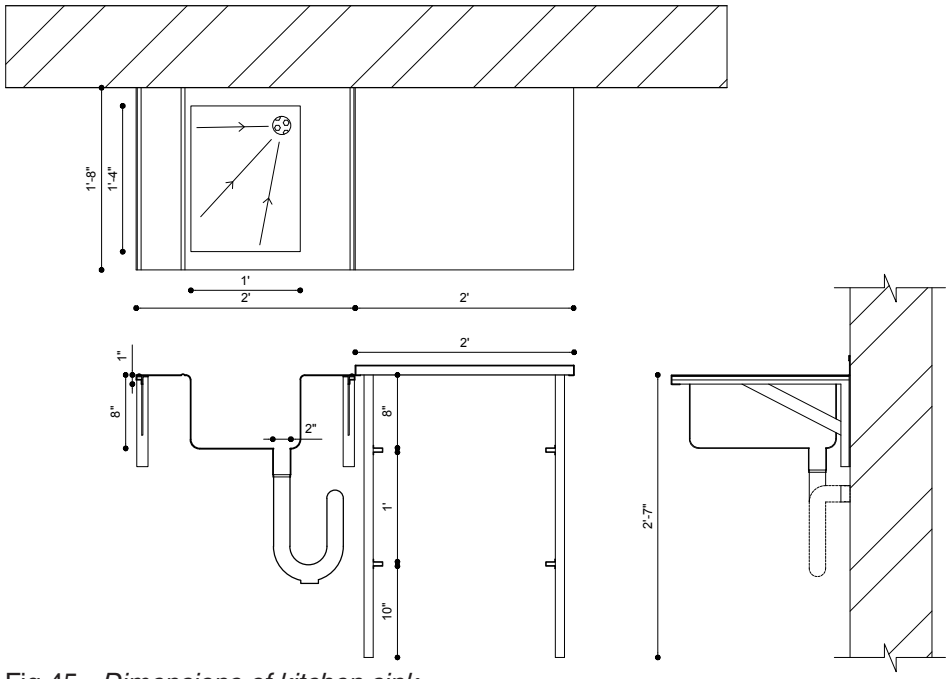


Fig 45. *Dimensions of kitchen sink*

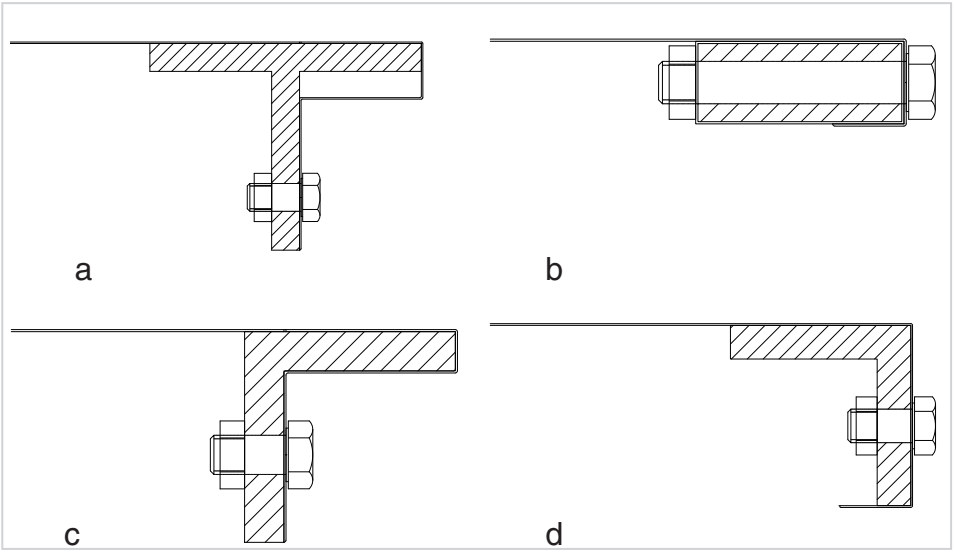


Fig 46. *Joining details of cantilevered beam and sink*

4. Concept detailing

4.1. Sink part

Material

Stainless steel was chosen for the kitchen sink during material research as that appeared to be a well accepted material among the community, at the same time durable and robust in nature. The initial investment might be higher in the case of stainless steel furniture, but the bigger lifespan of the material compared to other furniture makes it an affordable choice.

