CHAPTER IV

DESIGN WAREHOUSE LAYOUT AND ALLOCATION SYSTEM

Warehousing management concerns the orderly execution of physical storage and retrieval activities and the processing of information needed about the good stored. Warehouse management must ensure that the company always has been available at the correct stock level the goods it needs; that the warehousing capacity is both economic and efficient; and that the goods are properly kept. The right methodology implies in itself the choice of efficient media, but basically it is information-oriented. It focuses on the correct evaluation, identification, classification and quantification of the goods to be stored and retrieved – and on the ways and means of handling information.

Customer requirement are simply the demand to have the right product in good condition at the right place at the right time. Therefore, the product must be accessible and protected. If a warehouse cannot meet these requirements adequately, the warehouse does not add value to the product and, in fact, very likely subtracts value from the product.

Therefore, the following objectives must be met for a warehouse to be successful:

1. Maximize the effective use of space.
2. Maximize effective use of equipment.
3. Maximize effective use of labor.
4. Maximize accessibility of all items.
5. Maximize protection of all items.

As it was mentioned earlier, the current warehouse management causes many problems that affects to both warehouse operation and business operation then with the current warehouse management, it is impossible to achieve the objectives of warehouse. Then the new warehouse management must been established to bring the warehouse meet its objective and eliminate causes of the problems. On the way to accomplish the warehouse's objectives, we must consider the variable warehouse resources and mold them into an effective method.

A good warehouse management must maximize the effective use of the warehouse resources while satisfying customer requirements. It can be said in other

words that warehouse management concerns to every aspects in a warehouse from which is the basic physical structures and facilities of warehouse to warehouse activities that been done by the operators. The new warehouse management must consider and improve the warehouse from the infrastructure of warehouse to the warehouse operation. As a result, the new warehouse management consists of 5 methods that bring warehouse to meet its objectives and these methods concerns to all significant functions of the warehouse from the infrastructure to the warehouse operation following this:

Step 1: Space planning and Warehouse Layout planning: Space is a primary, finite resource common to all warehouses. Proper planning of warehouse space and layout requirements is needed to ensure that all the objectives of the warehouse are adequately met. This step addresses proper space planning and layout planning for the warehouse which includes determination the warehouse equipment using in each area.

Step 2: Assign the material to be stored to the storage locations: The stock location system is the system that allows you to track product movement throughout the facility. The locator system that suit to each warehouse, depend on consideration such as Space available, Dimension of product, Weight of items, Storage methods, Equipment and Labor availability.

Stock Location systems provide a broad overview of where items will be found within a facility. Item placement system is the system that manages where a particular item should be physically positioned.

Step 3: Designing Location Addresses and Item Identifiers system: This system is very important because it is not possible to control what it can't be found. This system helps warehouse staff to keep track of where items are at any given time.

Step 4: Designing Warehouse database system: This is the last activity of storage function which is a paper work or record keeping of all activities in warehouse. In the modern day, most warehouses operate this activity through computer system and warehouse software. It can provide information of stock level and movement of each item. This system is very important to storage planning and inventory management.

Step 5: Designing Warehouse operation which goes well with a new system: The requirements of a warehouse operating system vary. What constitutes the optimum system depends on the special circumstances within each organization. Factors such as organization style, economic needs, and materials characteristics are also influenced by environmental considerations. The above and other factors are in a state of continuing change. In order to plan for the schedule in a warehouse, it is necessary to identify and establish standards for the tasks to be performed and the operation procedure. The warehouse operation must support with the other system, equipment and space in a warehouse.

This chapter will discuss about step 1 to step 3 of the warehouse management design process which concerns about how to improve layout and space of warehouse and warehouse systems that would be suit to this warehouse.

4.1 Warehouse space planning and warehouse layout planning

4.1.1 Warehouse Space Planning

From the Warehouse space planning in chapter 2 of this thesis, space planning is the part of the science of warehousing concerned with making a quantitative assessment of warehouse space requirements. As is true of any science, space planning possesses a very specific methodology, and it consists of the following general steps:

1. Determine what is to be accomplished.
2. Determine how to accomplish it.
3. Determine space allowances for each element required to accomplish the activity.
4. Calculate the total space requirements.

The first two steps of the space planning process define the activity and the techniques, equipment, information, and so on, to be used in performing that activity. Step three involves determining the space requirements of each element that goes into performing the activity. In warehousing, these elements might include personnel and personnel services, and utilities. Finally, step four combines the space requirements of the individual elements to obtain total space requirements.

There are two major activities in a warehouse require space planning: receiving and shipping activities.

4.1.1.1 Space Planning for Receiving and Shipping

(A) Define the materials to be received or shipped: The first step in space planning for receiving and shipping operations is to define what is to be accomplished, that is to define the materials to be received or shipped. The Receiving and Shipping Analysis Chart (RSAC) in chapter2 is a good tool to define what is to be received or shipped. A completed RSAC appears in chapter2 of this thesis. In this chapter, RSAC is adapted to define what is to be received or shipped in a warehouse and it was divided into 2 charts: Receiving analysis chart and Shipping analysis chart. Detail of all item at the receiving stage and shipping stage are showed with receiving analysis chart and shipping analysis chart in the appendix B. Receiving analysis chart provides data of unit load type, size of unit load and quantity of item at receiving stage. The information of these charts is obtained by historical data and real measuring at a warehouse.

(B)Determine Dock Requirements: After the items to be received or shipped have been defined, the next step is to determine the requirements for the receiving or shipping dock bays. In this warehouse, there are 2 types of transportation that deliver items to a warehouse: truck and pick-up. Because of the shape of the warehouse site, it is impossible to have a dock area inside a warehouse area. The dock area of this warehouse is a public street in front of a building.

Figure 4.1- Dock bay area on a public street

(C) Determine buffer and staging area requirements: Specifying accurately the optimum amount of receiving buffer space or shipping staging space is very difficult task. The receiving buffer area serves as a depository for the materials

unloaded from the carriers. The receiving buffer area allows the supplier's staffs to concentrate on unloading the carrier for fast receiving "throughput". Fast receiving throughput is essential for this warehouse because they use a public street as a dock bay area. Once their carrier is unloaded and released, a more through check-in and inspection of the items will be performed within the receiving buffer area.

From the receiving analysis chart in table B.1 in the appendix B, maximum length of receiving unit size is 140 cm and maximum width of receiving unit size is 120 cm. Maximum height of receiving unit size is 120 cm. In that case, area for placing receiving items must have length more than 140 cm, width more than 120 cm and height more than 120 cm. From the receiving analysis chart in table B.1 in the appendix B, required cubic space of each receiving unit is showed in the chart and maximum required cubic space for a single receiving unit is 528,000 cm^3. After required cubic space of a single receiving unit multiples with receiving quantity, item's total required cubic space that required at buffer area is the outcome. From the receiving analysis chart in table B.1 in the appendix B, maximum total cubic space for one item that required at receiving buffer area is 4,639,800 cm^3. Most of receiving activity is handle only one type of item at a time but in some case, receiving activity has to deal more than one item then the space for stacking activity must be larger than in previous calculation. In receiving area, received items can not be stacked too high because they need to be inspected in the term of quantity and quality. Normally, received items are stacked lower than 1.2 m so the approximated required space for placing item in a buffer area is 10 square meters.

The area for inspection activity must be preserved in a buffer area. The inspection activity has been done by only one operator and requires no machine or special tool. Thus, approximated allowance for inspection activity is 3 square meters.

As a result, required buffer area is equal allowance for inspection activity plus space for placing item in a buffer area = 10 + 3 = 13 square meters.

The shipping staging area serves as an accumulation point for the items that comprise a shipment. Various levels of accumulation may be established within the shipping buffer area. Activities performed within the staging area might include packing. Unitizing, or verifying that the entire customer order or shipment is ready for loading onto the carrier.

From the shipping analysis chart in table B.2 in the appendix B, the maximum length of shipping unit size is 140 cm and maximum width of shipping unit size is 120 cm. Maximum height of shipping unit size is 120 cm. In that case, area for placing shipping items must have length more than 140 cm, width more than 120 cm and height more than 120 cm.

From the shipping analysis chart in table B.2 in the appendix B, cubic space of each shipping unit is showed in a chart and maximum cubic space of 1 shipping unit is 528,000 cm^3. After required cubic space of a single shipped unit multiples with shipping quantity, item's total cubic space that required at shipping staging area is the outcome. From the shipping analysis chart in table B.2 in the appendix B, maximum total cubic space for one item that required at shipping staging area is 528,000 cm^3. That product is the shower sponge and its size is 110 cm width, 120 cm length and 40 cm height. But in the real situation, a shipping order comprises more than one item then the space for stacking item must be larger than in previous calculation. Minimum requirement of area for placing shipping items must have length more than 140 cm, width more than 120 cm and height more than 120 cm. But beside the items placing space, the allowance space for pre-delivery checking and operation area such as unloading from material handling equipment must be preserved in the stacking area also. From historical record of order quantity, approximated required space for placing item is 8 square meters and allowance space for operation area is 8 square meters. Then total space for stacking area is 16 square meters.

Since, packing activities are done in this area, Space for packing activities must be included in planning. Space for packing activities consist of a packing machines area, an area for keeping packing tool and an operational area. According to 3.2.6.3 packing equipment in chapter 3, the size of packing machine is 60 cm width, 110 cm length and 80 cm height and packing tools consist of plastic string, pincer, scissors, and self adhesive cellulose tape. Thus, approximated required space for packing activities is 4 square meters.

As a result, required staging area is equal packing area plus item stacking area = 16 +4 = 20 square meters.

Aisle space: Aisle space must be provided within the buffer or staging area. This aisle space is not intended for use in placing materials in or taking them out

of the buffer or staging area. Instead, it provides access to and egress from the dock area to other parts of the warehouse. Most of the traffic type in a buffer or staging area aisle is predominantly pedestrian traffic. As a result; requirement of the width of aisle space within a buffer or staging is only for a single-direction travel with feet thus the approximate width of aisle in a buffer or staging area is 0.8 m.

(D) Determine Dock-Related Space Requirements:

Office space: Office space must be provided for receiving and shipping supervision and for clerical activities. In this warehouse, office space is located at the first floor of the building no.1 and this area can not be moved or modified.

A receiving hold area: A receiving hold area is essential for accumulating received material that has been rejected during a receiving or quality-control inspection and that is awaiting either return to the vendor or some other form of disposition. In this warehouse, rejected items are never be allowed to accumulate in the receiving buffer area because supplier's staffs stay at the warehouse until quality-control inspection finishes so if their items were rejected, they will bring it back immediately.

Trash area: Particularly receiving function, generate a tremendous amount of trash, including corrugated boxes, binding materials, broken and disposable pallets, bracing, and packing materials. Space must be allocated within the receiving and shipping areas for disposal of these items. Failure to do so will result in poor housekeeping, congestion, unsafe working conditions, and a loss of productivity. Trash disposal in this warehouse is not much and most of them are paper boxes. Paper box will be stacking on a floor after they are folded into flat shape. From the Receiving and Shipping analysis chart, maximum length of shipping unit size is 140 cm and maximum width of shipping unit size is 120 cm. Maximum height of shipping unit size is 120 cm. After paper boxes are folded, their sizes will be increased. As a result, approximate area for trash disposal is about 2m x 2m.

4.1.1.2 Space planning for storage activities

The second major area in a warehouse that requires space planning is the storage activity. Storage space planning is particularly critical because the storage

activity accounts for the bulk of the space requirements of a warehouse. Storage space planning must be approached from a quantitative viewpoint as opposed to a quantitative assessment of requirements. Thus, storage space planning requires the planned inventory level and size of stock-keeping-unit. The planned inventory levels depend on the stock locator system followed in assigning material to storage space. In the current system, some stock-keeping-units have the storage unit-type that is different from the unit-type that is shipped so it requires more work in order picking operation. The new storage system has determined that the unit-type of stock-keeping-unit is the same as the unit-type that is shipped.

The stock locator system is the system that allows you to track product movement throughout the facility. Stock locator systems provide a broad overview of where items will be found within a facility. Due to, the amount of space planned for a stock-keeping unit is directly related to the method of assigning space. Therefore, before the storage space for each item would be planned, the stock locator system has to be determined firstly.

***(A) Determine storage locator system*:** There are several type of storage locator system and each of them is the storage philosophy that suit to each warehouse, depend on consideration such as space available, dimension of product, weight of items, storage methods, equipment and labor availability. In this warehouse, "maximize the effective use of space" is the first priority objective and the second priority objectives of a warehouse layout are "maximize accessibility of all items". Then selection of the storage locator will be focused on maximize the effective use of space.

From the previous collection data in the table B.3 of the appendix B, there are numerous item and these items have various unit types, size, weight and shape. The storage methods that are used in this warehouse are shelving and floor stacking. The weight of some items may be over 20 kg or lower than 1 kg but most of them are lower than 5 kg.

Consequently, the storage philosophy chosen for a specific stock-keeping unit should not be strictly fixed-location storage or random-location storage. Instead, it should be combination of the two. The suit storage philosophy is a combination philosophy which enables warehouse to assign specific locations to

those items requiring special consideration, while the bulk of the item mix will be randomly located. Conceptually the best features of the fixed and random systems can be combined at the same time. It can be achieved by assigning only the selected items to the fixed home but not all items.

(B) Define the Materials to Be Stored: The first step in storage space planning, as in receiving and shipping planning, is to define what is to be accomplished, that is, to define the materials to be stored. A useful tool in defining the materials to be stored is the storage analysis chart (SAC) given in the chapter 2 of this thesis. A completed SAC appears in chapter2 of this thesis. In this chapter, SAC is adapted to define what is to be stored in a warehouse. Detail of all items at the storage activity is showed in the storage analysis chart in the table B.3 of the appendix B. The maximum and average inventory levels for each category of item listed are derived from *invoice* from suppliers and a purchasing recording book of administration. The rest information requirements for the SAC are obtain by physically surveying the existing storage areas. The survey proceeded by identifying. Generically classifying, measuring, and weighing the unit loads presently in the storage areas.

Consequently, the storage analysis chart (SAC) provides data of unit load type, size of unit loaded and the current storage method. The SAC also provides the maximum and average number of unit loads of each item that should be on hand, thus the required storage area and volume of each item at the maximum and average number of unit loads of each item are calculated and showed in SAC.

(C) Determine the proper inventory level: Determining the proper inventory level is directly related to the storage locator system that will be used for stock-keeping items. Once the maximum and average inventory levels have been recorded, the inventory level that will be used as a basis for planning required storage space must be determined. The planned inventory levels depend on the storage locator system followed in assigning material to storage space. The amount of space planned for a stock-keeping unit is directly related to the method of assigning space.

Combination system is selected to apply for the storage locator system of this warehouse. Therefore, it needs to plan around the maximum space required by

the selected items instead of that required by all items. For the items not in fixed homes, it can be planned around the average quantities on a daily, ongoing basis. So, the fixed location storage is used for the selected items and the random location storage for everything else. So, the required storage cubic space for each item depends on item's characteristic. Each item needs to be considered whether it requires special specific storage location and storage method or not, and quantity of unit load stored in a warehouse.

Therefore, selection of the items that requires special specific storage location and storage method will be considered in the term of weight, size, shape, special storage method and turn-over rate. The special item can be indicated in many term and the factors of each item has been illustrated in the C.1 of the appendix C and from this factor, inventory level and storage space requirement of each item are able to be determined.

According to the appendix C, below this are the special items that are required special specific storage location and storage method. Therefore, they need to plan around the special space required.

In the term of weight: They need to be stored in the low layer of the shelves or stacked on the floor because they will be difficult to lift and move these heavy items. The philosophy suggests that heavy, hard-to-handle items should be close to their point of use. These heavy items require special specific storage location and storage method. Then storage space planning for these items should be planned around maximum space requirement.

The histogram graph is used to demonstrate the distribution of weight data of items in warehouse and the result is illustrated below this:

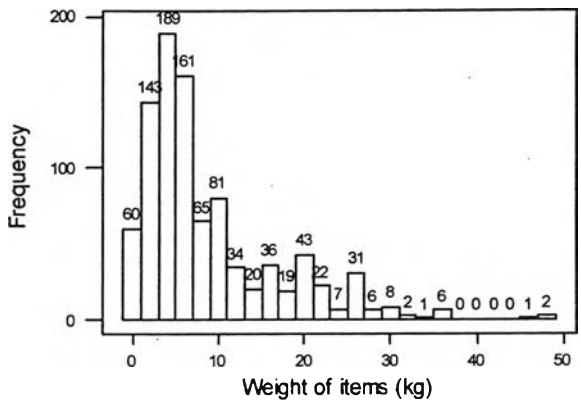


Figure 4.2-Histogram of weight data

From figure 4.2, most items have weight below 30 kg. Then items that have the weight over 30 kg are require special specific storage location and storage method because they will be difficult to lift and move these heavy items.

In the term of size: The philosophy also asserts that the size of the storage location and storage equipment should fit the size of the material to be stored. A variety of storage location sizes and storage equipment must be provided so that different items can be stored differently. In addition to looking at the physical size of an individual item, one must consider the total quantity of the item to be stored. These dominantly big size items require special specific storage location and storage method. Then storage space planning for these items should be planned around maximum space requirement.

The histogram graph is used to demonstrate the distribution of dimension data of items in warehouse and the result is illustrated below this:

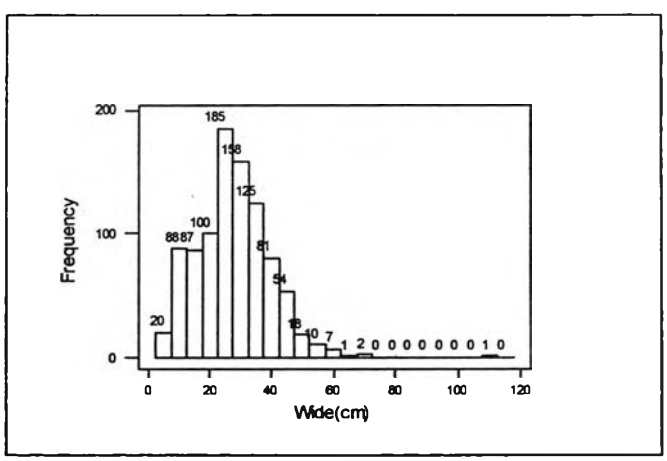


Figure 4.3-Histogram of the width dimension of items

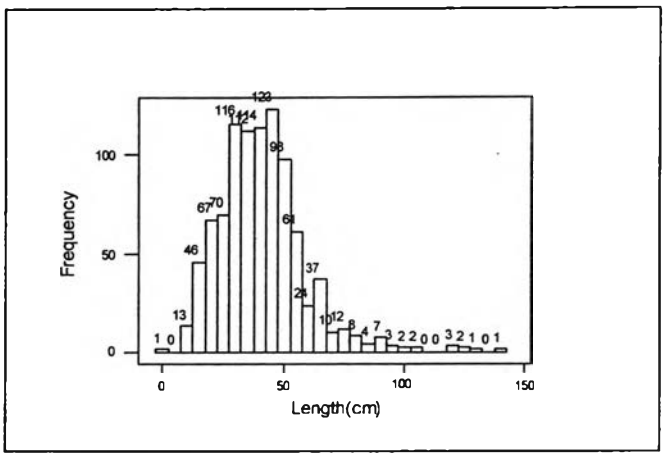


Figure 4.4-Histogram of the Length dimension of items

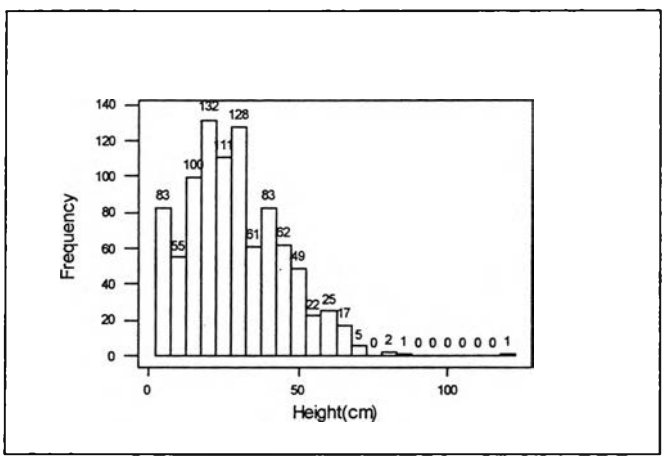


Figure 4.5-Histogram of the Height dimension of items

From figure 4.3, in the term of width dimension, most items have width dimension below 60 cm. Then items that have the width dimension over 60 cm are considered to require special specific storage location and storage equipment.

From figure 4.4, in the term of length dimension, most items have length dimension below 110 cm. Then items that have the length dimension over 100 cm are considered to require special specific storage location and storage equipment.

From figure 4.5, in the term of height dimension, most items have height dimension below 70 cm. Then items that have the height dimension over 70 cm are considered to require special specific storage location and storage equipment.

These items are considered to require special specific storage location and storage equipment because their dimensions are different from bulk items.

In the term of oddly shape: Shaft shape items is the special shape items which require special s storage method. Then storage space planning for these items should be planned around maximum space requirement.

In the term of turn-over rate: The popularity philosophy maintains that the items having the greatest throughput should be located in an area that allows the most efficient material handling. Consequently, high-turnover items should be located as close as possible to the point of use. These high turn-over items require special specific storage location. Then storage space planning for these items should be planned around maximum space requirement.

The histogram graph is used to demonstrate the distribution of the turn-over rate of items in warehouse and the result is illustrated below this:

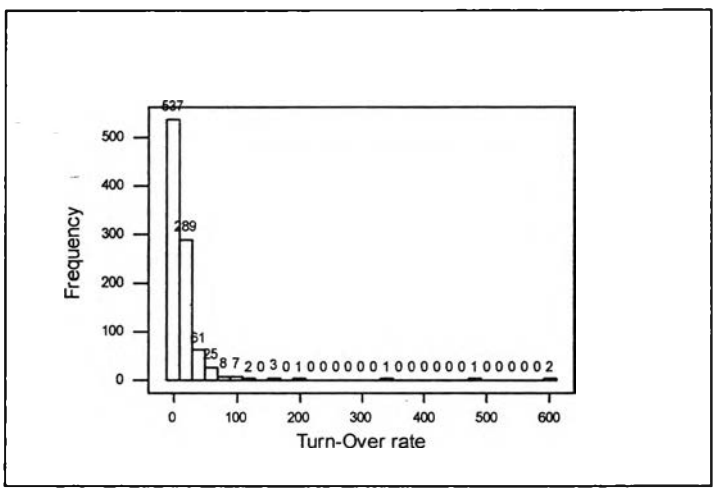


Figure 4.6- Histogram of the turn-over rate of items

From figure 4.6, most items have the turn-over rate below 100 box/ month. Therefore, items that have the high-turnover rate over than100 boxes/month should be located as close as possible to the point of use. The items that have high turn-over items require special specific storage location. Then storage space planning for these items should be planned around maximum space requirement.

These special items are planned storage space around the maximum space requirement. In other word, they need to plan around their maximum of their stock. Then, the others items are planned around their average amount of stock or average space requirement. All the cubic requirement of each items are demonstrated in the table C.1 of the appendix C.

The histogram graphs are used to demonstrate the distribution of cubic storage requirement of each item in warehouse and the result is illustrated below this:

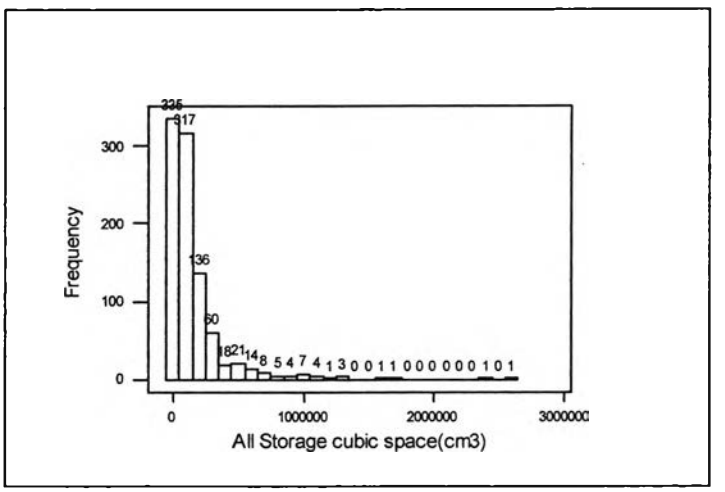


Figure 4.7- Histogram of the storage cubic space of all items

If histogram is used to demonstrate only the distribution of the required storage spaces of special items, the outcome is shown below this:

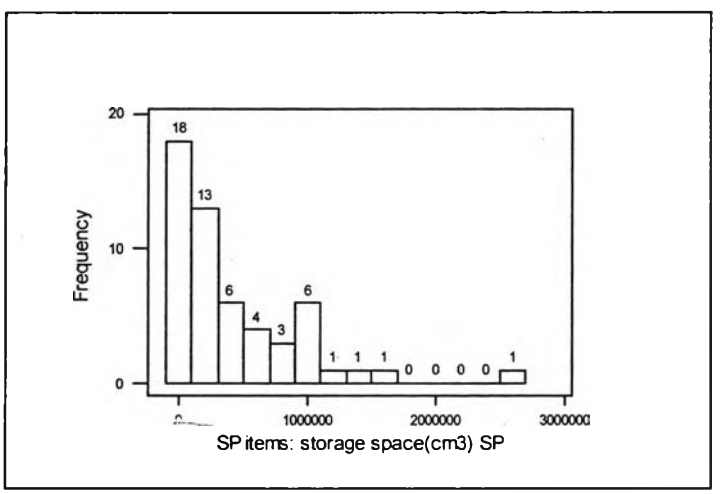


Figure 4.8- Histogram of the storage cubic space of Special items

If histogram is used to demonstrate only the distribution of the required storage spaces of normal items, the outcome is shown below this:

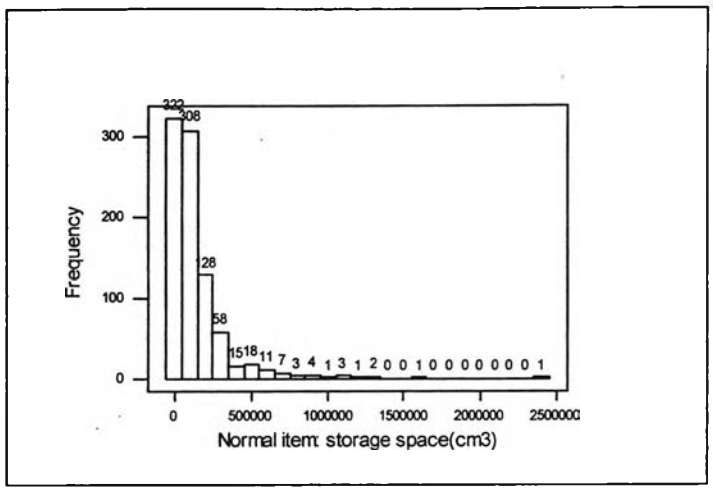


Figure 4.9- Histogram of the storage cubic space of Normal items

(D) Determine the use-of-space characteristics of the storage space:

The space requirements of a storage area are directly related to the volume of items to be stored and to the use-of-space characteristics. The two most important use-of-space characteristics are aisle allowances and honeycombing allowances.

Aisle allowance is the percentage of space occupied by aisles within storage area. Aisles are necessary within a storage area to allow accessibility to the material being stored. The amount of aisle allowance depends on the storage method, which dictates the number of aisles required, and on the material-handling method, which dictates the size of the aisles. Expected aisle allowance must be calculated for storage space of the warehouse.

In this warehouse, the most of the storage method is shelving and stacking on the floor. The material-handling methods are hand-truck and pedestrians. Then the width of aisle in the space area has no need to be so wide. Although from the shape of storage buildings, there are many floors in storage building then they must contain many stairs and gates. Each floor requires main aisles and aisles within a storage area. As a result, aisle allowance or percentage of space occupied by aisles within storage area must be quite high then aisle allowance must be planned around 40% of a storage area.

Honeycombing allowances are the percentage of storage space lost because of ineffective use of the capacity of a storage area. The unoccupied area within the storage location is honeycombed space. Honeycombing occurs whenever a

storage location is only partially filled with material and may occur horizontally and vertically. Honeycombing, while it should be minimized, must be considered a natural and allowed for phenomenon of the storage process.

This warehouse employs the combination of fixed and random philosophy into the stock locator system so items may be placed wherever there is space for them. Combination locator systems provide us with the best use of space and maximum flexibility while still allowing control over where an item can be found. But size of items is very various and there is variety of container and package of items. Therefore, the honeycombing allowances should be preserved around 30% of a storage area.

(E) Determine the required storage space for each item and total stock-keeping-items: Once the aisle and honeycombing allowances for a storage method have been determined, the total storage space required can be calculated. Given the cubic space required for storage of each items and the allowance of aisle and honeycombing, the total space required for that all items can then be calculated. Therefore, the cubic space required for storage of each items can be summed up in the table C.1 of the appendix C and add up with the allowance of aisle and honeycombing. The result of that calculation is the cubic space planning for storage area. As a result, the numbers are putted into this calculation:

: Total cubic space required for all items + Allowance of Aisle and Honey combing = **the cubic space planning for storage area**

: 151.82 meter^3 + (40%+30%)*(151.82) = **258.1 meter^3**

Then the **cubic space planning for storage area** is **258.1 meter^3.**

4.1.2 Warehouse layout planning

From the topic 3.2.5 warehouse layout in chapter 3, layouts and detail of each building and floor of the warehouse have been illustrated by both pictures and letters. In this chapter, layout of the warehouse will be revised and improved to meet its objectives.

So before layout planning can begin, the specific objectives of a warehouse layout must be determined. In this warehouse, "maximize the effective use of space"

is the first priority objective and the second priority objectives of a warehouse layout are "maximize accessibility of all items".

4.1.2.1 Define the fixed obstacles of the warehouse

From the topic 3.2.5 warehouse layout in chapter 3, the fixed obstacles at each floor of both buildings that are used as a warehouse, have been discussed and illustrated in that topic. Therefore, the conclusion of determination of fixed obstacles at each floor will be given details in following this and if it is possible, how to improve it to make warehouse more efficiently may be added.

(A) Fixed obstacle in the first floor of building No.1: The first floor of building no.1 is an office for an administration but there are some other activities have been done at this floor. Length of this floor is 11.5 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters. Total area of this floor is 43.7 square meters and the lift area is 1.82 square meters. Size of the first office area is 2 meters width and 1.9 meters length then the width of entrance and exit is 1.80 meters. Width of the aisle between stair to upper floor and second office is only 0.8 meters.

Total area of this floor is 43.7 square meters and the lift area is 1.82 square meters. The first office area is 3.8 square meters and the second office area is 5.4 square meters. Stair area is 4.32 square meters.

In term of improvement in fixed obstacles of this floor, there is nothing to do to make it more efficiently so the fixed obstacles of this floor are still the same.

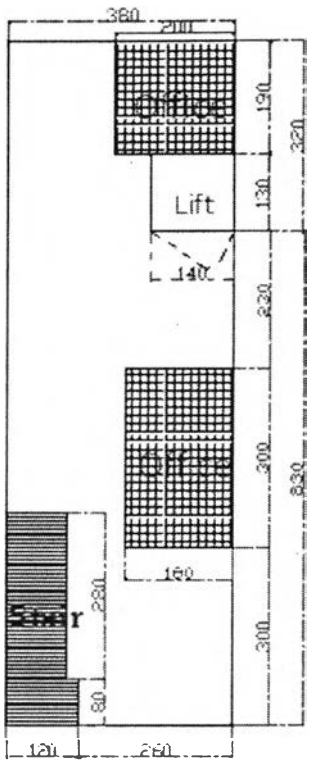


Fig.4.10-Fixed of obstacle in the first floor of building no.1

(B)Fixed obstacle in the floated floor of building no.1: Floated floor is the floor between the first floor and second floor. This floor is assigned to be a storage area. The ground of this floor has 2 types and 2 levels. The first type is a cement floor and another is a wooden floor. The floor has 2 levels which one level is higher than another one about 10 cm. Items move in and out this floor through lift or stair.

Length of this floor is 11.5 meters and width is 3.80 meters. Height of the ceiling is 2.30 meters. Length of cement ground is 8.3 meters and width of cement ground is 3.8 meters. Length of wooden ground is 3.2 meters and width of wooden ground is 3.8 meters.

Total area of this floor is 43.7 square meters and the lift area is 1.82 square meters. The cement ground area is 27.22 square meters and the wooden ground area is 10.34 square meters. Stair area is 4.32 square meters.

In term of improvement in fixed obstacles of this floor, there is nothing to do to make it more efficiently so the fixed obstacles of this floor are still the same.

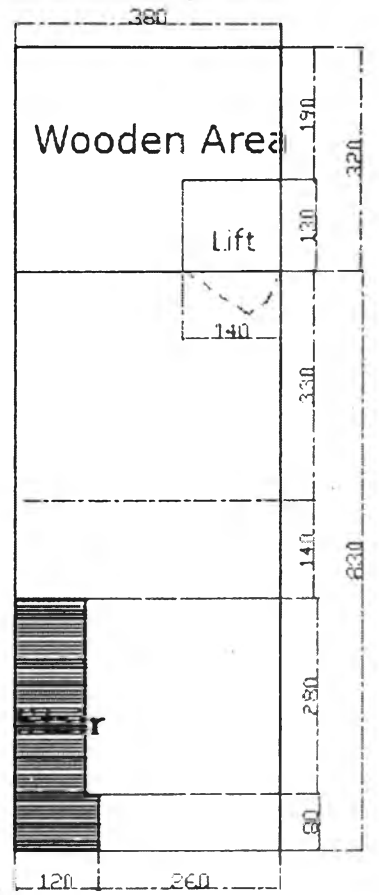


Fig.4.11-Fixed of obstacle in the floated floor of building no.1

(C)Fixed obstacle in the second floor of building no.1: This floor is used as a storage area but some areas of this floor are used as a bedroom and a toilet then they can not be used as a storage area. Items move in and out this floor through lift or stair.

Length of this floor is 11.8 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters. Size of a bed room is 2.28 meters length and 3.8 meters width.

Total area of this floor is 44.84 square meters and the lift area is 1.82 square meters. The bed room area is 8.64 square meters and toilet area is 2.3 square meters. Stair area is 4.32 square meters.

In term of improvement in fixed obstacles of this floor, there is nothing to do to make it more efficiently so the fixed obstacles of this floor are still the same.

