



ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

Project-Thesis submitted in partial fulfillment of the requirement of MSc. Degree
in construction management technology teachers education

BEST ALTERNATIVE APPROACH TOWARDS FIXED INTERIOR PARTITION WALL BY MOVABLE WALL FOR CONDOMINIUM BUILDINGS

Project location - Addis Ababa, Ethiopia

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**May, 29, 2015
Adama**



Approval sheet

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By

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CANDIDATES' DECLARATION

We hereby declare that the work which is being presented in the Project-Thesis in titled “**Best alternative approach towards fixed wall by movable partition wall**” in partial fulfillment of the requirement of MSc. Degree in construction management technology teacher’s education is an authentic record of our own work carried out from April 2015 to Jun2015 under the supervision of Mr. Mekdim M. in the Department of Civil engineering in Adama science and technology university, Ethiopia.

The matter embodied in this has not been submitted by us and other for the award of any other degree or diploma. All relevant resources of information used in this project-thesis have been duly acknowledged.

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ABSTRACT

The current explosion of construction projects in Ethiopia are widely expanded throughout the nation which include infrastructures, agricultural, public, industrial and commercial buildings. Particularly in order to eliminate the housing problem of its citizens, Ethiopia is currently working many different housing projects in most towns, like Addis Ababa. In aggregate to this, real estates, apartments and condominium buildings are widely constructed. However, particularly in Addis Ababa, considering those who are low incomes population that could not construct their homes per the standard stated by the municipality office, the federal and the state government are constructing many low cost condominiums buildings. Almost all condominium buildings have similar design with different categories. As their design drawings show that the sizes of each room are too small to furnish standard furniture. In addition the interior wall of these building is fixed which do not allow any modification or flexibility. So considering such kind of problem the movable type of interior partition wall construction gives a freedom to the owner of the house to modify the size of the rooms as the allowed flexibility. Movable Partition walls are building units that are constructed internally and are normally used to divide a room in to the intended amount for the purpose of privacy, function and like. They are mostly made of light weight materials. The size, color, type and mechanism of such kind walls are determined by the principles considering the desire of the owner. Actually such kinds of building units are not new to this world, although not adopted commonly in Ethiopia. Most developed countries are constructing partition walls in order to divide their meeting hall, cinema, Workshops etc.

Key words: - Fixed walls, Portable walls, space flexibility

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LIST OF ABBREVIATIONS

USD.....	United states' dollar
Rc.....	Reinforced concrete
HCB.....	Hollow Concrete Block
3-D.....	Three dimensional
CNC.....	Computerized numerical Control
Tvet.....	Technical and Vocational Education Training
M12.....	Metric Diameter 12

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CHAPTER I

1. INTRODUCTION

1.1 Background of the study

Building interiors shall be designed to provide maximum flexibility for future modifications or change in use. Load bearing walls will be minimized and restricted to areas such as the building core for stairwells, lift shafts and toilets. All other internal walls and partitions can be non-load bearing and able to be readily removed and altered at minimum cost.

Movable partitions are walls that open to join two or more rooms into one large floor area. Their systems are easily adjustable for any space configuration. The walls are simple in the assembly process and easily transformable, depending on the room usage requirements and aim. When disassemble the partitioning system, sometimes it doesn't leave any essential installation track in the walls, ceiling or floor. This ensures partitioning system convenient configuration and transformation.

There are two systems of portable walls. These are: -

- ❖ Sliding: - it is a series of panels that slide in tracks fixed to the floor and ceiling, similar to sliding doors.



Fig. 1.1 Sliding movable wall

- ❖ Sliding and folding: - it is similar to sliding folding doors, these are good for smaller spans.



Fig. 1.2 Sliding and folding

Although it is impossible to get any related research that is conducted to solve room flexibility problem for condominium buildings in any country including Ethiopia, so many attempt had been done on other references. Books, journals, websites, videos and Television were the sources of information that show movable interior walls are applicable in office, recreation area, and cinema and so on.

1.2 Statement of the problem

The rationale of this project is based on different observation on the living style of the condominium house dwellers.

And hence to play professional role and contribute in solving the space related problem of the dweller and transferring them to modern living style and to live freely within limited space.

Some furniture making industries are tried to produce multipurpose and space saving furniture's with different types, styles, color, size and design. But they are not still satisfying the demand of the dweller.

In Ethiopia particularly for condominium buildings there is no any related research that is conducted to solve the space related problems by constructing movable interior partition walls. For the problem identified this project will response and fill the gap by substituting the fixed interior partition wall by movable interior partition walls.

Therefore, these will be the best opportunity and solution that the condominium dwellers should not miss. Whatever any standard furniture they buy or any ceremony they prepare there will be sufficient space within their limited home.

The Ethiopian government constructed different types of condominium buildings, but the room size is too small and has limited space to provide the necessary function. The dwellers both formally and informally rise about the space related problem of their house repeatedly. Therefore the occasion has become the best opportunity to conduct on the solution.

1.3 Objective

1.3.1 General Objective

The general objective of this project is to substitute fixed interior partition wall by movable wall to allow space flexibility between two adjacent rooms for any category of condominium buildings in Addis Ababa.

1.3.2 Specific objective

The followings are the specific objectives of the project.

- ❖ To replace fixed by movable wall by producing portable type
- ❖ To compare cost of fixed wall to movable
- ❖ To compare and contrast fixed and movable partition walls concerning their size, aesthetics and materials.
- ❖ To construct substitute wall without inducing significant additional weight

1.4 Scope of the project

The scope of the project bounded only on the mechanism of how movable interior partitions walls can be constructed and installed and by revising the existed interior design of the condominium buildings, creating space flexibility to the rooms.

1.5 Limitation of the project

Since there is no any movable interior partitions walls manufacturing industry in Ethiopia, the project used estimates from foreign movable partitions wall manufacturing companies and related research works.

In view of the fact that no study is conducted on production and assembly of movable interior partitions walls in Ethiopia, the analysis of this project will be limited by data, time, budget and other resources. Even if the project is restricted to the production and assembly of movable interior partitions walls, its findings can be used as a spring board for more studies associated to modern interior wall design and production in the country.

1.6 Significance of the project

The project provides better space flexibility among different rooms. It enables to displace standard sized home furniture from room to room without any collision with interior doors and used to minimize significant load imposed on the floor than fixed wall type. In addition it allows more opportunity to interior aesthetics.

1.7 Intended beneficiaries

The project provides very satisfactory benefits to the following parties.

- The owner of the house
- The government gets benefits from tax and minimizes political burden on unemployment rate.
- Investment opportunity to small and micro enterprises
- Architects, the interior designers' and construction constructors will benefit from the project even after a project completed.

CHAPTER II

2. FEASIBILITY STUDY

From the feasibility study analyzed below the project is viable. It shows the realization of the alternative solution for the problem identified. In addition it is intended to invite small and micro enterprises industries to invest on the project. They can easily understand and determine whether it is profitable or not to invest on our project. Beside this, those sources of finances can surely lend money for micros. Among the main government programs are encouraging the small and micro enterprises industries to make them participate on the construction sector. Therefore it is indication for the government to play its role on the part both in supporting the micros for the job opportunity created and the condominium dwellers for transferring them to modern living style and satisfying their demand.

2.1 Technical Feasibility

Technical feasibility study seeks to determine whether the prerequisites for the successful commissioning of the project have been considered and reasonably good choices have been made with respect to location, size, process, etc.

- The project can possess the current necessary technology such as circular saw, wood CNC machine and simple hand tools. The equipment and machines chosen are appropriate. It doesn't require additional technology.
- The project can use proven technology and open to new art work as well. For instance the wall panels can be made of Cheep wood, plywood, hard plastics, etc...
- This portable wall technology can be made with simple manufacturing process. Such as measuring, cutting, assembly and installation to the site.
- All necessary raw materials for the project can be easily obtained from near building materials shops.
- The project can be manufactured within the existed small and micro enterprises shops. It doesn't require future expansion of the shops.
- Those wood, metal and construction technicians with their business assistance can participate on the project without further skill and knowledge. If it is necessary they can train in one of the above field of study in the surrounding TVET colleges or Institutes.

- The technology proposed to be employed is appropriate from the social point of view because it participates the TVET trainers, Small and micro enterprises industries, the project raw material sellers, the government for the tax, the house owners for the opportunity of room flexibility, etc...
- Since the successful operation of a project critically depends on adequate availability of utilities. Therefore the local and federal government 100% supports the project by providing available utilities with fair cost. Such as water, Electric power, telephone and principally the land.

2.2 Financial feasibility

The financial feasibility of this project is possible because the small and micro enterprises are capable of raise the appropriate fund needed to implement the proposed project.

- The proposed project will satisfy the return expectations of those who provided the capital. Since the entire process for a single project doesn't take more than a week from the design phase up to installation phase donors of the fund will be motivated to lend again and the project owner will not suffer in the sense of being able to meet the burden of servicing debt.

2.2.1 Means of financing

The small and micro enterprises are well known to different government formed credit associations. In Addis Ababa, there are 20 small saving and credit institutions that support the community by providing loans and counseling services, which enable the community to engage in business of their choice and produce according to their ability and skill.

So the micro and small scale enterprises can directly get loan from these associations if they fulfill the criteria stated by the government and the organization.

The following Procedures is stated for getting loan from Addis Micro-financing Institute (taken from their brochure)

Types of loans provided by the institution

- Loans for small and micro finance activities
- Loans for materials lease
- Loans for personal cases
- Loans for construction works Entrepreneurs
- Loans for short period of repayment

Beneficiaries

- Individuals who reside in Addis Ababa and are participating (or wish to participate) in small and micro finance activities.
- Residents in Addis Ababa who are above 18 years of age.
- Business group
- Social institutions with legal personality like Edir and cooperative societies and joint ventures.

