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Flexibility as a Strategy for Reducing Cost of Renovation in Building Construction Projects

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Abstract

Flexible buildings are the need of the present society. Flexibility leads to adaptability and adaptability of buildings has become the utmost requirement in today's world. Flexibility is understood to be the ability to adapt to continually changing requirements and conditions of the environment. This paper deals with a comparative study of renovation costs incurred for buildings that are flexible and buildings that are not flexible from utility point of view. The authors have assessed 15 cases of renovation of building projects in Nagpur city in India. To measure the degree of flexibility of buildings, a flexibility tool has been developed. The findings of the study suggest that the buildings that are having high degree of flexibility incurred less cost for renovation as compared to the buildings that are having low degree of flexibility. This research can help in making buildings more flexible so as to reduce the future renovation costs. A building that is more flexible will be utilized more efficiently, and will be more sustainable, because it can respond to changes at a lower cost. A longer and more efficient service life for the building may, in turn, translate into improved environmental performance over the lifecycle of the building.

Keywords: *Adaptability, Construction Projects, Flexibility, Renovation Costs*

Introduction

Flexibility of building is one such characteristic of building that influences the sustainability of existing building as well as the functional value of new building. It has been seen in many big cities that there is continuous redevelopment of old industrial buildings that were degenerated due to various reasons into offices or residential buildings. Most of the buildings are planned to have a life span of minimum 50 years and during this life span many buildings are demolished, while some buildings are renovated and given a second functional life. There are some built in characteristics in every building that makes it suitable for redevelopment and renovation than others. It has been observed in most of the renovation cases that the conditions that made these buildings suitable for renovation with changed functional value, were not foreseen in the design process and buildings were not designed to serve functional changes. There are few rule of thumb in construction industry for example a large floor to ceiling height of the building, that make it possible to accommodate new changes in a building with new appropriate functions. As there is continuous change in the requirement of the occupant of a building, there are more changes/ renovation work taking place on relatively young buildings. The present study explores the scope of structural design characteristics of building (flexible building structure) that can make the renovation work much easy and relatively less costly. The study uses 15 renovation cases of old building projects for exploring the scope of design flexibility in building structures.

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Literature Review

There is a huge mismatch between what the occupant requirement is and how the building is functioning, (Gereadts 2001). Most of the large construction projects are planned at least 5-6 years in advance. During this time, demands on the infrastructure are likely to change significantly. Changing demands may result from new forms of construction technology, changes in government regulations, change of rules in funding agencies, etc., (Arge 2005). There are many key stakeholders who are directly linked with a construction projects like project owners, users, project management, architects, consultants, and contractors. With so many stakeholders playing a key role there is scope of frequent changes in the requirements of each stakeholder. This creates a need of flexibility in the construction projects, (Paslawski 2008). It has been observed that a very little thought has been given on the design of flexible building structure to meet future requirement. The building developers do not want to invest for attaining future flexibility of buildings, particularly when the future requirement is not known, (Cowee & Schwehr 2008). In the present dynamic society where the occupants requirement are changing very fast, the buildings need to be design so as to adapt to the changing needs of its occupants. It has been observed that in order to cater to the occupant's requirements, relatively young buildings (10-25 years old) are demolished. This is not a desirable situation in terms of investment, waste production, energy, materials and sustainability of building, (Blok & Harwijnen 2005). There is a need to increase the functional life span of building which could be achieved if the buildings could easily be adapted to new occupant requirements, (Gereadts 2008). It is therefore important to look at buildings from a broader perspective than just the first occupant requirements. "Flexibility can be defined as the ability to change or react with little penalty time, effort, cost or performance", Upton (1994). This means that flexibility describes the ability of the project to cope with changes in the project definition or scope and compensate them with little influences on schedule (time), costs and quality by appropriate management policies and actions. Mandelbaum (1978) defines flexibility in relation to construction industry as the ability of the system to respond to change by taking an appropriate action and the inner capability of the system to function well in more than one state. To understand how flexibility can be applied in a building structure it is important to understand a building model.