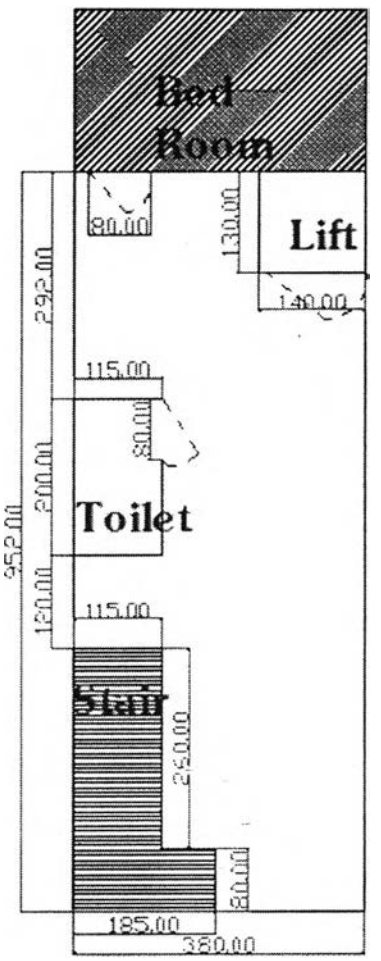


Fig.4.12-Fixed of obstacle in the second floor of building no.1

(D)Fixed obstacle in the 4th floor of building no.1: This floor is used as a storage area. Items move in and out this floor through lift or stair. Length of this floor is 11.8 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters.

Total area of this floor is 44.84 square meters and the lift area is 1.82 square meters. Shelves area is 11.2 square meters and stair area is 4.32 square meters.

In term of improvement in fixed obstacles of this floor, there is nothing to do to make it more efficiently so the fixed obstacles of this floor are still the same.

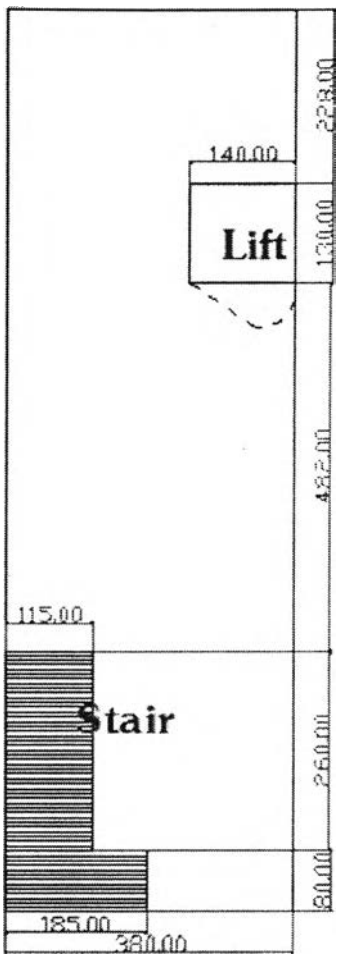


Fig.4.13-Fixed of obstacle in the 4th floor of building no.1

(E)Fixed obstacle in the 5th floor in building no.1: This floor is used as a storage area. This floor is divided into 2 room and both rooms are used as a storage area. Items move in and out this floor through a stair. There are 2 stairs in this floor. The first stair is a down stair to the 4^{th} floor and the second stair is an up stair to the 6^{th} floor.

Length of this floor is 11.8 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters. Size of the first room is 8 meters length and 3.8 meters width. Size of the second room is 3.8 meters length and 3.8 meters width.

Total area of this floor is 44.84 square meters. Area of the first room is 30.4 square meters and area of the second room is 14.44 square meters. Down stair area is 4.32 square meters and up stair area is 4.05 square meters.

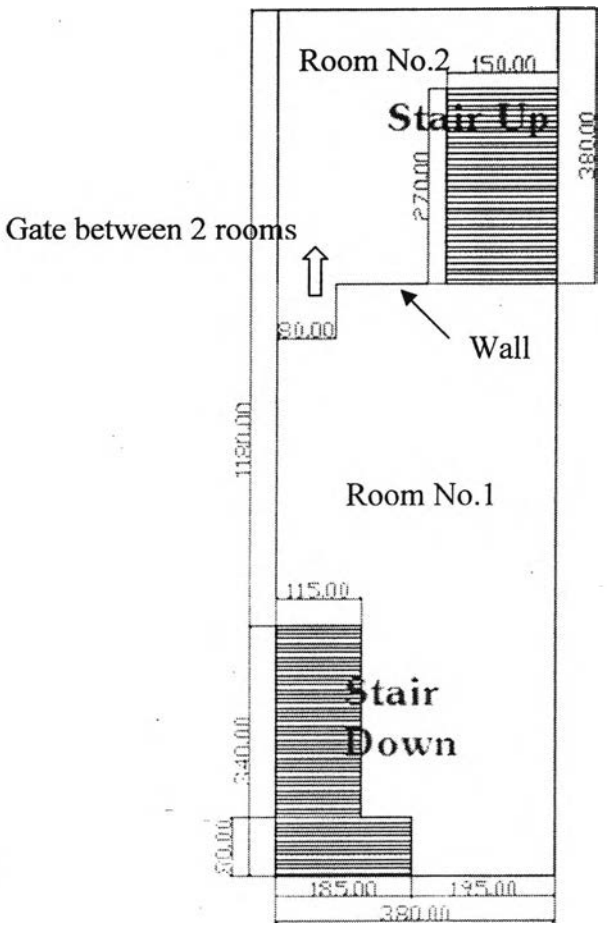


Fig.4.14-Fixed of obstacle in the 5th floor of building no.1

From the figure 4.14, there is a wall that is used to separate the space of this floor into 2 rooms and, items and operators use the gate on the wall to move between these 2 rooms. Width of the gate is quite narrow and not suit to transfer item through this gate. It has no benefit to split the floor with the wall into 2 rooms and beside that it likely to be a big obstruction to use the space efficiency in the term of material handling and storage method. Because of the width of the gate, the room no. 2 and the sixth floor can not store the items that have the big size.

Therefore, to improve the use of space efficiency, this wall must be removed. Then, there is no gate to limit material handling method and size of moving items. After that all items can be stored in this floor without restriction from the wall and gate.

Illustration of the layout of the fixed obstacle in this floor that has been improved, are shown in figure 4.15. The total area of the new layout is 36.32 square meters.

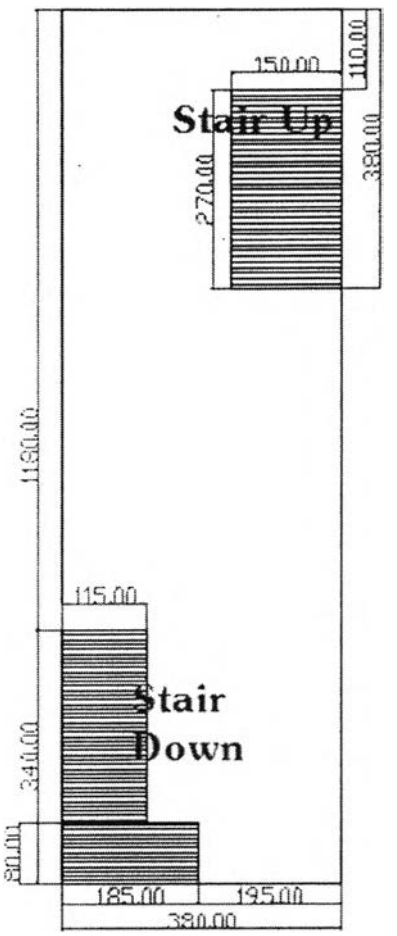


Fig.4.15-Improved on the fixed of obstacle in the 5th floor of building no.1

(F)Fixed obstacle in the 6th floor in building no.1: This floor is used as a storage area. This floor is divided into 2 room and both rooms are used as a storage area. Items move in and out this floor through a ladder.

Length of this floor is 7 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters. Size of the first room is 3.4 meters length and 3.8 meters width. Size of the second room is 3.2 meters length and 3.8 meters width.

Total area of this floor is 26.6 square meters but the areas that are used to stored item are just 2 storage rooms. Area of the first room is 12.92 square meters and area of the second room is 12.16 square meters. Path way area is 4.32 square meters.

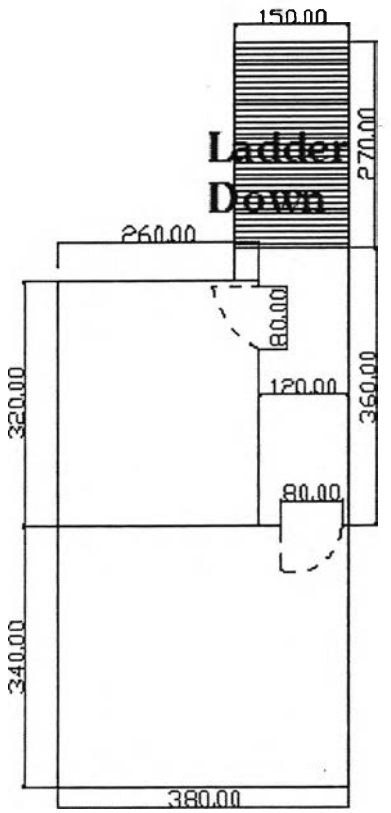


Fig.4.16-Fixed of obstacle in the 6th floor of building no.1

From the figure 4.16, there is a wall that is used to separate the space of this floor into 2 rooms and a path way area. Width of the gate in each room is quite narrow and not suit to transfer item through this gate. In term of item storages and material handling, to separate the floor into 2 rooms is useless and it likely to be a big obstruction to use the space efficiency. Beside that, the items that are stored in this floor have been limited by the width of the gate of each room.

Therefore, if the walls that separate the floor into 2 rooms are demolished, the storage space and material handling will be use more efficiently. After that all items can be stored in this floor without limitation in material handling and storage method.

Illustration of the layout of the fixed obstacle in this floor that has been improved, are shown in figure 4.17. The total area of the new layout is 26.6 square meters.

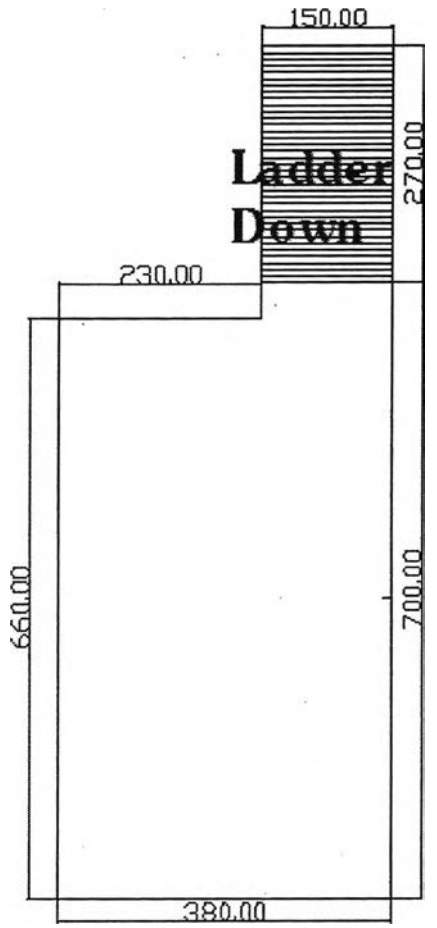


Fig.4.17-Improved on Fixed of obstacle in the 6th floor of building no.1

(G)Fixed obstacle in the 1st floor in building no.2: In this floor, there is a toilet and a small room behind a stair. Items move in and out this floor through an entrance, a lift and a stair.

Length of this floor is 11.5 meters and width is .80 meters. Height of the ceiling is 2.80 meters. Length of a small room is 1.8 meters and width of small room is 2.6 meters. Length of a toilet is 1.8 meters and width of a toilet is 1.2 meters.

From figure 4.18, total area of this floor is 43.7 square meters. Area of a small room is 4.68 square meters and area of the toilet is 2.16 square meters. Stair area is 3.86 square meters and Lift area is 1.94 square meters. Due to there is no area that is specified to be an aisle or a stacking area, areas that can be managed as a storage area can be calculated from total area minus with areas of fixed obstacle. Then available storage area of 1st floor in building no.2 is 35.74 square meters.

In term of improvement in fixed obstacles of this floor, there is nothing to do to make it more efficiently so the fixed obstacles of this floor are still the same.

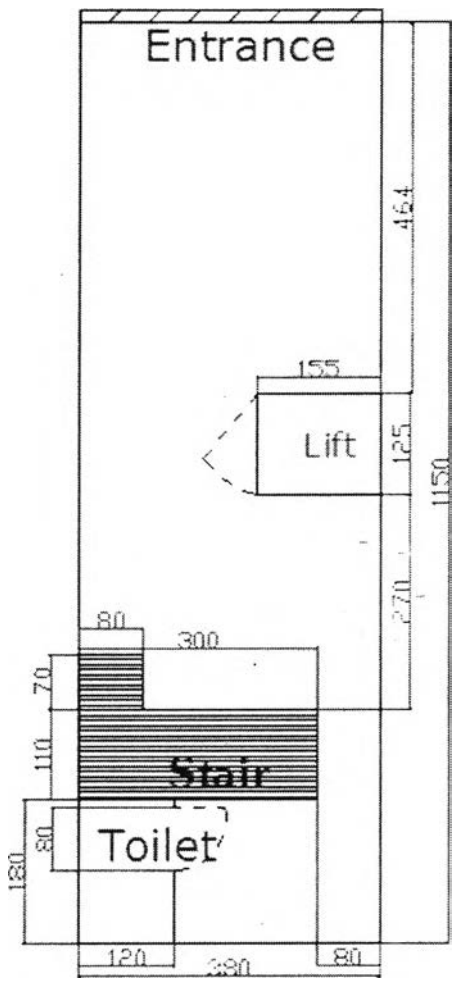


Fig.4.18-Fixed of obstacle in the 1st floor in building no.2

(H)Fixed obstacle in the floated floor in building no.2: Floated floor is the floor between the first floor and second floor. This floor is assigned to be a storage area. This floor has an old toilet which is used to store item and a small storage room which is next to a toilet. As illustrated in figure 4.19, floor area has been divided into 2 parts by a short steel fence and there is a hollow area which is an area with no floor, in second area. Items move in and out this floor through a lift and a stair.

Length of this floor is 11.5 meters and width is 3.80 meters. Height of the ceiling is 2.30 meters. Length of the first area is 4.55 meters and width is 3.8

meters. Length of the second area is 4.04 meters and width is 3.8 meters. Dimension of an old toilet is 1.80 meters lengths and 1.55 meters wide. Dimension of a small storage room is 1.80 meters lengths and 2.25 meters wide.

From the fig.4.10, total area of this floor is 43.7 square meters and the lift area is 1.94 square meters. Stair area is 3.86 square meters and old toilet area is 2.79 square meters. The hollow area is 1.2 square meters.

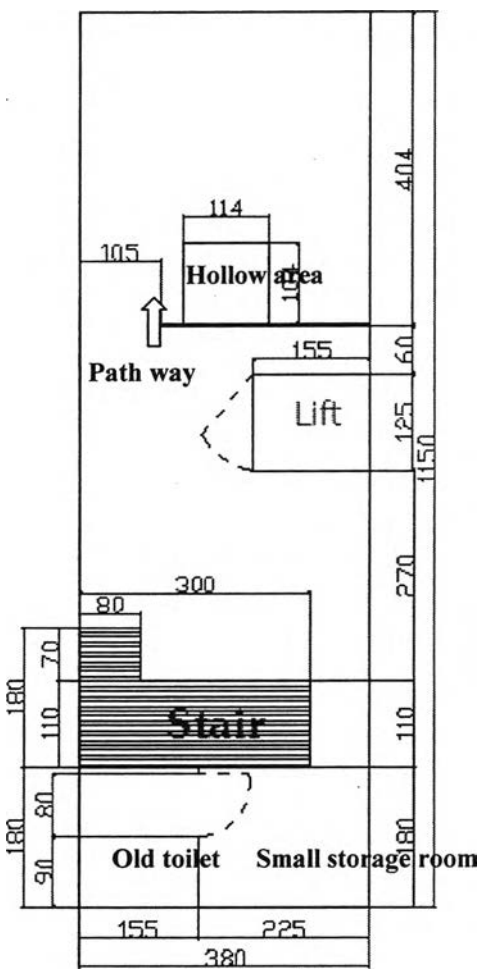


Fig.4.19-Fixed of obstacle in the floated floor in building no.2

From the figure 4.19, there is a short steel fence that is used to separate the space of this floor into 2 parts. Width of the gate into other area is quite narrow and not suit to transfer item through this gate. In term of item storages and material handling, to separate the floor into 2 parts is useless and it likely to be a big obstruction to use the space efficiency. The old toilet which is used to store item and a small storage room which is next to a toilet are separated into each room by a wall. The old toilet room still has some toilet equipments in side it. There is no benefit to

use the wall to separate the room anymore, after this toilet is no longer be used as a toilet room and mow it is used as an another storage room instead.

Therefore, if the short steel fence that separate the floor into 2 parts are demolished, the storage space and material handling will be use more efficiently. After that all items can be stored in this floor without limitation in material handling and storage method. But the fence must be built around the hollow area for safety concern of the operator. The old toilet room must be improved by removing the wall and the toilet equipments in side there. This will improve in using space efficiency and using storage equipment.

Illustration of the layout of the fixed obstacle in this floor that has been improved is shown in figure 4.20.

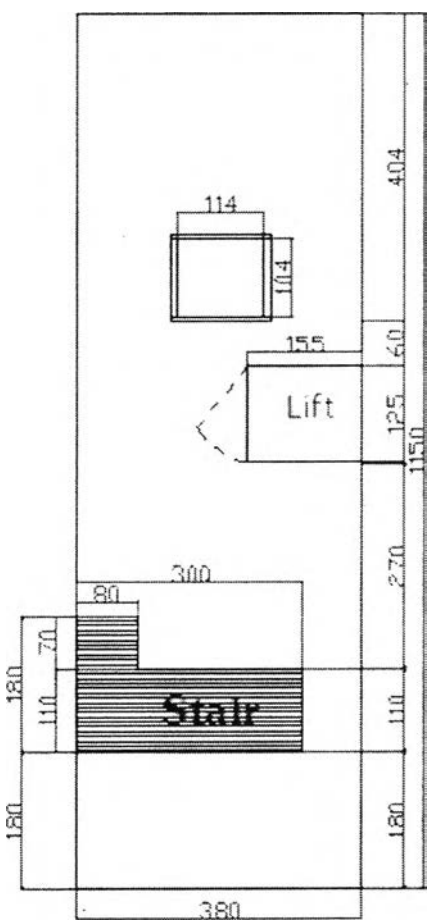


Fig.4.20-Improved on Fixed of obstacle in the floated floor of building no.2

(I) Fixed obstacle in the second floor in building no.2: This floor is used as a storage area. There is an operator's bed room on this floor. Bed room area on this floor is not be used as a storage area. This floor has 2 small rooms behind a

stair and both rooms are used as a storage area. Items move in and out this floor through a stair or a lift.

Length of this floor is 11.8 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters. Dimension of the first room is 1.8 meters length and 2.2 meters width. Dimension of the second room is 1.8 meters length and 1.6 meters wide. Width of a bed room is 3.8 meters and length is 2.25 meters.

From the fig.4.21, total area of this floor is 44.84 square meters and the lift area is 1.94 square meters. Stair area is 3.86 square meters and bed room area is 8.1 square meters.

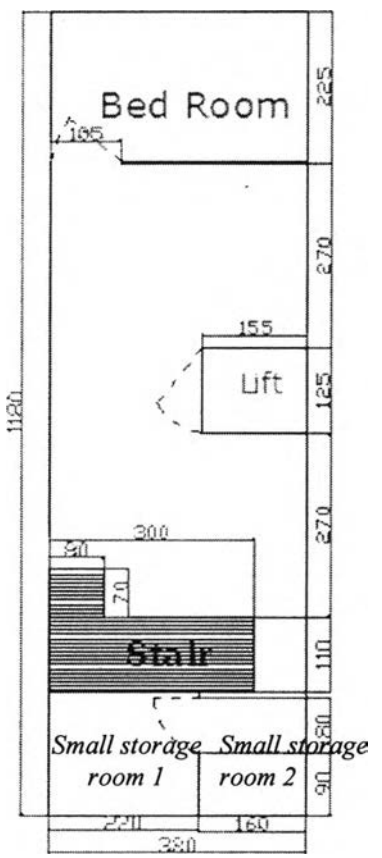


Fig.4.21-Fixed of obstacle in the Second floor of building no.2

From the figure 4.21, this floor has 2 small rooms behind a stair and both rooms are used as a storage area. These 2 rooms are separated into each room by a wall. There is no benefit to use the wall to separate the room anymore, after both 2 rooms are used as a storage area.

Therefore, the rooms must be improved by removing the wall between these 2 rooms. This will improve in using space efficiency and using storage equipment of that area.

Illustration of the layout of the fixed obstacle in this floor that has been improved is shown in figure 4.22.

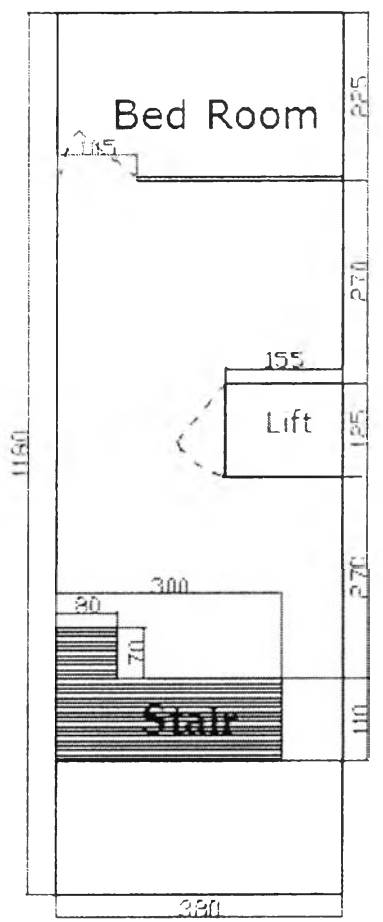


Fig.4.22-Improved Fixed of obstacle in the second floor of building no.2

(J)Fixed obstacle in the 3rd floor of building no.2: This floor is used as a storage area and there are 2 rooms at this floor which are separated by a wooden wall and both rooms are used as a storage area. Items move in and out this floor through a stair or a lift.

Length of this floor is 11.8 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters. Dimension of the first room is 7.6 meters length and 3.8 meters width. Dimension of the second room is 4.2 meters length and 3.8 meters wide.

From the fig.4.23, total area of this floor is 44.84 square meters and the lift area is 1.94 square meters. Stair area is 3.86 square meters.

From the figure 4.23, the wooden wall is used to divide this floor into 2 rooms. There is no benefit to use the wall to separate the room because both of them are used as a storage area. In term of item storages and material handling, to separate the floor into 2 rooms is useless and it likely to be a big obstruction to use the space efficiency. Beside that, the items that are stored in this floor have been limited by the width of the gate between these rooms.

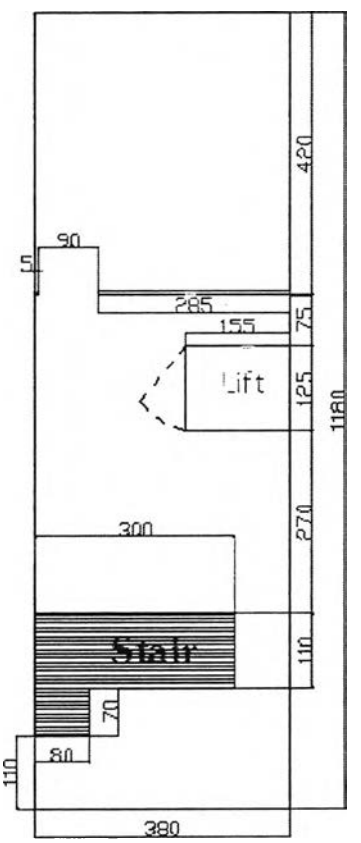


Fig.4.23-Fixed of obstacle in the 3rd floor of building no.2

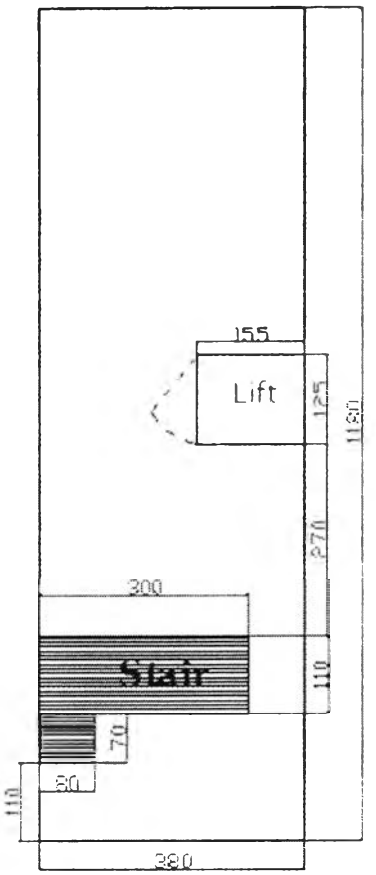


Fig.4.24-Improved fixed of obstacle in the 3rd floor of building no.2

Therefore, the floor must be improved by removing the wooden wall between these 2 rooms. This will improve in using space efficiency and using storage equipment of storage area.

Illustration of the layout of the fixed obstacle in this floor that has been improved is shown in figure 4.24.

(K)Fixed obstacle in the 4th floor of building no.2: This floor is used as a storage area. Items move in and out this floor through a stair or a lift. This floor has 2 small rooms behind a stair and both rooms are used as a storage area.

Length of this floor is 11.8 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters. Dimension of the first storage room is 1.8 meters length and 2.2 meters width. Dimension of the second storage room is 1.8 meters length and 1.6 meters wide.

From the fig.4.25, total area of this floor is 44.84 square meters and the lift area is 1.94 square meters. Stair area is 3.86 square meters.

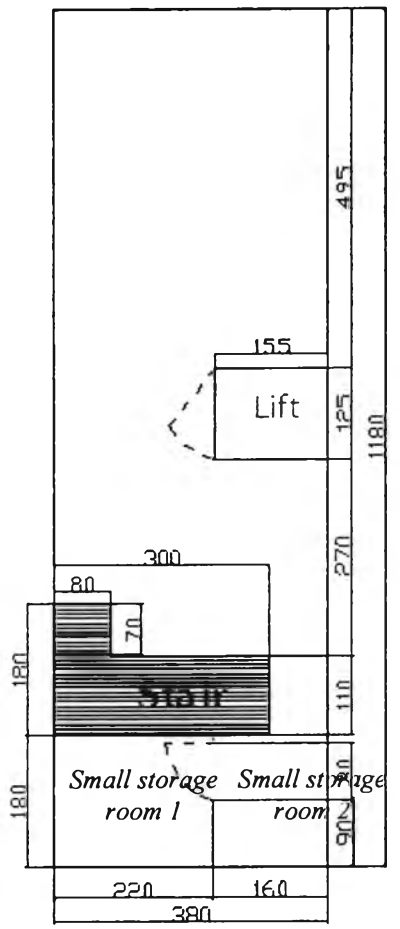


Fig.4.25-Fixed of obstacle in the 4th floor of building no.2

From the figure 4.25, this floor has 2 small rooms behind a stair and both rooms are used as a storage area. These 2 rooms are separated into each room by the wall. There is no benefit to use the wall to separate the room anymore, after both of them are same used as a storage area.

Therefore, the rooms must be improved by removing the wall between these 2 rooms. This will improve in using space efficiency and using storage equipment of that area.

Illustration of the layout of the fixed obstacle in this floor that has been improved is shown in figure 4.26.

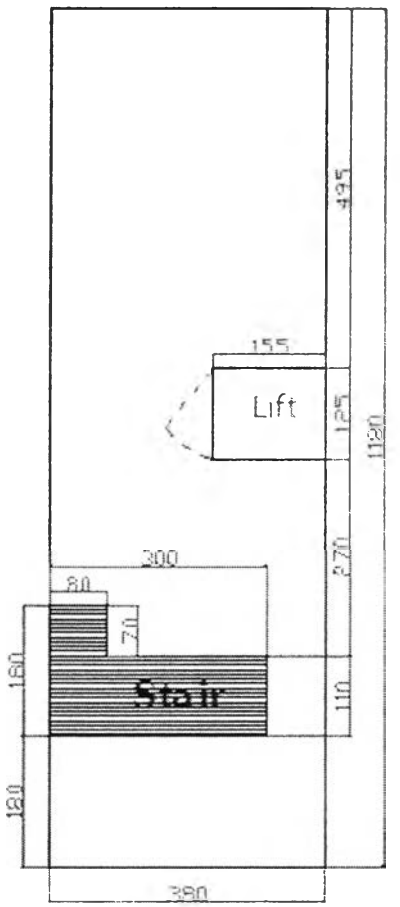


Fig.4.26-Improved fixed of obstacle in the 4th floor of building no.2

(L)Fixed obstacle in the 5th floor of building no.2: This floor is used as a storage area. Items move in and out this floor through a stair or a lift. This floor has a stair to a lower floor and a ladder to a roofdeck. Roof of this floor has 2 parts. The first part is a cement roof and another part made of a tile.

Length of this floor is 11.8 meters and width is 3.80 meters. Height of the ceiling is 2.80 meters.

From the fig.4.27, total area of this floor is 44.84 square meters and the lift area is 1.94 square meters. Stair area is 3.3 square meters.

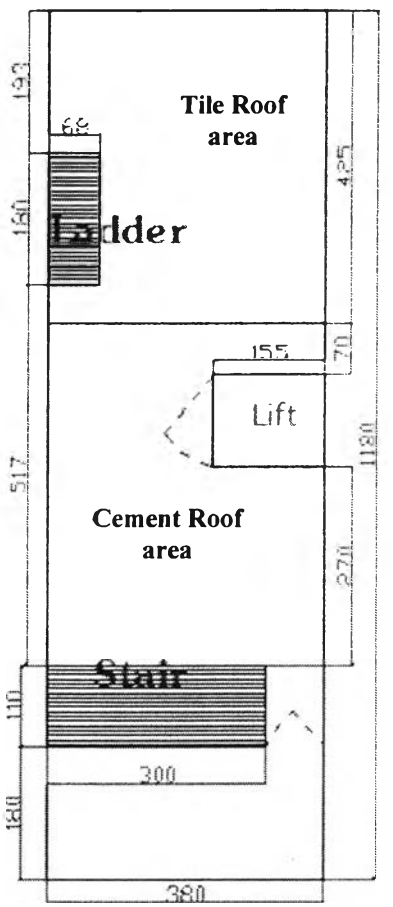


Fig.4.27-Fixed of obstacle in the 4th floor of building no.2

In term of improvement in fixed obstacles of this floor, there is nothing to do to make it more efficiently so the fixed obstacles of this floor are still the same.

4.1.2.2 Define the location of the receiving and shipping space and other related area

After space planning and fixed obstacles determination have been done, the next step is to locate each space into a warehouse area.

A buffer area for a shipping dock should be located behind the dock maneuvering aisle. The receiving buffer area serves as a depository for the materials unloaded from the carriers. From 4.1.1, receiving space consists of dock area, inspection area and buffer area. According to 4.1.1, space planning for inspection area and buffer area is 3 and 10 square meters sequent. Shipping area consists of staging

area and packing area. According to 4.1.1, space planning for packing area and staging area is 4.5 and 20 square meters sequent.

The requirement of the receiving space is listed following this:

1. Near dock area
2. Space at least 13 square meters
3. Space for Trash area 2m x 2m
4. Aisle within buffer area. Width at least 0.8 m.

And the requirement of the shipping space is listed following this:

1. Near dock area
2. Space at least 16 square meters
3. Space for Packing area 2m x 1.8m or 4 square meters
4. Aisle within staging area. Width at least 0.8 m.

From the requirement, receiving and shipping area should be close to the dock area and the dock area of this warehouse is a public street in front of a building. Then receiving and shipping area must be in the first floor of building no.1 or no.2.

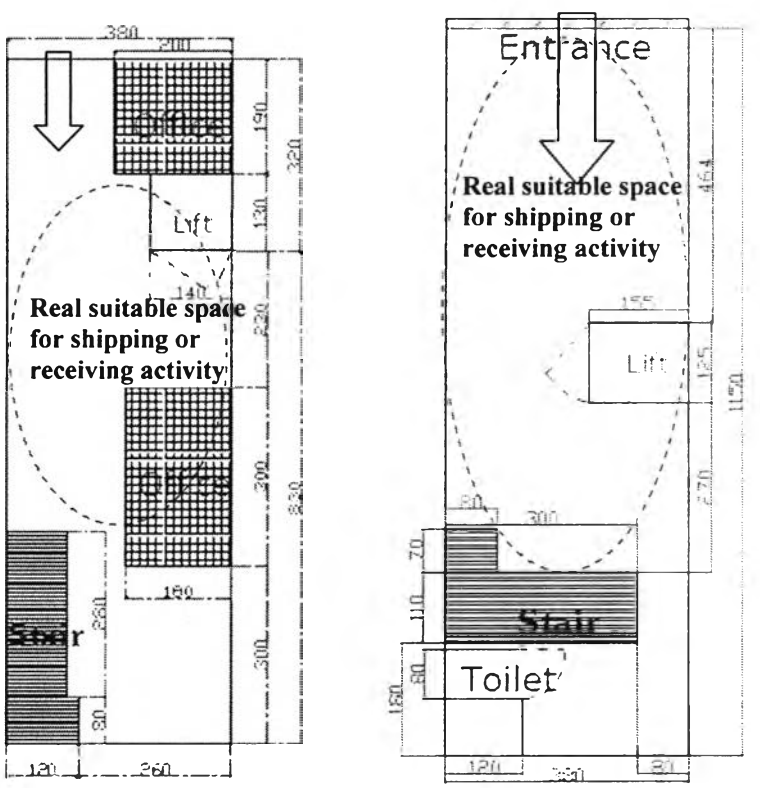


Fig.4.28- Comparison layout of the first floor of building no.1 (Left) and building no.2 (Right)

After considering at the first floor of each building in term of space for receiving and shipping area in the fig 4.28, the first floor of building no.1 has the office spaces so it is quite difficult to do some activity in this area. Total available space of the first floor of building no.2 is 35.74 square meters. Total available space of the first floor of building no.1 is 28 square meters.

In the first floor of the building no.1, the real available space for locate the shipping or receiving activity is the only space that locates between 2 offices. Due to limitation of the aisle size and available space, it is quite difficult and inconvenient to do some activities such as moving or stacking items in the rest area. Therefore, the new available space of the first floor of building no.1 is 17.42 square meters.

In the first floor of the building no.2, the real available space for locate the shipping or receiving activity is the only space that locates in front of the stair. Therefore, the new available space of the first floor of building no.2 is 30.18 square meters.

From the requirement of shipping and receiving space location, the first floor of building no.2 is the only place in a warehouse which can meet those requirements. However, the available space at this floor is not sufficient for the requirement of both receiving and shipping space. The total space requirement of shipping and receiving activity is above 30 square meters but the available spaces for these activities are 30 square meters. In that case, both activities have to share their space and equipment.