Conditions to get a loan

- An identification card which shows that the applicant is a resident of Addis Ababa
- If the applicant is a business group, PLC, Social Institution like Edir, Cooperative Society or any other organization must present a document which shows it has a legal personality and it is located in Addis.
- If the applicant, excluding a business group, is requesting for a loan greater than 5000 Birr, it has to produce trade license.
- The applicant shouldn't have any unsettled loan from any institution including Addis Micro financing.

Procedures for loan

- Group loan
- Individual loan
- Loans for cooperative societies
- Joint venture
- Short term loans

Repaying of the debt

For all business loans, except short term loans, the debt should be fully settled in 36 months.

- Short term loans should be settled in six months.
- Loans for personal cases should be fully settled in 24 months.
- Loans for construction related should be fully settled in 60 months.

Grace period

The institution will give grace period for persons participating in new small and micro financing activities. Accordingly,

- Persons working on selected focus areas will get 4 months grace period.

- Persons participating in other business activities will be given one month grace period.
- Those who are working on construction and related activities will not be given a grace period.

Loan insurance

The institution gives three kinds of insurances for the loan it provides:

- Life insurance
- Property insurance
- Business insurance

Guarantees

The institution accepts the following forms of guarantees alternatively:

- Group guarantee
- Salaries of permanent employees
- Customers of the institutions
- Savings in various saving institutions
- Money paid for “Equb”
- Persons and machineries joint guarantee
- Television, jewelries and other movables
- Land lease

2.2.2 Cost of project

The Investment doesn't require any additional expansion except the project cost for pre-organized industries. Anything of the project can be implemented in the existed conditions if the companies are organized on wood and metal work sectors. There are varies investment cost of the project just based on the size and quality of the work. For instance

- The cost of a project for one bed room unit condominium building is 13,661.4Birr/week if the organization intended to produce portable walls only with wood materials.

2.2.3 Cost of capital

The addition on the cost of capital for the project is only for the expenses of raw material, Transportation and training for the workers if necessary. The other cost can be considered from the existing capital cost but for new organization there are two alternatives.

- For type-I portable wall production, if the organization rent circular saw machine for cutting process 130birr/week and additional cast for Material cost, Labor cost, Utilities

Cost and Factory overhead cost 11, 384.50Birr/week then the total cost of capital will be 11,514,50Birr/week.

- On the other hand if the organization is new and needed to bay circular saw machine they will expense from 20,000birr to 100,000birr based on their quality.
- Therefore the investment cost of the new organization will be 11,461.20Birr/week to 11,768.06Birr/week if the payback period of the machine cost is 76.70birr/week to 383.56birr/week for five consecutive years.

2.2.4 Project profitability

From the observation found the problem knocked at the door of every dweller. Most of the occupants want the substitution of fixed wall by mobile partitions. Therefore there is a great demand of the project. For the one bed room unit of condominium building, the production and installation of Type-I portable wall, it is estimated that it costs about 13,661.4birr considering the existence of instability of the market.

$$\text{Product cost} = 11,384.50\text{Birr}$$

$$\text{Total Profit before tax} = 20\% \text{ of Product cost} = 2276.90\text{Birr/week}$$

$$\begin{aligned} \text{Selling price} &= \text{Product cost} + 20\% \text{profit} \\ &= 13,661.4\text{Birr/week} \end{aligned}$$

$$\text{Net profit after tax} = 341.535\text{Birr/week}$$

The following table shows the specification of different portable wall products that can be manufactured in the micros enterprises.

Table 2. 1 Portable wall material specification

Cost of Production				
Portable wall Type	Material	Style	Track option	Remark
Type I	Wooden frame, plywood panel, Aluminum track (0.6x70x260)cm ³	Folding & sliding	Floor supported	With all accessory
Type II	Aluminum Frame and track, glass panel (0.4x70x260) cm ³	Folding	Suspended	“
Type II	Recycle plastic panel with Aluminum frame & track (0.4x70x260) cm ³	Sliding	Suspended	“

Table 2.2 Cost of production

No	Major component		Qua.	Unit price	Total cost Birr	Remark
1	Material cost	Type-1	5	1722.50	8612.50	See table 3
		Type-2	5	1850.00	9250.00	
		Type-3	5	1890.50	9450.00	
2	Labor cost	Manager	1	444.50/week	444.50	But all are Technicians
		Technician	2	444.50/week	889.00	
		secretary	1	444.50/week	444.50	
		Purchaser	2	444.50/week	889.00	
3	Utilities Cost	Electric power	-	25/week	25.00	
		Water	-	10/week	10.00	
		Transport	-	40/week	40.00	
4	Factory overhead cost	Repairs and maintenance		30/week	30.00	
Total production cost with type-I/week					11,384.50Br	
Total production cost with type-II/week					12,022.00Br	
Total production cost with type-III/week					12,222.00Br	

2.3 Economical Feasibility

As different sources of information in the nation describes now a time Ethiopia is on the transition of ideology that leads the country from Agriculture to Industry strategy. So in order to compatible the demand and supply of the society in the construction sector, the government is moving to construct many housing development projects. The proposed project for small and micro enterprises will be produced from local materials that may not demand import raw materials. Most portable wall materials are not scarce in Ethiopia. In addition they are made of renewable materials, such as Aluminum, sheet metals and hard plastics. Therefore, since it is the best alternative to the problem faced the community as a whole, they will stand to gain as a result of the project.

2.4 Commercial Feasibility

This project is new to the condominium building dwellers. So in order to create awareness to the customer different means of information such as Local and national TV, Radio, News papers and show rooms can be used. It is good opportunity to commercial investment as well.

2.5 Ecological Feasibility

Although the material suggested for the manufacturing of different parts of the proposed project is wood and metals which are environmentally friendly , but they can also be produced from waste plastic material by recycling process and hence it contributes for environmental preservation struggles.

2.6 Safety Feasibility

The project will be implemented and operated safely with minimum adverse effects on the environment. Special care must be taken during the installation phase of the project. Because improper installation will definitely harm the dweller and the other is it needs some orientation on how to handle and move the panels.

2.7 Cultural Feasibility

The project leads the society to the modern living style. In addition it preserves those cultural assets such as birthday, Holiday, Mourning and religious ceremonies that are vanishing due to lack of space flexibility in their room.

2.8 Political Feasibility

Among different strategies that the current government planned for some previous and the coming years, there is strong support for construction sector. It has held many integrated housing development programs like condominium buildings and so that it has prepared almost all necessary resources like land, loan and construction service. In addition it has prepared many technicians and professional for the construction sectors in different level and organized them in micro and small scale enterprises. The only exceptional restriction here is the housing development office does not allow any modification on any building units of the condominium buildings.

CHAPTER III

3. REVIEW OF RELATED LITERATURE

3.1 Basics of Wall

A wall is a structure that defines an area, carries a load, or provides shelter or security. The word Wall comes from Latin VALLUM meaning "...an earthen wall or rampart set with palisades, a row or line of stakes, a wall, a rampart, fortification..." while the Latin word MURUS means a defensive stone wall. English uses the same word to mean an external wall and the internal sides of a room, but this is not universal. Many languages distinguish between the two. In German, some of this distinction can be seen between *WAND* and *MAUER*, in Spanish between *PARED* and *MURO*.

There are many kinds of walls:

- Defensive walls in fortification
- Walls in buildings that form a fundamental part of the superstructure or separate interior sections, sometimes for fire safety
- Retaining walls, which hold back earth, stone, or water
- Walls that protect from oceans (seawalls or rivers levees
- Permanent, solid fences
- Border barriers between countries (sometimes)

Building walls further can be classified as:-

- Load bearing and non load bearing
- Fixed and movable
- Internal and external
- Stone wall, Block wall, Brick wall etc. just based on their material.

To be more specific on this project title and for the purpose of competition fixed interior partition wall and movable interior partition wall are taken. Partition walls may be defined as wall of division made up of bricks, studding, and glass. Partition walls are designed as non-load bearing walls. They may be of folding, collapsible or fixed type.

3.2 Fixed interior partition wall

These types of walls are mostly load bearing walls. They transmit the load that comes from the beam and used to divide the rooms in to functional units. They are strong with related to movable walls but they do not invite for modification unless a lot of wall materials are demolished.

3.3 Movable interior partition wall

Movable partitions are used where the walls of a room are frequently opened to form one large floor area. That means it divide space quickly where non-mobile permanent room dividers may be unavailable or unpractical. It is a cost effective way to create a classroom or meeting room in existing space. In addition it provides convenient sight divider to conceal door openings to restrooms, commercial kitchens, and other backroom areas. Portable Partitions are commonly used in: - Arena's, Houses of Worship, Funeral Homes, Convention Centres, Government and Corporate offices, Hotels, Restaurants, Residences, Salons and Spas and Schools of all levels.

3.3.1 Properties of portable wall

Movable interior partition walls should fulfil different specifications that are stated by Authorized concerned bodies.

- **Aesthetics:** formal walls have smooth surfaces and are symmetrical in the window and door placements. They are also more closed with more of a vertical emphasis. Informal walls are rough, asymmetrical, and are more open with a horizontal feel.
- **Function and Flexibility:** why use moveable walls? They offer flexibility for tenants that experience change. Moveable walls provide electrical and data lines (some even offer plumbing) built into the wall system. The flooring is installed continuous so that the walls can be moved and not require the flooring to be changed.
- **Degree of enclosure and privacy:** opaque walls mean that you can't see through them. Translucent means that you can see through the panels. So the movable partition wall can be either of the two depending on their function.
- **Light qualities:** is Psychology of light. White reflects up to 89% of light and black reflect about 2%. Texture also plays a role. Smooth surfaces reflect more light than rough textures. Therefore the portable walls should be designed accordingly.