Strength

The strength was taken care of by incorporating ridges near the sink part, which could also function as a separation for storage area.

Support member and connection

Support member is a cantilevered piece that is bolted to the wall. The section was chosen after detailing out the bolting in such a way that it (the bolt) stays hidden. The Fig.57 explains the different bolting options tried out, after which it was decided to use either a T-section or an L-section (a&c), which are locally available for the support member. It could be either mild steel or Iron sections.

Drain and P-trap

The position of the drain was shifted to the rear corner to reduce plumbing material at the same time provide space for storage options. The P-trap was oriented in a horizontal fashion so that the it uses minimum space in the storage area.

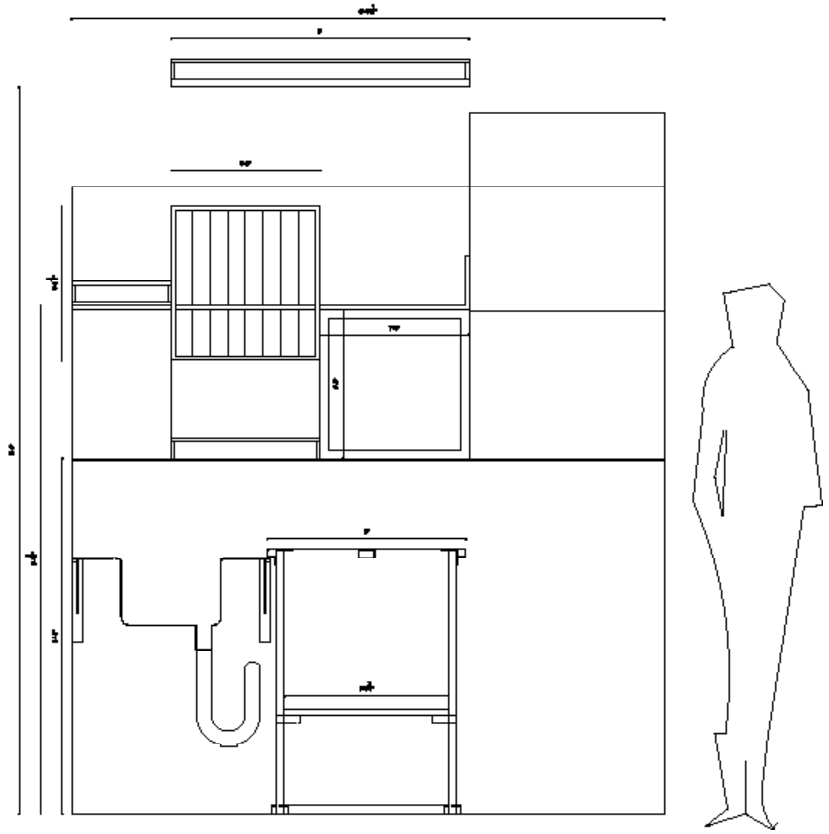


Fig 47. *Kitchen space dimension details*

Mesh

Mesh provided for use for vertical space above the kitchen, functioning as a hanging storage. This could either function as a static entity, which could be reached through using a stool or as a pulley system that could be brought up and down as and when needed. The top part of the mesh functions as a storage option that could be accessed from the upper level.