Brand (1994) and Worthington (1994) has defined seven layers of building namely,

- Scenery (furniture, interior finishes, ceilings)
- Space plan (partition walls)
- Access (stairs, corridors, and lifts)
- Servant elements (building services, pipes, cables and involved spaces)
- Envelope (façades, base, roof)
- Compartments (firewalls)
- Structure (floors, columns, beams, load-bearing walls)
- Location (building environment)

In order to achieve flexibility of building structure it should have a capacity to accommodate changes to the structure itself without or with minor consequence to other building layers. Such kind of flexibility will allow changes in one or more other building layers (for example scenery, space plan, servant elements) without the necessity to change the structure itself, (Blakstad 2009). Blok & Herwijnen (2005) defines Flexible Building as a building with the capacity to accommodate, in a relatively easy way, future changes in use. This can be achieved by allowing for "relatively easy" changes to one or more of the following building layers: Scenery/Servant

elements/Envelope (Skin)/Access/Structure/ (Location). In other words it means that a building which can be renovated in a relatively easy way with relatively less cost. These are typical factors that serve as a basis for all construction projects. Although certain flexible solutions are repeated from one project to the next, no serious thought is given to making flexible allowances for the potentially different needs of future users of the building, (Patrizi *et al*, 2006). If a building is not readily flexible or is poorly adaptable to different uses, this will restrict its later use and have a negative impact on its value, (Saari et.al.2006). Flexibility is a property of a building that is realized to some extent in all projects, even if it had not been actually taken into account in during the design phase. There are certain design characteristics of building which makes it feasible for a building for renovation work. There is a need to understand these design characteristics in order to save the future renovation cost.

Strategy for Flexibility

By using a strategy of flexibility based on the structural design of building and its installations it is possible to achieve sustainability of building with increased functional value throughout its life span. Such type of flexibility of buildings will reduce the gap between the occupant's requirement and the building functions by making the renovation of buildings easy and less costly.

Research Method

A case study approach was used in this study to explore the scope of flexibility in design structures that makes renovation work easy. In all 15 cases of renovation of old buildings were studied. Almost all the buildings were at least 20-30 years old. The 15 cases of renovation and extension contain residential buildings, offices, mall, hospitals, hotels and guest house. In few of the cases there is a complete change of the occupant creating a need of conversion of present building function into a completely new one. After a careful analysis of all the cases it has been observed that wherever there was flexibility in the existing design of the building it made the renovation work easy and less costly. The authors in this paper give details and drawings of only 5 cases as sown below.

Data Analysis

Case Study 1

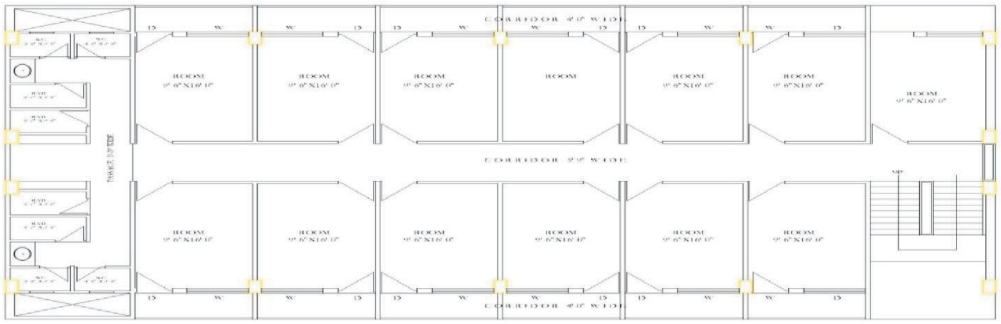
This case is of Dharmashala which is located near Adasa Ganesh Temple, Nagpur .Built almost 45 years before, the purpose was to give shelter for the devotees who come to the temple and want to stay for 1-2 days. The existing Dharamshala had rooms and there were no attached toilets with individual rooms. Since the number of devotees coming to this temple was increasing day by day the trustees of the temple thought of giving a comfortable stay at the temple campus to the devotees. Hence they decided to convert this Dharamshala into lodge/hotel which will have attached toilets, reception area, pantry, dormitory so as to give a comfortable stay to the devotees. The existing rooms were given attached toilets as shown in the drawing. The two rooms are converted into dormitory with eight bed provision and toilet for families. There was requirement of duct to the rooms attached toilets for which extra treatment to the front elevation was done. This required additional expenses. This duct was open out on terrace for repair and maintenance of pipe network.