- **Durability:** the amount of time and money needed to maintain the walls must be considered. This is the designer responsibility when specifying a wall treatment to understand the clients' needs.
- **Acoustics:** smooth, hard surfaces reflect sound while porous and soft surfaces absorb sound. Insulate wall cavities when sound transmission is an issue. To achieve the optimum audible condition in a room, it is necessary to consider reverberation times. In general, a concert hall needs acoustically 'live' conditions, whereas a seminar room needs reduced levels of reverberation for intelligible speech. Where a partition is required to provide sound insulation, the acoustic characteristics of the floor, ceiling and surrounding construction should be considered. In order to achieve good acoustic performance the partition should ideally be constructed between the floor and the structural soffit. If built on top of a raised floor and beneath a suspended ceiling then a sound insulation barrier will need to be installed in both plenums.
- **Thermal qualities:** It is important to remember when considering Fire Resistance of movable walls, that only those products which have successfully passed the Fire Test are awarded a Building Control Certificate. Because of their mobility, the fire resistance rating of a movable wall only relates to its performance when in a closed position with the seals fully extended. Where a partition is required to provide fire protection, voids above or below the partition may need to be sub-divided with cavity barriers in the plane of the partition. Fire seals will also be required where openings are made within the partition for trunking and cabling etc.
- **Self-weight**

According to Ethiopian building code of standard for self-weight of construction elements on (51414, page 665) number 5, the self-weight of construction elements will be considered as: -

2.5.1 Representation of Actions

- (1) Construction elements include structural and non-structural elements.
- (2) For the purpose of this section, the self-weight of non-structural elements shall include the weight of fixed machinery
- (3) Non-structural elements include:
 - (a) Roofing

- (b) Surfacing and coverings
- (c) Non-structural partition walls and linings
- (d) Hand rails, safety barriers, parapets and kerbs
- (e) Wall cladding
- (f) Suspended ceilings
- (g) Insulation
- (h) Fixed machinery
- (i) Earth and ballast

The following table shows the possible portable wall material density.

Table 3.1 Construction material form EBCS Table 2.1

Material	Density γ [kN/m ³]
wood	
Bahir Zaf (Eucalyptus Globulus Labill)	8.5
Kerero (Pouteria Ferrginea)	6.5
Sombo (Ekebergia Rueppeliana)	6.5
Tid (Juniperus Procera)	7.5
Zegba (Podacargus Gracilior)	6.0
plywood:	
raw plywood (softwood and birch)	6
laminboard and blockboard	4
particleboards:	
chipboard	8
cement-bonded particleboard	12
flakeboard, oriented strand board, waterboard	7
fibre building board:	
hardboard, standard and tempered	10
medium density fibreboard	8
softboard	4

- **Imposed loads**

Ethiopian building code standard for loading: -

(5) Loads due to movable partitions shall be treated as imposed loads (see Section 2.6).

2.6 Imposed loads on buildings

2.6.1 Representation of Actions

(1) Imposed loads on buildings are those arising from occupancy. They may be caused by:

- (a) Normal use by persons;
 - (b) **Furniture and moveable objects** (e. g. lightweight moveable partitions, storage, the contents of containers)
 - (c) Machines and vehicles
 - (d) Exceptional use, such as exceptional concentrations of persons or of furniture, or the moving or stacking of commodities which may occur during reorganization or redecoration.
- 2) The self-weight of structural and non-structural components and of fixed equipment shall be taken into account according to Section 2.5.
- 3) Imposed loads are modeled by uniformly distributed loads or concentrated loads or combination of these loads.
- 4) The characteristic values of the loads are determined for a reference period, (See Chapter 1 of EBCS).
- 5) The characteristic values of the loads are composed of long-term, medium-term and short-term components that, according to their duration, may have different effects on materials sensitive to time:- dependent actions.

3.3.2 Elements of portable wall

There are different elements of movable partition wall. The amount and type may vary depending up on the designers' skills and knowledge as well as the function intend. The basic parts are elaborated below.

Panel board

Panels are vertical plans that used for shelter with various sizes, materials and finishing styles by considering the client need, the cost, the rules and regulations of the municipality design office. The panels may be integrated with doors.

The Size determination of the panels needs different important points.

- The load it imposes on the floor
- The standard sizes of boards to minimize material wastage during manufacturing phase
- The numbers of frames increase as the width of the panel getting smaller.
- When the width is small it will be easy for transportation, assembly and movement.

The possible sizes of movable partition wall panels are approximately with widths from 650mm up to a maximum of 1260mm, heights from 2.00m up to 10.00m and thickness from 13mm to 130mm.

Commonly used movable partition wall panels materials are: - wood, Aluminum, Thermoplastics, sheet metal.

Locker

Any type of door lockers can be applied to Movable partition walls wherever available.

Finishing

The movable walls may take the appearance of the adjacent wall or other attractive creativity can be made on it. Since the external part is exposed to many factors, it has to be well finished with chemical, weather, water and fire protection materials.

Panel frame

The frame of the board can be made of different shape, materials and size. It is usually constructed internally and/or externally. It must be strong enough to support the panel.

Roller

The rollers are used to smoothly slide the panel through the sliding rail towards the intended direction. There are different types of rollers. The type of roller determines whether the panel is suspended or floor supported. Mostly they are made of rubber for noise control.

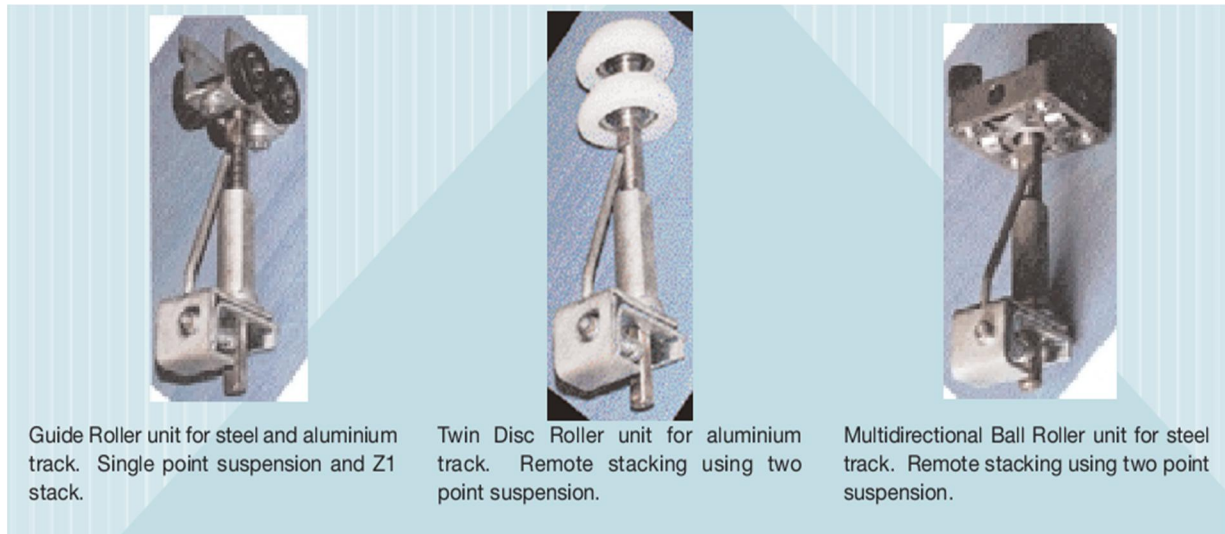


Fig. 3.1 Top Track Rollers

Rail/ Track

It is a horizontal or vertical channel which used as a path for the panel or the roller to slide on. The commonly manufacturing materials are wood, aluminum and steel. There are two types of rails.

Top rail/ Track

It used to slide the roller or suspend the panel board. There must be a Rc. beam or steel beam if the track carries the panel board. Here the weight of the panel must be light relatively. Because in addition to the weight of the panel, the track must resist the lateral load that imposed on the panel.

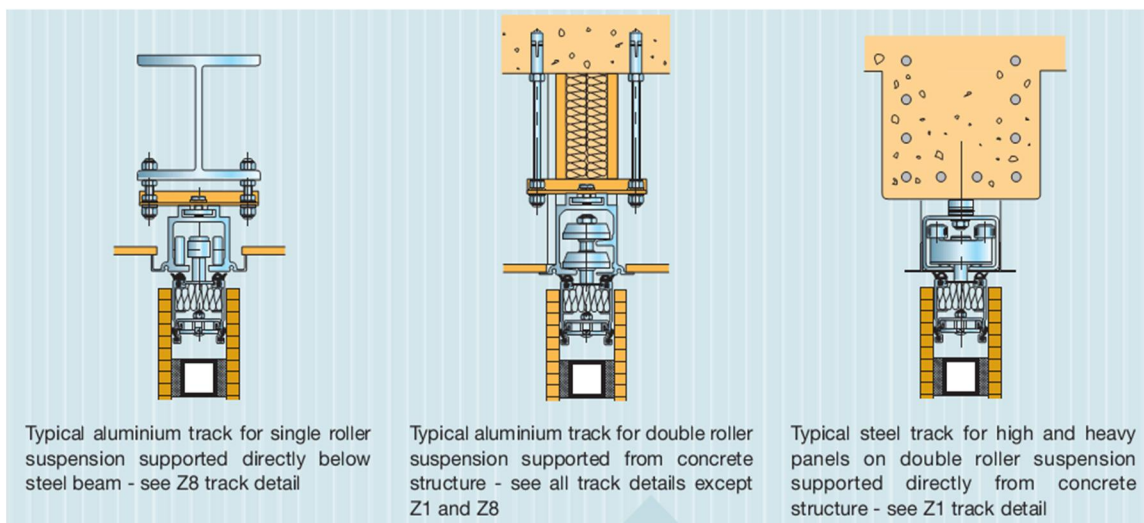


Fig. 3.2 Top track Detail

Bottom rail/ Track

It used to slid the bottom roller and transmit the entire load of the movable wall to the floor. If the type of portable wall is suspended, no need constructing of bottom track. An Important care that should be taken here is to close or to narrow the width of the bottom track in order to avoid obstacle to the one who pass on it and for neatness.