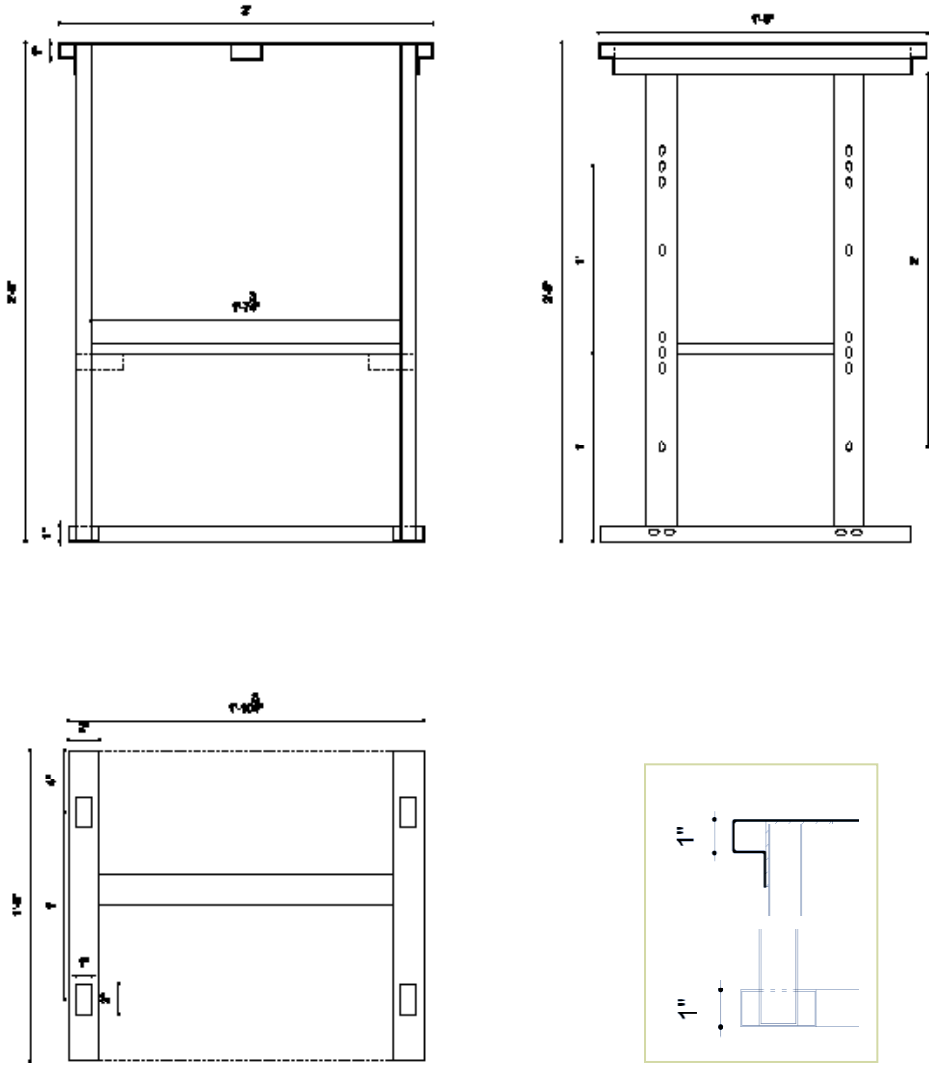


Fig 48. *Kitchen countertop details*

4.2. Countertop

Material

Various material choices included Laminates, Slate, Marble, Concrete and stainless steel. Of these except for laminate and stainless steel, others were non-industrial materials. Laminates, even though affordable and having better customizable options, had a less lifespan compared to stainless steel. This made stainless steel a better option considering its life span, durability and acceptability among the users.

Knockdown details

The countertop was designed to be easily assembled and disassembled by the user himself. It was divided into 3 parts, all planar, which makes it easy to store and transport:

– Countertop : Stainless steel sheet of 1mm with a half hat edge(similar to the kitchen sink) with a welded L framed support member.

– Legs : H-shaped leg, with holes on the sides that provide for attaching area for racks and hooks. The leg is attached to an I shaped member that acts as the base.

– Base : I-shaped member with slots to bolt in the legs.