Flexibility in initial design

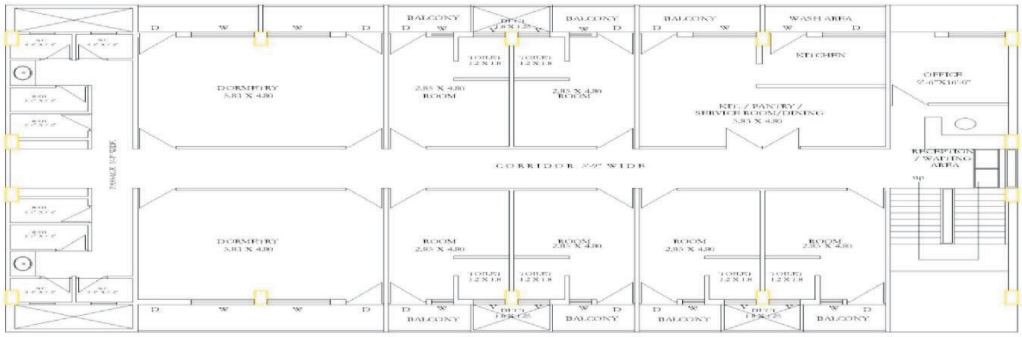
1. The initial design was not having flexible sewage system so as to incorporate for additional requirements of toilets. Due to modification in the existing building for installation of new sewage lines additional treatment for front elevation was required to improve the aesthetics.

This cost could have been saved if there would have been additional sewage lines given in the existing design.

2. There was a column beam frame structure constructed 45 years before which proved to be supportive in giving flexibility of removing internal walls. If there was a load bearing structure (open foundation) which used to be made during those days then it would have been difficult to remove internal walls.
3. The structure was stable due to framed behavior.