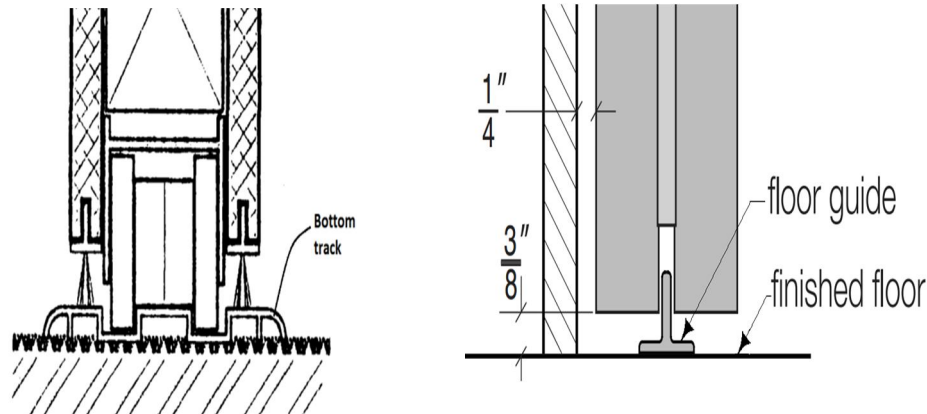


Fig. 3.3 Bottom Track Detail

3.3.3 Styles of portable wall

Sliding

Sliding partitions consists of series of panels that slide in tracks fixed to the floor and ceiling. These styles of wall panel may have more than one adjacent track. The mechanism of the partition is similar to those of sliding doors. Since it impossible to rotate the panels, the maximum flexibility of such style is restricted by the width of a single portable wall.

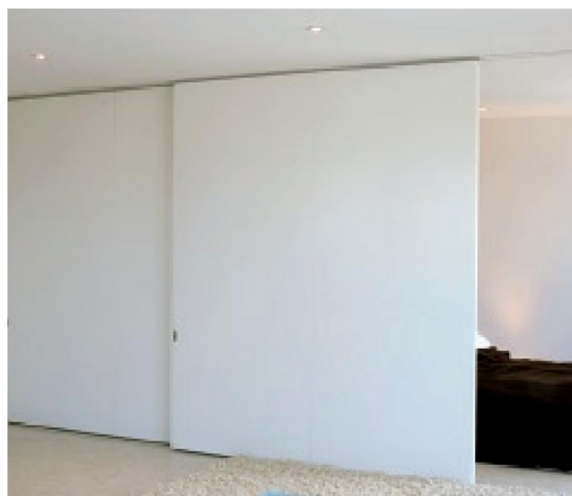


Fig. 3.4 Sliding portable interior wall

Sliding & folding

Sliding and folding partitions operate in a similar manner to sliding folding doors. The panel width of such wall is small. The partitions move in the direction of the top or/and bottom track and can rotate a certain degree in the axis of its top roller. If there is no connection between adjacent panels by means of hinge, the wall can rotate 360° on its roller.



Fig. 3.5 Sliding and folding interior wall

Stacking option

It is the place where those folded panels to be accumulated. For the reason of aesthetics and stability on the intended place, the movable walls may have their cage. Sometimes they can be tied by a belt or they can be stacked by a pivot or locker at the top or bottom track. There are many design options that can be applied. Some common types of stacking are shown below on the next figure.

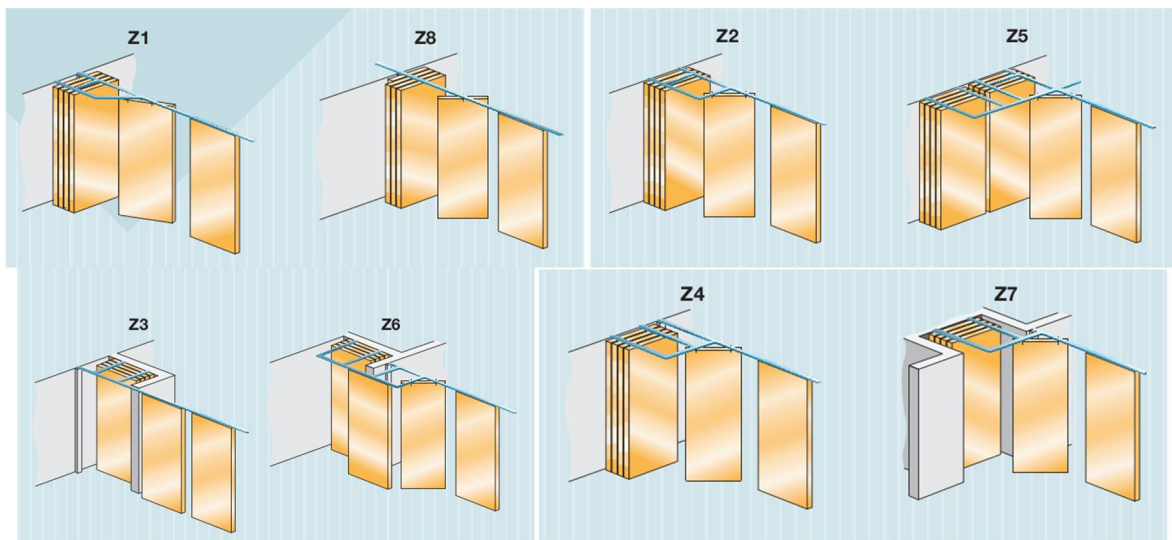


Fig. 3.6 Stacking option

3.3.4 Construction Strategy

❖ Installation

Before commencing any installation, site dimensions should be taken and where appropriate compared with architects drawings; discrepancies or problems should be discussed with and approved by the relevant authority. If necessary an official instruction or variation order should be sought before proceeding.

❖ Special considerations

Partitions that are fixed to suspended ceilings may require special provisions in the ceiling construction or have appropriate supports fixed along the line of the partition between the ceiling grid and the structural soffit. Care should be taken to ensure that the head fixing of the partition does not impair the stability of either the partition or the ceiling it is fixed to. In a similar way, partitions installed on raised access floors or platforms should be located at the positions within maximum loadings recommended by the floor system supplier or have additional supports included in the design. When a partition is required to provide fire resistance, voids above or below the partition, e.g. ceiling or platform floor voids, may require to be sub-divided with cavity barriers in the plane of the partition. Fire stopping will also be required to seal any gaps between fire resisting partitions and other elements, such as trunking, pipes, etc...

❖ Setting out

Partitions should be erected in accordance with layout drawings and/or other instructions from agreed identifiable data and reference points, allowing for permitted deviations from nominal panel sizes and dimensional variations of finished ceilings, floors, walls etc.

❖ Perimeter fixings

-  When appropriate fire and acoustic seals/sealants should be fitted during the installation of the perimeter sections in continuous strip leaving no gaps.
-  Abutments, junction posts, head and floor tracks should be fixed in line and plumb in both vertical planes in accordance with manufacturer instructions.

- ✚ Special procedures may be appropriate for proprietary metal monobloc, bibloc and storage wall systems that have integral ceiling channels and special modules for junctions to wall, columns and mullions.

❖ **Intermediate, vertical and horizontal members**

- ✚ All vertical sections should be fixed plumb in both planes and unless curved, in line with each other. Special attention should be paid to the fixing of verticals adjacent to door frames.
- ✚ Horizontal members, e.g. transoms or crash rails, should be set out level and in line with each other, after ensuring prior to fixing that each member is cut square.

❖ **Infill panels, cladding and trims**

Infill and cladding panels should be free from bowing, undulations or other distortions with joints accurately aligned with no lipping. Intermediate joints in exposed perimeter section sand trims should be minimized by using the full range of section lengths available. Joint compounds should be those approved by the manufacturer. Certain types of panels may be prone to movement in areas of extreme temperature or moisture content. In these circumstances, appropriate allowances should be made or special fixing details incorporated.

From the above discussion we can understand that there is advantage and disadvantage of fixed partition wall over movable. For countries like Ethiopia who gives special emphasize for space related problem, it is advisable to construct movable walls for better room flexibility but for those who are small in number and have sufficient room size movable walls may not be as such necessary. Because there is no space related problems with them.

Although there is some related research that are conducted in Ethiopia, different foreign country researchers have been conducted on movable partition walls that are mostly applicable for offices, shops, cinema and auditorium. The main focuses of these researchers were on the material selection, movement style, Aesthetics, Acoustic property, fire resistance and other engineering properties of the movable partition walls.

3.4 Portable interior wall manufacturing industries

There are many foreign privet limited companies that manufacture and install movable partition walls. Some of them are: -

- ❖ Alco Beldan Plc. have been designing, manufacturing and installing movable walls in the U.K. and throughout the world for over 30 years. Their products are installed in

many of the world's most prestigious buildings, from top sporting stadium and commercial institutions to high street stores and leading hotel chains. Their mission is creating space flexibility among rooms of Church Halls, Sports Halls, Community Centers and Convention Centers and so on.