Countertop render

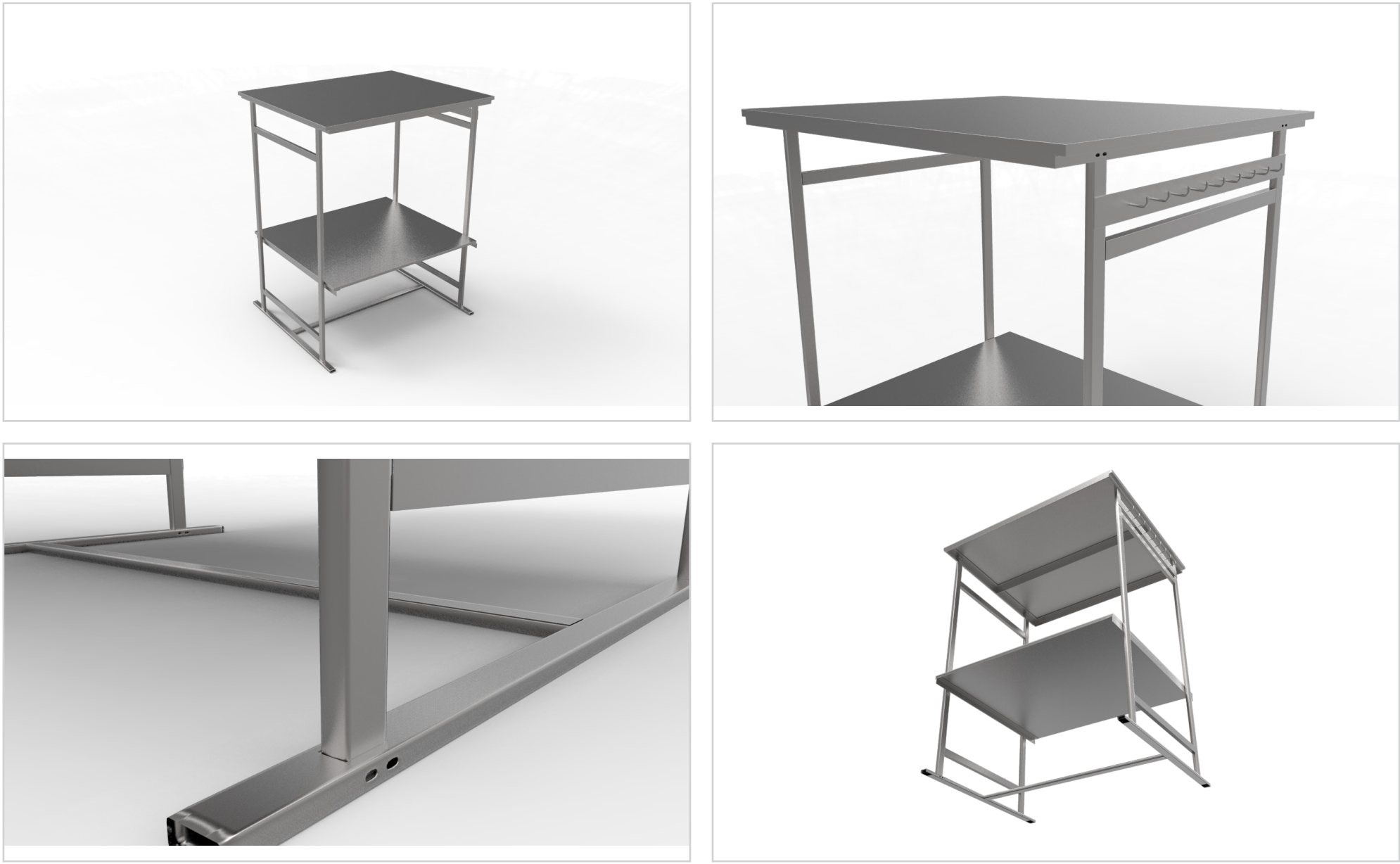


Fig 49. *Kitchen countertop details render*

Kitchen space render

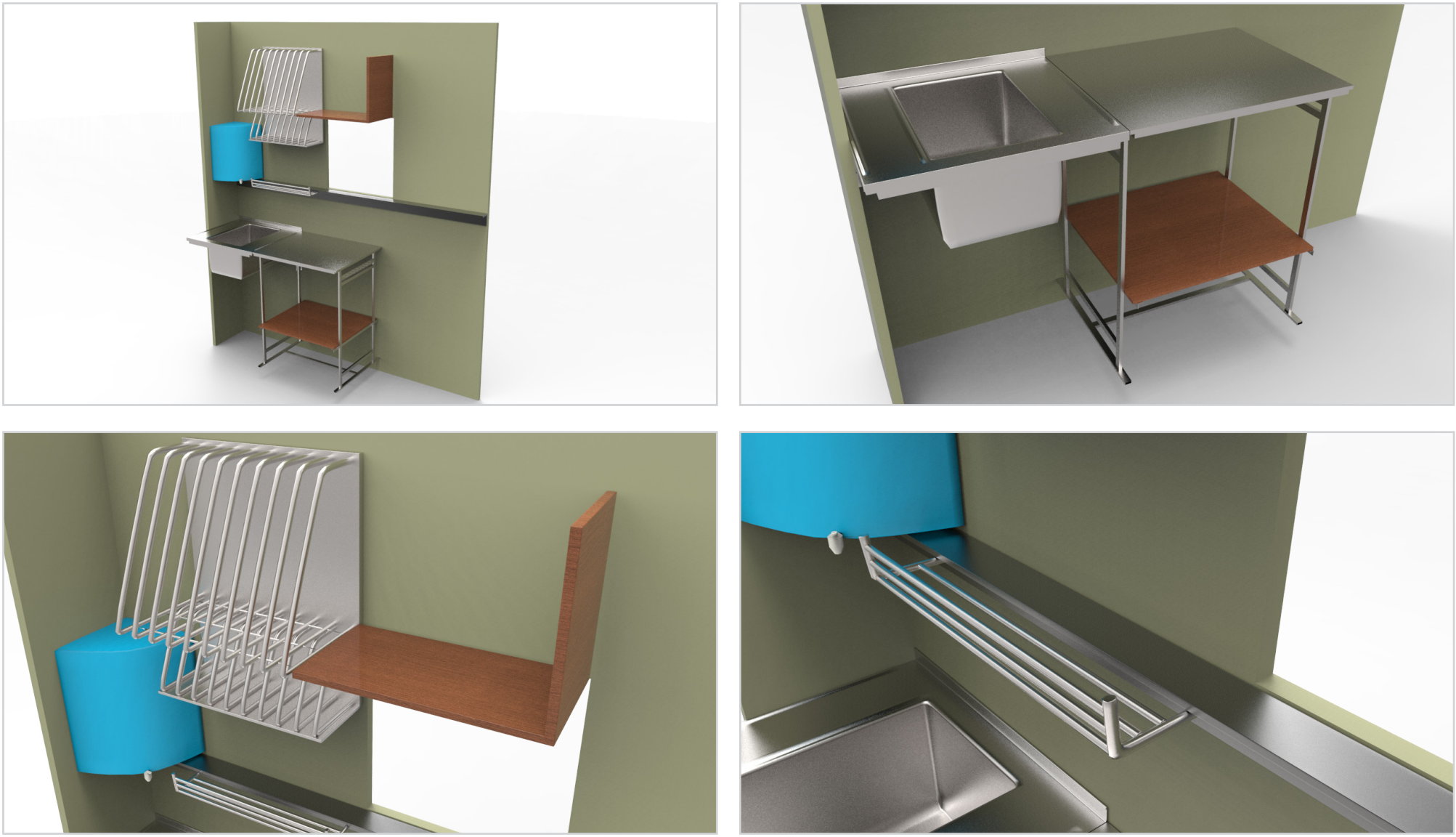


Fig 50. *Kitchen space render*

Material Research

The study of materials were done parallel to the design process in various stages. A good contact with various distributors and manufacturers were maintained through out the project to understand and learn about various materials available in the market. As the project zoom in affordability as the major factor, special considerations were given in choosing the materials for the furniture inside the house. After contacting various distributors, a final chart was made , which consisted of the market prices for various materials. After comparing the materials with its affordability and life span, the suitable material were chosen for the final design. The various cultural issues and user perceptions were also taken into consideration. Certain trade-offs had to be done in case of few furniture to suit the need of the project.