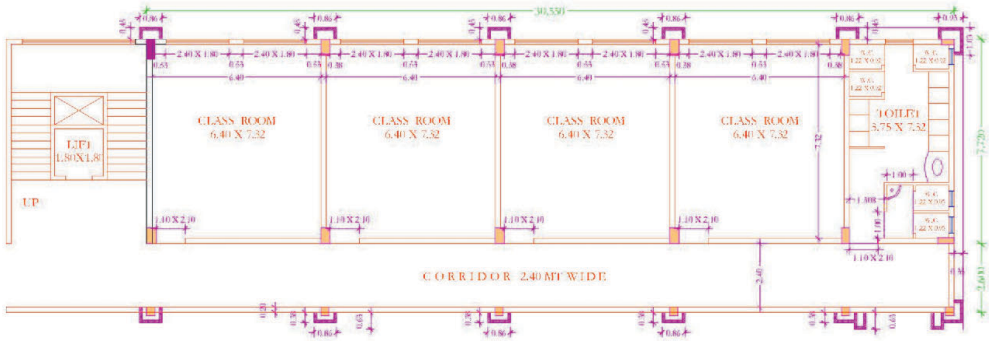


EXISTING FIRST FLOOR PLAN
OF DHARMASHALA



PROPOSED FIRST FLOOR PLAN
FOR LODGE

Case Study 2



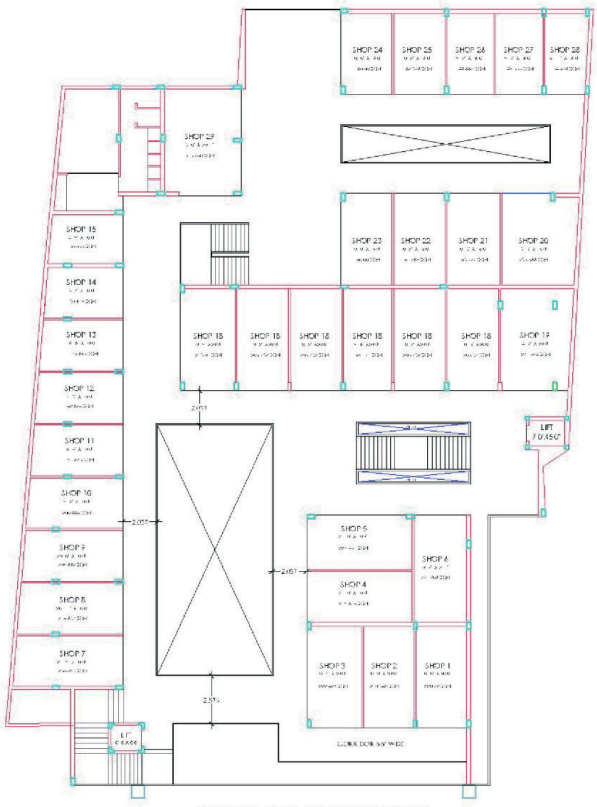
EXISTING PLAN

The above drawing is of a school building situated in Nagpur. The building has three floors having classrooms and labs on all the floors with sizes as shown in the drawing. The drawing shows only one floor and one side of the building. There are four such class rooms on the right side of the toilets. There is an administrative office and staffrooms on the ground floor. The building was built 15 years before and at that time the school was having only primary classes till 4th standard. Later the school also started with higher classes till 10th standard. The initial school building was not having a fully equipped auditorium. It was the requirement as per the new rules of school building codes. The school management thought to combine four classrooms shown in the above drawing and convert it into auditorium. The drawings were built as follows but the auditorium could not be constructed because the building structure was not flexible enough to support these changes. Because of this problem the school had to build a new auditorium in the adjacent plot which they purchased later so as to fulfill the school building requirements. This cost of making a completely new auditorium could have been easily saved if during the planning of the school building a thought on the flexible design structure was given.