Fig. 3.7 Swaminarayan Hindu Temple, in North London

- ❖ Wallenium is a company in Tallinn, Estonia that develops, sells, produces and installs movable partition wall systems. What they offer is a modern way of providing privacy, transparency and design to any office space, shopping mall or public place. The Wallenium Partition Wall systems VAL90 and MODULARE92 have passed sound tests at the VTT Technical Research Centre in Finland.



Fig. 3.8 Wallenium Movable partition wall for conference room

3.5 Multipurpose furniture making companies

Many foreign and some domestic furniture making industries are produce multipurpose and space saving furniture's with different types, styles, color, size and design. This furniture

basically provides flexibility to the rooms. Which means at a time when one of the integrated furniture is not available, it displaces its location temporarily and gives an opportunity to the other or makes the space free.



Fig. 3.9 Integrated Bed and Shelf furniture

3.6 Research on maximizing floor area

On the other hand On the research conducted in Addis Ababa University on the title “Alternative design and construction techniques for maximizing net floor area” by Abel Bekele and Misgun Samuel (August 27, 2010), the researchers tried to indicate that a net floor area can be save from those wide concrete structural parts like columns by substituting with small steel structures. Wider space in a room always allows flexibility but in some case when there is no sufficient area we need to think more. So if the researchers’ idea is supported or integrated with this study it easy for the one to think what the result looks like.

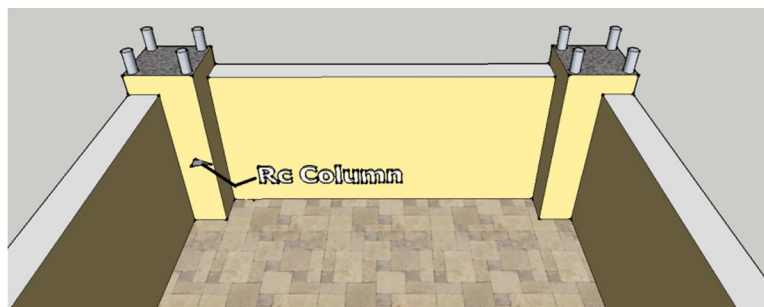


Fig. 3.10 Room size with Rc. Structure



Fig. 3.11 Room size with steel structure

Now from the above discussion it can be said that each company's and the researchers' ultimate goal is to create room flexibility. In addition in order to satisfy their customer demand and obey the rule and regulation stated by the government, they grapple to keep standards.

The application of movable interior partition wall for offices, halls, cinemas, shops, etc are possible. This type of building units are not practiced for residential buildings as such. However in the form of sliding and folding doors, they divide a room in to two. But unlike that there is great possibility to move the entire partition wall to the intended place, even including bath and kitchen. The only thing to take attention is on sanitary and electrical fixtures, mounted kitchen cabinets, the fire and chemical resistance quality of the walls. There for construction of movable partition walls for condominium buildings are incomparable choices to play on rooms' flexibility in Addis Ababa, Ethiopia where there is burning issue of massive society.

CHAPTER IV

4. THE PROJECT DESIGN

4.1 Floor plan design

4.1.1 Existed floor plan

After the problem has been identified, the Architectural and structural drawings of the condominium buildings of Tulu-Dimtu and Kilinto sites had taken from Addis Ababa integrated housing development office and then analyzed in to different possible options on the floor plan where and how to apply movable interior partition walls to the rooms. The room size for studio and one room units is 25 – 40 m², for two bedroom units is 60 m² and for three bedroom units of 100 m². These housing projects utilize low-cost designs, and are multi-storied. The interior partition walls are fixed type and are constructed with agro stones.

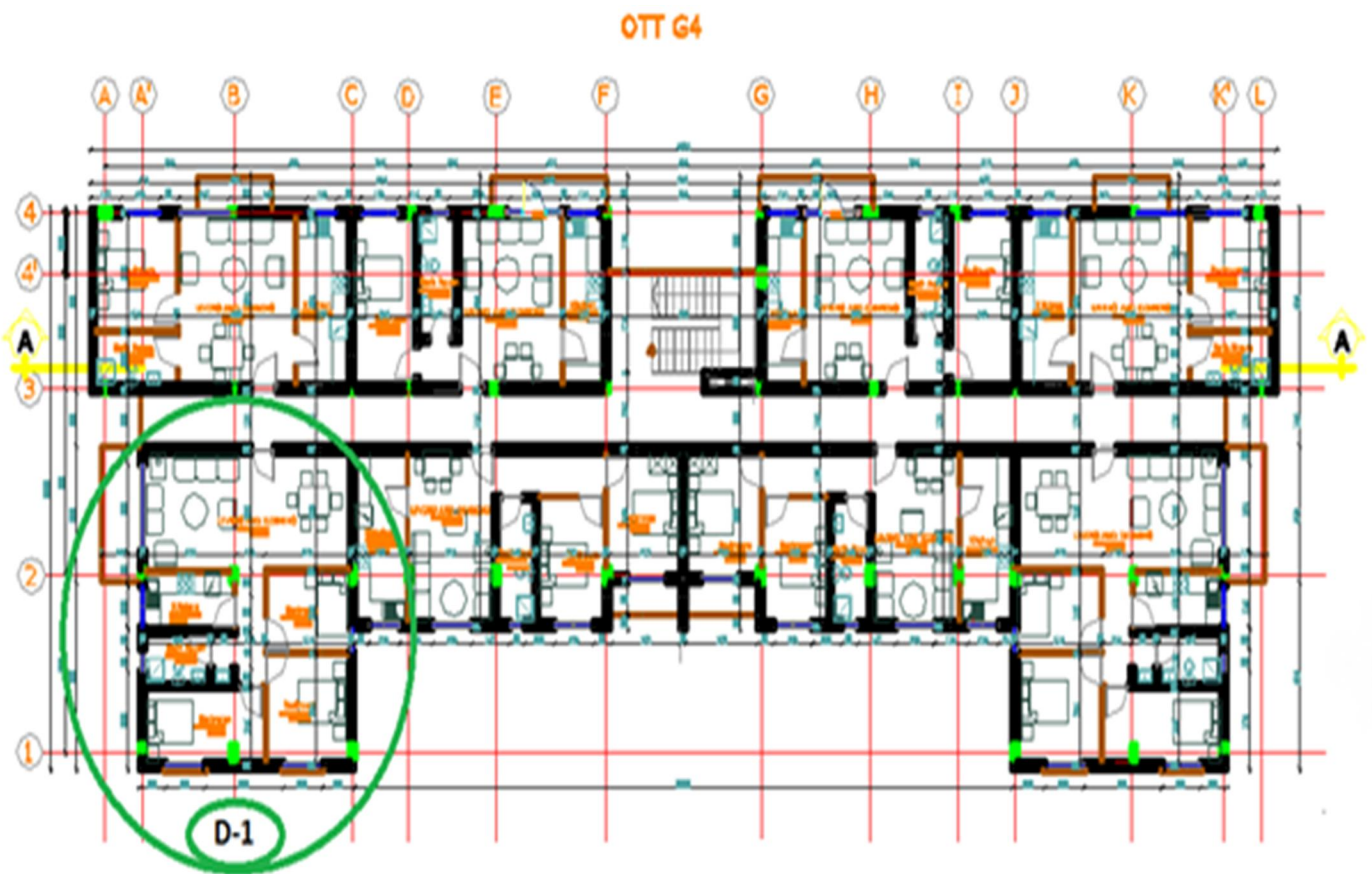


Fig. 4.1 Typical Floor Plan

On the Figure below the letters A, B and C indicate the target fixed walls that can be substituted by movable partition walls for the Three-Bed room unit condominium building.

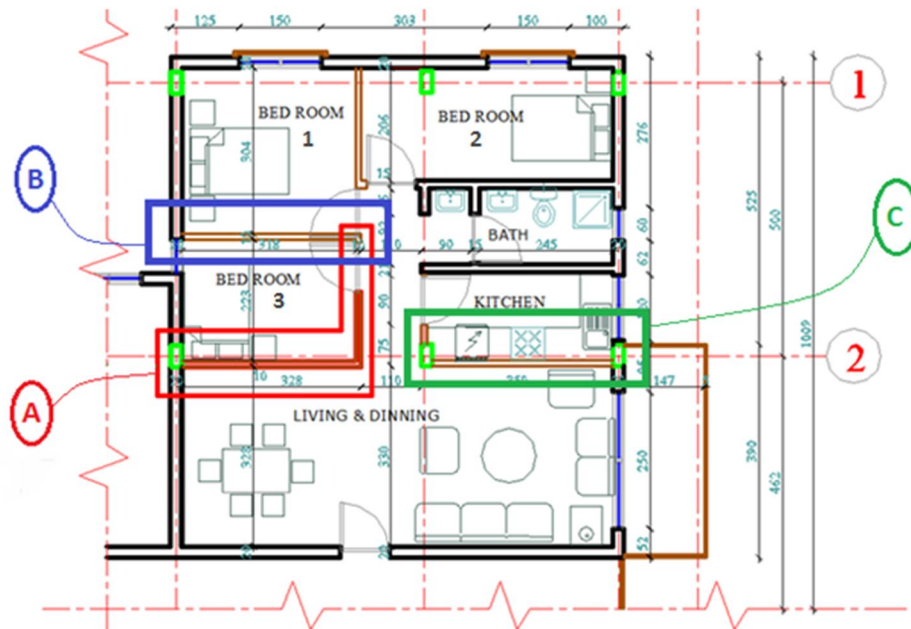


Fig. 4.2 Detail plan view (D-1)

4.1.2 Improved floor plan

The figure bellow shows the possible changes made on bed room-3 and now function as additional Dinning area in case of ceremony