Flooring	Rate (per sqm)	Rate (per sqft)	Thickness	Rate (per running foot)
Bison Board	755.784	69.98	16mm	
Silver wood			12mm	100
Flooring wood			12mm	100
Packaging pinewood			12mm	155
Checkered aluminium sheet	1198.8	111	3mm	
Aluminium Honeycomb panels	1252.8	116	18mm(core)	
Stainless steel				
Toilet Flooring	**Rate (per sqm)**	**Rate (per sqft)**	**Thickness**	**Rate (per running foot)**
SS				
SS (0.6mm) +Ferrocement				
Toilet Partition	**Rate (per sqm)**	**Rate (per sqft)**	**Thickness**	**Rate (per running foot)**
White Acrylic	162	15	12mm	
PVC roofing sheet	199.584	18.48		
Corrugated PP (Bubble honeycomb)	253.8	23.5	4mm	
Phenolic laminate board	287.28	26.6	3mm	
Sun Mica Laminate	388.152	35.94	6mm	
Extruded PVC sheet	540	50	4mm	
Compact grade Laminate	572.4	53	3mm	
Wired Glass	648	60		
Polycarbonate corrugated sheet / Lexan	1026	95	10mm	
Solid PP	1652.4	153	10mm	
Toilet pan lid	**Rate (per sqm)**	**Rate (per sqft)**	**Thickness**	**Rate (per running foot)**
Aluminium Honeycomb panels	1252.8	116		
Extruded HDPE	1998	185	20mm	
Solid HDPE				
Solid PP				
Polycarbonate Solid sheet	4320	400	12mm	
Kitchen Countertop	**Rate (per sqm)**	**Rate (per sqft)**	**Thickness**	**Rate (per running foot)**
MDF laminate	594	55	12mm	
Concrete				
SS (1 mm)				
SS + Plywood				
Marble				
Granite				

Fig 51. *Material research*

Protoyping

A life-size prototype was fabricated in order to get a first hand experience of the actual built environment. All the individual units were assembled and fixed inside. This showed how each unit was integrated with the other.

The prototype gave us a real-time knowledge about the ventilation and natural lighting inside the house. The colour scheme was chosen (dark blue for structure and light blue for walls and olive green for certain furniture) such that it appeals to their taste. Familiar materials such as mild steel, packaging wood, stainless steel and plastic sheets were considered for furnitures inside the house. This helps in reducing the time needed for getting accustomed to the new environment.

The prototype was used for getting the user feedback and learn how the people respond to this optimal space consideration. More feedback is being taken to refine the data and make the changes accordingly.

Fig 52. *Row wise : Structural frame building (top); Kitchen table and sink fabrication (middle); Toilet base fabrication (bottom)*

Fig 53. *Protoype external view*

Fig 54. *Toilet when unoccupied (left); occupied (right)*

Fig 55. *Lower level - Bathroom, kitchen and living space*

Fig 56. *Upper level - Sleeping area, study, clothe drying area, storage*

Fig 57. *Taking feedback from users regarding the experience inside the house.*

User feedback

The prototype was evaluated based on inputs from actual users with respect to their experiences in comparison with their respective households. This would help in further refinement of the space design in future prototyping. Following were the comments pointed out during the feedback stage:

– *Extend the length of countertop to accommodate a gas stove and a gas cylinder.*

– *Their family (parents and relatives, say around 20 people) visit their home during holidays and birthdays. During that time they may require bigger utensils, therefore, storage space for the same is essential.*

– *The position of TV should be reconsidered as there will be a lot of fumes from the kitchen. Also, it would be difficult for the person who is working in the kitchen to watch the TV while working.*

– *There should be room for accommodating a steel almirah.*

– *The position for keeping the 'mandir' should be on the top floor.*

– *Instead of steel chairs, a sofa cum storage could be*

used, thereby increasing the storage space.

– Some people believe in 'vaastu' and they would prefer the main door to face east. This may not be possible in Mumbai.

– The family liked the multi-purpose bathroom.

– The multi-utility space in the bathroom will be difficult for using as a space for washing utensils or clothes since the since the usage of bathroom is not pre-determined.

– They would require continuous water supply for washing purposes.

– Usually they prefer to keep TV, fridge and shoe rack under the staircase.

– There is no actual need for two beds as it will reduce the space for children to play.