Normally, receiving and shipping docks can often result in economies of scale related to sharing space, equipment, and personnel. Separate receiving and shipping areas may, on the other hand, be best to ensure better material control and reduce congestion. Determining the amount of buffer or staging space required is largely a matter of the degree of control which exists over the work load is throughout the day, the more flexible the receiving buffer area or the shipping staging area must be. From this warehouse schedule, suppliers' carrier arrivals are controlled to arrive in the afternoon of a daily working day and they arrive only one at a time because their dock area can be placed only one truck at a time. From this warehouse schedule, most of the shipping activities are done before noon of every working day. Then, the activity in a buffer and staging area of this warehouse will be done at different time because time schedule of shipping activity and receiving activity are clearly different.

Be side that, the operators which are responsible for receiving activity are the same groups which are responsible for shipping activity then both activities will not be possible to be done at the same time. Then, there is no problem for sharing the receiving and shipping space. Because when shipping and receiving activities are done at the different time, material control can be ensured and congestion at the space will be much reduced.

After determination to sharing a space of the first floor of building no.2 for the receiving and shipping activity, the next step is to locate space of receiving and shipping activity, and other related activity into this floor.

Therefore, below this is the list of space that needs to be located at the first floor of building no.2:

1.Approximated buffer area and stacking area 16 square meters. A buffer area and stacking area should be located behind the dock.

2.Space for Trash area 2m x 2m Particularly receiving function, generate a tremendous amount of trash, including corrugated boxes, binding materials, broken and disposable pallets, bracing, and packing materials. Space must be allocated within the receiving and shipping areas for disposal of these items.

3.Aisle within buffer area or staging area. This aisle space is not intended for use in placing materials in or taking them out of the buffer or staging area. Instead, it provides access to and egress from the dock area to other parts of the warehouse. Then, the only traffic that occurs in this aisle is pedestrian. Thus, the required width of this aisle is 0.8 m and it is enough for the pedestrian.

4.Space for Packing area 1.8m x 2.2m or 4 square meters

5.Main aisle from/to buffer and stacking area to move item from/to storage areas. Most of the traffic type in this aisle is predominantly pedestrian traffic and hand truck. As a result, width of the aisle should be wider than 1.3 m.

Locations of each space are assigned into the first floor of building no.2 by following their requirement. The figure 4.29 illustrates the location of spaces in receiving and shipping function. As it shown in the figure 4.29, the buffer and stacking area is 14 square meters which is less than the approximated space requirement of buffer area and stacking area. From 4.1.1.1, the space requirement of a buffer area and a stacking area came from estimation of the historical record. Then, it is not necessary to preserve the number of space area as same as approximated

required space but it should be close to that number. Therefore, the new space of buffer and stacking area is acceptable to operate shipping and receiving function.

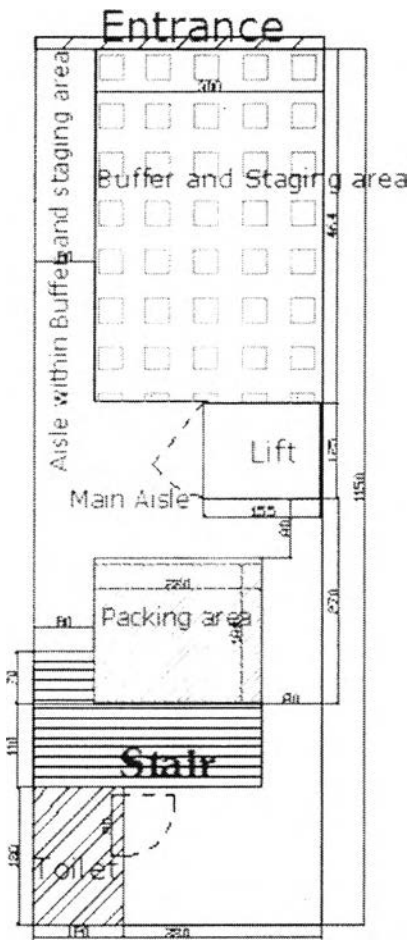


Fig.4.29-New layout of the first floor of building no.2 after the receiving and shipping activity is located in this floor

As it shown in the fig 4.29, space for trash area is not located in this floor because the rested space in this floor can not meet the requirement of trash area. Therefore, its location is assigned into the first floor of building no.1 as it shown in fig.4.30.

Actually, there is a road between two storage buildings of this warehouse. Then, with the new location of shipping and receiving space, when items need to be taken from building no.1, it must be moved from storage location at building no.1 to stacking area at building no.2. In other hand, when items need to be storage in building no.1, it must be moved from buffer area at building no.2 to storage location at building no.1. In that case, the main aisle space must be preserved in the first floor

of building 1 to be a path way for material handling equipment to storage area. As illustrated in fig. 4.30, the main aisle space and trash area is located into the first floor of building no.1.

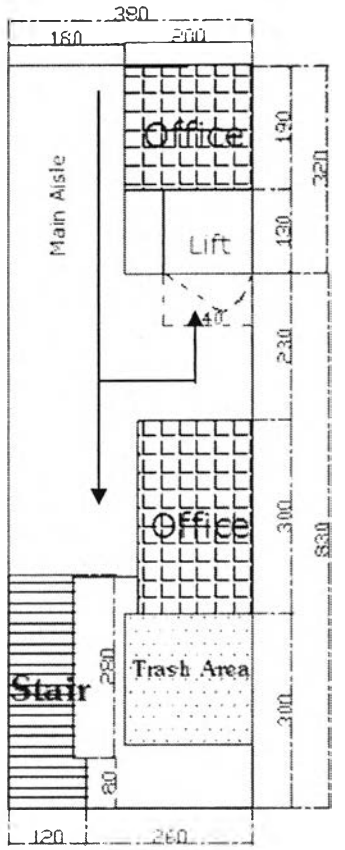


Fig.4.30-New layout of the first floor of building no.1 with trash area

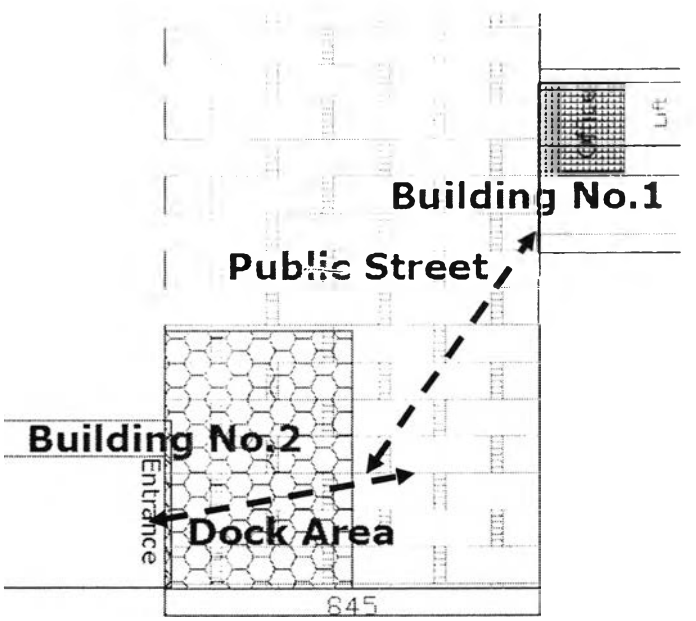


Fig.4.31-Overview location of 2 warehouse buildings and a public street

As illustrated in Fig 4.31, the overview of the 2 warehouse buildings' location has been illustrated and this shows the location of dock area and the distance between these 2 building. Shipping and receiving space are located in the first floor of building no.2 and some related area is located in the first floor of building no.1. Although, these locations are not perfectly suits them in term of theory and requirement, this is the most efficient location for them within the constraint of the building shape and fixed obstacle.

After define the location of the receiving and shipping space and other related area has been completed, the next step to complete "the warehouse layout improvement" is to locate the storage areas and equipment, including required aisles.

4.1.2.3 Locate the storage areas and determine equipment, including required aisles.

(A) Locate the storage area: The types of storage areas and equipment to be used will dictate to some extent the configuration of the storage layout and the aisle requirements.

The cubic space planning for storage area is **258.1 meter^3.** The required space of storage area are located in every floors of the warehouse buildings except the first floor, the third floor of building no.1 and the first floor of building no.2. From the 4.1.2.1 improvement in fixed obstacles of the warehouse, the total available space of the floors that can be used as a storage area is 328.3 square meters and the stock keeping items should be shelved or stacked higher than 2 meters. Given the total available space of the floors and the height of storage method, the result is the available cubic space for storage area. Then the numbers are putted into this calculation:

The available cubic space for storage area = 328.3 square meters **x** 2 meters = **656.68 m^3**

The available cubic space for storage area is much larger than the cubic space planning for storage area then it is appropriate to locate the storage areas at these floors.

(B) Determine Material Handling Equipment: There are many types of equipment that are able to move items then prior to the purchase and

implementation of product-handling equipment, the operational parameters must be clearly defined:

- Unit –load dimensions with overhang (length, width, height, plus weight): In this warehouse, most of the unit-load is quite small and low weight but there are some items which have special size or weight. Therefore, it may require different size of material handling equipment.
- Stacking height and storage area's environmental conditions: In this warehouse, stacking height is expected around 2 meters.
- Condition of storage area floor and surface: The surface condition of the floor is quite smooth and made of cement.
- Aisle width and length: Main aisle within storage area can not be so wide due to the shape of each storage floor is not convenient for using large material handling equipment.

Therefore, the type of equipment that is suit to the condition of this warehouse is the hand truck. It is a vehicle that required hand-operated truck. It is designed to use with small to medium size and light weight items. Beside that, it requires small aisle width to move around storage area.

From figure 4.3 and 4.4, most unit load size of item have width less than 70 cm and length less than 120 cm then the hand truck that required must be bigger than this size.

Fig.4.32- Material handling equipment - Hand truck

There are many type and size of the hand trucks but below this is a standard size and type that have been used widely. This data comes from the official website of the advanced handling services material handling company (http://www.advancedhandling.com).

Fig.4.33- The platform hand truck

The Standard size of the platform hand trucks	
Aluminum smooth platform truck	**Steel platform truck**
6" rubber wheels 24"X48" platform	6" rubber wheels 24"X48" platform
6" rubber wheels 27"X54" platform	6" rubber wheels 27"X54" platform
6" rubber wheels 30"X60" platform	6" rubber wheels 30"X60" platform
6" rubber wheels 24"X48" platform	6" rubber wheels 36"X72" platform
6" rubber wheels 27"X54" platform	8" rubber wheels 24"X48" platform
	8" rubber wheels 27"X54" platform
	8" rubber wheels 30"X60" platform
	8" rubber wheels 36"X72" platform

Table 4.1- Standard size of the platform hand trucks

In this warehouse, a hand truck is used to move item to storage location or from storage location so it needs to be moved up and down by lifts. Therefore, there size must not bigger than the size of lifts. The lift size is 130 cm width and 140 cm length then the selected hand truck must be smaller than this at least. As a result, the only size which fit to this requirement is 24"X48" Platform. Because the surface of floor in the storage area is smooth, the wheels of the hand truck do not need to be high. Then, the 6" rubber wheels are good enough to operate in this warehouse. There are 2 types of hand truck which is steel platform hand truck and aluminum platform hand truck. Generally, aluminum platform hand truck is more durable and easier to clean than steel platform hand truck but its price is double of steel platform hand truck also. Aluminum platform hand truck is suit to be used in wet or high humidity area because it can avoid rust to occur on its body. As a result, the type of platform hand truck that should be used is steel.

The material handling equipment that is determined to use in this storage area is the steel platform truck with 6" rubber wheels 24"X48" platform. It requires at least 2 hand trucks to do activities in this warehouse.

(C) Design storage equipment: A warehouse is more than a storage building. It needs equipment to handle cargo, and the selection and use of that equipment that may spell the difference profit and loss. The equipment choice is usually governed by the following criteria:

- Degree of flexibility desired for different uses: There are various size of items which is much different from each other.
- Nature of the warehouse building: Warehouse building is a rectangular shape and consisted by many small floors. The warehouse building is quite small so the equipment should be fit to the size of building.
- Nature of the handling job-bulk, unit load, individual package, or broken package distribution: Unit loads of this warehouse are carton, parcel, box and bundle but most of them are carton.
- Volume to be handled by the warehouse: Volume of storage items that warehouse need to be stored is 152 meter^3. Due to the storage area is quite small so storage equipment needs to use the cubic space of area with high efficiency.
- Reliability: The storage equipment must be able to handle high load and durable.

There are several storage modes. Items may be floor-stored, solid-stacked, or in racks. Storage equipments are various types such as Pallet, Rack, Shelf and Bin. Beyond that, the size of the storage location in storage equipment should fit the size of the items to be stored. Because if storage location in storage equipment is too small, some big items can not be located in but if it is too big, honeycombing in storage area may occurs too much. Then a variety of storage location sizes must be provided so that different items can be stored differently

(C.1)Storage equipment for normal items: From 4.1.1.2, there are special items in term of dimension size, oddly shape, weight and other that need specific storage location or equipment. Then their storage equipment should be determined with special consideration. Determination of the size of storage equipments must be based on the unit load size of storage items. Therefore,

determination of normal items must base on the dimension data distribution of items' unit load size only.

After excluding the special item that required special storage method or equipment out of the normal items, the new histogram graphs of items' dimensions are illustrated as below this:

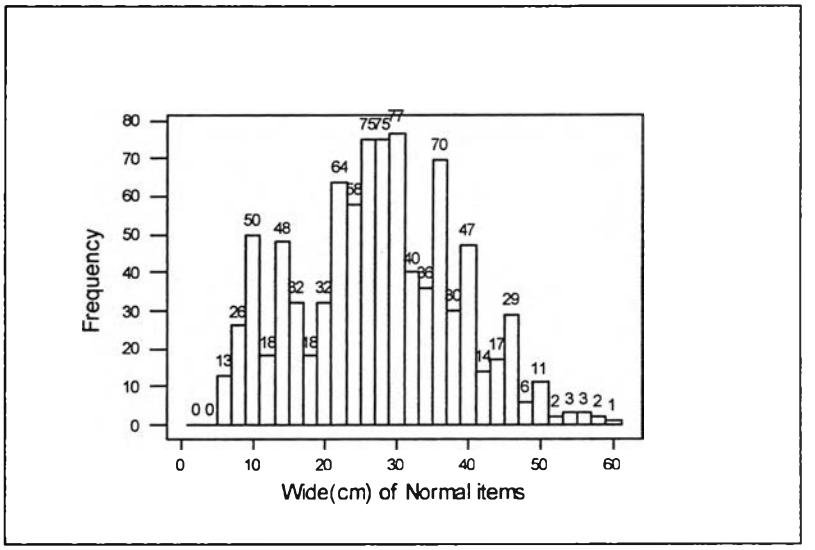


Fig.4.33- Histogram of width dimension of Normal items

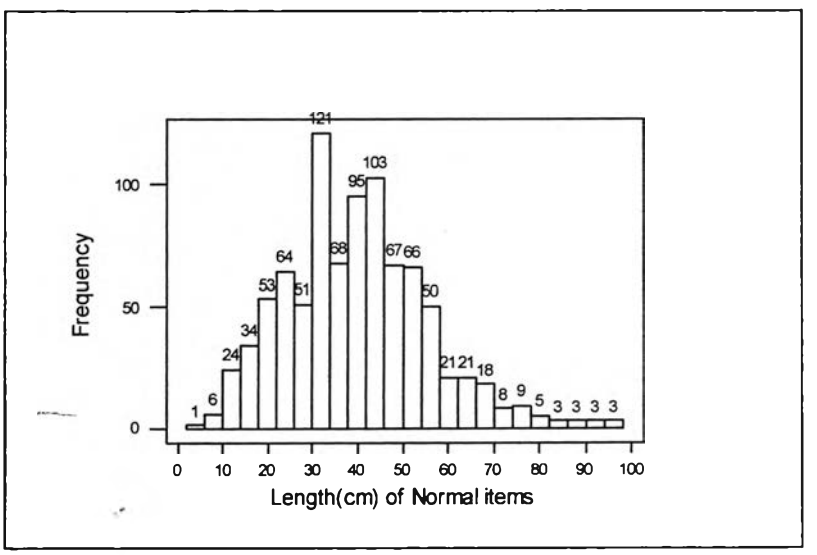


Fig.4.34- Histogram of length dimension of Normal items

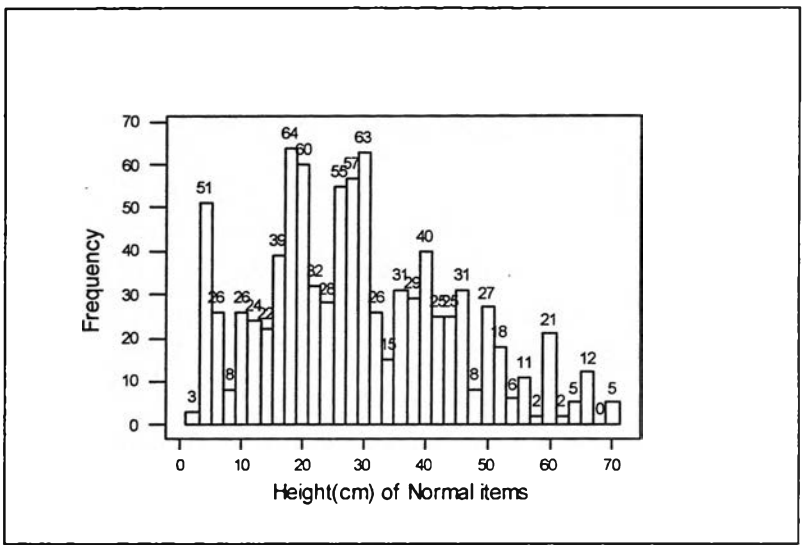


Fig.4.35-Histogram of height dimension of Normal items

From the figure 4.33 – 4.35, the size of item would be classified in to many classes but if there are too many classes, the storage location will be tight and specified too much and combination storage location system can not be done. Then, the size of item should be classified into 2 classes and the storage equipments sizes are determined based on these classes.

The most suit storage equipment for these items is shelving because shelving is a very basic storage method that affords the user significant flexibility in the type and quantity of goods that can be stored, and at a relatively low capital investment. In the term of item size, shelving is suit to the size which is not too big and not too small so it fits with item characteristic of this warehouse.

Shelving is the most suitable storage equipment of the items in this warehouse. In warehouse situations, shelves require solutions that offer much more capacity on shelves for efficient storage of numerous items. Because a larger capacity is important, the shelving must also be able to take heavier loads. Warehouse shelving also may need to withstand a certain amount of destruction.

For storage shelves, a greater emphasis should be put on the material's strength and durability. Because of this reason, metal is the suit material to build the storage shelves. Beside that it is cheap and its construction is very strong. The Warehouse is environments where shelves may be prone to long periods of no maintenance (storing means the shelves may not be cleaned regularly) and so the

finish on material that is chose should be very long lasting. Because a warehouse is likely to be an industrial environment, shelves may need to withstand damage from moving, knocking, scraping as well as corrosion from rust and chemicals. Temperature may also be a factor. It is wise for choosing very hard-wearing finishes such as chrome plated or powder coated finishes.

The first class is the class for small size so the items in this class must have the width dimension shorter than 30 cm, the length dimension shorter than 80 cm and height dimension shorter than 30 cm. There are 339 items in this class and the sum up of required storage cubic space of each item is 26 meter^3 but it need to add 30% allowance space for honeycombing. Therefore, total required storage cubic space for first class that needs to plan for storing in the shelves is 34 meter^3.

As a result, from the size of items in the first class, the shelves that should be used to store first class items are shown in fig.4.36. This storage equipment is called "the model A shelf".

Shelve in figure 4.36 is designed to fit the requirement of the items in the first class size. The width of this shelve is 35 cm, length is 90 cm and height of this shelve is 210 cm. There are 6 storage locations on this shelve.

The dimensions of storage location in this shelve is deigned by adding clearance space in each of them. Width dimension of the storage location in this shelve is 35 cm which is longer than the maximum width of items in this class 5 cm and Length dimension is 90 cm which is longer than the maximum length of items in this class 10 cm. Height dimension of the storage location is 32 cm which is longer than the maximum length of items in this class 2 cm also. Therefore, approximated the cubic space of each storage location in this shelve is 100,800 cm^3. Then 1 shelve has the storage cubic space about 0.6 m^3 and the total required storage cubic space for first class that needs to plan for storing in the shelves is 34 meter^3 then the amount of storage shelves which is required to store all items is approximated around 58 shelves.

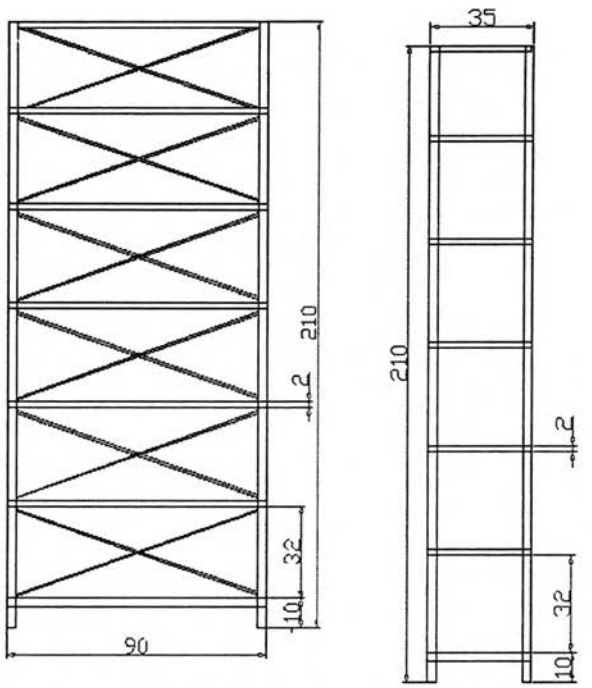


Figure.4.36 Front view (Left) and side view (Right) of the model A shelf

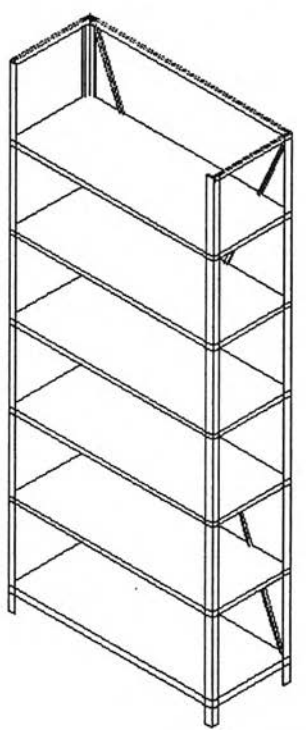


Figure.4.37 Isometric view of the model A shelf

The second class is the class for medium to big size so the items in this class must have the width dimension longer than 30 cm or the length dimension longer than 80 cm or height dimension longer than 30 cm. There are 536 items in this class and total required storage cubic space for second class item is 102.6 meter^3 but

it need to add 30% allowance space for honeycombing. Therefore, the total storage cubic space of second class that needs to plan for storing in the shelves is 133.4 meter^3.

As a result, from the size of items in the second class, the shelves that should be used to store first class items are shown in figure 4.38. This storage equipment is called "the model B shelf".

Shelve in figure 4.38 is designed to fit the requirement of the items in the second class size. The width of this shelve is 65 cm, length is 120 cm and height of this shelve is 230 cm. There are 3 storage locations on this shelve.

The dimensions of storage location in this shelve is deigned by adding clearance space in each of them. Width dimension of the storage location in this shelve is 65 cm and Length dimension is 120 cm. Height dimension of the storage location is 73 cm. Therefore, approximated the cubic space of each storage location in this shelve is 569,400 cm^3. Then 1 shelve has the storage cubic space about 1.7 m^3 and the total storage cubic space of second class that needs to plan for storing in the shelves is 133.4 meter^3. As a result, the amount of storage shelves which is required to store all items is approximated around 79 shelves.

Generally, the model of the shelves in fig.4.36 and 4.38 are called "the metal storage shelves with crossbar connector". The materials that is used to build these shelve are metal and zinc connector with chrome plated finish because it is quite strong, durable and cheap.

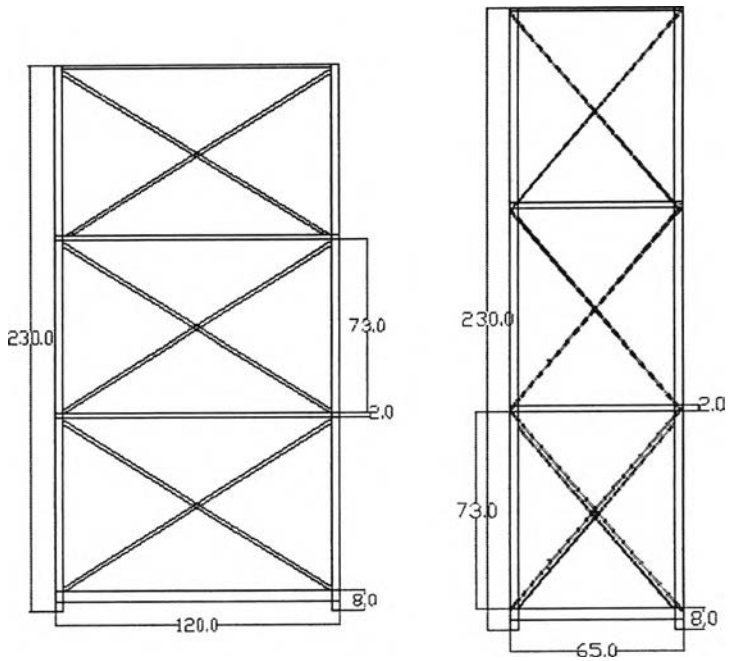


Figure.4.38-Front view (Left) and side view (Right) of the model B shelf

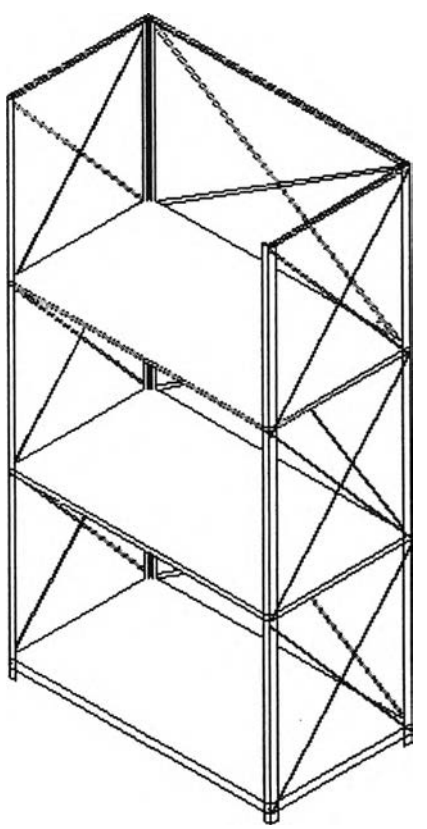


Figure.4.39-Isometric view of the model B shelf

(C.2) Storage equipment for special items: From 4.1.1.2, there are special items in term of dimension size, oddly shape, weight and other that need

special storage method or equipment. Then their storage equipment should be determined with special consideration.

Oddly shape- Shaft shape: There are only 2 items that have the shaft shape and their dimensions have small width about 10 cm, height about 16 cm and length in the region of 140 cm. There are only 2 items that their shape is shaft and planning storage space area of each item is 201,600 cm^3 and 366,080 cm^3. But it needs to add 30% allowance space for honeycombing for storage space area of each item. As a result, required storage cubic space of each item is 262,080 cm^3 and 436,094 cm^3 so the total required cubic space is 698,174 cm^3.

Therefore, from the shape of items, the storage equipment that should be used to store shaft shape items are racks and it is shown in figure 4.40. This storage equipment is called "Rack".

Storage equipment in figure 4.40 is designed to fit the requirement of the shaft shape items. The width of this shelve is 60 cm, length is 140 cm and height of this shelve is 190 cm. There are 5 storage locations on this shelve.

The dimensions of storage location in this shelve is deigned by adding clearance space in each of them. Width dimension of the storage location in this shelve is 50 cm and Length dimension is 140 cm. Height dimension of the storage location is 32 cm. Therefore, approximated the cubic space of each storage location in this shelve is 224,000 cm^3. Then 1 rack has the storage cubic space about 1,120,000 cm^3 and the total required storage cubic space is 698,174 cm^3. As a result, the amount of storage rack which is required to store shaft shape items is only 1 rack.

Special size items: From 4.1.1.2, the special items in term of dimension size that need special storage method or equipments are the items that have one of these attributes width dimension longer than 60 cm, the length dimension over 100 cm or the height dimension over 70 cm.

As it mentioned earlier, determination of the size of storage equipments must be based on the unit load size of storage items. Therefore, determination storage equipment of special size items must base on the dimension data distribution of items' unit load size.

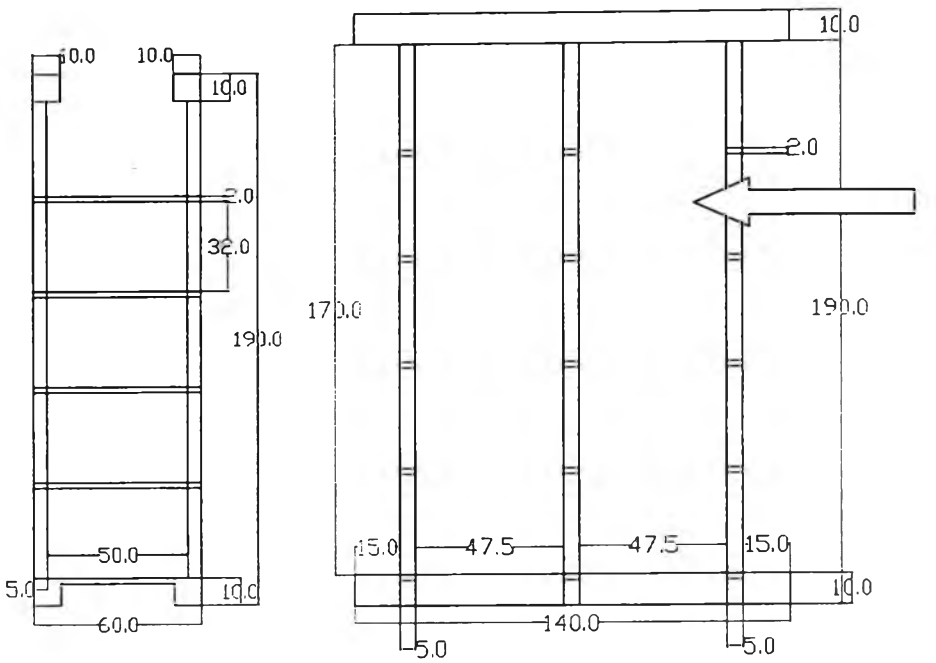


Figure.4.40-Front view (Left) and side view (Right) of the rack

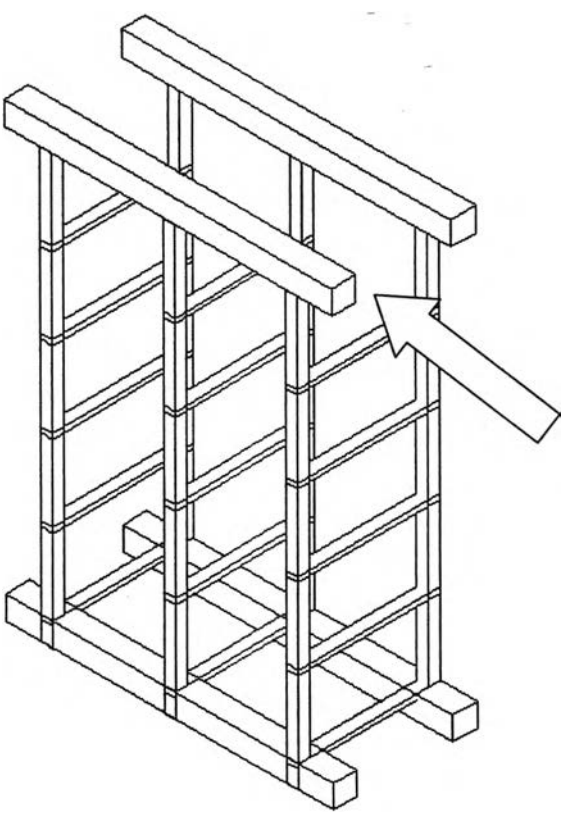


Figure.4.41-Isometric view of the rack

From the table C.1 in the appendix C, there are 16 items in this group and the histogram graphs of dimensions of these items are illustrated as below this:

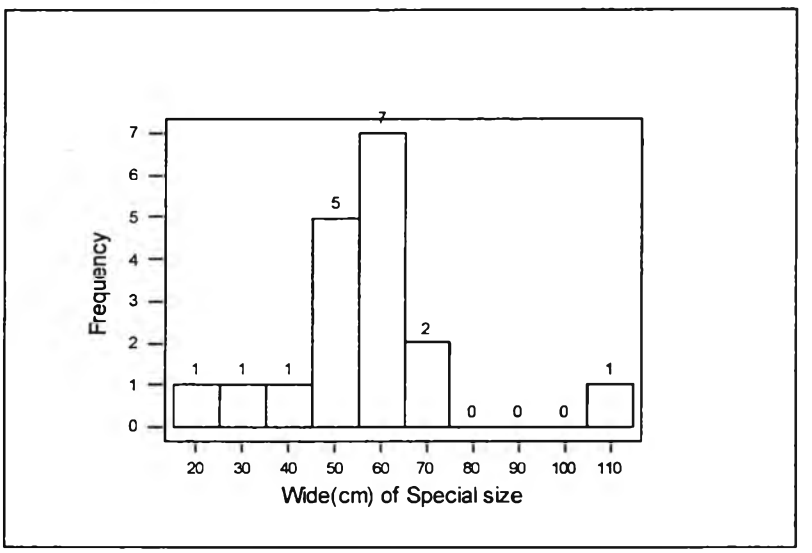


Figure 4.42-Histogram of width dimension of special size items

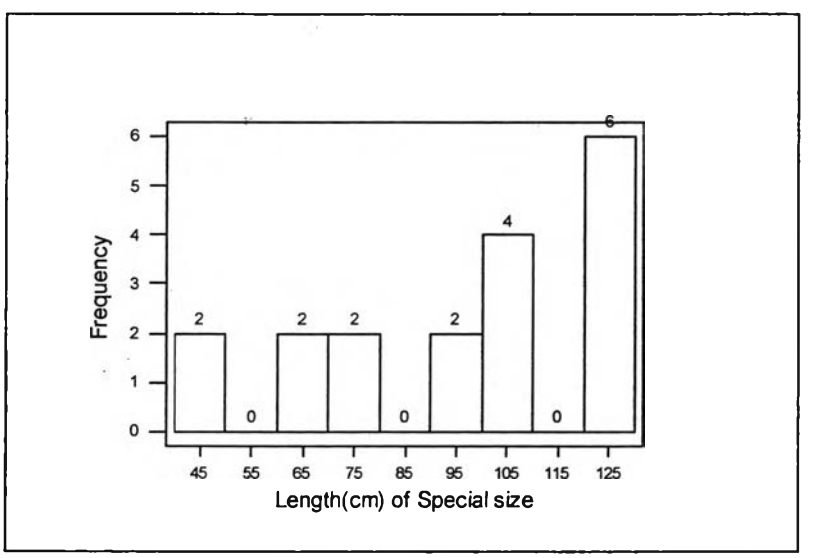


Figure 4.43-Histogram of length dimension of special size items

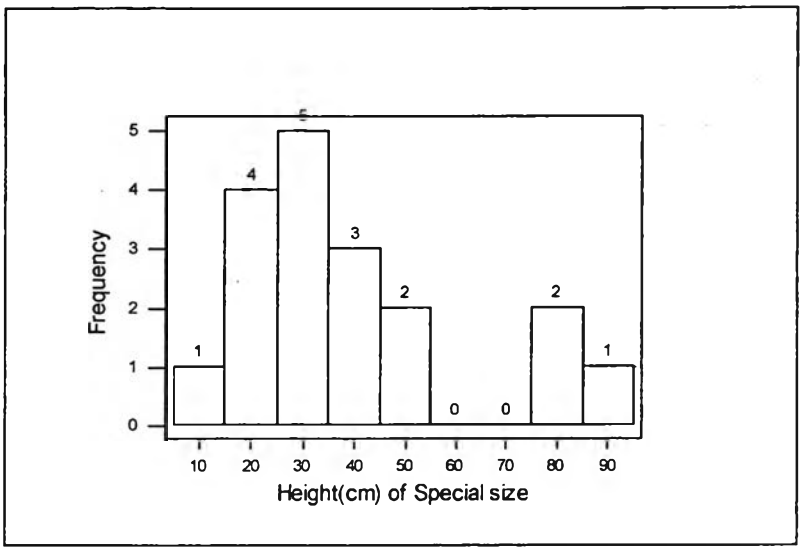


Figure 4.44-Histogram of height dimension of special size items

From the figure 4.42 – 4.44, the unit load size of items in this group is quite large so the storage equipment and storage location need to be large to fit their size also. The maximum dimensions of items in this group are 110 cm for the width dimension, 125 cm for the length dimension and 90 cm for the height dimension.