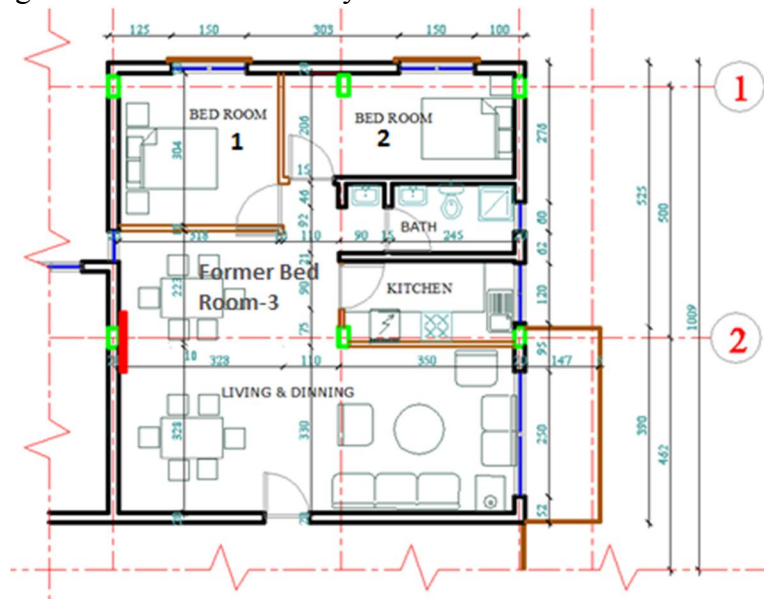


Fig. 4.3 Draw the improved floor plan

❖ Interior elevation

The following figures show some possible alternative design options that can be applied to the Three-Bed room unit condominium buildings. If the type of portable wall is suspended by the top track, the rooms will not separate by bottom rail.



Fig. 4.4 Interior view if the change is made only on “A”



Fig. 4.5 Interior view if the change is made on “A and B”

On the figure below in addition to getting wide space temporarily by combining the three bed rooms together, the kitchen wall can also be changed by portable walls. The special attention that should be taken here is to provide the wall materials with enough fire and chemical resistance. In addition, it is totally prohibited to construct anything on structural parts of the building unless the necessary permission is allowed from the municipality office. Therefore to construct portable partitions for as built buildings, it is must to jump columns as seen on the next figure. But for new buildings the strength and location of structural parts can be seen early for future installation of portable walls.

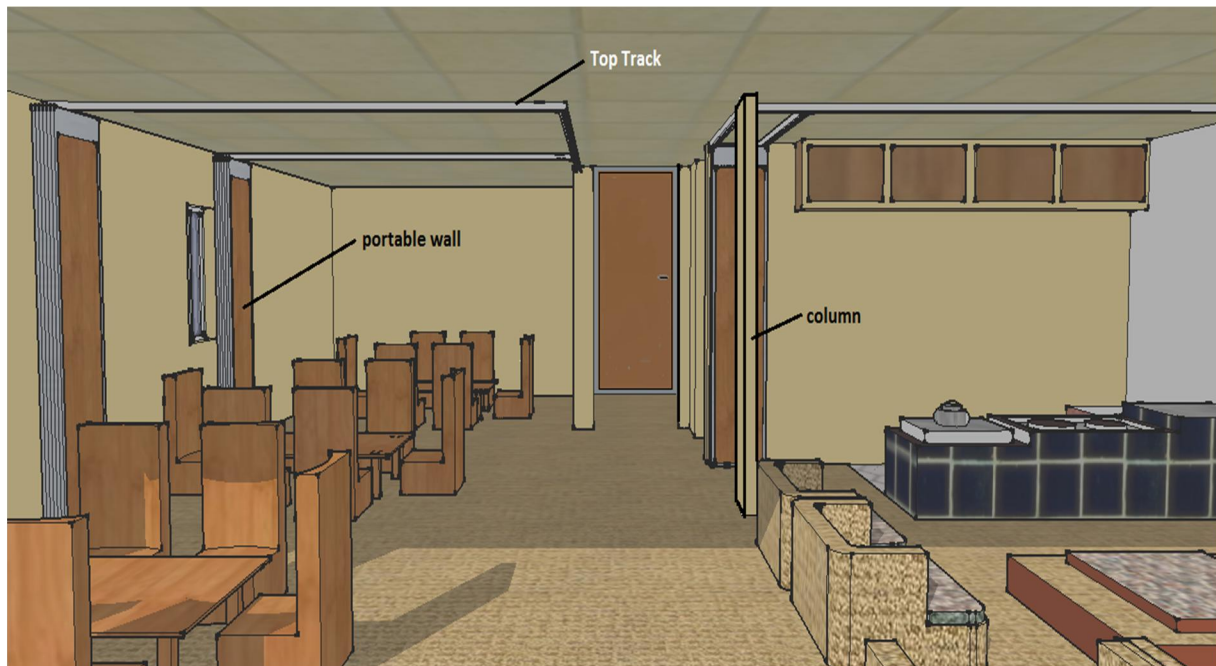


Fig. 4.6 Interior view if the change is made on “A, B and C”

4.2 Portable Interior wall sample design

Based on the above discussion so far there are many different foreign companies that manufacture movable partition wall with high standards and styles. Basically they do not produce with low costs that do not much with Ethiopian condominium owners' income if import is expected. Therefore considering this limitation it is possible to produce the walls with domestic materials and relatively low cost. Portable wall manufacturing requires three basic stages.

4.2.1 Design Phase

Condominium buildings are made with minimum cost of construction considering the purchasing capacity of the citizens in Ethiopia. Although there is income difference among the dwellers, varies types of movable interior partition walls can be design and install according to their economical statues. The following detail drawings show the low cost movable partition walls for one bed room unit condominium building in Addis Ababa Gelan site.

The targeted fixed wall that needs to be changed perimeter and height is 350cm x 260cm respectively. Therefore perimeter can be divided by the number of portable walls. Since it is possible to move the walls it doesn't matter if the door width is 70cm. the door is integrated in the last portable wall.

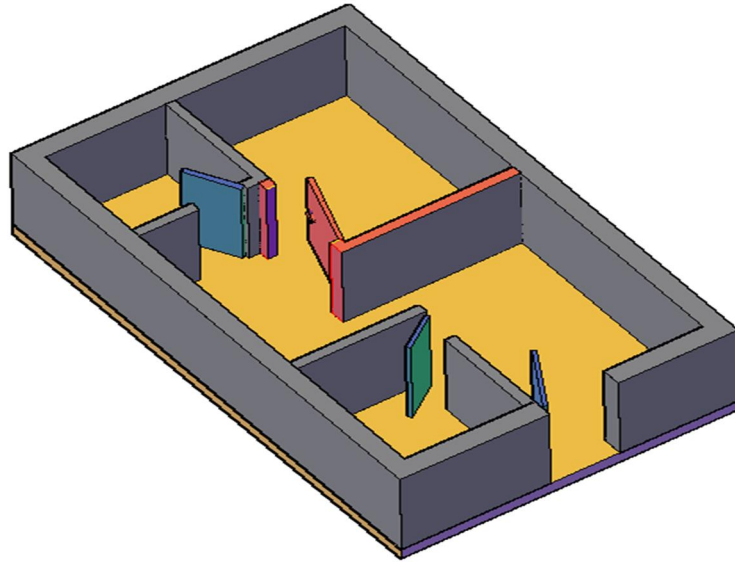


Fig. 4.7 3-D sectional view of Existed one bed room unit design

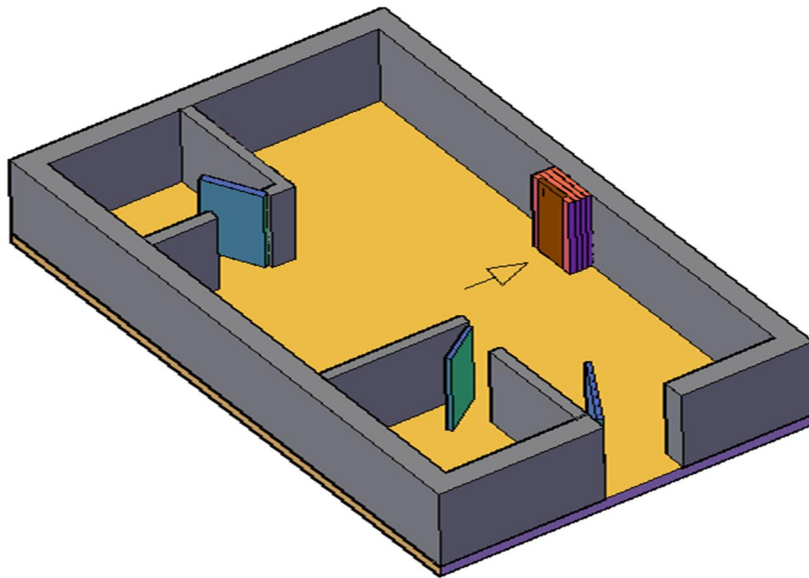


Fig. 4.7 3-D sectional view of Existed one bed room unit design

❖ Sliding-Folding partition wall

This model is made to replace the fixed partition walls in condominium buildings that their construction phase has already completed.

☞ Style

Folding is a simple style than the other because it doesn't require much care during movement of the portable walls to fit one to the other adjacent panel.



Fig.4 9 Folding style

☞ **Edge option**

The connection between each adjacent panel is hinged together so as to keep their balance in movement. The panels can be separated easily after they are taken out at the end of the track and pulled up from the hinge. This is helpful for maintenance.



Fig.4.10 Butt Hinge

☞ **Staking system**

The staking option for this type of wall is designed just considering advantages of saving space. The panels will be gathered together near to the wall and stack by means of pivot plat at the bottom rail. To minimize the cost of construction stacking cage is excluded.