– Sleeping on floor is more prefered as there is no restriction in consuming space.

– The family appreciated the foldable table.

– They would not be subletting the space they have.

Design contributions and features

1. Affordability

The users of the product are people at the bottom of the pyramid with an average annual wage of Rs.90,000.

Achieved through:

1.1. Efficient use of floor space [FSI] and volume

In the current context, most of the floor space is utilised for storage. The storage spaces are inefficient and hence crowds the limited space available.

The new model promises efficient, multi-purpose and minimal usage of space.

– Convertible bathroom cum kitchen space

– Toilet cum bathing space

– Storage for the bathroom incorporated in the door itself

– Living cum bed space

– Different layouts possible with the same structural

members

– Flexibility for users to make changes in the layout as he wishes

– Efficient positioning of racks

– Bed raised to accommodate fans and increase ventilation and lighting

1.2. Incremental capability

In consideration to the sequential changes in a person's life, for example, marriage or having children, his requirements tend to change in an incremental fashion over a certain period of time.

– Keeping kitchen sink as a minimal option, the countertop can be added further for future upgradations

– Enough provisions are given on structural members so that the user can add non structural members according to the incremental need

1.3. Do-It-Yourself

In the present scenario, most of the people are dependent on few skilled labourers such as carpenters and welders for most of the construction works. If it is a do-it-yourself furniture kit, this dependency is reduced and the users are self empowered to build their own furniture system. There are some skills which he has and some which he does not. Current system is a mixture of the two; where there is a dire need of highly skilled labour, such as in fixing the commode of the toilet, he may have to depend on a skilled labourer but at the same time the user himself can fix the partition

of the bathroom.

– Knock down kitchen countertop

– Even though the user may seek the help of skilled labourers for installing the structural members, he/she can do the repair/ maintenance by himself at a later stages.

– The commode for the toilet has to be fixed by a skilled labourer but the panels/ partition and door can be fitted by the user himself.

Reduction in manufacturing investments.

– By being do-it-yourself furniture system, the manufacturers are converting each house into an assembly line of its products, thereby, reducing the overall capital input, manufacturing cost as well as product cost.

– On-site welding is completely avoided in the new modular structural system by standardising each component.

1.4. Low material cost

The materials are chosen after careful evaluation against various trade-offs, keeping the price per each square feet as the primary factor.

By accommodating more number of families in a much smaller area, the developer also would get a benefit by saving the precious land meant for the company's construction works.

2. Accommodation for migrants who are exploring jobs.

The housing unit would become a shelter for the new migrants who are in search of jobs in the city.

References

Fig 1: www.censusindia.gov.in/2011-Documents/Slum-26-09-13.pdf as on sept 30 2014

Fig 2: Affordable housing team photo archive

Fig 4: Affordable housing team photo archive

Fig 5: Affordable housing team photo archive

Fig 6a: http://www.airoots.org/wp-content/uploads/2008/05/socialnagardharavi-airoots.jpg as on Nov 2 2014

Fig 6b: http://www.trekearth.com/gallery/Asia/India/West/Maharashtra/Dharavi_Mumbai/photo1197368.htm as on Nov 2 2014

Fig 7a: http://mreverydaydollar.com/wp-content/uploads/2013/03/fencl-e1362883565172.jpg as on Nov 2 2014

Fig 7b: http://kristabeck809.files.wordpress.com/2013/04/tinyhouseecoliving.jpg as on Nov 2 2014

Fig 8: https://s3.yimg.com/bt/api/res/1.2/c6tnCqjSCnEMzOj2r5p_Ow--/YXBwaWQ9eW5ld3M7cT04NTt3PTYyOQ--/http://l.yimg.com/os/publish-images/finance/2013-12-16/a9e12c7b-48b9-480c-ba06-33668d193da7_NTI_CUBE_HOUSE_01-2-.jpg as on Nov 2 2014

Fig 9: http://i.huffpost.com/; http://3.bp.blogspot.com/- accessed on 20-10-2014

Fig 10: http://www.livinginashoebox.com/convertible-furniture-suitable-for/ accessed on 20-10-2014

End