Total planning storage space area of items is 14.84 meter^3 but it needs to add 30% allowance space for honeycombing. Therefore, total required storage cubic space for special size items is 19.3 meter^3.

The most suit storage equipment for these items is shelving because in the term of item size, shelving can be designed to store items in many sizes so it can be build to fit the items in this group. Beside that, shelving affords the user significant flexibility in the type and quantity of goods that can be stored, and at a relatively low capital investment.

Therefore, from the size of items, the storage equipment that should be used to store special size items is shown in figure 4.45. This storage equipment is called "model C shelf".

Storage equipment in figure 4.45 is designed to fit the requirement of the special size items. The width of this shelve is 120 cm, length is 150 cm and height of this shelve is 200 cm. There are 2 storage locations on this shelve.

As it mention earlier, material of storage shelves should be put a greater emphasis on the strength and durability. Because of this reason, metal is the

suit material to build the storage shelves. Beside that it is cheap and its construction is very strong. The materials that is used to build shelve are metal and zinc connector with chrome plated finish because it is strong, durable and cheap.

The dimensions of storage location in this shelve is deigned by adding clearance space in each side of them. Width dimension of the storage location in this shelve is 114 cm and Length dimension is 144 cm. Height dimension of the storage location is 92 cm. Then, approximated the cubic space of each storage location in this shelve is 1,510,272 cm^3. Then 1 shelf has the storage cubic space about 3,020,544 cm^3 and total required storage cubic space for special size items is 19.3 $meter^3$. As a result, the amount of storage shelve which is required to store all special items is 7 shelves.

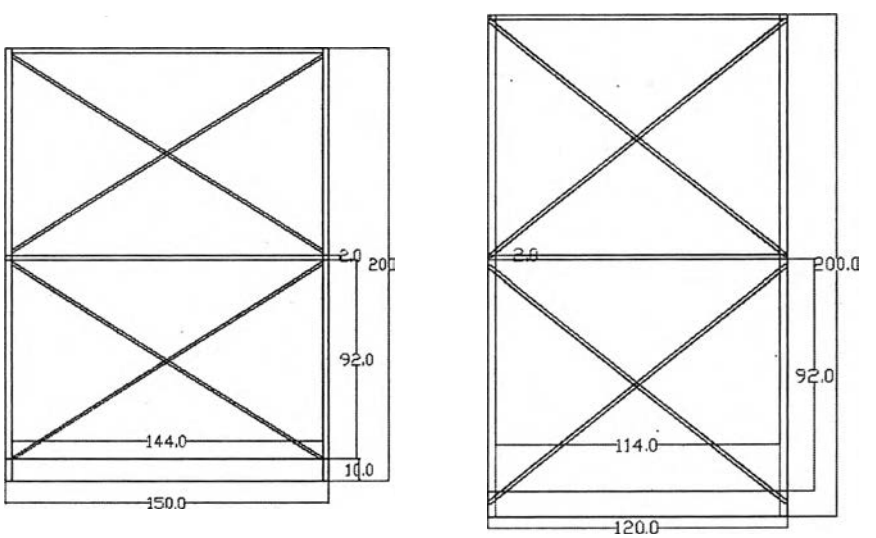


Figure.4.45-Front view (Left) and side view (Right) of model C shelf

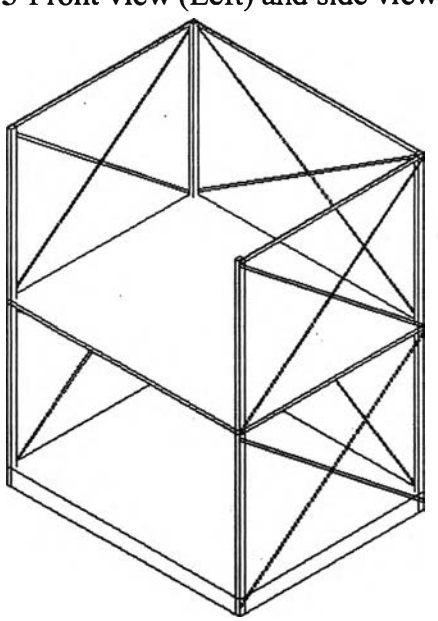


Figure.4.46-Isometric view of the model C shelf

Special high weight items: The size concept suggests that heavy should be close to their point of use. Heavy items can not be stored at great height because they are too heavy to be lifted highly. Then, they are not suit to store at the high storage location. Therefore, their storage method can be selected between floor-stored, solid-stacked, or in racks.

As it mentioned earlier, determination of the size of storage equipments must be based on the unit load size of storage items. Therefore, storage equipment determination of special high weight items must base on the dimension data distribution of items' unit load size.

From table C.1 in the appendix C, there are 12 items in this class and the histogram graphs of dimensions of these items are illustrated as in figure 4.47-4.49. From the figure 4.47-4.49, the maximum dimensions of items in this group are 55 cm for the width dimension, 87 cm for the length dimension and 50 cm for the height dimension.

Total planning storage space area of high weight items is 4.6 meter^3 but it needs to add 30% allowance space for honeycombing. Therefore, total required storage cubic space for special high weight items is 6 meter^3.

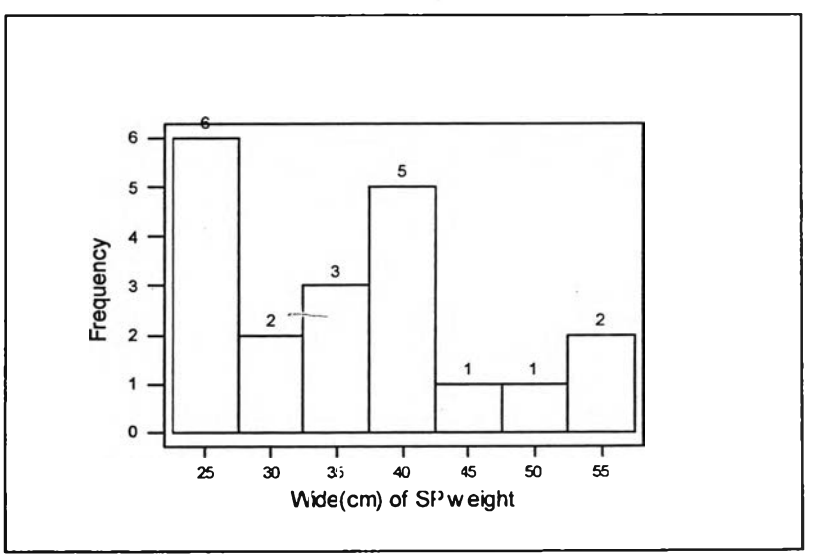


Figure.4.47-Histogram of width dimension of high weight items

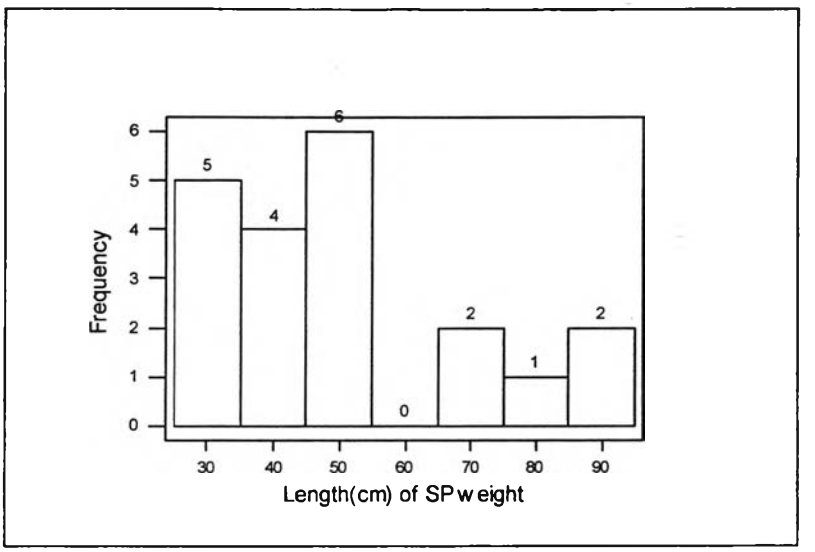


Figure.4.48-Histogram of length dimension of high weight items

Figure.4.49-Histogram of height dimension of high weight items

The suit storage equipment for these items is shelving but it needs to avoid being stored in high storage location. But if the storage equipment is designed to use only at the low and medium layer, their storage cubic space can not be used efficiently. Then, heavy weight items should share their storage equipments with other group of items but they need to reserve the low and medium layer of storage equipment for the group of heavy weight items.

Therefore, from the size of items, the storage equipment that should be used to store heavy weight items can be the same type of shelves that is used to store

second class of normal item. That type of shelve is shown in figure 4.39. The width of this shelve is 65 cm, length is 120 cm and height of this shelve is 230 cm. There are 3 storage locations on this shelve.

The dimensions of storage location in this shelve is deigned by adding clearance space in each of them. Width dimension of the storage location in this shelve is 65 cm and Length dimension is 120 cm. Height dimension of the storage location is 73 cm. As a result, approximated the cubic space of each storage location in this shelve is 569,400 cm^3. In one shelve, the high weight items can be stored at the low and medium layer of shelve so in one shelve, the storage cubic space that is available for the high weight items is 1.14 $meter^3$. The total required storage cubic space for special high weight items is 6 $meter^3$ then the amount of storage shelves which is required to store high weight items is expected around 6 shelves.

Special high-Turn over items: Special high-turn over items is the item that its turn over rate is over 100 units per month. The turn over rate of each item is shown in table C.1 in the appendix C. There are 14 items in this group and these items should be located closet to receiving and shipping location. Determination of the size of storage equipments must be based on the unit load size of storage items. Therefore, storage equipment determination of special high-turn over items must base on the dimension data distribution of items' unit load size. The histogram graphs of dimensions of these items are illustrated as in figure 4.47-4.49. From the figure 4.47-4.49, the maximum dimensions of items in this group are 45 cm for the width dimension, 45 cm for the length dimension and 22 cm for the height dimension.

Total planning storage space area of high-turn over items is 2.7 $meter^3$ but it needs to add 30% allowance space for honeycombing. Therefore, total required storage cubic space for special high-turn over items is 3.5 $meter^3$.

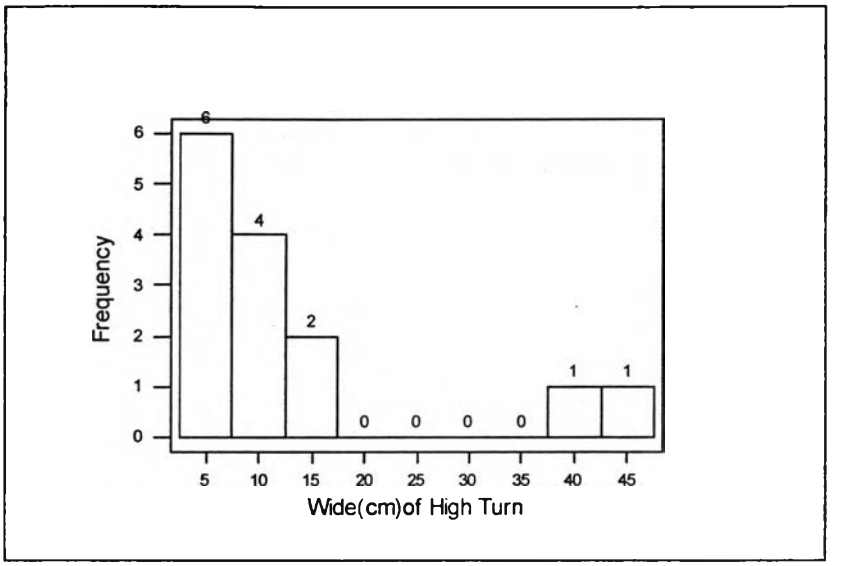


Figure.4.50-Histogram of the width dimension of high-turn over items

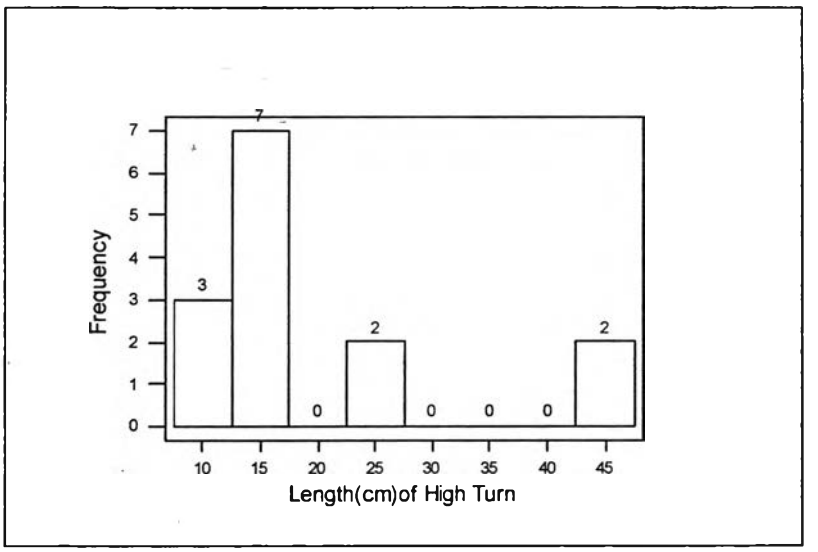


Figure.4.51-Histogram of the length dimension of high-turn over items

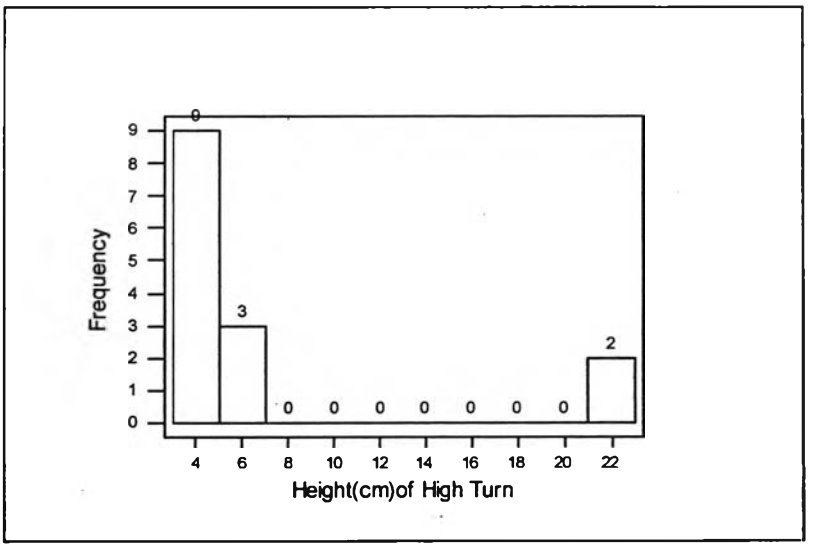


Figure.4.52-Histogram of the height dimension of high-turn over items

The suit storage equipment for these items is shelving but it needs to be noticed easily and being stored in low storage location would not support that. But if the storage equipment is designed to use only at the high layer, their storage cubic space can not be used efficiently. Then, high-turn over items should share their storage equipments with other group of items but storage equipment needs to reserve the highest layer for them. The group of items that they ould share the storage equipment with is the heavy items group because heavy items are determined to store at the low and medium layers of storage equipment and both of them should be located near the receiving and shipping area. As, type of shelve that is used to store heavy items are shown in figure 4.39 so this shelf will store the high-turn over items also.

There are 3 layers and 3 storage locations in this shelve. Approximated the cubic space of each storage location in this shelve is 569,400 cm^3. In one shelve, the high weight items would be stored at the low layer and the medium layer of shelve so the other layer is used to store high-turn over items. Then, in one shelve, the storage cubic space that is available for the high turn-over items is 0.57 meter3. The total required storage cubic space for special high-turn over items is 3.5 $meter^3$ then the amount of storage shelves which is required to store high turn-over items is expected around 7 shelves.

After warehouse equipment determination for all groups of items is completed, the next step is to determine aisle within storage area.

(D)Determine aisle within storage area: The required aisles within storage need to be determined based on the material handling method. The material handling method that been selected to use in this warehouse is a hand truck and the steel platform truck with 6" rubber wheels 24"X48" platform is the model that is selected. The minimum required width of aisle is 65 cm. Then, the appropriate width of aisle within storage area is 0.9 meter.

Therefore, in the 4.1, warehouse space planning and warehouse layout improvement has done on fixed obstacle improvement, space planning for each and to locate the area of receiving, shipping, and storage. Beside that, this chapter has determined warehouse equipment and aisle within storage area also. However, it is not completed yet until the all items are assigned to be stored to the storage locations.

4.2 Assign the material to be stored to the storage locations

4.2.1 Determine storage locator system

The storage locator system has been determined in the topic 4.1.1.2 Space Planning for Storage Activities already. It has been determined based on these factors space available, dimension of product, weight of items, storage methods, equipment and labor availability. Beside that, it must go well with the objectives of the warehouse which are "maximize the effective use of space" and "maximize accessibility of all items".

The combination philosophy is selected because it can response to the objectives while can fit well with other considered factors. Conceptually the best features of the fixed and random systems can be combined at the same time. It can be achieved by assigning only the selected items to the fixed home but not all items.

4.2.2 Determine item placement system or Allocation system

Item placement system is the system that manages where a particular item should be physically positioned. There are various concepts of placing items so below this is the conclusion of these concepts:

4.2.2.1. Popularity concept

This item placement approach is based on "Pareto's Law". Accordingly, for efficient physical inventory control, using popularity (speed of movement into and through the facility) as the criterion, the most productive overall location for an item is a storage position closet to that item's point-of-use. Items are separated into A-B-C categories, with "A" representing the most popular, fastest moving items, "B" representing the next most active, and "C" the show-movers.

4.2.2.2. Family Grouping concept

This approach to item placement positions items with similar characteristics together. Theoretically, similar characteristics will lead to a natural grouping of items, which will be received/stored/picked/shipped together.

Grouping can be based on:

- Like characteristics
- Items that are regularly sold together.

- Items that are regularly used together.

4.2.2.3. Size concept.

The size concept suggests that heavy, bulky, hard-to-handle goods should be close to their point of use. In addition, if the ceiling height in the warehouse varies from one area to another, the heavy items should be stored in the areas with a low ceiling, and the lightweight, easy-to-handles items should be stored in the areas with a high ceiling. Available cubic space in the warehouse should be used in the most effective way while meeting restrictions on floor loading capacity. Lightweight material can be stored at greater heights within typical floor loading capacities than heavy materials can.

The size philosophy also asserts that the size of the storage location should fit the size of the material to be stored. A variety of storage location sizes must be provided so that different items can be stored differently.

4.2.2.4. Product Characteristics concept

Some materials have certain attributes or traits that restrict or dictate the storage methods and layout used. Perishable material is quite different from non-perishable material, from a warehousing point of view. The warehouse layout must encourage good stock rotation so that limitations on shelf life are met. Oddly shaped and crushable items, subject to stocking limitations, will dictate special storage methods and layout configurations to effectively use available cubic space. Hazardous material such as explosives, corrosives, and highly flammable chemicals must be stored in accordance with government regulations.

In the real case, only one concept is impossible to deal with all items in a warehouse because there are various items with different characteristic, size etc. Then, effective item placement can often be achieved through tying many concepts together. The end result is a more efficient overall layout.

The item placement system of this warehouse will be determined by tying these concepts together. The item placement system for this warehouse would be divided into 2 systems. The first system is to locate the storage locations for each group of item such as high turn-over items group, special size items group and normal

item group. The second system is as a guideline to locate storage location for each particular item.

Therefore, process of the system to assign the storage location for group of items is operated by following below steps:

1. Using Popularity concept to locate the storage location of high turn-over items group. Fast moving items should be located closet to receiving and shipping location.

2. Using size concept to locate the storage location of the very high weight items group (above 30 kg). Heavy weight items should be located near receiving and shipping location.

3. Using Product Characteristics concept to locate the storage location of the oddly shape or Hazardous material items. They should be stored with special storage method and equipment.

4. Using size concept to locate the storage location of the special size items group (Width more than 60 cm or Length more than 100 cm or Height more than 70 cm). They should be stored in storage location that fit the size of the material to be stored and convenient for material handling.

5. Using size concept to classify size of item into 2 groups and store them in storage location that fit the size of the material to be stored.

After assigned the storage location for groups of items, the guideline process to locate storage location for each particular item in each group operated by following below steps:

1. Employ Family grouping concept that based on "Like characteristics" to group all item by their characteristics into each group of item.

2. Using Popularity concept to locate the storage location of each "like characteristics" group. The groups that have the high average of items' turn-over should be located to receiving and shipping area.

3. After each "like characteristics" groups have been located, the size concept will be used to locate the storage location of each item in the characteristic group. This concept will lead to if items are stored in shelves, the heavy items should be stored in a low level and the lightweight should be stored in a high level.

These steps in the item placement system are the guiding to where each item should be physically positioned that make the most benefit to the warehouse operation.

4.2.3 Assign storage area of each item and locate aisle within storage area

This step is very important because it directly concerns to the overall performance of warehouse activities. Assign items to storage area will employ combination system which enables warehouse to assign specific locations to those items requiring special consideration, while the bulk of the item mix will be randomly located in broadly view. But in depth detail of where a particular item should be physically positioned, steps of the item placement system in 4.2.2 must be followed.

4.2.3.1 Assign the storage location for group of items is operated by following below steps

Step1. Using Popularity concept to locate the storage location of "A items" which is the item that its turn over rate is over 100 units per month.

Type of item - The turn over rate of each item is shown in the table C.1 of the appendix C. From 4.1.1.2, the item that its turn over rate is over 100 units per month is considered as a special item and it need special storage location. These special items are the selected items to have the fixed home. It means high turn-over item must stored at the same storage locations always and no other item are allowed be stored at its storage location.

Storage cubic space requirement - There are 14 items in this group. Total planning storage space area of high-turn over items is 2.7 meter^3 but it needs to add 30% allowance space for honeycombing. Therefore, from the table C.1 of the appendix C, total required storage cubic space for special high-turn over items is 3.5 meter^3.

Model and quantity of storage equipment - According to 4.1.2.3, the storage equipment of high-turn over items are the shelves in figure 4.39 or it is called "the model B shelf" and they need to share the storage equipment with the heavy items group. Then, in one shelve, the storage cubic space that is available for the high turn-over items is 0.57 meter3. The total required storage cubic space for special

high-turn over items is 3.5 meter^3 then the amount of storage shelves which is required to store high turn-over items is expected around 7 shelves.

Requirement of storage location- These items should be located closet to receiving and shipping location.

Locate the storage location into storage area- The storage area which is nearest to receiving and shipping area is the floated floor of building no.2 so the storage location of the high turn-over items should be located at this area. The layout of floated floor area needs to be considered to find the best location for the main aisle within storage area and the storage location of high-turn over item. The storage locations consideration is based on requirement of storage location. From considering the layout of floated floor in building no.2 in figure 4.20, the main aisle and storage location of high-turn over items are located as in figure 4.53. The number in the fig.4.53 is the sequence number of shelf and the area in the red line is the main aisle within storage area. The area outside the red line is a storage area. The group of high turn-over items is stored on the top layer of model B shelves no. 1-7.

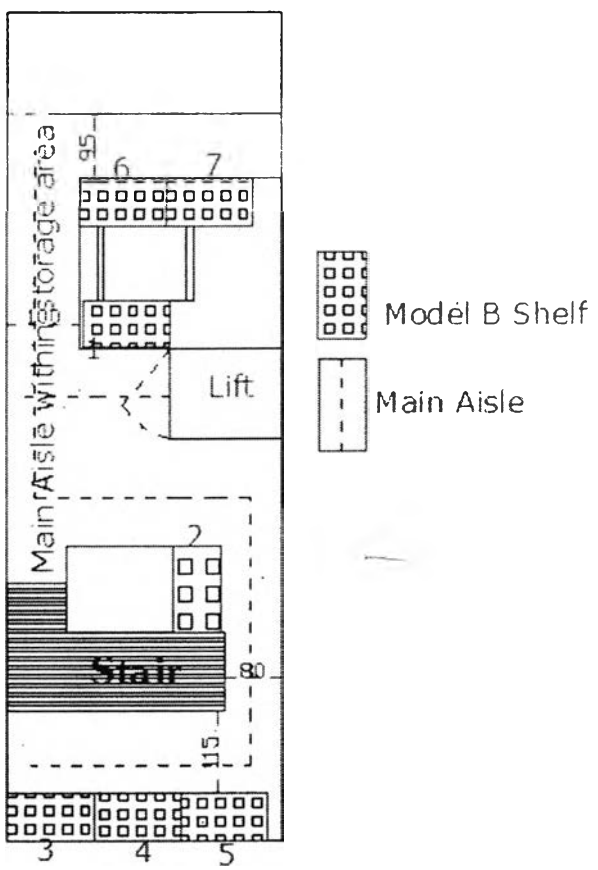


Fig.4.53-Layout of the floated floor in building no.2 with the storage shelves of high turn-over item and aisle within storage area

Step2. Using size concept to locate the storage location of the very high weight items (above 30 kg) and locate them near receiving and shipping location.

Type of item - The weight of each item is shown in the table C.1 of the appendix C. From 4.1.1.2, items that have the weight over 30 kg are require special specific storage location and storage method because they will be difficult to lift and move these heavy items. These special items are the selected items to have the fixed home. It means heavy item must stored at the same storage locations always and no other item are allowed be stored at its storage location.

Storage cubic space requirement - There are 12 items in this group. Total planning storage space area of high weight items is 4.6 meter^3 but it needs to add 30% allowance space for honeycombing. Therefore, total required storage cubic space for special high weight items is 6 meter^3.

Model and quantity of storage equipment - According to 4.1.2.3, the storage equipment of heavy items are the shelves in figure 4.39 or it is called "the model B shelf" and they need to share the storage equipment with the high turn-over items group. In one shelve, the high weight items can be stored at the low and medium layer of shelve so in one shelve, the storage cubic space that is available for the high weight items is 1.14 meter^3. The total required storage cubic space for special high weight items is 6 meter^3 then the amount of storage shelves which is required to store high weight items is expected around 6 shelves.

Requirement of storage location - These items should be located closet to receiving and shipping location. Heavy items can not be stored at great height because they are too heavy to be lifted highly. Then, they are not suit to store at the high storage location.

Locate the storage location into storage area- The storage area which is nearest to receiving and shipping area is the floated floor of building no.2 so the storage location of the heavy items should be located at this area. The layout of floated floor area needs to be considered to find the best location for the storage location of heavy item. The storage locations consideration is based on requirement of storage location. From considering the layout of floated floor in building no.2 in figure 4.53, the storage location of heavy items are located on the low and medium layer of model B shelves no. 1-4,6,7 in figure 4.53.

Step3. Using product characteristics concept locates the storage location of the oddly shape or hazardous material items. They should be stored with special storage method and equipment.

Type of item - The items that have special characteristic are shown in the table C.1 of the appendix C. From 4.1.1.2, there are 2 items that have special characteristic which is oddly shape. These 2 items have shaft shape so they are considered to require special specific storage location and storage equipment. They require special specific storage location and storage equipment because their shapes are different from bulk items. These special items are the selected items to have the fixed home. It means special size item must stored at the same storage locations always and no other item are allowed be stored at its storage location.

Storage cubic space requirement - There are only 2 items that their shape is shaft and planning storage space area of each item is 201,600 cm^3 and 366,080 cm^3. But it needs to add 30% allowance space for honeycombing for storage space area of each item. As a result, required storage cubic space of each item is 262,080 cm^3 and 436,094 cm^3 so the total required cubic space is 698,174 cm^3.

Model and quantity of storage equipment - According to 4.1.2.3, the storage equipment of shaft shape items are the rack in figure 4.53. Approximated the cubic space of each storage location in this shelve is 224,000 cm^3. Then 1 rack has the storage cubic space about 1,120,000 cm^3 and the total required storage cubic space is 698,174 cm^3. As a result, the amount of storage rack which is required to store shaft shape items is only 1 rack.

Requirement of storage location – they should be located at the area that has long allowance area such as area at the main aisle.

Locate the storage location into storage area- The other groups of special item are stored at the floated floor of building no.2. Then, special size items group should be located at this floor also because it will be easy to recognize the storage location of special groups. After some special groups are located at this floor, the rest storage area of the floated floor in building no.2 is around 16.24 $meter^3$ so this space is good enough to store group of shaft shape items. The layout of floated floor area needs to be considered to find the best location for the storage location of shaft shape items. The storage locations consideration is based on requirement of storage location.

From considering the layout of floated floor in building no.2 in figure 4.53, the storage location of heavy items are located in the rack no. 1 in figure 4.54.

In figure 4.54, the area in the red line is the main aisle within storage area. The area outside the red line is a storage area.

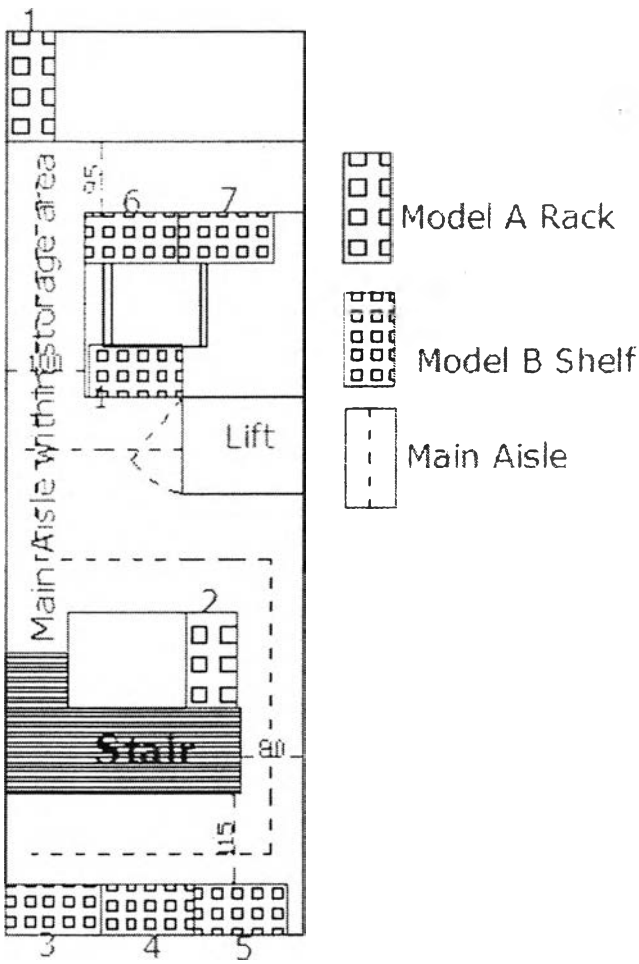


Fig.4.54-Layout of the floated floor in building no.2 with the storage shelves of high turn-over item, shelf of shaft shape items and aisle within storage area

Step4. Using size concept to locate the storage location of the special size items (width more than 60 cm or length more than 100 cm or height more than 70 cm) and store them in storage location that fit the size of the material to be stored and convenient for material handling.

Type of item - The dimension of unit size of each item is shown in the table C.1 of the appendix C. From 4.1.1.2, items that have the width dimension over 60 cm or the length dimension over 100 cm or the height dimension over 70 cm are considered to require special specific storage location and storage equipment. They

require special specific storage locations and storage equipment because their dimensions are different from bulk items. These special items are the selected items to have the fixed home. It means special size item must stored at the same storage locations always and no other item are allowed be stored at its storage location.

Storage cubic space requirement - There are 16 items in this group. Total planning storage space area of items is 14.84 meter^3 but it needs to add 30% allowance space for honeycombing. Therefore, total required storage cubic space for special size items is 19.3 meter^3.

Model and quantity of storage equipment - According to 4.1.2.3, the storage equipment of big size items are the shelves in figure 4.58 or it is called "the model C shelf". Approximated the cubic space of each storage location in this shelve is 1,510,272 cm^3. Then 1 shelf has the storage cubic space about 3,020,544 cm^3 and total required storage cubic space for special size items is 19.3 meter^3. As a result, the amount of storage shelve which is required to store all special items is 7 shelves.

Requirement of storage location - These items should be located in the area that is easy to access and near the shipping and receiving area because it is quite difficult to move big items in the long distance and it needs more area to put it into storage location.