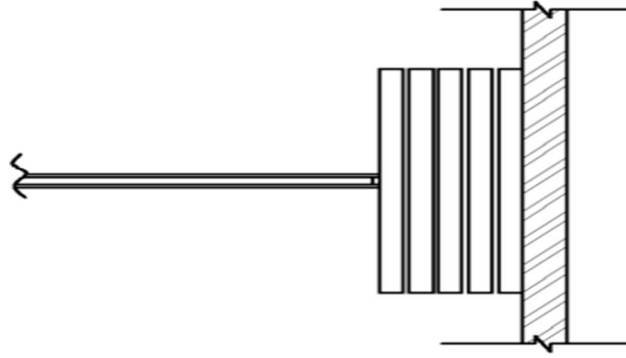


Fig. 4.11 plan view of Staking system

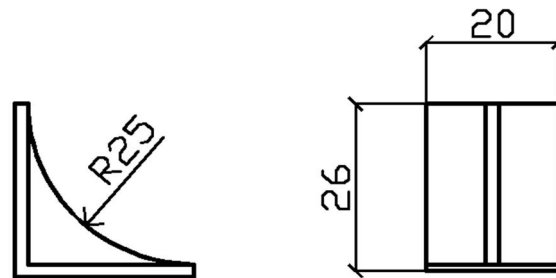


Fig. 4.12 Pivot plat

☞ Lock system

Locks, Latches and Bolts ~ the means of keeping the door in its closed position and providing the required degree of security. The handles and cover plates used in conjunction with locks and latches are collectively called door furniture.

Letter Plates fitted in external doors to enable letters etc., to be deposited through the door.

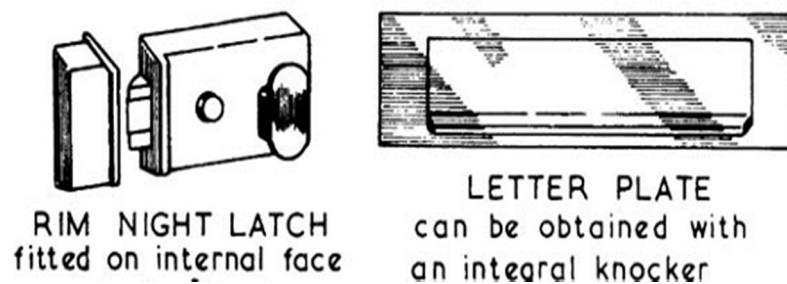


Fig.4.13 Locker

☞ The panel board

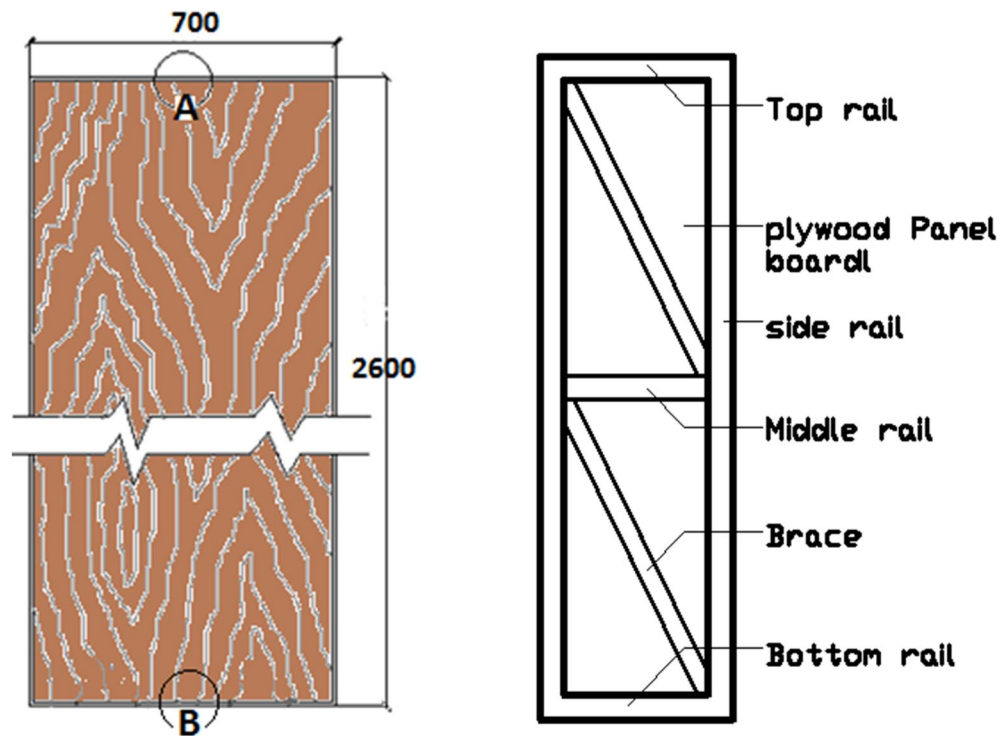


Fig. 4.14 Panel board structure

- All dimensional units are in mm

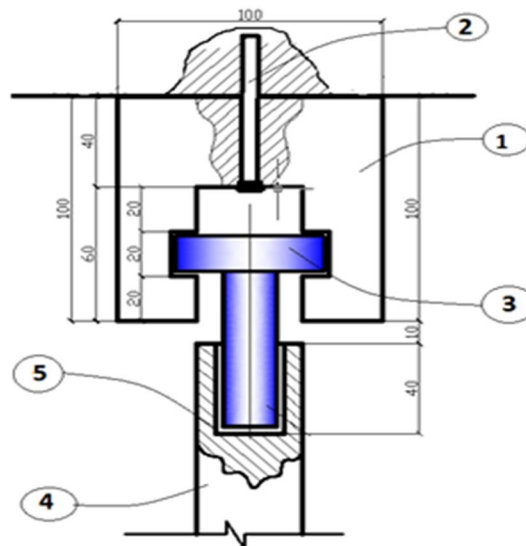


Fig. 4.15 Detail of "A"

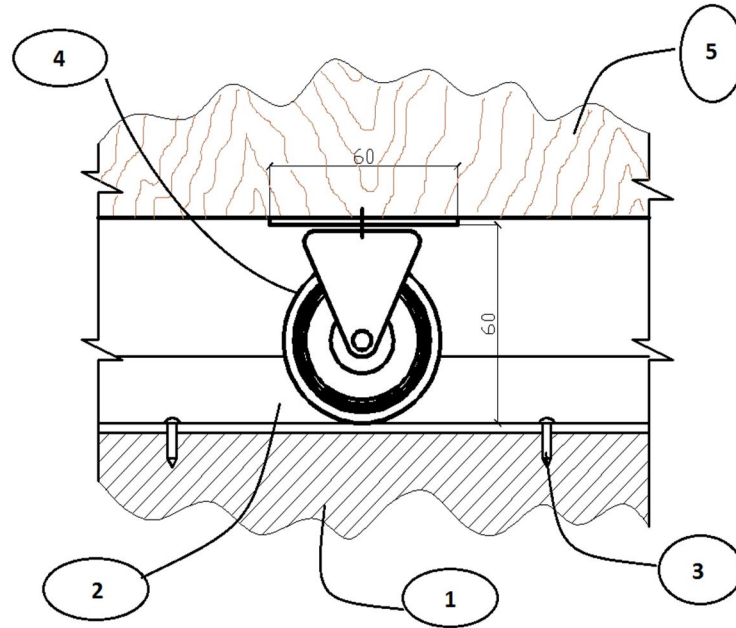


Fig. 4.16 Detail “B”

☞ Track

Top Track

The top track for the project is made of wood to cut the offset easily. It is strong enough to resist the imposed lateral load from the roller.

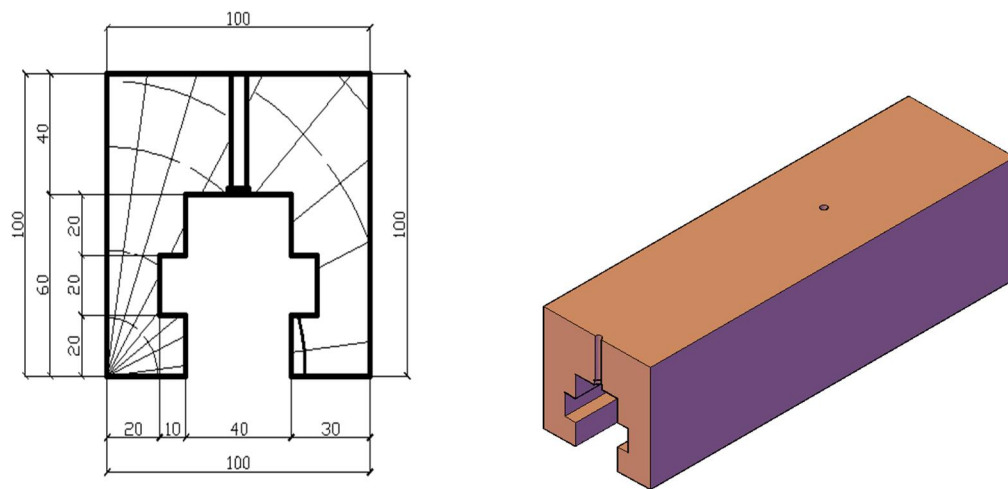


Fig. 4.17 Top track

Bottom Track

The bottom track is made of 2mm thick steel plate. It is constructed equal to the floor tile level to eliminate obstacle to feet during walking.