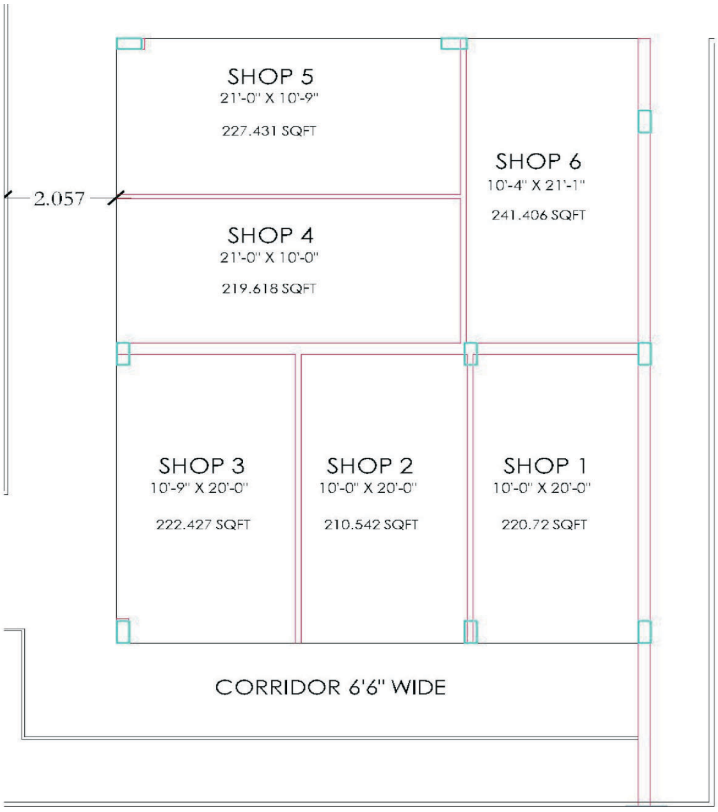
Flexibility Problems in Existing Design

1. The ceiling to floor height was very less due to which an auditorium cannot be planned in that much height
2. The classrooms column will come in between the auditorium which will hamper the view on stage. These columns cannot be removed from the structure. The dais cannot have sufficient height because of constrain of the ceiling floor height.

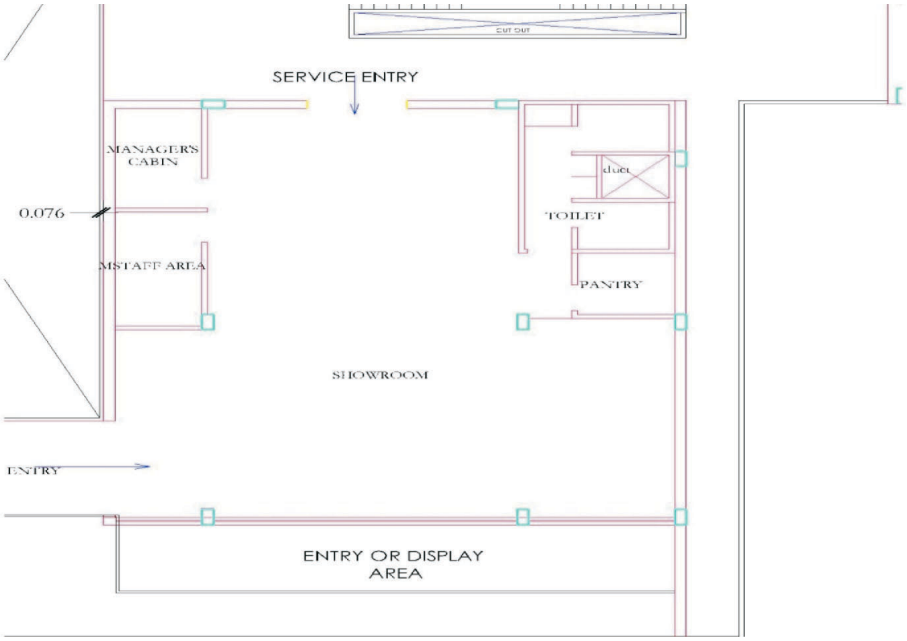
Case Study 3



EXISTING PLAN OF UPPER GROUND FLOOR OF MALL



The new plan of the big showroom shown below.