Locate the storage location into storage area- The other groups of special item are stored at the floated floor of building no.2. If special size items group is located at this floor, it will be easy to recognize the storage location of special groups. After some special groups are located at this floor, the rest storage area of the floated floor in building no.2 is estimated around 10 meter^3 which is not enough for storing all items in this group. Therefore, some of them need to be located in other floor and the second floor of building no.2 is the suit storage area because it is close to the receiving and shipping area and the available storage area at the second floor of building no.2 is estimated about 65.76 meter^3. The layout of floated floor area and the second floor area of building no.2 need to be considered to find the best location for the storage location of big size items. The storage locations consideration is based on requirement of storage location. From considering the layout of the floated floor in building no.2 in figure 4.54, and second floor of building no.2 in figure 4.21, the storage location of big size items are located in the model C shelf no. 1-7 as in figure 4.55 and 4.56.

In figure 4.55 and 4.56, the area in the red line is the main aisle within storage area. The area outside the red line is a storage area.

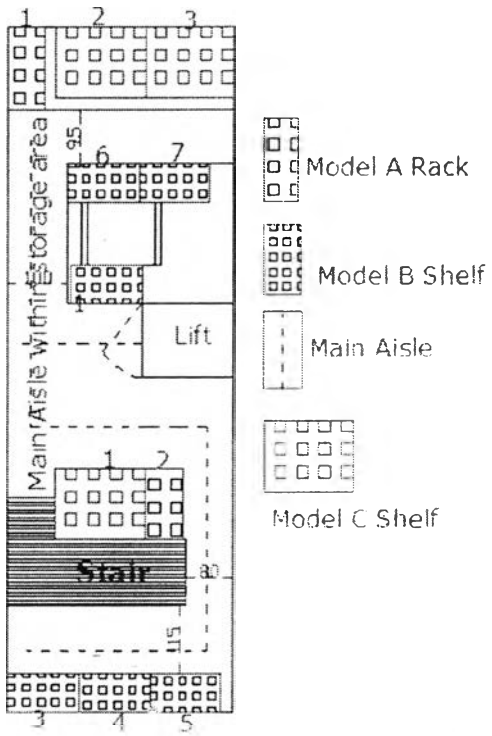


Fig.4.55-Layout of the floated floor in building no.2 with the storage equipments and aisle within storage area

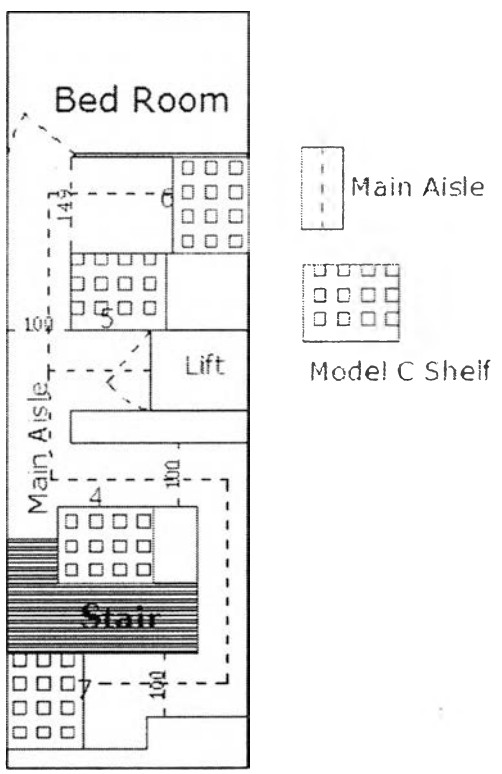


Fig.4.56-Layout of the second floor in building no.2 with the storage equipments of big size item group and aisle within storage area

Step5. Using size concept to classify size of normal item into 2 groups and store them in storage location that fit the size of the material to be stored.

Type of item - Normal items do not require special specific storage location and storage equipment so it means normal items are stored randomly and no item has a fixed home. Although, there are stored randomly but they should be stored in storage location that fit the size of the item to be stored. Then, the size of normal item is classified into 2 groups.

From 4.1.2.3, the first group of normal item is the group of small size so the items in this group must have the width dimension shorter than 30 cm, the length dimension shorter than 30 cm and height dimension shorter than 30 cm.

The second group is the group for medium to big size so the items in this group must have the width dimension longer than 30 cm or the length dimension longer than 30 cm or height dimension longer than 30 cm.

Storage cubic space requirement –There are 876 items in the group of normal item. After they are divided into 2 groups, the first group of normal item has 339 items in this group and the sum up of required storage cubic space of each item is 26 meter^3 but it need to add 30% allowance space for honeycombing. Therefore, total required storage cubic space for first class that needs to plan for storing in the shelves is 34 meter^3.

The second group of normal item has 536 items in the group and total required storage cubic space for second group item is 102.6 meter^3 but it need to add 30% allowance space for honeycombing. Therefore, the total storage cubic space of second class that needs to plan for storing in the shelves is 133.4 meter^3.

Model and quantity of storage equipment - According to 4.1.2.3, the storage equipment of first normal group are the shelves in figure 4.37 or it is called "the model A shelf". Approximated the cubic space of each storage location in this shelve is 100,800 cm^3. Then 1 shelve has the storage cubic space about 0.6 m^3 and the total required storage cubic space for first class that needs to plan for storing in the shelves is 34 meter^3 then the minimum amount of storage shelves which is required to store all items is approximated around 58 shelves.

The storage equipment of second normal group is the shelf in figure 4.39 or it is called "the model B shelf". Approximated the cubic space of each storage location in this shelve is 569,400 cm^3. Then 1 shelve has the storage cubic space

about 1.7 m^3 and the total storage cubic space of second class that needs to plan for storing in the shelves is 133.4 $meter^3$. As a result, the amount of storage shelves which are required to store all items is approximated around 79 shelves.

Requirement of storage location – There is no special requirement for these 2 groups but the requirement of particular item will be followed guideline process to locate storage location for individual item.

Locate the storage location into storage area- All the storage area can be located the storage location of these 2 groups. The total storage area in building no.1 is 331.22 $meter^3$ and the total storage area that still available in building no.2 is 235.36 $meter^3$. But there is a limited of the ceiling height in floated floor of building no.1. The ceiling height of that floor is 2.3 meters so the storage equipment "the model B shelf" can not be located at that floor. Another factor is the lift transportation, the 5^{th} floor and 6^{th} floor of building no.1 do not have lift transportation so to move material from these floors need to use stairs and width walk way in stairs is only 80 cm. Then, these 2 floors should not store the second group of normal items because their size is not convenient to carry up and down the stairs.

As a result, the second group of normal items can be located in the building no.2, the second and fourth floor of building no.1. The layout of the storage area of building no.2 and other floors need to be considered to find the best location for the storage location of the second group of normal items. The storage locations consideration is based on requirement of storage location. From considering the layout of storage area floors, the storage locations of normal items in the second group are located in model B shelf no. 8- 90 as in figures 4.57 to 4.61. Therefore, there are 81 shelves to store the second group of normal items and the total storage cubic space is 129 $meter^3$ which is over than the minimum requirement.

In figure 4.57 to 4.61, the area in the red line is the main aisle within storage area. The area outside the red line is a storage area.

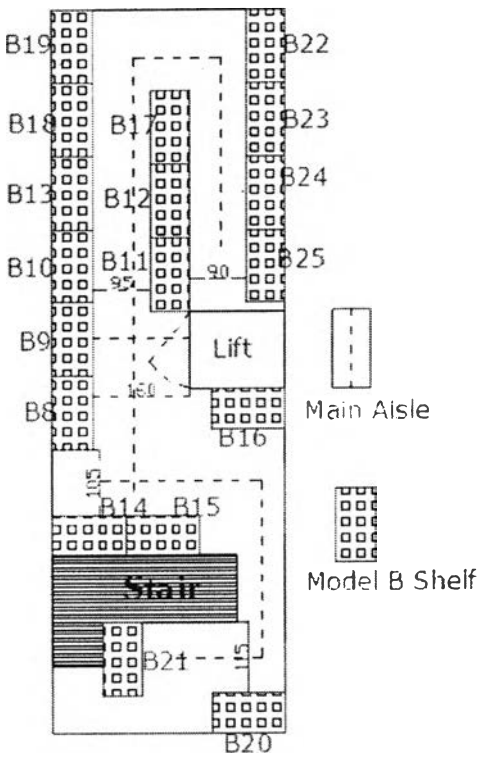


Fig.4.57-Layout of the 3rd floor in building no.2 with the storage equipments and aisle within storage area

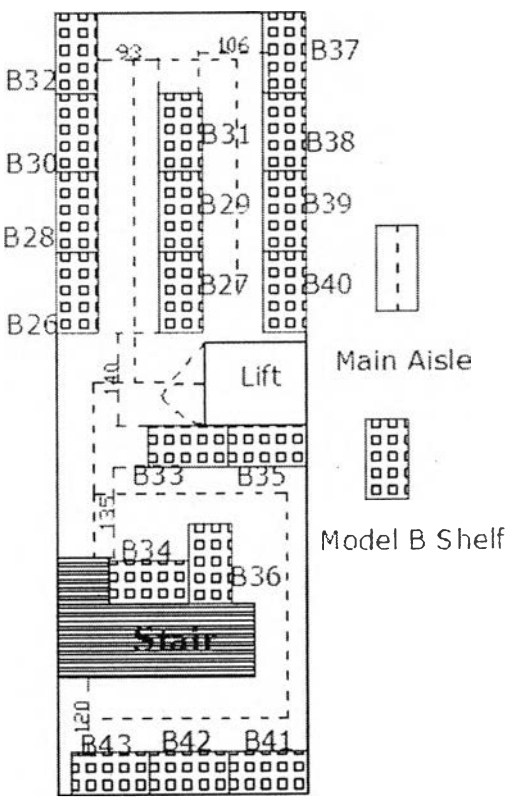


Fig.4.58-Layout of the 4th floor in building no.2 with the storage equipments and aisle within storage area

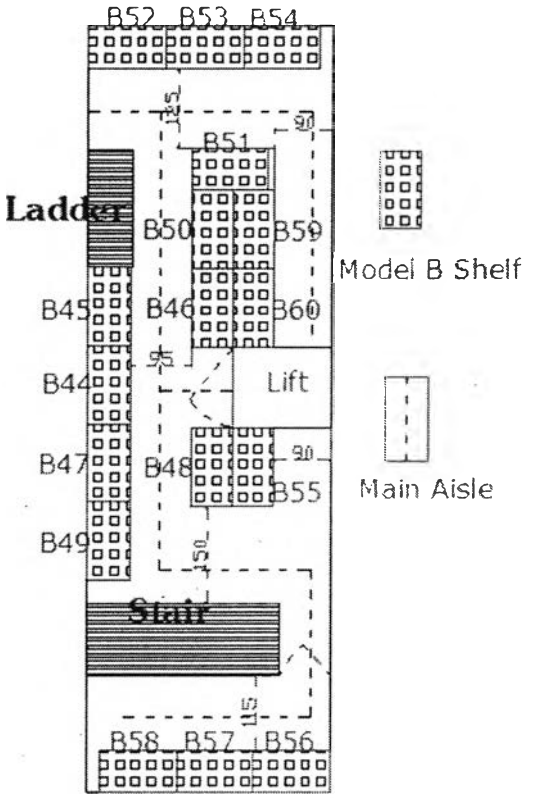


Fig.4.59-Layout of the 5th floor in building no.2 with the storage equipments and aisle within storage area

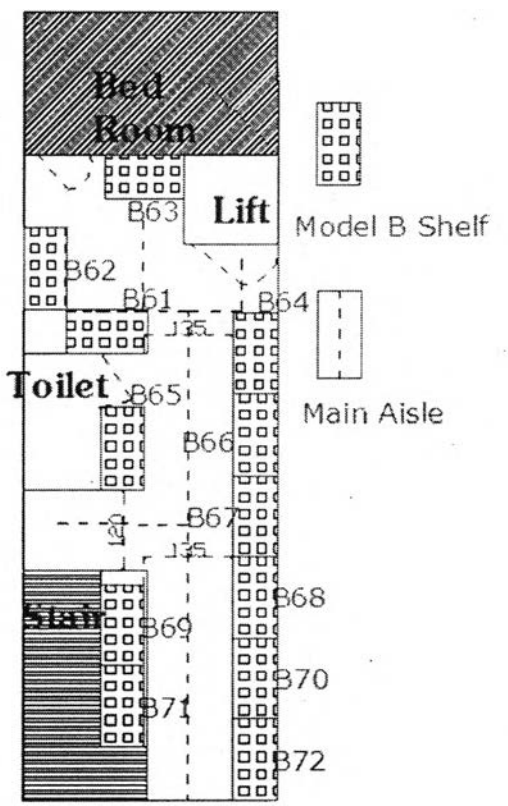


Fig.4.60-Layout of the 2nd floor in building no.1 with the storage equipments and aisle within storage area

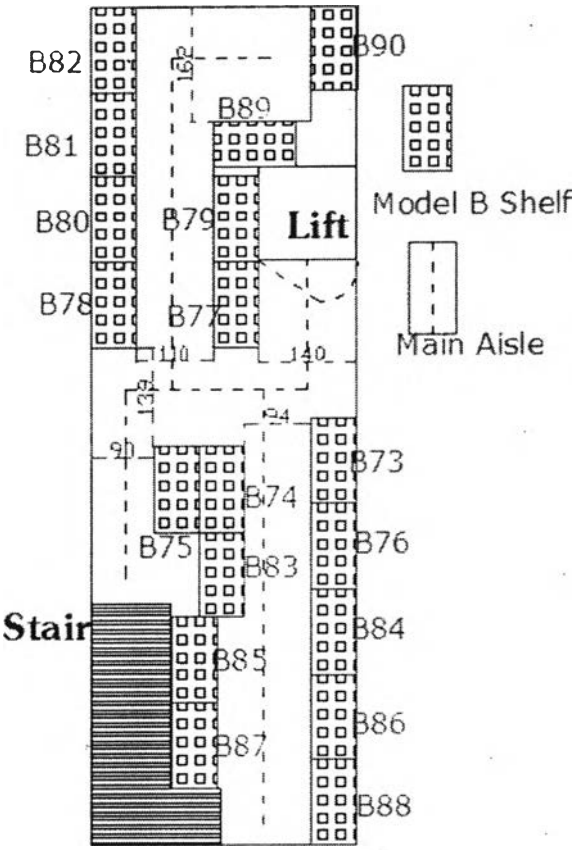


Fig.4.61-Layout of the 4th floor in building no.1 with the storage equipments and aisle within storage area

The first group of normal items can be located in the floated and 5th floor of building no.1. The layouts of these floors of building no.1 need to be considered to find the best location for the storage location of the first group of normal items. The storage locations consideration is based on requirement of storage location. From considering the layout of storage area floors, the storage locations of normal items in the first group are located in the model A shelf no. 1- 62 as in figures 4.62 to 4.63. Therefore, there are 62 shelves to store the first group of normal items and the total storage cubic space is 37 meter^3 which is over than minimum requirement.

In figure 4.62 to 4.63, the area in the red line is the main aisle within storage area. The area outside the red line is a storage area.

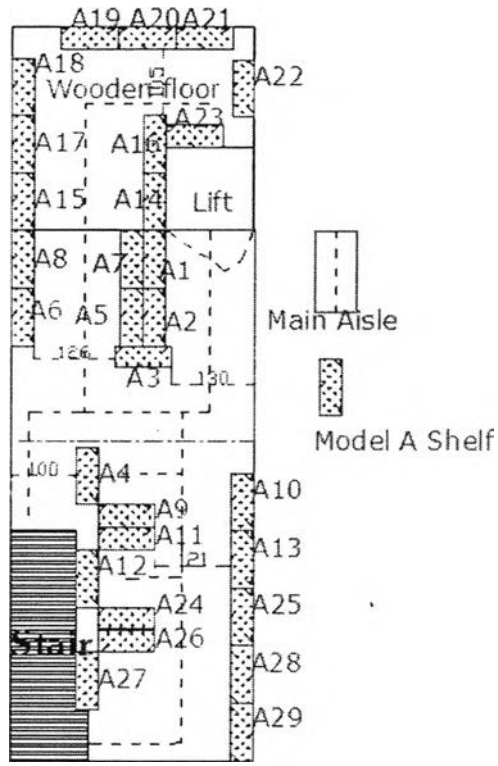


Fig.4.62-Layout of the floated floor in building no.1 with the storage equipments and aisle within storage area

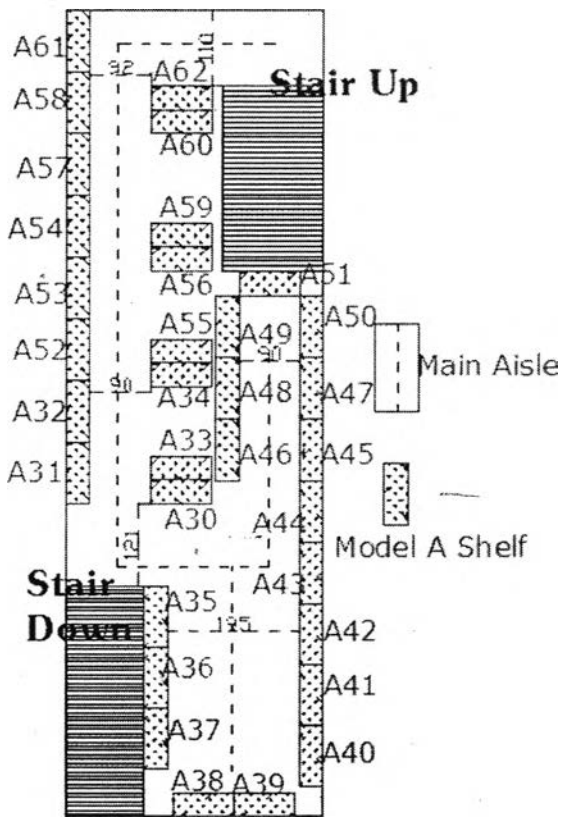


Fig.4.63-Layout of the 5th floor in building no.1 with the storage equipments and aisle within storage area

After define the storage location of each item group, storage area in 6th floor of building no.1 is still available then this floor is assigned as a back up storage area for any item.

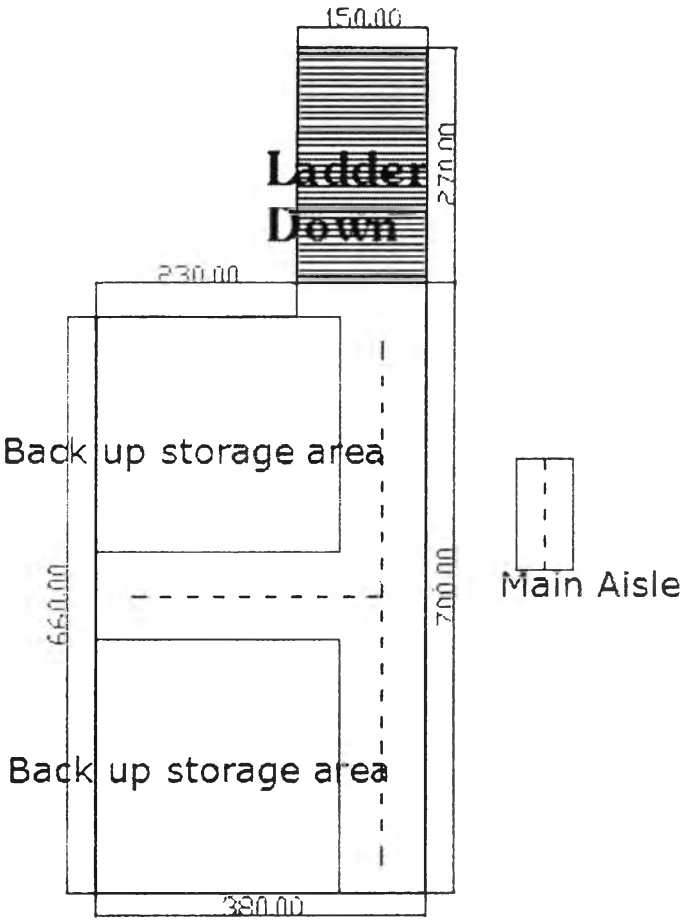


Fig.4.64-Layout of the 6th floor in building no.1 and aisle within storage area

4.2.3.2 The product flow

After the layout of storage area design and arrangement of facilities have been completed, the flow of product must be studied closely to show sequence and the location of all activities in the process. The product flow follows the activities of a product within the layout of buildings.

One of the most useful techniques for the study of flow is the flow-process chart. A product flow process chart displays actual or potential movement of material. Each activity that is performed is classified as one of five types shown below with their symbols.

Operation: ◯ An operation occurs when a product is intentionally changed in any of its physical or chemical characteristics.

Inspection: An inspection occurs when a product is examined for identification or is verified for quality or quantity.

Transportation: Transportation occurs when a product is moved from one place to another.

Delay: A delay occurs to a product when the next step does not permit or require immediate performance of the next step planned step.

Storage: A storage occurs when an objects is kept and protected against unauthorized removal.

The product flow of this warehouse can be separated into 2 processes. The first process is product flow in to warehouse and the second process is product flow out of warehouse.

Flow Process of product moving into warehouse

	Detail of Activities	Operation	Transport	Inspection	Delay	Storage
1	Inspect quantity and quality of product	○	⇨	■	D	▽
2	Identify the storage location	○	⇨	□	■	▽
3	Move product to its storage location	○	■	□	D	▽
4	Store product in its storage location	○	⇨	□	D	▼

Figure 4.65- Flow process of product moving into warehouse

Flow Process of product moving out of warehouse

	Detail of Activities	Operation	Transport	Inspection	Delay	Storage
1	Move product from its storage to shipping area	○	■	□	D	▽
2	Checking product quantity and quantity	○	⇨	■	D	▽
3	Move product to packing area	○	■	□	D	▽
4	Packing product	●	⇨	□	D	▽
5	Move product to shipping vehicle	○	■	□	D	▽
6	Shipping product to customers	○	■	□	D	▽

Figure 4.66- Flow process of product moving out of warehouse

After the product flows have been determined, the other technique, flow diagram, needs to be used to sketch the layout of floors and of building which shows the location of all activities appearing on a flow process chart. Each activity is located and identified on the flow diagram by symbol and number, corresponding to that appearing on the flow process chart.

The product flow diagrams of this warehouse are illustrated below this. The first and second flow diagram demonstrates the flow of over all building and others show the flow diagram of product in each floor.

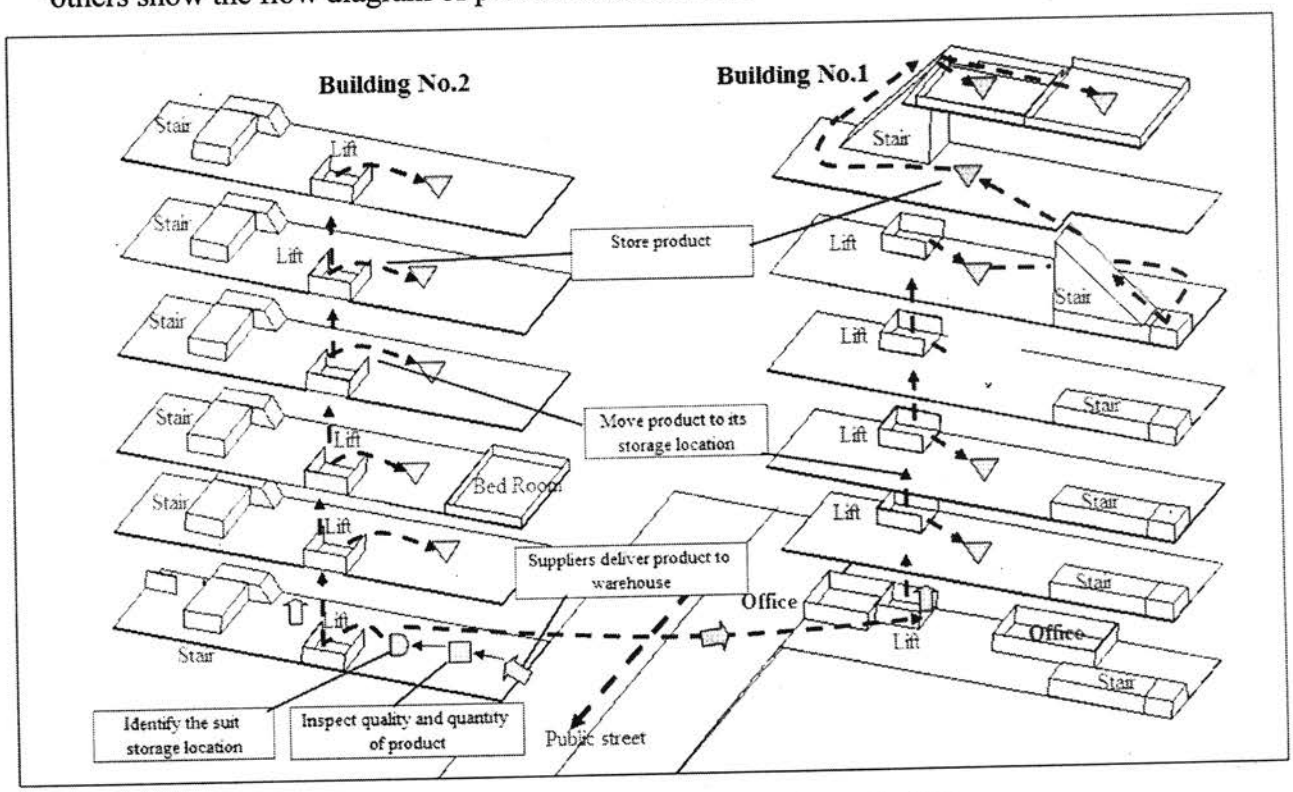


Figure 4.67- Flow diagram of product moving into warehouse buildings

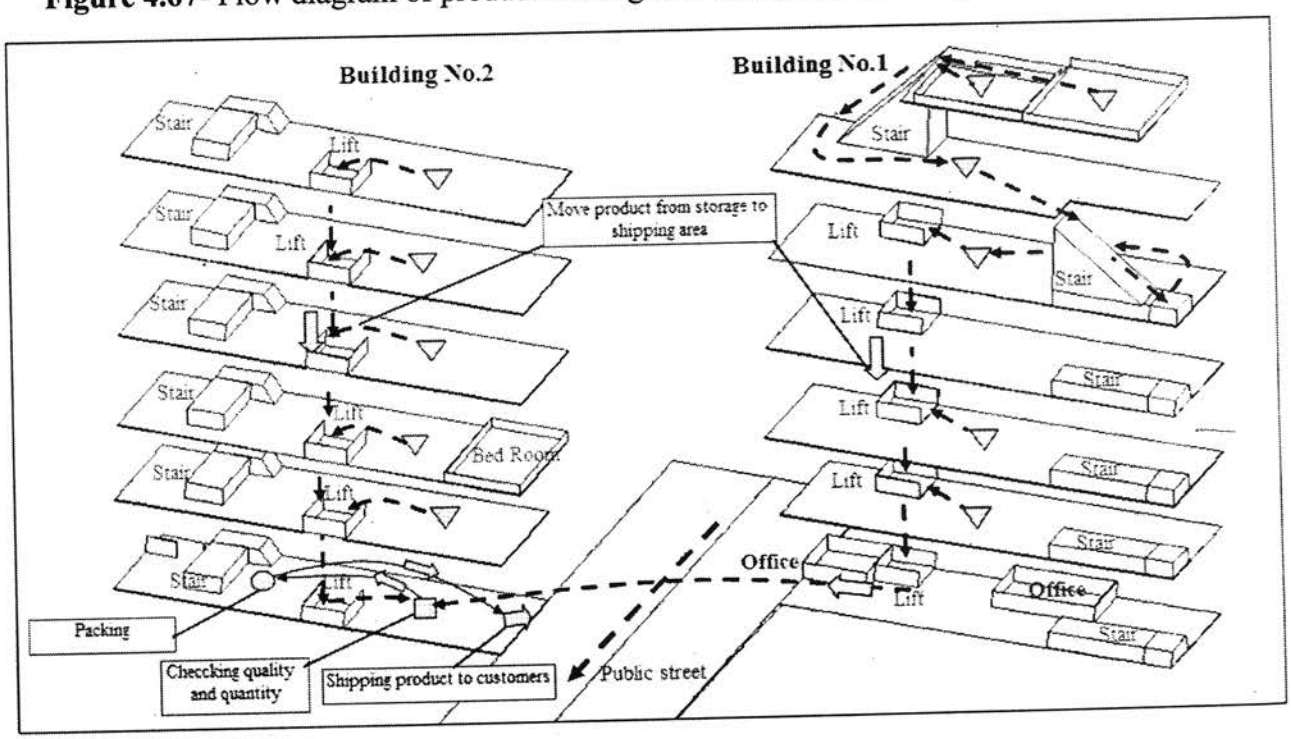
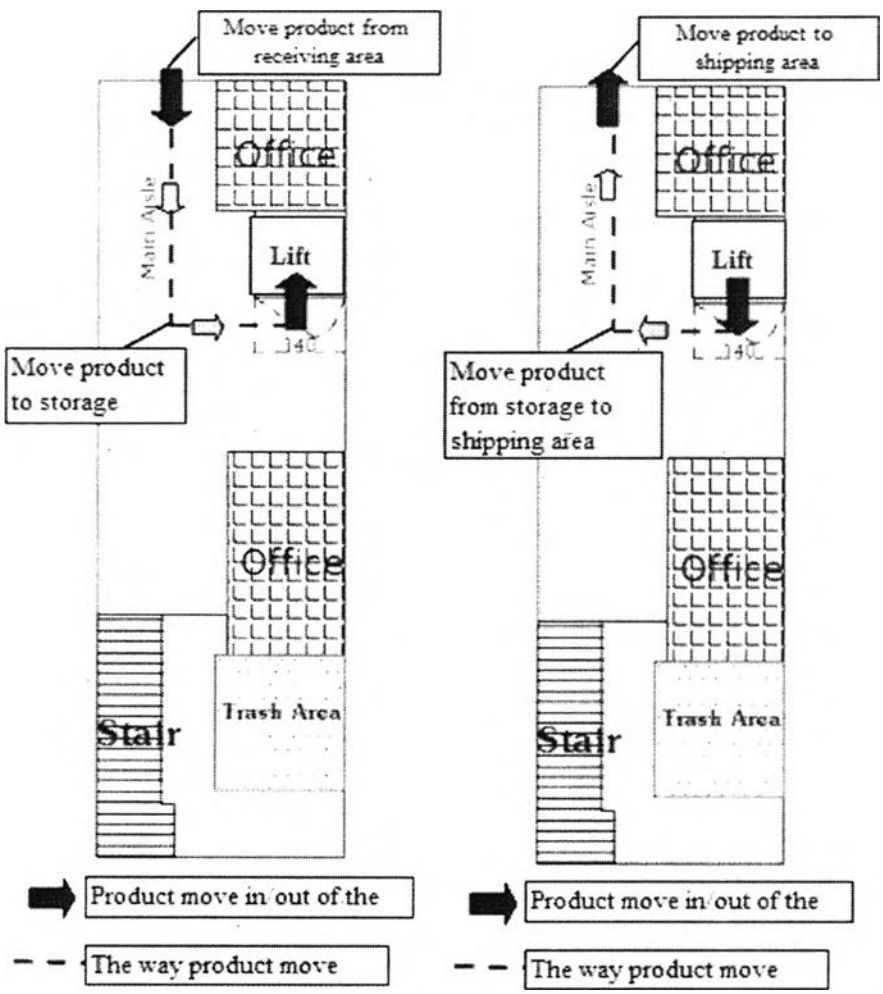


Figure 4.68- Flow diagram of product moving out of warehouse buildings

Figure 4.67 show the product flow diagram of putting product into storage location and figure 4.68 show the product flow diagram of shipping product to customers. Each activity of each process is located and identified on the flow diagram by symbol. The following figures show the product flow diagram of each floor in both storage buildings which indicates the way product move in and out and the storage area of the floor.