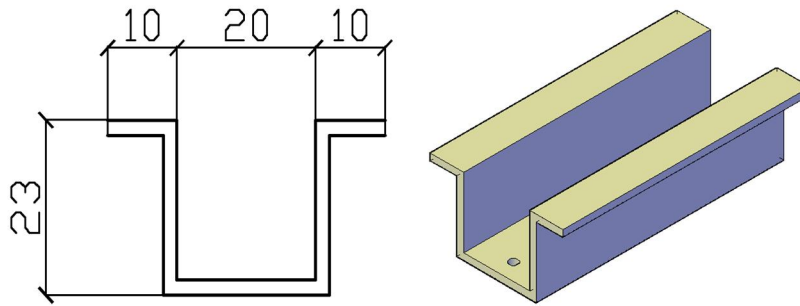


Fig. 4.18 Bottom track

☞ Screw

The Screw is made of steel. It used to mount the top track with the ceiling or slab. There is fisher for each screw to prevent slipping out of the screw from the slab or ceiling.

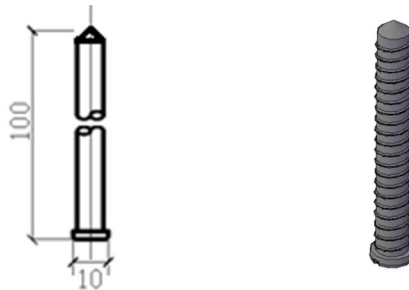


Fig. 4.19 Screw for the top track

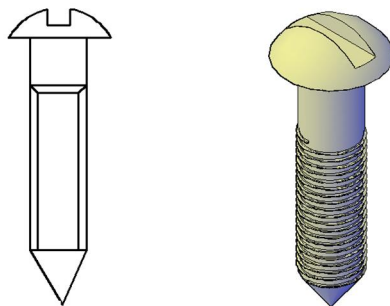


Fig. 4.20 Screw For bottom track

The roller

The roller is made of steel with rubber bind round the wheel to prevent noise during movement.

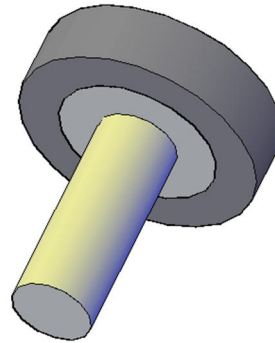
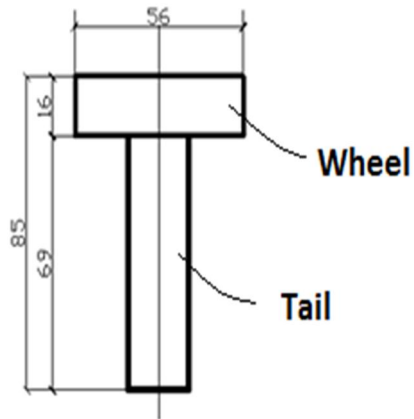


Fig. 4.21 Roller

Cup

It is a cylinder made of steel which is inserted on the top frame of the panel board with force fit and used to reduce friction between the roller tail and the top frame of the panel if the panel is made of wood.

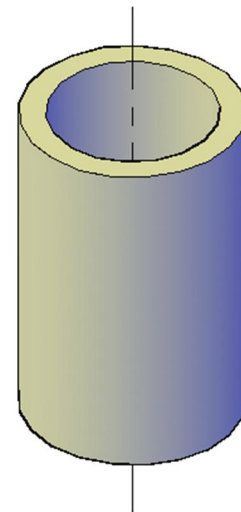
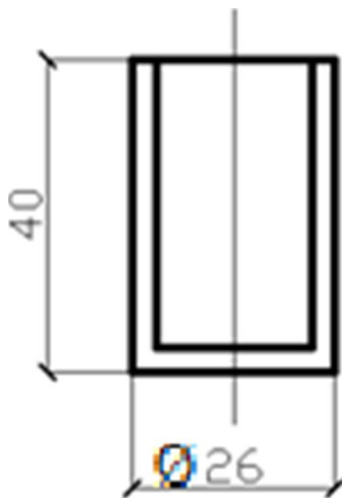


Fig. 4.22 Cup

☞ **Roller wheel**

For the bottom rail we used sofa wheel. It has enough strength to carry the weight of the portable wall and easily available.

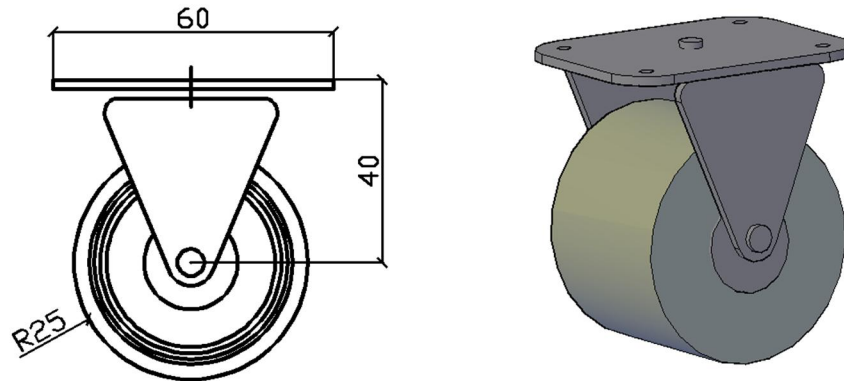


Fig. 4.23 Roller wheel

5.2.2 Manufacturing Phase

❖ **Measuring**

Every technician in engineering field of study should clearly understand the working drawings and specifications. Taking in to account such dieseline the working drawing was well analyzed and the materials were measured accurately by means of measuring tap and tri square with metric system of units.

❖ **Cutting**

This process was accomplished by circular saw for the long timbers and plywood, portable circular saw for the 45⁰ edges and thicknesses. The reasons we choose these machines were only save time and accuracy.

❖ **Assembling**

The panel frames were coated with glue properly and placed on the plywood accurately to avoid wastage and they bind together by c-clamp. They were stay bind for two day until there is strongly fitted.

5.2.3 Installation Phase

The first stage in this phase will be plotting points on the ceiling and floor if it is both supported type. And next will be fix the tracks on their accurate location by means of screws.

The rollers can now be joined on the edge of the portable wall in their design place. Finally we can insert the top rollers on the top track carefully. That will be the end stage of the installation for our project.

CHAPTER V

5. SPECIFICATION AND COST ESTIMATION

5.1 The project materials and specification

Table 5. 1 Material and specification

Part name	Specification				Remark
	Material Type		Unit	size	Qua.
Panel	Internal Timber Frame		m	0.7x0.7x4	8
	Glue		lt	3	2
	Nails		Kg	4&5	2
	Vainer		Lt	0.5	2
	Sofa stain		Pcs	1	2
	Plywood (oak) panel board		Pcs	0.3x122x244	6
	Locker		Pcs	1	1
	Hinge		pcs	2	4
Trolley accessory	For Top	Rubber roller Wheel	Pcs	1	4
	For Bottom	Rubber roller Wheel with Steel Wheel support	Pcs	4	2
Track	Top	Wooden track	pcs	10x10x350	1
		Steel screw	pcs	M12	8
	Bottom	Steel track	pcs	0.3x 86 Dev.	1
		Steel screw	pcs	M12	8

5.2 The project Bill of quantity

On the following table the Price of each material listed is estimated from April 2015 in Addis Ababa, Ethiopia.

Table - 5.2 Bill of quantity

No	Description		Unit	Unit Rate (Br.)	Qua.	Total (Br.)
1	Panel	Internal Wooden Fame	m	600	4	2400.00
		Glue	lt	350	2	700.00
		Nails	Kg	100	2	200.00
		Vainer	Lt	450	2	900.00
		Sofa stain	Pcs	220	2	440.00
		Plywood (oak) panel board	Pcs	220	6	440.00
		Locker	Pcs	350	1	350.00
		Hinge	pcs	100	4	400.00
2	Roller	Top Rubber roller Wheel	Pcs	15	4	60.00
		Bottom Rubber roller Wheel with Steel Wheel support	Pack	45	2	90.00
3	Track	Top Wooden track	pcs	500	1	500.00
		Steel screw for top	pcs	10	8	80.00
		Steel track for bottom	pcs	250	1	250.00
		Steel screw for bottom	pcs	10	8	80.00
Total cost						6,890.00
Contingency 10%						689.00
Grand Total						<u>7,579.00</u>

CHAPTER VI

CONCLUSION

The main objective of this project is to substitute fixed interior partition wall by movable wall to allow space flexibility between two adjacent rooms for any category of condominium buildings in Addis Ababa. The reason behind this project is that almost all condominium dwellers are in trouble of room flexibility. It is the occupants' strong desire if there is means of solution for the problem happened. There for substitution of fixed interior wall by portable partition walls are the best alternative solution that every condominium dwellers accept. Constructing portable walls to their rooms will provide room flexibility that enables moving furniture without damage, prepare any ceremony without anxiety of room size, etc in addition to low cost of construction. In advance it is the best job opportunity for different parties such as the micro and small scale industries, Architects, Contractors and means of tax income for the government.

RECOMMENDATIONS

- From the project output it can be recommended for the integrated housing development program office to revise its design on condominium interior partition walls that are constructed with fixed Agro stone and HCB to substitute them by portable walls.
- The other our recommendation goes to Architects, Engineers, Wood and Metal Technicians to play their professional roll in changing the society to modern living style.
- Since it is feasible project, the next recommendation is to Micros and small scale enterprises to invest on this project.
- Finally understanding the benefits of the project, applying this to condominium buildings, Meeting holes, Cinemas, Shops, Religious organizations to their scale is the best alternative for rooms' area management.
- Based on the project thesis conducted further studies can be made on
 - Automatic system integrated to portable walls
 - Manufacturing of portable walls from recycling plastics
 - Structural strength of the as built condominium slabs to carry suspended type portable walls

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