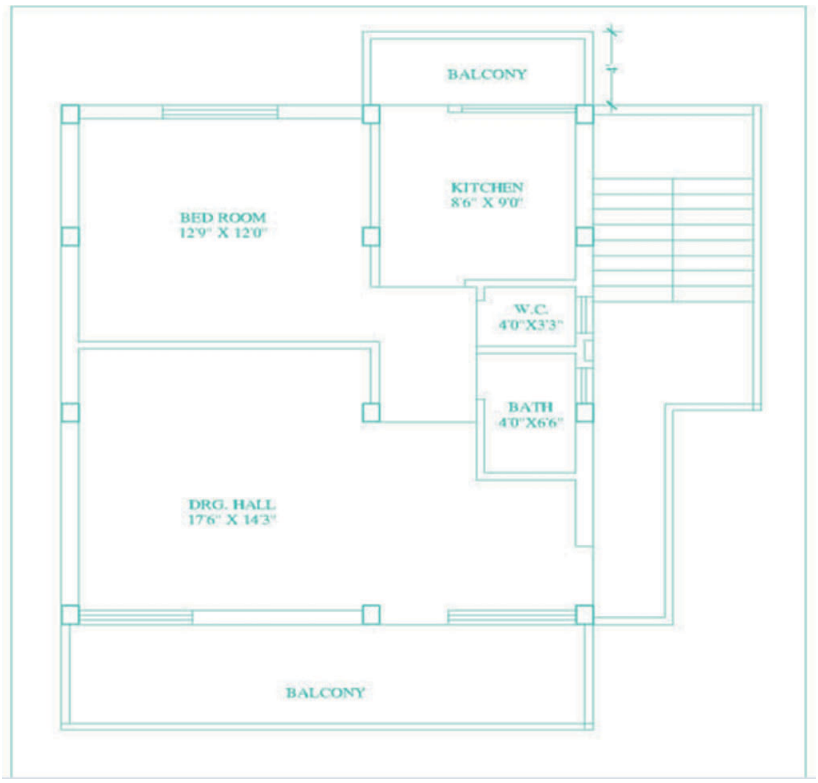


The above drawing is of a shopping complex situated in Nagpur. The drawing shows the upper ground floor of the mall. As shown in the drawing there were different sizes of shops owed by the shopkeepers. The shopping complex was built almost 10 years back. The shops 1,2,3,4,5 and 6 were not till six months. After six months a client approached the builder to purchase all the 6 shops provided the builder will make arrangement to convert all those six shops into a big showroom. The six shops are shown in the drawing below. Since it was a column structure (framed structure) it was very easy to remove the partition walls and convert the small shops into a big showroom.

Flexibility Strategy in the Existing Design

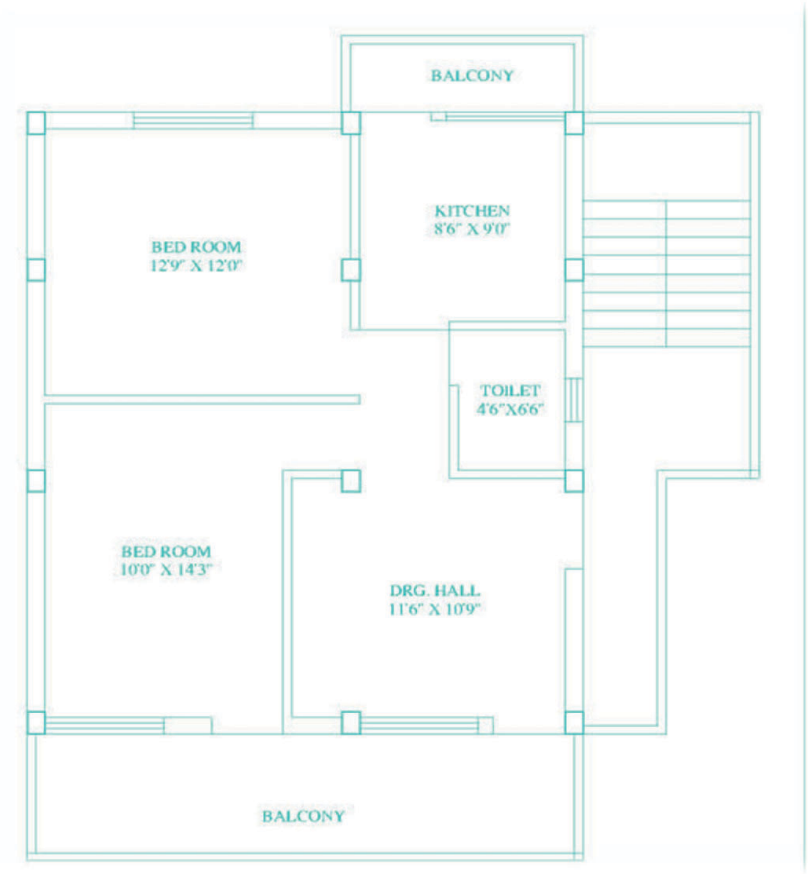
1. The existing design was column structure (framed structure) having partition walls which could be easily removed on the requirement of a big showroom.
2. If the initial structure was load bearing it could have been difficult to remove the walls.
3. The size of the shops was easily converted into big showroom as per the requirement of the client because of this flexibility.