(a) **(b)**

Figure 4.69- Product flow diagram of the first floor of the building no.1

a. Flow diagram of moving product to storage location process in the 1st floor of building no.1

b. Flow diagram of moving product to shipping area process in the 1st floor of building no.1

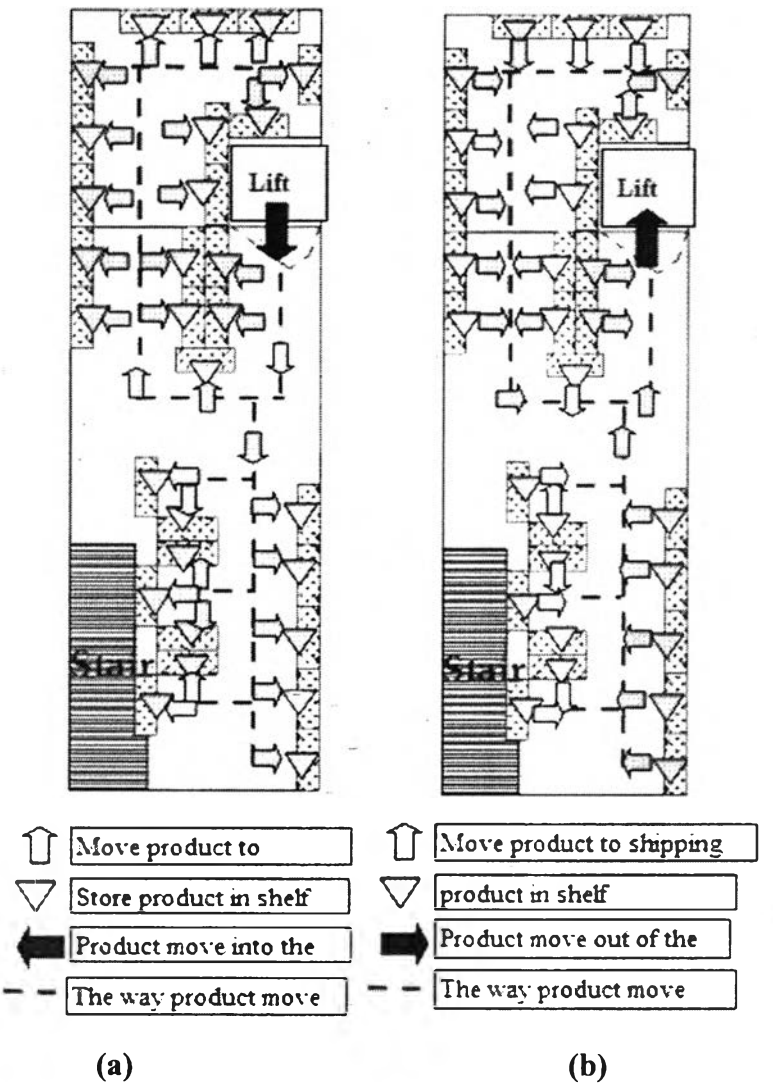


Figure 4.70- Product flow diagram of the floated floor of the building no.1

a. Flow diagram of moving product to storage location process in the floated floor of the building no.1

b. Flow diagram of moving product to shipping area process in the floated floor of the building no.1

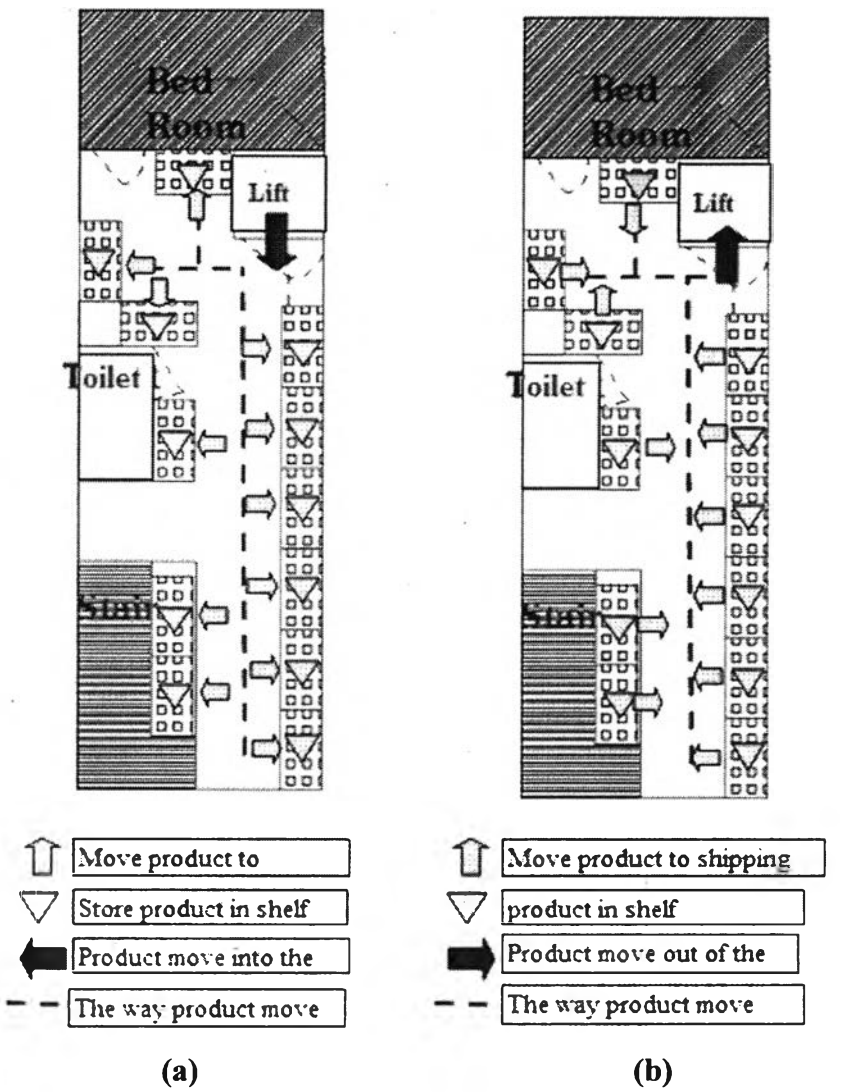


Figure 4.71- Product flow diagram of the second floor of the building no.1

a. Flow diagram of moving product to storage location process in the second floor of the building no.1

b. Flow diagram of moving product to shipping area process in the second floor of the building no.1

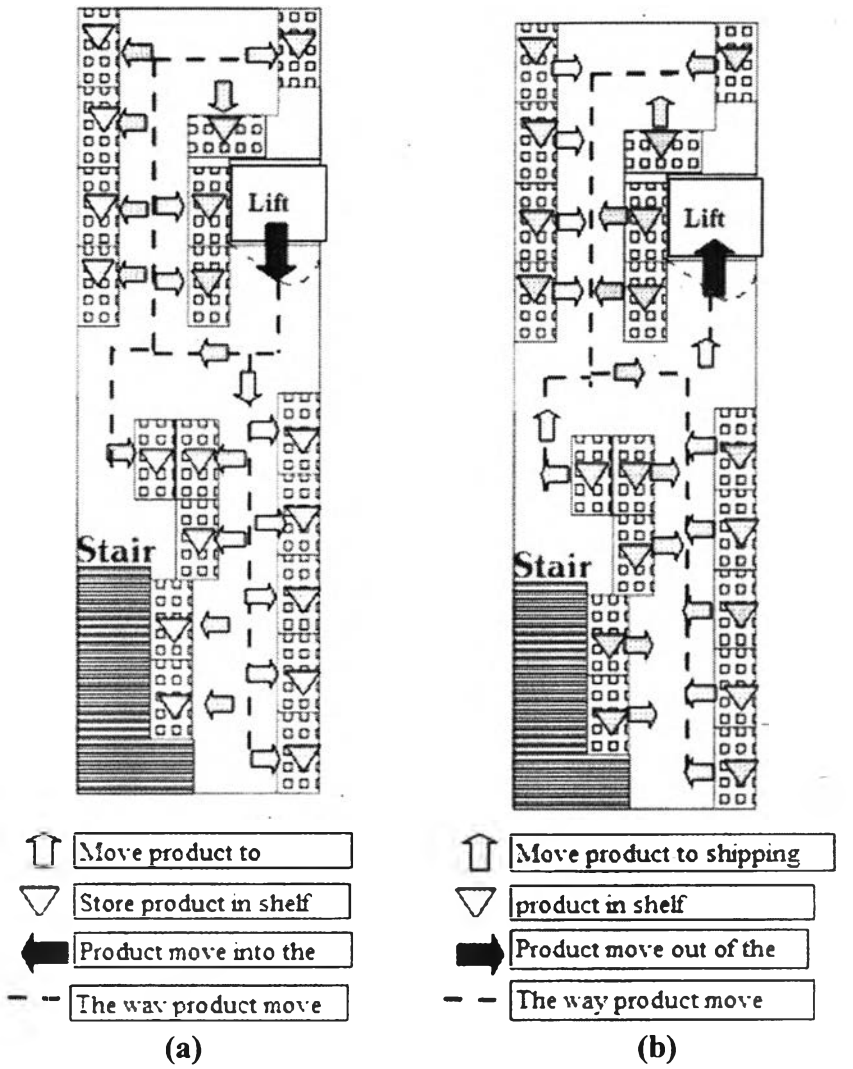


Figure 4.72- Product flow diagram of the 4th floor of the building no.1

a. Flow diagram of moving product to storage location process in the 4th floor of the building no.1

b. Flow diagram of moving product to shipping area process in the 4th floor of the building no.1

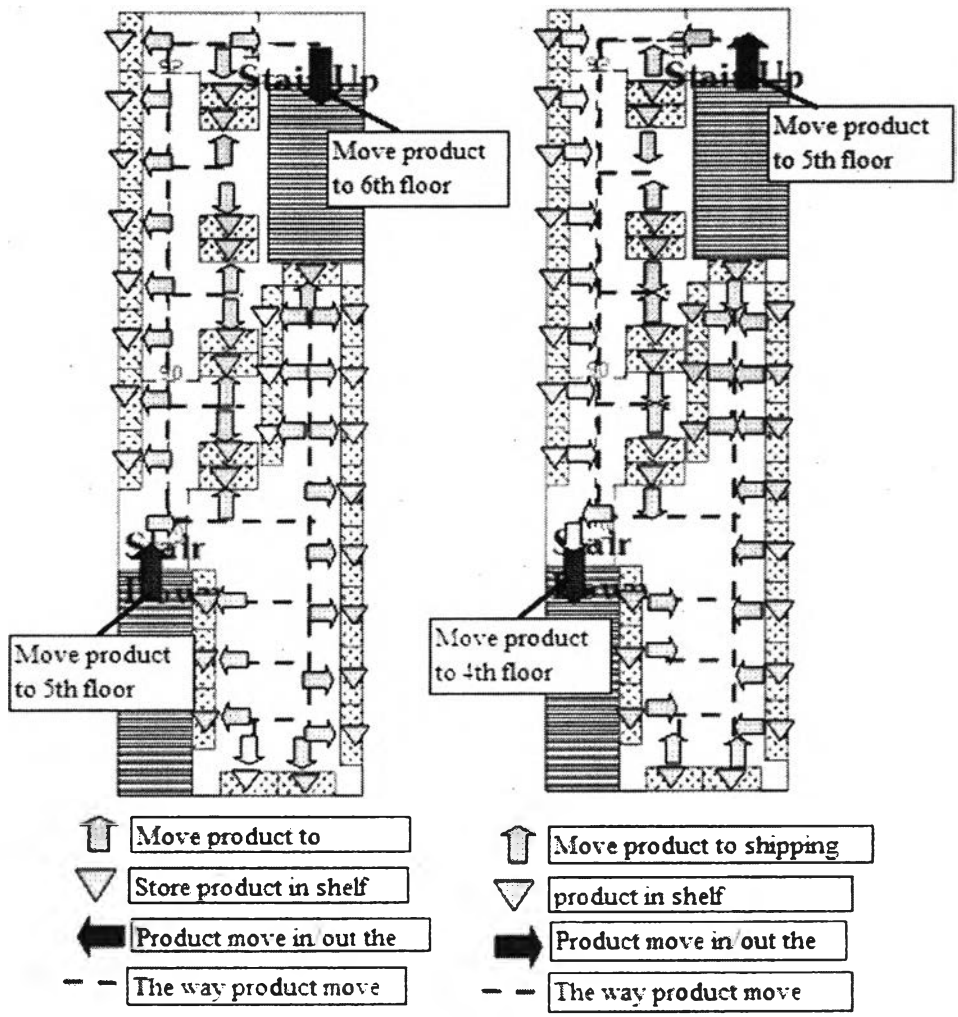
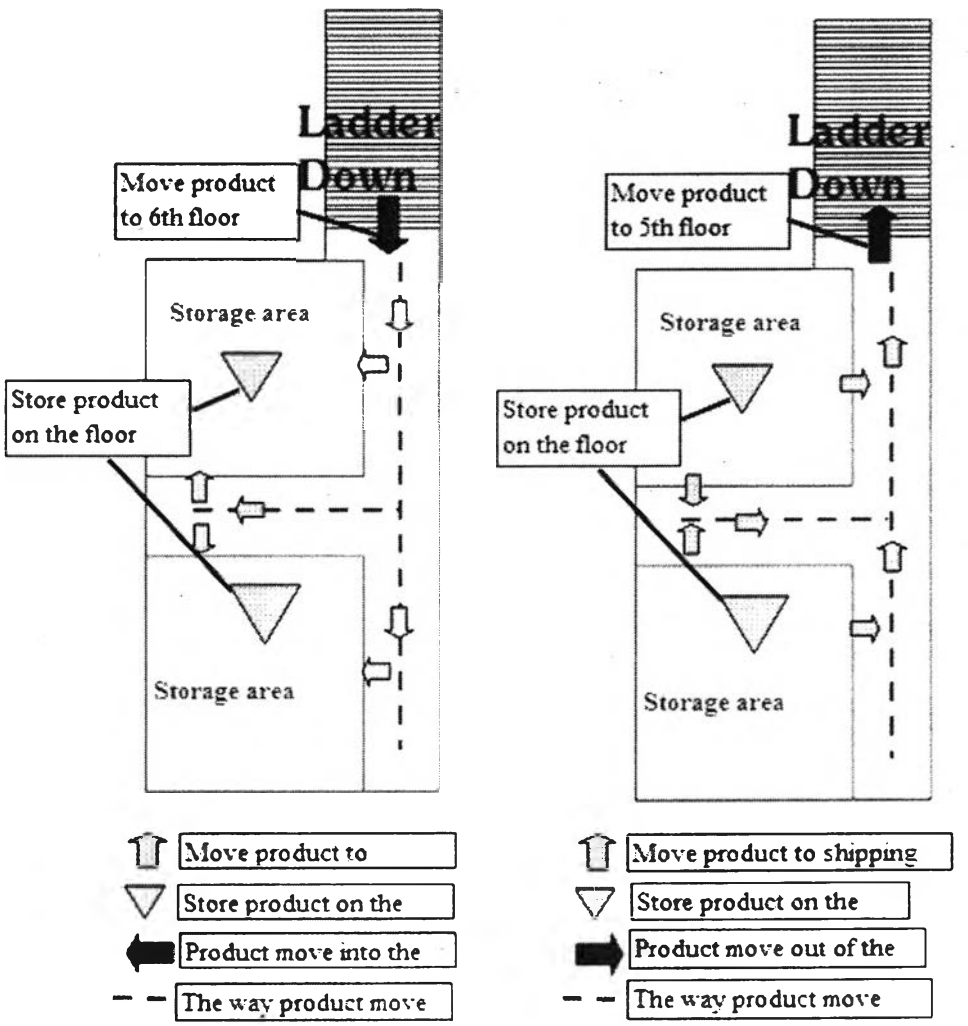


Figure 4.73- Product flow diagram of the 5th floor of the building no.1

a. Flow diagram of moving product to storage location process in the 5th floor of the building no.1

b. Flow diagram of moving product to shipping area process in the 5th floor of the building no.1



(a) **(b)**

Figure 4.74- Product flow diagram of the 6th floor of the building no.1

a. Flow diagram of moving product to storage location process in the 6th floor of the building no.1

b. Flow diagram of moving product to shipping area process in the 6th floor of the building no.1

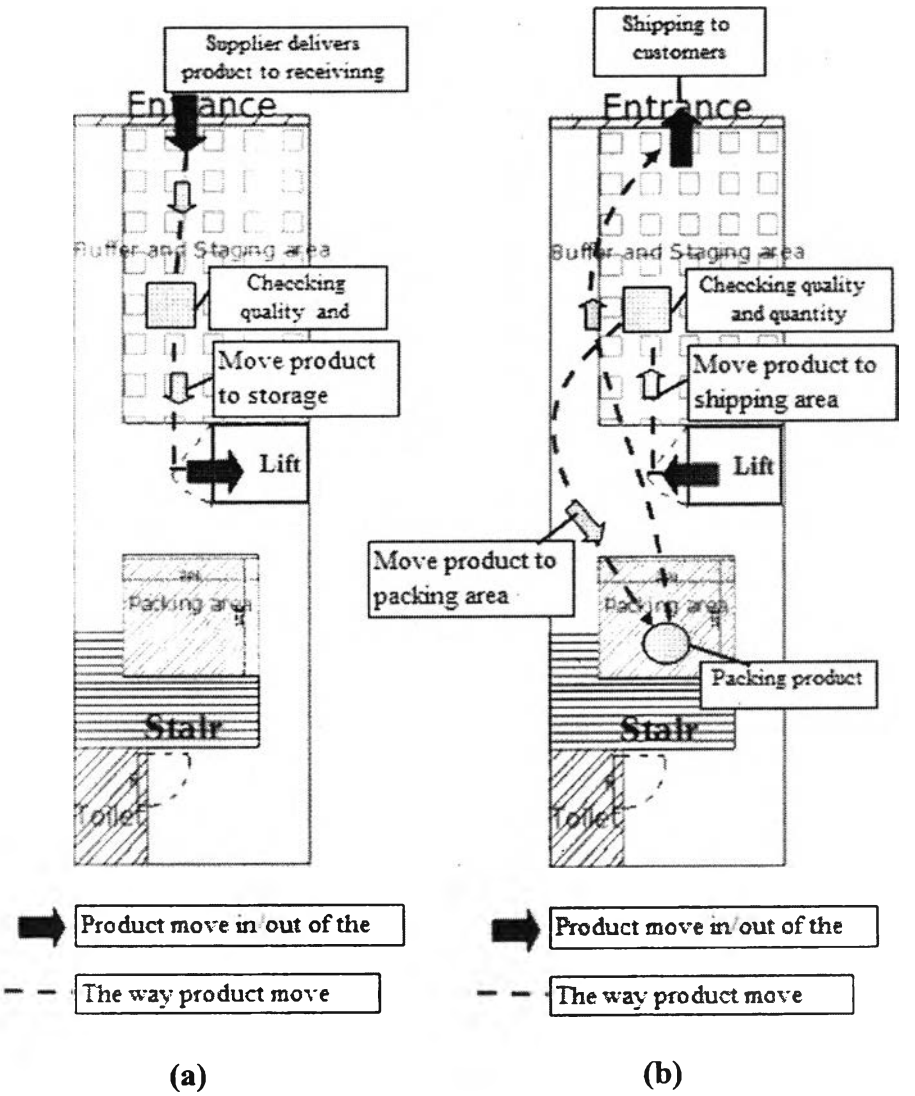


Figure 4.75- Product flow diagram of the 1st floor of the building no.2

a. Flow diagram of moving product to storage location process in the 1st floor of the building no.2

b. Flow diagram of moving product to shipping area process in the 1st floor of the building no.2

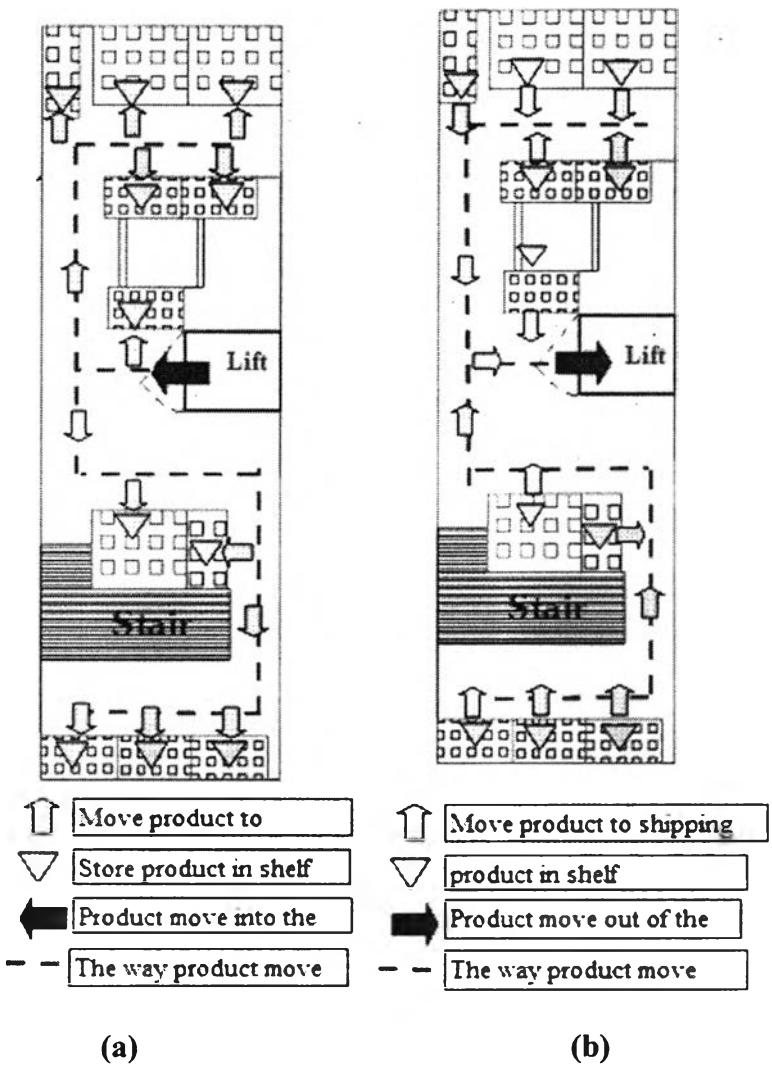


Figure 4.76- Product flow diagram of the floated floor of the building no.2

a. Flow diagram of moving product to storage location process in the floated floor of the building no.2

b. Flow diagram of moving product to shipping area process in the floated floor of the building no.2

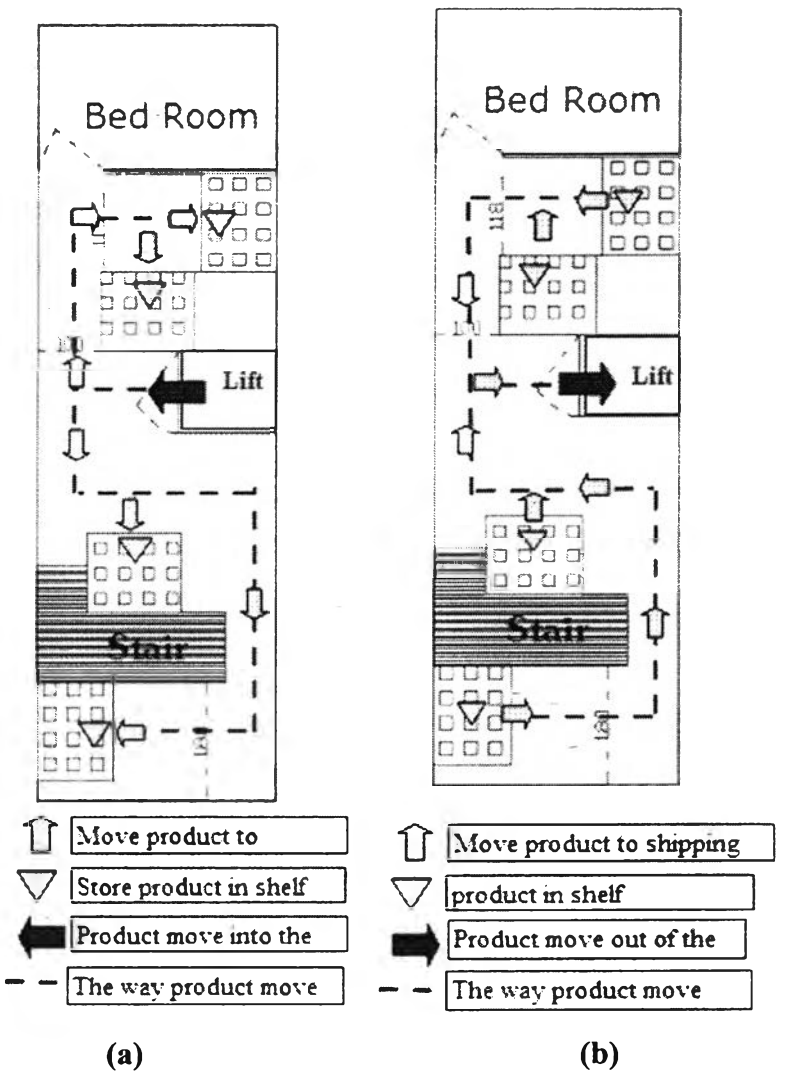


Figure 4.77- Product flow diagram of the 2nd floor of the building no.2

a. Flow diagram of moving product to storage location process in the 2nd floor of the building no.2

b. Flow diagram of moving product to shipping area process in the 2nd floor of the building no.2

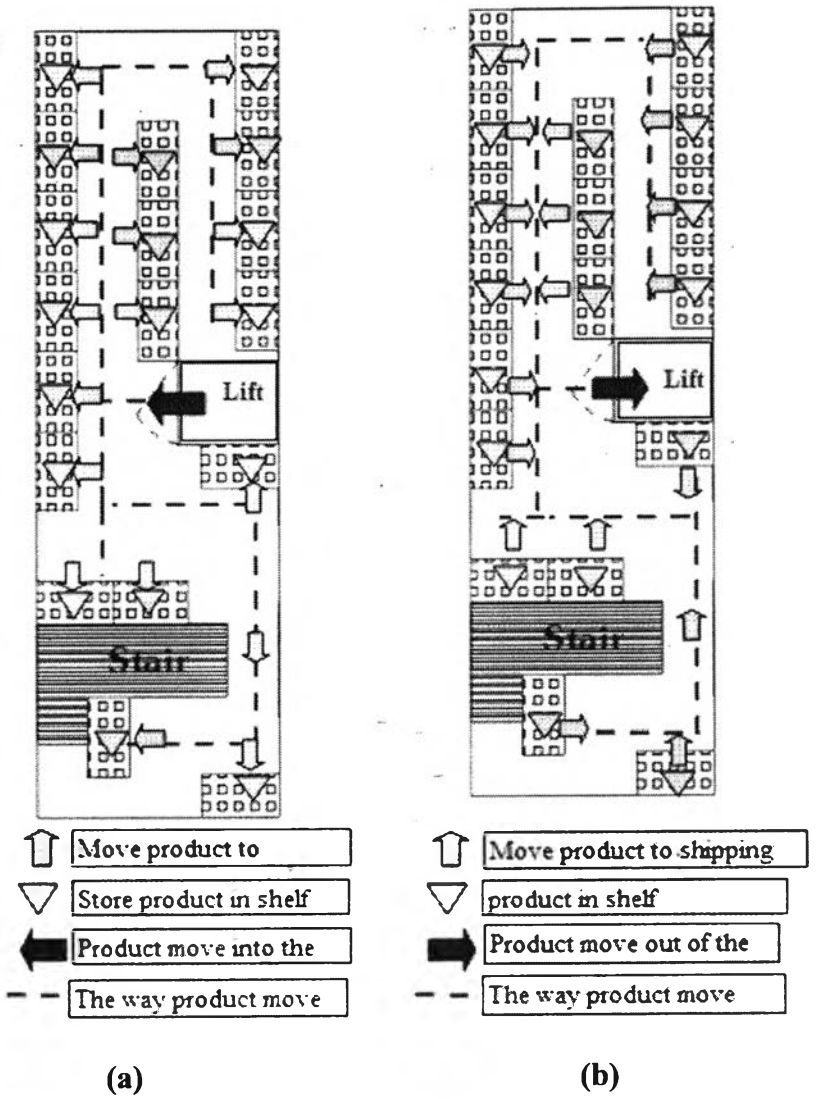
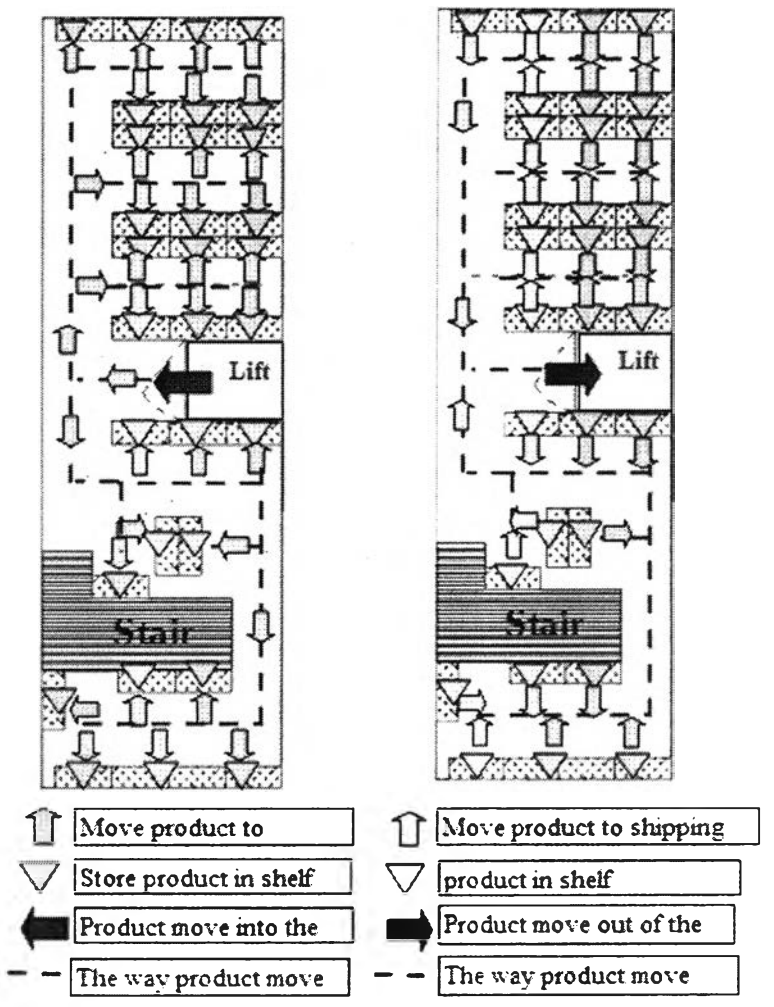


Figure 4.78- Product flow diagram of the 3rd floor of the building no.2

a. Flow diagram of moving product to storage location process in the 3rd floor of the building no.2

b. Flow diagram of moving product to shipping area process in the 3rd floor of the building no.2



(a) **(b)**

Figure 4.79- Product flow diagram of the 4th floor of the building no.2

a. Flow diagram of moving product to storage location process in the 4th floor of the building no.2

b. Flow diagram of moving product to shipping area process in the 4th floor of the building no.2

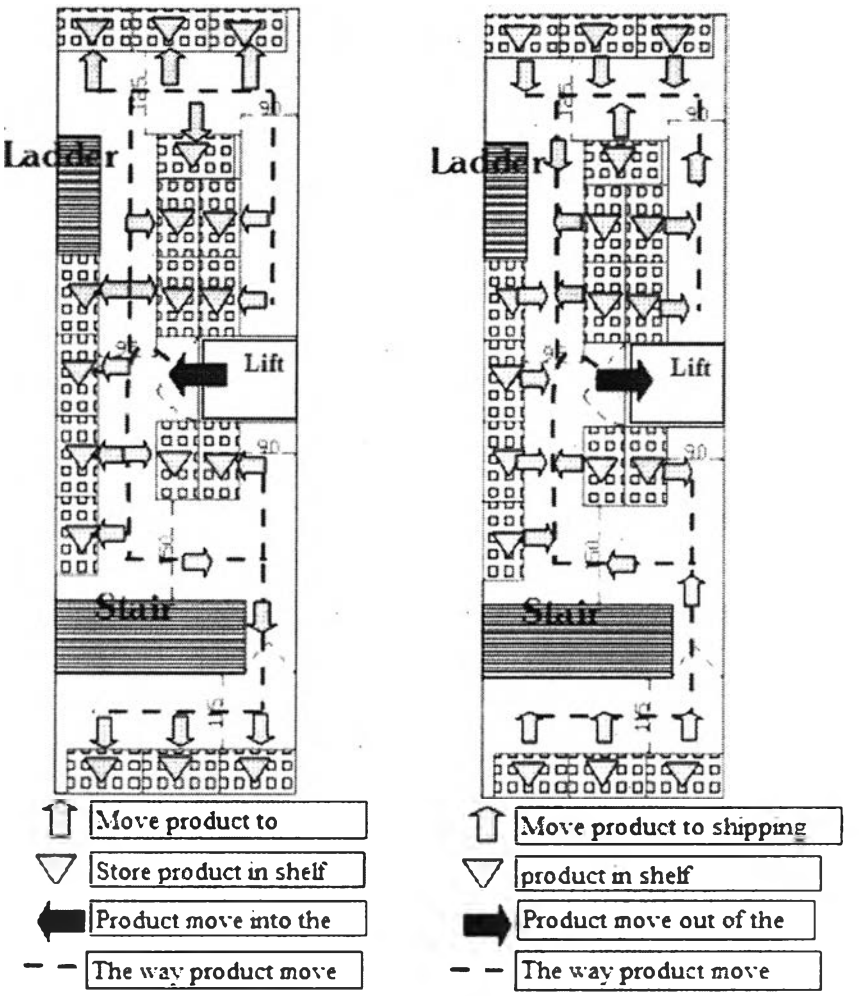


Figure 4.80- Product flow diagram of the 5th floor of the building no.2

c. Flow diagram of moving product to storage location process in the 5th floor of the building no.2

d. Flow diagram of moving product to shipping area process in the 5th floor of the building no.2

4.2.4 Assigned the storage location for each particular item in each group.

After assigned the storage location for groups of items has been done, the guideline process to locate storage location for each particular item in each group must be employed to locate specific storage location for particular item. One storage

location can store more than 1 item and 1 item can be stored in many storage locations.

4.2.4.1 Assign the fixed storage location for each item in special group

The special item groups are assigned to be stored at floated floor and second floor of building no.2 already but each particular item has not been assigned to its fixed storage location yet. In the combination stock locator system, the special items must have fixed storage location that is fit with their maximum required storage cubic space.

Therefore, the guiding steps to where each item should be physically from 4.2.2 determine Item placement system must be employed to locate the fixed storage location for each particular item in special groups.

From the 4.2.2, the guide line process to determine fixed storage location for each special item can be illustrated in below figure.

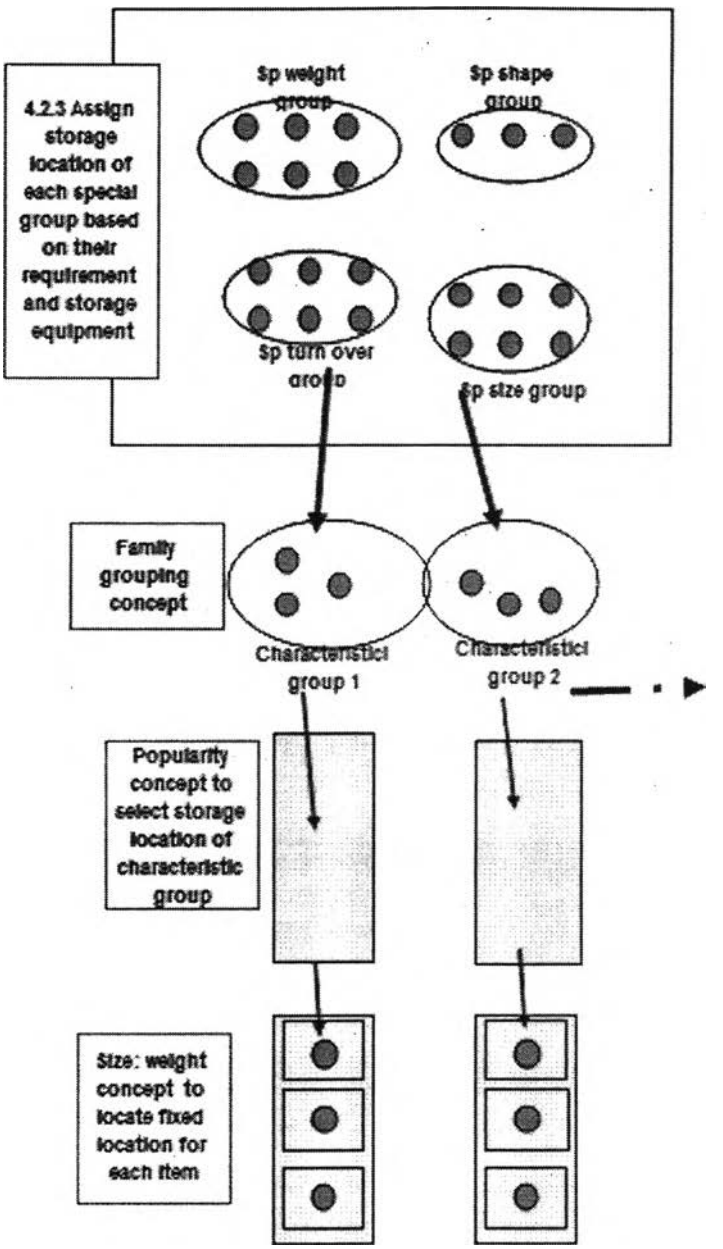


Fig.4.81-The guide line process to determine fixed storage location for each special item

Then, employ this guide line process into every group of special items is the final procedure to locate the fixed storage location for each special item.