Case Study 4



The above drawing is of a flat owned by a couple in 1998. The total sq feet area of flat is around 1000 sq feets. The couple got newly married at that time and as their requirement and budget they bought this flat. In 2009 the couple thought that there was a need of one extra bedroom. But they did not wanted to shift from this place, neither their budget allowed them to purchase a two bedroom flat in the same location. Hence they thought of converting their one bedroom flat into two bedrooms flat. Their existing flat of one bedroom was converted into two

bedrooms with a little renovation done and with cost within their budget due to the initial design structure of columns this was quite feasible. The following is the new drawing.



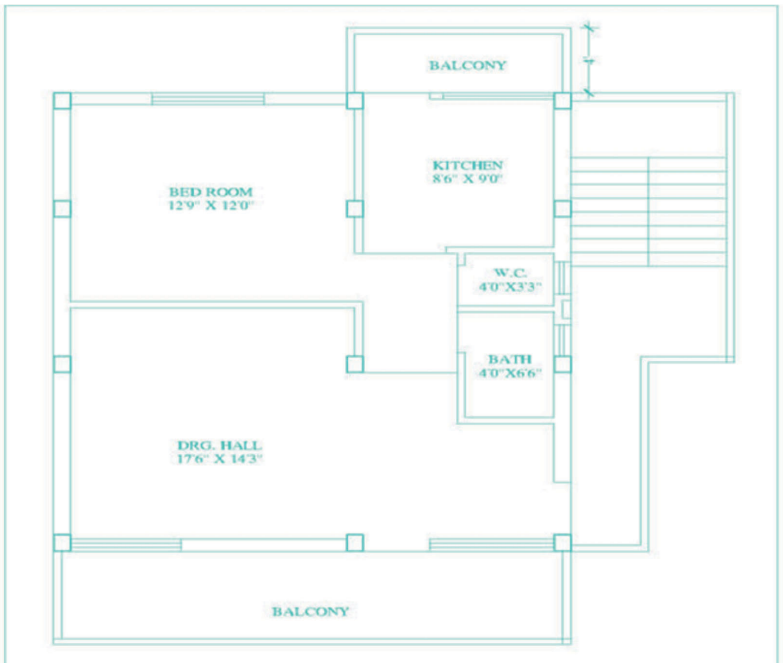
Flexibility Strategy

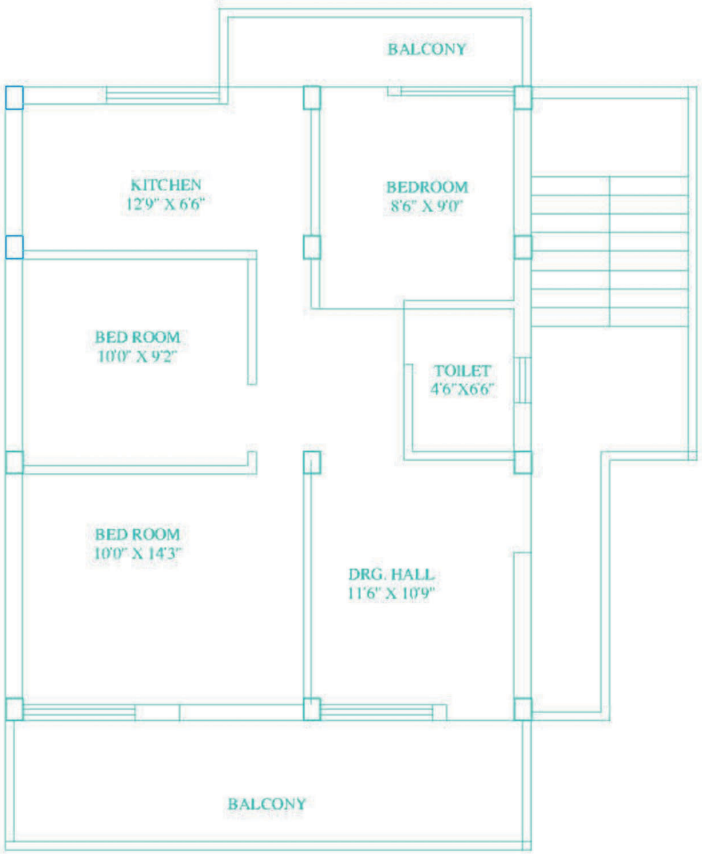
1. The initial design of the flat was column structured due to which it was easy to move the walls.
2. The initial drawing room size and the position of the columns provided scope for reducing the drawing room size for making extra bedroom.
3. The columns in the existing design allow changing the setting of build profile as need/ requirement changes.

Case Study 5

In the same flat scheme there was another couple who had purchased another flat in the year 1998. The requirement at that time was only of one bedroom. But later in 2010 when their requirement was of three bedrooms with increase in their family size they too thought of converting the 1000 sq feet one bedroom flat into two. There was lot of constraints for not leaving this flat like budget, location, etc.

The existing one bedroom flat was converted into three bedrooms flat with little renovation and cost within their budget. As shown in the drawing below the kitchen was shifted from its existing place to give provision for the third bedroom.


BALCONY
KITCHEN
8'6" X 9'0"
BED ROOM
12'9" X 12'0"
W.C.
4'0"X3'3"
BATH
4'0"X6'6"
DRG. HALL
17'6" X 14'3"
BALCONY


BALCONY
KITCHEN
12'9" X 6'6"
BEDROOM
8'6" X 9'0"
BED ROOM
10'0" X 9'2"
TOILET
4'6"X6'6"
BED ROOM
10'0" X 14'3"
DRG. HALL
11'6" X 10'9"
BALCONY

Flexibility strategy

- The initial design of the flat was column structured due to which it was easy to move the walls.
- The initial drawing room size and the position of the columns provided scope for reducing the drawing room size for making extra bedroom.
- The kitchen was shifted from its place to give provision for the third bed room. The balcony was increased to provide wash area for the kitchen.
- The only drawback is of the compact room size in this design which is the compromise due to lack of sufficient funds to go for a new 3 bedroom big flat in the same location.
- The columns in the existing design allow changing the setting of build profile as need/ requirement changes.

In similar way remaining 10 cases of renovation were studied that showed how flexible design structure helped the renovation work.

Value of Flexibility

In order to have flexible buildings it is necessary to see how much investment cost is required to make such flexible arrangements in the buildings in order to cater future needs. For this one should compare (First Cost Premium + Operating Cost Premium) with (Future Cost Savings + Mitigated Disruption)

- First Cost Premium – Additional Cost of Flexibility
- Operating cost Premium – Additional Operating Cost
- Future Cost Savings – Savings Derived from Flexibility at Time of Modifications
- Mitigated Disruption – Disruption not Experienced due to Build-in Flexibility

Such kind of comparison will give the benefits of having flexible building design structures in the form of future savings. The new role of the design project is to guarantee future flexibility and sustainability. If requirements on a building change, the primary and secondary structures often need to be modified.

Conclusion

Flexible design strategy in initial building design can bring significant savings in total materials flows, with economic benefits to building owners, facility managers and tenants over the building life. Incorporating flexible design for renovation /remodeling of buildings will contribute to more sustainable buildings by extending the useful life of a building and optimizing materials reuse and recycling potential. Flexibility cannot be a universal property of a building. Thus, no universal aims and goals can be set for flexibility in building structures nor can “absolutely flexible” building be built. Flexibility is a property of a building which is very relative. It must be determined which alternative use situations one should prepare for since it is not possible, in practice, to be prepared for arbitrary changes. Likewise, one must estimate acceptable conversion costs and disturbances to activities. This definitely will help us for preparing ourselves for the “unknown future” mainly by flexible solutions related to the building structure.

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