(A)Assign the fixed storage location for high-turn over items: There are 14 items in special high-turn over item group and this group is assigned to store in the floated floor of building no.2. The information of each item in this group is shown in below table.

(1)English Name	(2)Group of item	Factor 1 (3)Category of item	Factor 2 (4)Turn-over rate / month (quantity of moving items in 1 month)	Factor 3 (5)Weigh t	Required Storage space cubic space(cm3)
Knife. Kiwi 501	Sp - Turn over	Cooking	150.0	0.4	25380
Knife. Kiwi 502	Sp - Turn over	Cooking	150 0	0 4	25380
Padlock: gold. short 38mm	Sp - Turn over	Household	480.0	1.0	36855
Padlock: brass. short 32mm	Sp - Turn over	Household	342.9	0 6	24960
Padlock. Solo 25mm. pack	Sp - Turn over	Household	200.0	0.3	16500
Padlock. Wolf 20mm	Sp - Turn over	Household	150.0	0 4	13500
Padlock. black. long 38mm	Sp - Turn over	Household	128.6	1 0	21060
Padlock: black. short 38 mm	Sp - Turn over	Household	120.0	1 0	23400
Padlock: brass. long 38mm	Sp - Turn over	Household	60.0	1.0	10091 25
Padlock. Wolf 40mm	Sp - Turn over	Household	42.9	0 8	2900.625
Padlock. gold. long 50mm	Sp - Turn over	Household	42 9	1 7	7488
Padlock. black. long 50mm	Sp - Turn over	Household	30.0	2.2	5200
Clothes hanger. 5 rings	Sp - Turn over	Plastic	600 0	4 9	1136520
Clothes hanger. 3 rings	Sp - Turn over	Plastic	600.0	8.0	1335840

Table 4.2- Name and information of each item in high turn-over item

From 4.2.3.1, the storage locations that are assigned to store this group are the top storage location of "the model B shelf" no. 1-7. The table of storage location information for the special high turn-over item group is shown below this.

Storage location					Factor 1	Factor 2	Factor 3	Constraint
(1)Buil ding	(2)Floor	(3)Model Type	(4)Numb er	(5)Layer	(6)Storage group	(7)Location of storage equipmen	(8)Suit Item's weight	(9)Cubic space (cm3)
2	1 5	Shelf B	1	3	High Turn-over	N	L	570 000
2	1 5	Shelf B	2	3	High Turn-over	N	L	570 000
2	1 5	Shelf B	3	3	High Turn-over	M	L	570 000
2	1 5	Shelf B	4	3	High Turn-over	M	L	570 000
2	1 5	Shelf B	5	3	High Turn-over	M	L	570 000
2	1 5	Shelf B	6	3	High Turn-over	F	L	570 000
2	1 5	Shelf B	7	3	High Turn-over	F	L	570 000

F	Far from point of use(above 7 meter)	L	Suit for low weight item(0-5 kg)
M	Middle far from point of use(3-7 meter)		
N	Near from point of use(0-3 meter)		

Table 4.3- The storage location of high turn-over item group and specification to assign items to store in it.

The first to fifth column in table 4.2 is the location of storage location. The first column is the building location of storage location and the second column is the floor location of storage location. The third column is the model type of storage equipments and the fourth column, the number of storage equipment and the fifth column is the layer of storage equipment which is the location of storage location.

The sixth to eight column in table 4.2 is the condition factor for the items that are assigned to store in storage location. The sixth column is the special storage group that is assigned for this location; the 7th column is the distance of storage location from the point of use and the 8th column is the suit weight that should be stored on the storage location. The 9th column is the cubic storage space of storage location.

From the guide line process 4.2.2, the first step is to family group items by their characteristics and group characteristics are based on item's category. As it's mentioned in chapter 3, there are 10 categories and these categories are different in the term characteristic. According to the table C.1 of the appendix C, the item in high turn-over items group can be group based on category into 3 groups. The first group is cooking item, the second group is household item and the last group is plastic group.

The second step is to use popularity concept to locate the storage location of each "like characteristics" group. Then the average turn-over of each group must be calculated and it is used to determine the storage location of each "like characteristics" group.

The average turn-over of the cooking item group is 150 boxes per month; of the household item group is 159.7 boxes per month and the plastic item group is 600 boxes per month. Therefore, the plastic item group should be located nearest the point of use and it is followed by the household items group and plastic item group consequently.

The third step is to use the size concept to locate the storage location of each item in the each like characteristics group. This concept will lead to if items are stored in shelves, the heavy items should be stored in a low level and the lightweight should be stored in a high level. Then the items in like characteristics group must stand in a row by the weight of each item from the lightest to the heaviest of each like characteristics group. But for this group, all the storage location is on the same layer of storage equipments so weight of each item does not affect the determination of storage location for each particular item.

Therefore, the sequence of like characteristics group by turn-over and the sequence of item in each group by their weight are shown in below table.

English Name	Category of item	Turn over G.	sequence of Weight	Group of item	Turn-over rate (quantity of moving items in 1 month)	Weight	Required Storage space cubic space(cm3)
Knife: Kiwi 501	Cooking	1	1	Sp - Turn over	150.0	0.4	25380
Knife: Kiwi 502	Cooking	1	2	Sp - Turn over	150.0	0.4	25380
				Avg. of category	**150.0**		
Padlock: gold, short 38mm	Household	2	8	Sp - Turn over	480.0	1.0	36855
Padlock: brass, short 32mm	Household	2	3	Sp - Turn over	342.9	0.8	24960
Padlock: Solo 25mm, pack	Household	2	1	Sp - Turn over	200.0	0.3	16500
Padlock: Wolf 20mm	Household	2	2	Sp - Turn over	150.0	0.4	13500
Padlock: black, long 38mm	Household	2	7	Sp - Turn over	128.6	1.0	21060
Padlock: black, short 38 mm	Household	2	6	Sp - Turn over	120.0	1.0	23400
Padlock: brass, long 38mm	Household	2	5	Sp - Turn over	60.0	1.0	10091.25
Padlock: Wolf 40mm	Household	2	4	Sp - Turn over	42.9	0.8	2900.625
Padlock: gold, long 50mm	Household	2	9	Sp - Turn over	42.9	1.7	7488
Padlock: black, long 50mm	Household	2	10	Sp - Turn over	30.0	2.2	5200
				Avg. of category	**159.7**		
Clothes hanger: 5 rings	Plastic	3	1	Sp - Turn over	600.0	4.9	1136520
Clothes hanger: 3 rings	Plastic	3	2	Sp - Turn over	600.0	8.0	1335840
				Avg. of category	**600.0**		

Table 4.4-The sequence of like characteristics group by turn-over and the sequence of item in each group by their weight

The table 4.4 shows the factors of each item that lead them into their suit fixed storage location. When the table 4.4 and 4.3 are linked, the item placement follows the step in 4.2.2. As a result, the fixed storage location of each item in this group is shown in the table 4.5.

English Name	Storage location				
	Building	Floor	Model Type	Number	Layer
Knife: Kiwi 501	2	1.5	Shelf B	7	3
Knife: Kiwi 502	2	1.5	Shelf B	7	3
Padlock: gold, short 38mm	2	1.5	Shelf B	6	3
Padlock: brass, short 32mm	2	1.5	Shelf B	6	3
Padlock: Solo 25mm, pack	2	1.5	Shelf B	6	3
Padlock: Wolf 20mm	2	1.5	Shelf B	6	3
Padlock: black, long 38mm	2	1.5	Shelf B	6	3
Padlock: black, short 38 mm	2	1.5	Shelf B	6	3
Padlock: brass, long 38mm	2	1.5	Shelf B	6	3
Padlock: Wolf 40mm	2	1.5	Shelf B	6	3
Padlock: gold, long 50mm	2	1.5	Shelf B	6	3
Padlock: black, long 50mm	2	1.5	Shelf B	6	3
Clothes hanger: 5 rings	2	1.5	Shelf B	1	3
Clothes hanger: 5 rings(2nd location)	2	1.5	Shelf B	2	3
Clothes hanger: 3 rings	2	1.5	Shelf B	3	3
Clothes hanger: 3 rings(2nd location)	2	1.5	Shelf B	4	3
Clothes hanger: 3 rings(3rd location)	2	1.5	Shelf B	5	3

Table 4.5-The fixed storage location of item in high turn-over group

(B) Assign the fixed storage location for high weight items: There are 22 items in special high weight item group and this group is assigned to store in the floated floor of building no.2. The information of each item in this group is shown in below table.

(1)English Name	(2)Group of item	(3)Category of item	(4)Turn-over rate(quantity of moving items in 1 month)	(5)Weight	(6)Required cubic space(cm3)
Mentholated ointment	Sp - Weight 30 up	Chemical product	4.0	35.0	138966
Clothes for floor cleaning(Mob)	Sp - Weight 30 up	Fabric	7.5	36.0	300000
Bottle opener: 200	Sp - Weight 30 up	Household	1.3	35.0	180000
Bottle opener: 900	Sp - Weight 30 up	Household	1.3	35.0	180000
Wine opener: 800	Sp - Weight 30 up	Household	1.0	45.0	950400
Nail cutter: 211	Sp - Weight 30 up	Household	3.3	30.0	95220
Nail cutter: 602	Sp - Weight 30 up	Household	3.3	30.0	85425
Pingpong ball: white	Sp - Weight 30 up	Miscellanous	1.2	48.0	235161
Pingpong ball: orande	Sp - Weight 30 up	Miscellanous	2.4	48.0	235161
Whetstone	Sp - Weight 30 up	Miscellanous	6.7	31.0	211990
Book: tearable papert. without line.Small	Sp - Weight 30 up	Office	2.4	35.0	101840
Book. tearable papert. Small	Sp - Weight 30 up	Office	3.0	35.0	101840
Nail polisher Small size	Sp - Weight 30 up	Personal care	2.0	30.0	83824
Olive oil Small size	Sp - Weight 30 up	Personal care	3.0	30.0	83824
Razor Blade: Feather	Sp - Weight 30 up	Personal care	2.0	30.0	110745
Clipping Blade: Sakura	Sp - Weight 30 up	Personal care	2.0	30.0	36036
Clipping Blade: Dragonfly	Sp - Weight 30 up	Personal care	5.0	30.0	99000
Short Clipping Blade: Dragonfly	Sp - Weight 30 up	Personal care	10.0	30.0	224532
Nail polisher: Square bottle	Sp - Weight 30 up	Personal care	12.0	34.0	733623
Spoon: short. Zebra	Sp - Weight 30 up	Plastic	20.0	32.0	395480.25

Table 4.6-Name and information of each item in high weight item group

From 4.2.3.1, the storage locations that are assigned to store this group are the low and medium storage locations of "the model B shelf" no. 1-7. The table of storage location information for the special high weight item group is shown in table 4.7 below this.

The first to fifth column in table 4.7 is the location of storage location. The first column is the building location of storage location and the second column is the floor location of storage location. The third column is the model type of storage equipments and the fourth column, the number of storage equipment and the fifth column is the layer of storage equipment which is the location of storage location.

The sixth to eight column in table 4.7 is the condition factor for the items that are assigned to store in storage location. The sixth column is the special storage group that is assigned for this location; the 7^{th} column is the distance of storage location from the point of use and the 8^{th} column is the suit weight that should be stored on the storage location. The 9^{th} column is the cubic storage space of storage location.

Storage location					Factor 1	Factor 2	Factor 3	Constraint
(1)Building	(2)Floor	(3)Model Type	(4)Number	(5)Layer	(6)Storage group	(7)Location of storage equipmen	(8)Suit Item's weight	(9)Cubic space (cm3)
2	1.5	Shelf B	1	1	High weight	N	H	570,000
2	1.5	Shelf B	1	2	High weight	N	M	570,000
2	1.5	Shelf B	2	1	High weight	N	H	570,000
2	1.5	Shelf B	2	2	High weight	N	M	570,000
2	1.5	Shelf B	3	1	High weight	F	H	570,000
2	1.5	Shelf B	3	2	High weight	F	M	570,000
2	1.5	Shelf B	4	1	High weight	F	H	570,000
2	1.5	Shelf B	4	2	High weight	F	M	570,000
2	1.5	Shelf B	5	1	High weight	F	H	570,000
2	1.5	Shelf B	5	2	High weight	F	M	570,000
2	1.5	Shelf B	6	1	High weight	M	H	570,000
2	1.5	Shelf B	6	2	High weight	M	M	570,000
2	1.5	Shelf B	7	1	High weight	M	H	570,000
2	1.5	Shelf B	7	2	High weight	M	M	570,000

F Far from point of use(above 7 meter)
M Middle far from point of use(3-7 meter)
N Near from point of use(0-3 meter)

M Suit for high weight item(above 30 kg)
H Suit for very high weight item(above 40 kg)

Table 4.7- The storage location of high turn-over item group and specification to assign items to store in it.

From the guide line process 4.2.2, the first step is to family group items by their characteristics and group characteristics are based on item's category. As it mention in chapter 3, there are 10 categories and these categories are different in the term characteristic. According to the table C.1 of the appendix C, the item in high weight items group can be group based on category into 7 groups. These seven groups are chemical item, fabric item, household item, plastic item, office item, personal care and miscellaneous group.

The second step is to use popularity concept to locate the storage location of each "like characteristics" group. Then the average turn-over of each group must be calculated and it is used to determine the storage location of each "like characteristics" group.

The average turn-over of the chemical item group is 4 boxes per month; of the household item group is 1.8 boxes per month; of the fabric item group is 7.5 boxes per month; of the office item group is 2.7 boxes per month; of the personal care item group is 6 boxes per month; of the miscellaneous item group is 3.4 boxes per month and the plastic item group is 20 boxes per month. Therefore, the

plastic item group should be located nearest the point of use and it is followed by the other group consequently from the average turn-over.

The third step is to use the size concept to locate the storage location of each item in the each like characteristics group. This concept leads to the action that heavy items should be stored in a low level and the lightweight should be stored in a high level. Then the items in like characteristics group must stand in a row by the weight of each item from the lightest to the heaviest of each like characteristics group.

Therefore, the sequence of like characteristics group by turn-over and the sequence of item in each group by their weight are shown in below table.

English Name	Category of item	Turn over G.	sequence of weight	Group of item	Turn-over rate (quantity of moving items in 1 month)	Weight	Required Storage space cubic space(cm3)
Mentholated ointment	Chemical product	4	1	Sp - Weight 30 up	4.0	35.0	138966
				Avg. of category	**4.0**		
Clothes for floor cleaning(Mob)	Fabric	6	1	Sp - Weight 30 up	7.5	36.0	300000
				Avg. of category	**7.5**		
Bottle opener: 200	Household	1	1	Sp - Weight 30 up	1.3	35.0	180000
Bottle opener: 900	Household	1	2	Sp - Weight 30 up	1.3	35.0	180000
Wine opener: 800	Household	1	3	Sp - Weight 30 up	1.0	45.0	950400
Nail cutter: 211	Household	1	4	Sp - Weight 30 up	3.3	30.0	95220
Nail cutter: 602	Household	1	5	Sp - Weight 30 up	3.3	30.0	85425
				Avg. of category	**2.1**		
Pingpong ball: white	Miscellaneous	3	1	Sp - Weight 30 up	1.2	48.0	235181
Pingpong ball: orande	Miscellanous	3	2	Sp - Weight 30 up	2.4	48.0	235181
Whetstone	Miscellanous	3	3	Sp - Weight 30 up	6.7	31.0	211990
				Avg. of category	**3.4**		
pok. tearable papert. without line,Sm	Office	2	1	Sp - Weight 30 up	2.4	35.0	101840
Book. tearable papert, Small	Office	2	2	Sp - Weight 30 up	3.0	35.0	101840
				Avg. of category	**2.7**		
Nail polisher: Small size	Personal care	5	1	Sp - Weight 30 up	2.0	30.0	83824
Olive oil: Small size	Personal care	5	2	Sp - Weight 30 up	3.0	30.0	83824
Razor Blade Feather	Personal care	5	3	Sp - Weight 30 up	2.0	30.0	110745
Clipping Blade Sakura	Personal care	5	4	Sp - Weight 30 up	2.0	30.0	36036
Clipping Blade: Dragonfly	Personal care	5	5	Sp - Weight 30 up	5.0	30.0	99000
Short Clipping Blade Dragonfly	Personal care	5	6	Sp - Weight 30 up	10.0	30.0	224532
Nail polisher: Square bottle	Personal care	5	7	Sp - Weight 30 up	12.0	34.0	733623
				Avg. of category	**5.1**		
Spoon short, Zebra	Plastic	7	1	Sp - Weight 30 up	20.0	32.0	395480.25
				Avg. of category	**20.0**		

Table 4.8-The sequence no. of like characteristics group by turn-over and the sequence no. of item in each group by their weight for each heavy weight item

The table 4.8 shows the factors of each item that lead them into their suit fixed storage location. Then, when the table 4.7 and 4.8 are linked, the item placement follows the step in 4.2.2. As a result, the fixed storage location of each item in this group is shown in the table 4.9.

English Name	Storage location				
	Building	Floor	Model Type	Number	Layer
Mentholated ointment	2	1.5	Shelf B	7	1
Clothes for floor cleaning(Mob)	2	1.5	Shelf B	1	1
Bottle opener: 200	2	1.5	Shelf B	5	1
Bottle opener: 900	2	1.5	Shelf B	5	1
Wine opener: 800	2	1.5	Shelf B	3	2
Wine opener: 800(2nd location)	2	1.5	Shelf B	4	2
Wine opener: 800(3rd location)	2	1.5	Shelf B	5	2
Nail cutter 211	2	1.5	Shelf B	4	1
Nail cutter 602	2	1.5	Shelf B	4	1
Pingpong ball: white	2	1.5	Shelf B	7	2
Pingpong ball: orande	2	1.5	Shelf B	7	2
Whetstone	2	1.5	Shelf B	6	2
Book: tearable papert, without line,Small	2	1.5	Shelf B	3	1
Book: tearable papert, Small	2	1.5	Shelf B	3	1
Nail polisher: Small size	2	1.5	Shelf B	7	1
Olive oil: Small size	2	1.5	Shelf B	7	1
Razor Blade: Feather	2	1.5	Shelf B	6	2
Clipping Blade: Sakura	2	1.5	Shelf B	6	1
Clipping Blade: Dragonfly	2	1.5	Shelf B	6	1
Short Clipping Blade: Dragonfly	2	1.5	Shelf B	6	1
Nail polisher: Square bottle	2	1.5	Shelf B	2	1
Nail polisher: Square bottle(2nd location)	2	1.5	Shelf B	2	2
Spoon: short, Zebra	2	1.5	Shelf B	1	2

Table 4.9-The fixed storage location of item in heavy weight item group

(C) Assign the fixed storage location for Special size items: There are 18 items in special size item group and this group is assigned to store in the floated floor and the second floor of building no.2. The information of each item in this group is shown in below table.

(1)English Name	(2)Group of item	(3)Category of item	(4)Turn-over rate(quantity of moving items in 1 month)	(5)Weight	(6)Required cubic space(cm3)
Cleaning sponge: Tree, M	Sp - size	Household	7.5	2.7	989604
Floor cleaning sponge: Rose	Sp - size	Household	15.0	2.9	1132200
Cleaning sponge: Hama, L	Sp - size	Household	3.6	3.1	583200
Cleaning sponge with scrubber: Modern	Sp - size	Household	30.0	5.5	1005480
Scrubber: Bigsize 1mx2m	Sp - size	Household	6.0	10.0	630000
Floor cleaning sponge: Tree	Sp - size	Household	20.0	20.0	1132200
One baht cotton wool	Sp - size	Personal care	4.0	7.0	1680000
Ten baht cotton wool	Sp - size	Personal care	5.0	8.0	810000
27 baht cotton wool	Sp - size	Personal care	10.0	12.0	466240
Shower sponge with Shower Cream	Sp - size	Personal care	4.0	12.0	2640000
Cone No4	Sp - size	Plastic	6.0	2.0	276000
Cone No5	Sp - size	Plastic	5.0	3.0	181440
Bath roon cleaning brush: Sack	Sp - size	Plastic	6.0	5.0	270000
Water canteen:n-s	Sp - size	Plastic	6.0	5.3	387000
Broom: water Samor	Sp - size	Plastic	12.0	12.0	331500
Water sprayer: Bone shape, Murky	Sp - size	Plastic	5.0	12.0	828000
Water sprayer: Bone shape, transparency	Sp - size	Plastic	7.5	12.0	993600
Chair: M, Big	Sp - size	Plastic	3.0	22.0	500580

Table 4.10-Name and information of each item in special size item

From 4.2.3.1, the storage locations that are assigned to store this group are the storage locations in "the model C shelf" no. 1-7. The table of storage location information for the special high weight item group is shown in table 4.11 below this.

Storage location					Factor 1	Factor 2	Factor 3	Constraint
(1)Building	(2)Floor	(3)Model Type	(4)Number	(5)Layer	(6)Storage group	(7)Location of storage equipmen	(8)Suit Item's weight	(9)Cubic space (cm3)
2	1.5	Shelf C	1	1	SP size	N	H	1,500,000
2	1.5	Shelf C	1	2	SP size	N	L	1,500,000
2	1.5	Shelf C	2	1	SP size	F	H	1,500,000
2	1.5	Shelf C	2	2	SP size	F	L	1,500,000
2	1.5	Shelf C	3	1	SP size	F	H	1,500,000
2	1.5	Shelf C	3	2	SP size	F	L	1,500,000
2	2	Shelf C	4	1	SP size	N	H	1,500,000
2	2	Shelf C	4	2	SP size	N	L	1,500,000
2	2	Shelf C	5	1	SP size	N	H	1,500,000
2	2	Shelf C	5	2	SP size	N	L	1,500,000
2	2	Shelf C	6	1	SP size	M	H	1,500,000
2	2	Shelf C	6	2	SP size	M	L	1,500,000
2	2	Shelf C	7	1	SP size	F	H	1,500,000
2	2	Shelf C	7	2	SP size	F	L	1,500,000

F Far from point of use(above 7 meter)
M Middle far from point of use(3-7 meter)
N Near from point of use(0-3 meter)
L Suit for low weight item(below 15 kg)
H Suit for very high weight item(15-30 kg)

Table 4.11- The storage location of special size item group and specification to assign items to store in it.

The first to fifth column in table 4.11 is the location of storage location. The first column is the building location of storage location and the second column is the floor location of storage location. The third column is the model type of storage equipments and the fourth column, the number of storage equipment and the fifth column is the layer of storage equipment which is the location of storage location.

The sixth to eight column in table 4.11 is the condition factor for the items that are assigned to store in storage location. The sixth column is the special storage group that is assigned for this location; the 7^{th} column is the distance of storage location from the point of use and the 8^{th} column is the suit weight that should be stored on the storage location. The 9^{th} column is the cubic storage space of storage location.

From the guide line process 4.2.2, the first step is to family group items by their characteristics and group characteristics are based on item's category.

As it mention in chapter 3, there are 10 categories and these categories are different in the term characteristic. According to the table C.1 of the appendix C, the item in high special size items group can be group based on category into 3 groups. These three groups are household item, plastic item and personal care group.

The second step is to use popularity concept to locate the storage location of each "like characteristics" group. Then the average turn-over of each group must be calculated and it is used to determine the storage location of each "like characteristics" group.

The average turn-over of the household item group is 13.7 boxes per month; of the personal care item group is 5.8 boxes per month and the plastic item group is 6.3 boxes per month. Therefore, the household item group should be located nearest the point of use and it is followed by the other group consequently from the average turn-over.

The third step is to use the size concept to locate the storage location of each item in the each like characteristics group. This concept leads to the action that heavy items should be stored in a low level and the lightweight should be stored in a high level. Then the items in like characteristics group must stand in a row by the weight of each item from the lightest to the heaviest of each like characteristics group.

Therefore, the sequence of like characteristics group by turn-over and the sequence of item in each group by their weight are shown in below table.

English Name	Category of item	Turn over G.	Sequence of Weight	Group of item	Turn-over rate (quantity of moving items in 1 month)	Weight	Required Storage space cubic space(cm3)
Cleaning sponge: Tree. M	Household	3	1	Sp - size	7.5	2.7	989604
Floor cleaning sponge. Rose	Household	3	2	Sp - size	15.0	2.9	1132200
Cleaning sponge: Hama. L	Household	3	3	Sp - size	3.6	3.1	583200
Cleaning sponge with scrubber. Modern	Household	3	4	Sp - size	30.0	5.5	1005480
Scrubber: Biosize 1mx2m	Household	3	5	Sp - size	6.0	10.0	630000
Floor cleaning sponge: Tree	Household	3	6	Sp - size	20.0	20.0	1132200
				Avg. of category	**13.7**		
One baht cotton wool	Personal care	2	1	Sp - size	4.0	7.0	1680000
Ten baht cotton wool	Personal care	2	2	Sp - size	5.0	8.0	810000
27 baht cotton wool	Personal care	2	3	Sp - size	10.0	12.0	466240
Shower sponge with Shower Cream	Personal care	2	4	Sp - size	4.0	12.0	2640000
				Avg. of category	**5.8**		
Cone No4	Plastic	1	1	Sp - size	6.0	2.0	276000
Cone No5	Plastic	1	2	Sp - size	5.0	3.0	181440
Bath room cleaning brush: Sack	Plastic	1	3	Sp - size	6.0	5.0	270000
Water canteen:n-s	Plastic	1	4	Sp - size	6.0	5.3	387000
Broom: water Samor	Plastic	1	5	Sp - size	12.0	12.0	331500
Water sprayer: Bone shape. Murky	Plastic	1	6	Sp - size	5.0	12.0	826000
Water sprayer: Bone shape. transparency	Plastic	1	7	Sp - size	7.5	12.0	993600
Chair: M. Big	Plastic	1	8	Sp - size	3.0	22.0	500580
				Avg. of category	**6.3**		

Table 4.12-The sequence no. of like characteristics group by turn-over and the sequence no. of item in each group by their weight for each special size item

The table 4.12 shows the factors of each item that lead them into their suit fixed storage location. Then, when the table 4.11 and 4.12 are linked, the item placement follows the step in 4.2.2. As a result, the fixed storage location of each item in this group is shown in the table 4.13.

English Name	Storage location				
	Building	Floor	Model Type	Number	Layer
Cleaning sponge Tree. M	2	2	Shelf C	6	2
Floor cleaning sponge: Rose	2	1.5	Shelf C	1	2
Cleaning sponge: Hama, L	2	2	Shelf C	5	2
Cleaning sponge with scrubber: Modern	2	2	Shelf C	7	2
Scrubber: Bigsize 1mx2m	2	2	Shelf C	5	1
Floor cleaning sponge: Tree	2	1.5	Shelf C	1	1
One baht cotton wool	2	2	Shelf C	4	1
One baht cotton wool(2nd location)	2	2	Shelf C	4	2
Ten baht cotton wool	2	2	Shelf C	6	1
27 baht cotton wool	2	2	Shelf C	5	2
Shower sponge with Shower Cream	2	2	Shelf C	6	2
Cone No4	2	1.5	Shelf C	2	2
Cone No5	2	1.5	Shelf C	2	2
Bath room cleaning brush: Sack	2	1.5	Shelf C	3	2
Water canteen:n-s	2	1.5	Shelf C	2	1
Broom: water Samor	2	2	Shelf C	7	1
Water sprayer: Bone shape, Murky	2	2	Shelf C	7	1
Water sprayer: Bone shape, transparency	2	1.5	Shelf C	3	1
Chair: M, Big	2	1.5	Shelf C	2	1

Table 4.13-The fixed storage location of item in special size item group

(D) Assign the fixed storage location for Odd shape items: There are 2 items in shaft shape item group and this group is assigned to store in the floated floor of building no.2. The information of each item in this group is shown in below table.

(1)English Name	(2)Group of item	(3)Category of item	(4)Turn-over rate(quantity of moving items in 1 month)	(5)Weight	(6)Required cubic space(cm3)
Mop with round fabric	Sp- Shaft shape	Household	12.0	8.5	201600
Aluminium Mop	Sp- Shaft shape	Household	24.0	4.0	366080

Table 4.14-Name and information of each item in special size item group

From 4.2.3.1, the storage locations that are assigned to store this group are the storage locations in "the rack" no. 1. The table of storage location information for the special high weight item group is shown in table 4.15 below this.

Storage location					Factor 1	Factor 2	Factor 3	Constraint
(1)Building	(2)Floor	(3)Model Type	(4)Number	(5)Layer	(6)Storage group	(7)Location of storage equipmen	(8)Suit Item's weight	(9)Cubic space (cm3)
2	1.5	Rack A	1	1	Odd shape	-	H	224,000
2	1.5	Rack A	1	2	Odd shape	-	H	224,000
2	1.5	Rack A	1	3	Odd shape	-	M	224,000
2	1.5	Rack A	1	4	Odd shape	-	L	224,000
2	1.5	Rack A	1	5	Odd shape	-	L	224,000

L Suit for low weight item(below 5 kg)
H Suit for very high weight item(above 5 kg)

Table 4.15- The storage location of special shape item group and specification to assign items to store in it.

The first to fifth column in table 4.15 is the location of storage location. The first column is the building location of storage location and the second column is the floor location of storage location. The third column is the model type of storage equipments and the fourth column, the number of storage equipment and the fifth column is the layer of storage equipment which is the location of storage location.

The sixth to eight column in table 4.15 is the condition factor for the items that are assigned to store in storage location. The sixth column is the special storage group that is assigned for this location; the 7^{th} column is the distance of storage location from the point of use and the 8^{th} column is the suit weight that should be stored on the storage location. The 9^{th} column is the cubic storage space of storage location.

From the guide line process 4.2.2, the first step is to family group items by their characteristics and group characteristics are based on item's category. As it mention in chapter 3, there are 10 categories and these categories are different in the term characteristic. According to the table C.1 of the appendix C, the item in high special size items group can be group based on category into 1 group only. This group is the household item group.

The second step is to use popularity concept to locate the storage location of each "like characteristics" group. Then the average turn-over of each group must be calculated and it is used to determine the storage location of each "like

characteristics" group. But there is only 1 group so this step is not required to operate in this group.

The third step is to use the size concept to locate the storage location of each item in the each like characteristics group. This concept leads to the action that heavy items should be stored in a low level and the lightweight should be stored in a high level. Then the items in like characteristics group must stand in a row by the weight of each item from the lightest to the heaviest of each like characteristics group.

Therefore, the items stand in a row by their weight shown in below table.

English Name	Category of item	Turn over G.	Sequence of Weight	Group of item	Turn-over rate (quantity of moving items in 1 month)	Weight	Required Storage space cubic space(cm3)
Mop with round fabric	Household	1	2	Sp- Shaft shape	12.0	8.5	201600
Aluminium Mop	Household	1	1	Sp- Shaft shape	24.0	4.0	366080

Table 4.16-The sequence no. of item in group by their weight for each special shape item

The table 4.16 shows the factors of each item that lead them into their suit fixed storage location. Then, when the table 4.15 and 4.16 are linked, the item placement follows the step in 4.2.2. As a result, the fixed storage location of each item in this group is shown in the table 4.17.

English Name	Storage location				
	Building	Floor	Model Type	Number	Layer
Mop with round fabric	2	1.5	Rack A	1	1
Mop with round fabric(2nd location)	2	1.5	Rack A	1	2
Aluminium Mop	2	1.5	Rack A	1	3
Aluminium Mop (2nd location)	2	1.5	Rack A	1	4
Aluminium Mop (3rd location)	2	1.5	Rack A	1	5

Table 4.17-The fixed storage location of item in special shape item group

(E)Determine the allocation system code for special items

Allocation system code is used to inform the operators where items should be located. Allocation system code for each special item must be established to guide operators to store products in their fixed storage location. Then, each item in special groups must have the *allocation system code* to guide operators to move products into its appropriate storage location.

All special items have the fixed storage location so the allocation system code of them just informs their specific fixed storage location of each item. One special item possibly has more than 1 specific storage location and one storage location may store more than 1 item also.

The item must be indicated their stock locator system firstly so the operator would realize the fixed location system or random location system which is fit for that item. Although all items in special group are located by fixed location system, the operators need indicator to remind them to be not confused it with normal items.

The code that used to indicate item's stock locator system is the letter "F" which means the fixed locator system. "F" represents the items have fixed storage location and it can be stored in those storage locations only.

The code that used to indicate item's storage building is the building no. and there are only 2 storage buildings. Then, digit is used to represent the no. of building. The storage building no.1 is represented by code "1" and the storage building no.2 is represented by code "1".

The code that used to indicate item's storage floor is the floor no. and there are 6 storage floors in building no.1 and 5 storage floors in building no.2. Then, digit is used to represent the no. of storage floor except the floated floor is represented by the "F" letter. Example of the code that of indicate item's storage floor is the digit "1" is represented first storage floor and other floors also are represented by the digit no. of the floor.

The code that used to indicate the item's storage equipment is the letter "R", "A", "C" and "B". "R" represents the meaning that the suit storage equipment of that item is "rack", "B" represents the meaning that the suit storage equipment of that item is "the model B shelf" and "C" represents the meaning that the suit storage equipment of that item is "the model C shelf"

The code that used to indicate the suit sequence number of storage equipment that is suit to store item, is the sequence number of the storage equipment which is assigned to store item. Then this code must consist of 2 digits.

The code that used to indicate the suit layer of its storage location in the storage equipment is the sequence number layer in the storage equipment from the

lowest layer to the top layer of the storage equipment then it means the digit "1" represents the storage location at the lowest layer of storage equipment.

As a result, these codes are combined together as the allocation system code. One item may have more than one allocation system code and some items may have the same allocation system code because one special item possibly has more than 1 specific storage location and one storage location may store more than 1 item also.

Type of storage locator system	Building No.	Storage floor	Type of storage equipment	storage equipment no.	Layer No. in storage equipment
F	1	F	R	01	1
	2	2	B	02	2
		3	C	03	3
		4		04	4
		5		05	5
		6		06	6
				07	

Table 4.18- The allocation system code determination of special items

The allocation system code of all special items is shown in table E.3 of the appendix E.

4.2.4.2 Assign the storage location for each item in normal group

The normal item groups are divided by their size into 2 groups and assigned to be stored at both building no.1 and no.2 already but each particular item has not been allocated to its storage location yet. In the combination stock locator system, the normal item is located by using random storage location system. It means no item in this group has fixed storage location and it can be stored in any available storage location. Because there is no fixed storage location for normal item, Allocation system code for each normal item must be established to guide operators to store products in their most suit storage location. Then, each item in both normal groups must have the allocation system code to guide operators to move products into its appropriate storage location.

There are 2 groups of normal items. The first class of normal items group has 339 items and there are 536 items in the second class of normal items group. Storage products in this warehouse are divided into 10 categories by grouping the same product's characteristic.

The guiding steps to where each item should be physically from 4.2.2 determine item placement system must be employed to guide the item into their suit storage location for each particular item in normal groups.

1. Employ Family grouping concept that based on "like characteristics" to group all item by their characteristics into each group of item. Storage products in this warehouse are divided into 10 categories by grouping the same product's characteristic.

2. Using Popularity concept to locate the storage area of each "like characteristics" group. The groups that have the high average of items' turn-over should be located near to receiving and shipping area.

3. Employ Popularity concept into each like characteristic group and each particular item is guided to its appropriate storage equipment.

4. Using Size concept to guide item to its appropriate storage location in selected storage equipment. Then, if items are stored in shelves, the heavy items should be stored in a low layer and the lightweight should be stored in a high layer.

These concepts will lead items into their most suit storage locations. From the 4.2.2 and above reasons, the allocation system to guide items into their storage location is illustrated in below figure 4.82. Then, employ this guide line process into both groups of normal items is the final procedure to locate the storage location for each normal item.

(A)Assign the storage location for Normal item in class 1 group:

There are 339 items in first class item group and this group is assigned to store in the floated floor and fifth floor of building no.1. The storage equipment which is suits to storage items in this group is the model A shelf. The information of each item in this group is shown in the table E.1 factor to determine storage location for normal items of the appendix E. In that table, it shows the category group, turn-over rate, weight and required storage space of each item in first class normal group.

From 4.2.3.1, the storage locations that are assigned to store this group are the storage locations in "the model A shelf" no. 1-62. The model A shelf has 6 layers and storage cubic space of each layer is 100,800 cm^3 so storage cubic space of one model A shelf is 604,800 cm^3. The storage location information for the first class of normal items group is in the table D.2 specification of storage location for normal

items of the appendix D. This appendix provides locations of storage equipment and a condition factors for the items that should be stored in storage location. The sequence no. of the storage equipment indicates the distance of the storage location to the point of use. The less sequence no. means the less distance between storage equipment and point of use.

Item placement Guiding step1: Family grouping concept that based on "like characteristics". According to the table E.1 the factor to determine storage location for the normal item groups in appendix E, normal item in the first class is grouped by their characteristics into 10 groups.

Item placement Guiding step2: Popularity concept to locate the storage area of each "Like characteristics" group. According to popularity concept, the high turn-over groups should be located to shipping and receiving area. The average turn-over of each "like characteristics" group must be calculated to find the suit storage area of each group. The average turn-over and other details of each "like characteristics" group is shown in table E.1 the factor to determine storage location for the normal item groups in appendix E. Summarize of this data is shown in below table.

(1)Category	(2)Total required storage area(cm3)	(3)Total required storage area plus 30% honeycombing allowance(cm3)	(4)Average Turn-over	(5)Estimated required Quantity of storage location	(6)Estimated required Quantity of storage equipment(6 storage locations per shelf)
Fabric category	3,596,348	4,675,252	23	47	8
Mechanical category	977,338	1,270,540	22	13	3
Cooking category	540,230	702,299	22	7	2
Household category	4,342,452	5,645,188	21	56	10
Chemical category	4,937,771	6,419,102	19	64	11
Office category	2,232,171	2,901,822	18	29	5
Plastic category	5,400,366	7,020,476	18	70	12
Personal care category	2,098,474	2,728,016	10	27	5
Electrical category	1,917,545	2,492,808	9	24	4
Miscellanous category	503,596	654,674	4	7	2

Table 4.19-Average turn-over and other details of each "like characteristics" group

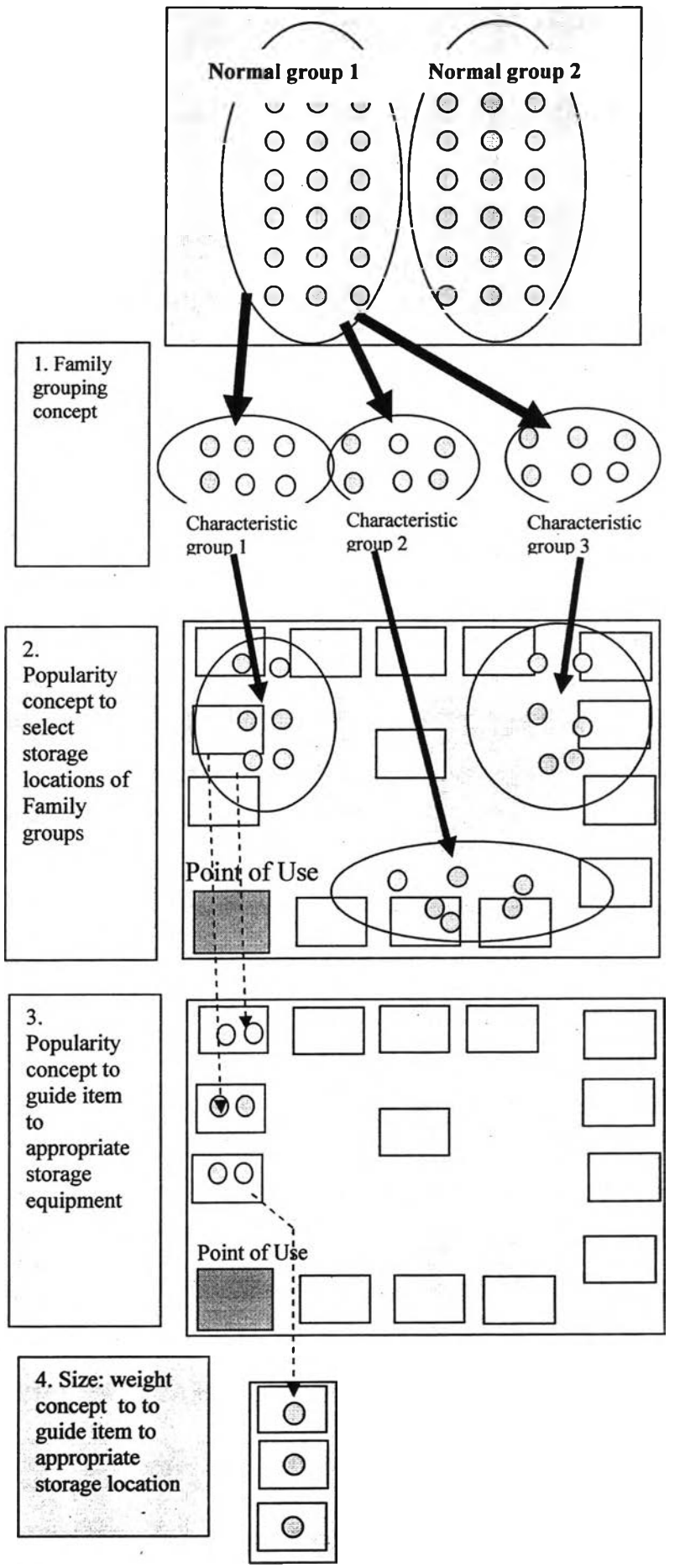


Fig.4.82-The guide line process to determine the storage location for each normal item

The second column of table 4.19 shows the total required storage area of each group and the third column shows the total required storage area plus with honeycombing 30% of the total required storage area of each group. The fourth column is the average turn-over of each group. The fifth column is the number of storage location that is required to store products in that group and these numbers are calculated by using total required storage area plus with honeycombing 30% divided by storage cubic space of one storage location. The sixth column is the number of storage equipment that is required to store products in that group and these numbers are calculated by using the number of storage location that is required to store products divided by number of storage location per storage equipment.

From the table 4.19, the like characteristic group that should be stored nearest the receiving and shipping area is the fabric category group and other groups should be located next to it by descending average turn-over of each group. The storage areas that are available for the first class of normal item group are the floated floor and the fifth floor of building no.1. From the fig.4.63 Layout of the 5th floor in building no.1, there is no lift transportation to the fifth floor so the fifth floor is far from the receiving and shipping area, if it is compared to the floated floor. There are 29 shelves or 174 storage locations in the floated floor and there are 33 shelves or 198 storage locations in the fifth floor.

From the figure 4.62 and 4.63 layout of the floated floor and the fifth floor in the building no.1 with the storage equipments, no. of the storage equipment indicates the distance of the storage location to the point of use and point of use which in this floor is lift transportation. The low shelf no. means the short distance between storage equipment and point of use. Then, the closet storage equipment is shelf no.1 and the most far storage equipment is shelf no.62.

From the information from the table 4.19 and figure 4.62, 4.63 layouts of the floated floor and the fifth floor with the storage equipments, the suit storage area for each like characteristic group should be assigned following the below table.

(1)Category	(1)Average Turn-over	(2)Estimated required Quantity of storage location	(3)Estimated required Quantity of storage equipment(6 storage locations per shelf)	(4)Storage Equipment: Model A shelf No.
Fabric category	23	47	8	1-8
Mechanical category	22	13	3	11-13
Cooking category	22	7	2	9-10
Household category	21	56	10	14-23
Chemical category	19	64	11	24-34
Office category	18	29	5	47-51
Plastic category	18	70	12	35-46
Personal care category	10	27	5	52-56
Electrical category	9	24	4	57-60
Miscellanous category	4	7	2	61-612

Table 4.20-Storage location for each like characteristic group

Item placement Guiding step3: Employ popularity concept into each like characteristic group then each particular item is guided to its appropriate storage equipment by its turn-over rate. Particular item in each like characteristic group should be located into its suit storage equipment by its turn-over rate. The high turn-over item should be stored in the storage equipment that is near the point of use as close as possible. In this warehouse, the distance of storage equipment from the point of use is correlated to the sequenced no. of storage equipment. The low sequence no. means the storage equipment has the short distance from a point of use and the high sequence no. means the storage equipment has the long distance from a point of use. It means the high turn-over item should be stored in storage equipment that has the low sequence number and the low turn-over item should be stored in storage equipment that has the high sequence number.

Therefore, each item must have the guiding indicator that informs the suit distance of its storage location to the point of use. Generally, distance is classified into 3 levels which are short distance, medium distance and long distance. From the popularity concept, item that has the short distance of its storage location to the point of use, is high turn-over item and item that has the long distance of its storage location to the point of use, is low turn-over item. Then, items in the first class normal group must be classified by their turn-over rates into 3 levels which are high turn-over, normal turn-over and low turn-over. Turn-over rate of the items in first normal group should be demonstrated as in below histogram graph to help classifying items.

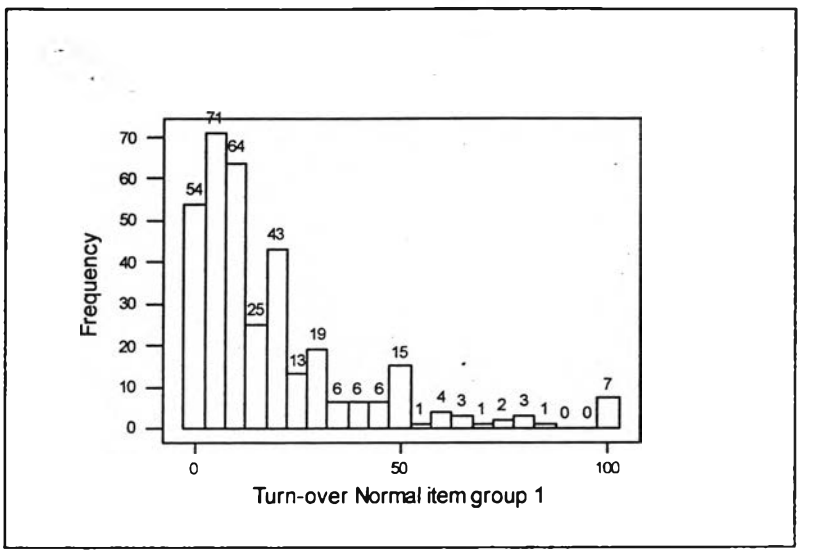


Fig.4.83-Histogram of turn-over rate of first normal group

From the figure 4.83, according to "Pareto's Law", the concept stands for the proposition that within any given population of things, approximately 20 percent of them 80 percent of the "value" of all of the items concentrated within them, and that the other 80 percent only have 20 percent of the value concentrated within them. The high turn-over items should be the items that have turn-over rate above 30 units per month and the low turn-over items should be the items that have turn-over rate below 5 units per month then the rest is normal turn-over item.

As a result, the items that have turn-over rate above 30 units per month should be stored near to the point of use. The items that have turn-over rate between 30 and 5 units per month have no specific requirement of their storage location. The items that have turn-over rate below 5 units per month should be stored far from the point of use. Consequently, the guiding indicator that informs the suit distance of its storage location to the point of use must have 3 levels also. The guiding indicator of each item must be included into it's the allocation system code. The guiding indicator should be a letter or a digit that demonstrates its meaning clearly. English letters are used to represent the suit distance of item's storage location to the point of use. "N" letter indicates that item should be located near to point of use as close as possible and "M" letter indicates that item has no specific requirement for storage equipment. "F" letter indicates that item should be located far from point of use as far as possible. This guiding indicator is expected to help the operators select the suit storage equipment within each like characteristic group's storage area for particular item in

each group. Then, guiding indicator of the storage equipment selection for each item is shown in the table D.2 the specification of storage location for normal items of the appendix D.

Item placement Guiding step4: Using size concept to guide item to appropriate storage location in its storage equipment. After using popularity concept to select the appropriate storage equipment for particular item, the size concept should be used to guide item to appropriate storage location in its storage equipment. The storage equipment of the first class normal group has 6 layers so there are 6 storage locations in the storage equipment.

Size concept indicates that the heavy items should be stored in a low layer and the lightweight should be stored in a high layer. Therefore, each item must have the guiding indicator that informs the suit layer of its storage location in the storage equipment. Generally, weight is classified into 3 levels which are heavy weight, normal weight and light weight. Then, the item in the first class normal group must be classified by their unit-type weights into 3 levels. Distribution unit-type weight of the items in first normal group should be demonstrated as in below histogram graph to help classifying items.

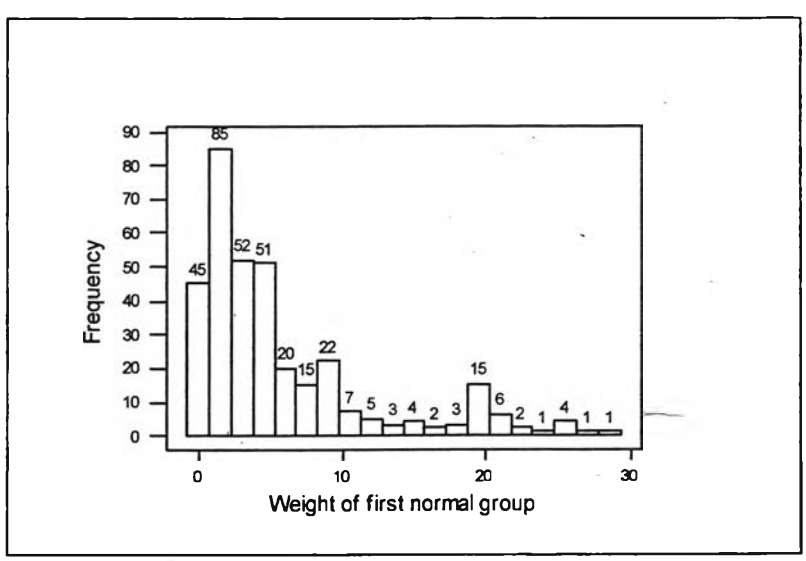


Figure 4.84-Histogram of unit-type weight of first normal group

From the figure 4.84, the heavy items should be the items that have weight over or equal 10 kg and the light weight items should be the items that have weight below or equal 2 kg then the rest is considered as a normal weight item.

As a result, the items that have weight over or equal 10 kg should be stored in low layer storage location as low as possible. The items that have weight between 2 and 10 kg have no specific requirement of their storage location. The items that have weight below or equal 2 kg should be stored in high layer storage location as high as possible. Consequently, the guiding indicator that informs the suit layer of its storage location in the storage equipment must have 3 levels also. The guiding indicator of each item must be included into its allocation system code. The guiding indicator should be a letter or a digit that demonstrates its meaning clearly. English letters are used to represent the layer of its storage location in the storage equipment. "L" letter indicates that item should be stored in low layer storage location as low as possible and "M" letter indicates that item has no specific requirement for storage location. "H" letter indicates that item should be stored in high layer storage location as high as possible. This guiding indicator is expected to help the operators store each particular item into its suit storage location within the storage equipment.

(B) Assign the storage location for Normal item in class 2 group:

There are 536 items in the second class of normal items group and this group is assigned to store in the 3rd floor, 4th floor and 5th floor of building no.2. They are also assigned to store in the 2nd floor and 5th floor of building no.1. The storage equipment which is suits to storage items in this group is the model B shelf. The information of each item in this group is shown in the table E.1 of the appendix E. In that table, it shows the category group, turn-over rate, weight and required storage space of each item in second class normal group.

From 4.2.3.1, the storage locations that are assigned to store this group are the storage locations in "the model B shelf" no. 8-90. The model B shelf has 3 layers and storage cubic space of each layer is 100,800 cm^3 so storage cubic space of one model A shelf is 564,900 cm^3. The table D.2 in the appendix D provides locations of storage equipment and the factors for the items that should be stored in storage location. Sequence No. of the storage equipment indicates the distance of the storage location to the point of use The less sequence no. means the less distance between storage equipment and point of use.

Item placement Guiding step1: Family grouping concept that based on "Like characteristics". According to the table E.1 the factor to determine storage

location for normal items in the appendix E, normal item in the second class is grouped by their characteristics into 10 groups. These characteristic groups are grouped based on item's category.

Item placement Guiding step2: Popularity concept to locate the storage area of each "Like characteristics" group. According to popularity concept, the like characteristics groups that have high turn-over should be located to shipping and receiving area. The average turn-over of each "like characteristics" group must be calculated to find the suit storage area of each group. The average turn-over and other details of each "like characteristics" group is shown in table E.1 the factor to determine storage location for normal items in the appendix E and summarize of this data is shown in below table.

(1)Category	(2) Total required storage area(cm3)	(3) Total required storage area(cm3) plus 30% honeycombing allowance(cm3)	(4) Average Turn-over	(5) Estimated required Quantity of srorage location	(6)Estimated required Quantity of storage equipment(3 storage locations per shelf)
Chemical category	3,834,336	4,984,637	12	9	3.00
Plastic category	39,253,331	51,029,330	11	90	30.00
Electrical category	3,149,017	4,093,721	10	7	3.00
Fabric category	3,622,038	4,708,649	9	8	3.00
Personal care category	15,890,187	20,657,242	8	36	12.00
Household category	23,601,996	30,682,595	7	54	18.00
Cooking category	1,053,476	1,369,518	7	3	1.00
Miscellanous category	3,044,040	3,957,252	7	7	3.00
Office category	7,229,335	9,398,135	6	17	6.00
Mechanical category	1,921,065	2,497,385	6	5	2.00

Table 4.21-Average turn-over and other details of each "like characteristics" group in normal second class group

The second column of table 4.21 shows the total required storage area of each group and the third column shows the total required storage area plus with honeycombing 30% of the total required storage area of each group. The fourth column is the average turn-over of each group. The fifth column is the number of storage location that is required to store products in that group and these numbers are calculated by using total required storage area plus with honeycombing 30% divided by storage cubic space of one storage location. The sixth column is the number of storage equipment that is required to store products in that group and these numbers are calculated by using the number of storage location that is required to store products divided by number of storage location per storage equipment.

From the table 4.21, the like characteristic group that should be stored nearest the receiving and shipping area is the chemical product category group and other groups should be located next to it by descending average turn-over of each group. The storage areas that are available for the second class of normal item group are the 3rd floor, 4th floor, 5th floor of building no.2 and the 2nd floor, 5th floor of building no.1.

From the layout of both storage buildings, the sequence of storage area by the distance from the receiving and shipping area is the 3rd floor, 4th floor and 5th floor of building no.2 and followed by the 2nd floor, 5th floor of building no.1 accordingly. Thus, the 3rd floor of building no.2 is the storage area that is nearest to the receiving and shipping area and the next nearest storage area is the 4th floor and 5th floor of building no.2 following.

From the fig.4.57 to 4.61, the layout of the storage area with storage equipments, there are 54 storage locations or 18 shelves in the third floor of building no.2 from the sequence no.8 to 25. There are 54 storage locations or 18 shelves in the fourth floor of building no.2 from the sequence no.26 to 43 and there are 51 storage locations or 17 shelves in the fifth floor of building no.2 from the sequence no.44 to 60. In the fig. 57 to 61, the no. of the storage equipment indicates the distance of the storage location to the point of use and point of use which in these floors is lift transportation. The low shelf no. means the short distance between storage equipment and point of use. Then, the closet storage equipment is shelf no.8 and the most far storage equipment is shelf no.90.

From the information from the table 4.21 and figure 4.57 to 4.61 layouts of storage areas with storage equipments, the suit storage area for each like characteristic group should be assigned following the below table.

(1)Category	(2) Average Turn-over	(3) Estimated required Quantity of srorage location	(4)Estimated required Quantity of storage equipment(3 storage locations per shelf)	(5)Storage Equipment: Model B shelf No.
Chemical category	12	9	3.00	8-10
Plastic category	11	90	30.00	11-40
Electrical category	10	7	3.00	41-43
Fabric category	9	8	3.00	44-46
Personal care category	8	36	12.00	47-58
Household category	7	54	18.00	64-82
Cooking category	-	3	1.00	59
Miscellanous category	-	7	3.00	61-63
Office category	6	17	6.00	82-87
Mechanical category	6	5	2.00	88-89

Table 4.22-Storage location for each like characteristic group of the second class normal item

Item placement Guiding step3: Employ popularity concept into each like characteristic group then each particular item is guided to its appropriate storage equipment by its turn-over rate. Particular item in each like characteristic group should be located into its suit storage equipment by its turn-over rate. The high turn-over item should be stored in the storage equipment that is near the point of use as close as possible. In this warehouse, the distance of storage equipment from the point of use is correlated to the sequenced no. of storage equipment. The low sequence no. means the storage equipment has the short distance from a point of use and the high sequence no. means the storage equipment has the long distance from a point of use. It means the high turn-over item should be stored in storage equipment that has the low sequence number and the low turn-over item should be stored in storage equipment that has the high sequence number.

Therefore, each item must have the guiding indicator that informs the suit distance of its storage location to the point of use. Generally, distance is classified into 3 levels which are short distance, medium distance and long distance. From the popularity concept, item that has the short distance of its storage location to the point of use, is high turn-over item and item that has the long distance of its storage location to the point of use, is low turn-over item. Then, items in the first class normal group must be classified by their turn-over rates into 3 levels which are high turn-over, normal turn-over and low turn-over. Turn-over rate of the items in

first normal group should be demonstrated as in below histogram graph to help classifying items.

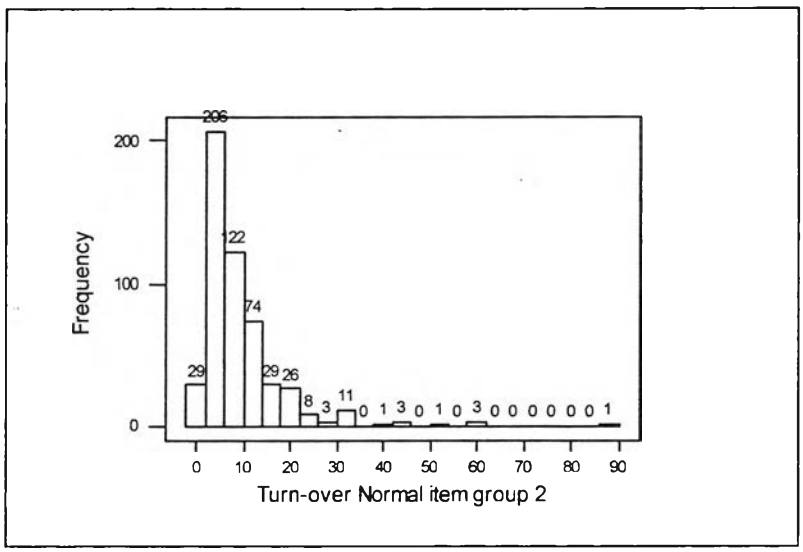


Figure 4.85-Histogram of Turn-over rate of second normal group

From the figure 4.85, according to "Pareto's Law", the concept stands for the proposition that within any given population of things, approximately 20 percent of them 80 percent of the "value" of all of the items concentrated within them, and that the other 80 percent only have 20 percent of the value concentrated within them. The high turn-over items should be the items that have turn-over rate above 10 units per month and the low turn-over items should be the items that have turn-over rate below 4 units per month then the rest is normal turn-over item.

As a result, the items that have turn-over rate above 10 units per month should be stored near to the point of use. The items that have turn-over rate between 10 and 4 units per month have no specific requirement of their storage location. The items that have turn-over rate below 4 units per month should be stored far from the point of use. Consequently, the guiding indicator that informs the suit distance of its storage location to the point of use must have 3 levels also. The guiding indicator of each item must be included into its allocation system code. The guiding indicator should be a letter or a digit that demonstrates its meaning clearly. English letters are used to represent the suit distance of item's storage location to the point of use. "N" letter indicates that item should be located near to point of use as close as possible and "M" letter indicates that item has no specific requirement for storage equipment.

"F" letter indicates that item should be located far from point of use as far as possible. This guiding indicator is expected to help the operators select the suit storage equipment within each like characteristic group's storage area for particular item in each group. The guiding indicator of the storage equipment selection for each item is shown in the table E.1 the factor to determine storage location for normal items of the appendix E.

Item placement Guiding step4: Using size concept to guide item to appropriate storage location in storage equipment. After using popularity concept to select the appropriate storage equipment for particular item, the size concept should be used to guide item to appropriate storage location in its storage equipment. The storage equipment of the second class normal group has 3 layers so there are 3 storage locations in the storage equipment.

Size concept indicates that the heavy items should be stored in a low layer and the lightweight should be stored in a high layer. Therefore, each item must have the guiding indicator that informs the suit layer of its storage location in the storage equipment. Generally, weight is classified into 3 levels which are heavy weight, normal weight and light weight. Then, the item in the second class normal group must be classified by their unit-type weights into 3 levels. Distribution unit-type weight of the items in second normal group should be demonstrated as in below histogram graph to help classifying items

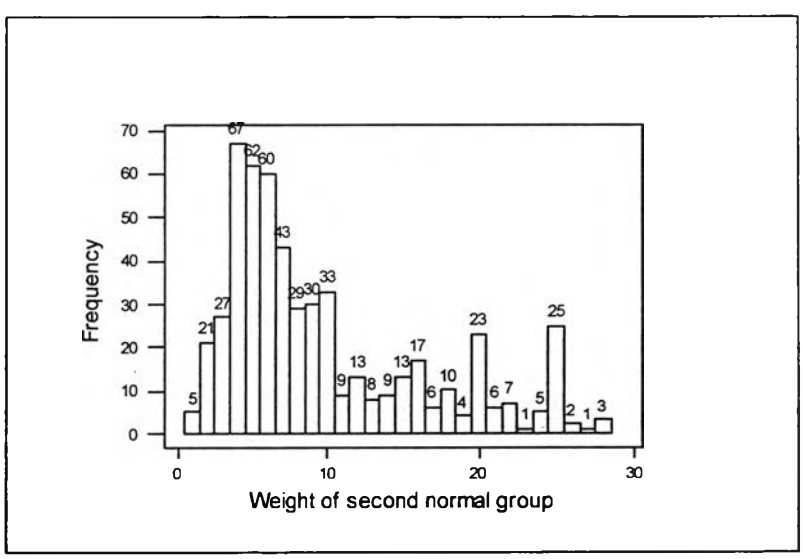


Figure 4.86-Histogram of unit-type weight of second normal group

From the figure 4.86, the heavy items should be the items that have weight equal or over 10 kg and the light weight items should be the items that have weight equal or below 5 kg then the rest is considered as a normal weight item.

As a result, the items that have weight equal or over 10 kg should be stored in low layer storage location as low as possible. The items that have weight between 5 and 10 kg have no specific requirement of their storage location. The items that have weight below or equal 5 kg should be stored in high layer storage location as high as possible. Consequently, the guiding indicator that informs the suit layer of its storage location in the storage equipment must have 3 levels also. The guiding indicator of each item must be included into its allocation system code. The guiding indicator should be a letter or a digit that demonstrates its meaning clearly. English letters are used to represent the layer of its storage location in the storage equipment. "L" letter indicates that item should be stored in low layer storage location as low as possible and "M" letter indicates that item has no specific requirement for storage location. "H" letter indicates that item should be stored in high layer storage location as high as possible. This guiding indicator is expected to help the operators store each particular item into its suit storage location within the storage equipment. The guiding indicator of the storage equipment selection for each item is shown in the table E.1 the factor to determine storage location for normal items of the appendix E.

(C)Determine the allocation system code for normal items: As it's mentioned earlier, in the combination stock locator system, the normal item is located by using random storage location system so no item in normal or bulk item group has fixed storage location and it can be stored in any available storage location. Because there is no fixed storage location for normal item, the allocation system code for each normal item must be established to guide operators to store products in their most suit storage location. Then, each item in both normal groups must have the allocation system code to guide operators to move products into its appropriate storage location.

The allocation system code must be able to guide the operators to bring items to their suit storage location. Then, the item must be indicated their stock locator system firstly so the operator would realize the fixed location system or random location system which is fit for that item. Although all items in normal group

are located by random location system, the operators need indicator to remind them to not confuse it with special items.

The second item's information that is used to determine their storage locations are the type of storage equipment that is fit them. As it was mention earlier, the normal item group is divided by their size into 2 group and these 2 groups require different storage equipment. The first class of normal items is assigned to be stored in "the model A shelf' and the second class of normal items is assigned to be stored in "the model B shelf'.

The third items' information that is used to determine their storage location is the sequence no. of storage equipments that is appropriate to store item and the fourth items' information that is used to determine their storage location is the suit distance of item's storage location to the point of use. The fifth items' information that is used to determine their storage location is the suit layer of its storage location in the storage equipment.

Therefore, the allocation system code must demonstrate this information by the code that operators can understand it well and recognize item's suit storage location easily.

The code that used to indicate item's stock locator system is the letter "R" which means the random locator system. "R" represents the item's do not have fixed storage location and it can be stored anywhere that is available.

The code that used to indicate the suit type of storage equipment of item is the letter "A" and "B". "A" represents the meaning that the suit storage equipment of that item is "the model A shelf" and "B" represents the meaning that the suit storage equipment of that item is "the model B shelf".

The code that used to indicate the suit sequence number of storage equipment that is suit to store item, is the range of sequence number from the least sequence no. to the highest sequence no. of storage equipment which is assigned to store item. The sample of this code is "12-30" and this code means item can store in the storage equipment no.12 to the storage equipment no.30.

The code that used to indicate distance of item's suit storage location to the point of use is the letter "N", "M" and "F". "N" letter indicates that item should be located near to point of use as close as possible and "M" letter indicates that item

has no specific requirement for storage equipment. "F" letter indicates that item should be located far from point of use as far as possible.

The code that used to indicate the suit layer of its storage location in the storage equipment is the letter "L", "M" and "H". L" letter indicates that item should be stored in low layer storage location as low as possible and "M" letter indicates that item has no specific requirement for storage location. "H" letter indicates that item should be stored in high layer storage location as high as possible.

As a result, these codes are combined together as the allocation system code and the allocation system code determination is shown in below table.

Type of storage locator system	Type of storage equipment	Range of storage equipment no.	Suit Distance from the point of use	Suit storage location in storage equipment
R	A	Least no. - Highest no.	N	L
	B	Sample	M	M
		15 - 19	F	H

Table 4.23-The allocation system code determination for normal items

The allocation system code of all normal items is shown in table E.3 of the appendix E.

After assigned the storage location for groups of items and the guideline process to locate storage location for each particular item in each group has been done, the operators can be acknowledged where they should store each item by the allocation system code of each item. As a result, it means all items are assigned to be stored to the storage locations already.

4.3 Determine storage location addresses and item identifiers system

This system is very important because it is not possible to control what it can't be found. This system relates to identify the assigned warehouse keeping location and it is ease of recognition reduces errors and time required for either stock selection of put-away. The placement of identifiers on both product and physical locations creates an infrastructure by which product and it move can be tracked.

4.3.1 Determine item identifiers system

In this warehouse, the purpose of identifying item is to quickly and easily identify a product. This ease of recognition reduces errors and time required for either

stock selection of put-away. In order to keep track of where items are at any given time, it is necessary to clearly mark items with an items identifier.

The item identifier is generally an organization's internal identifying code for the item rather than a manufacturer's or customer's number for that items. Then, the item number or name on the package itself is often adequate for identification purposes.

Because the item identifier system in this warehouse is used only to identify the item, the name of item on its package that is marked by the suppliers is good enough to identify system. As a result, item identifiers system of this warehouse relies on the suppliers markings on the exterior of package. Although most of product in this warehouse have been marked their name on the package by the suppliers, there are some of them which are not been marked by supplier. Then warehouse operator must mark the name of the item which is written on the receiving bill on the exterior of the package by them. The name on the exterior of product is used as item identifier of item and all functions of company that are related to product name such as purchasing, warehouse, administration must use the same item identifier.

4.3.2 Determine storage location addresses

The addressing or location system that is selected should have an underlying logic that is easy to understand. Addresses should be as short as possible, yet they should convey all needed information. The storage location addresses must be clearly marked on the storage location.

The addressing of storage location must contain the information that can inform its specific location including building no., storage floor, type of storage equipment, sequence no. of storage equipment and the layer in storage equipment. Then the location addresses is represented in the digits and letters code as it is shown in below table.

1st code	2nd code	3rd code	4th code	5th code
Building No.	Storage floor	Type of storage equipment	storage equipment no.	Layer No. in storage equipment
1	F	R	01	1
2	2	A	02	2
	3	B	03	3
	4	C	04	4
	5		05	5
	6		06	6

Table 4.24-Storage location addresses code determination

From the table 4.24, there are 5 codes that represent the storage location. The first code represents the no. of the building that storage location been located. The second code represents the no. storage floor that storage location been located. The "F" letter in this code means the floated floor. The third code represents the type of storage equipment and there are 4 type of storage equipment. The "R" letter represents that this storage location is in the rack storage equipment. The "A" represents that this storage location is in the he model A shelf, "B" represents that this storage location is in the model B shelf and "C" represents that this storage location is in the model C shelf.

The fourth code represents the no. of storage equipment that the storage location is located in and codes have 2 digits. The fifth code represents the layer no. in storage equipment that the storage location is located in.

As an example, if storage location address is 15A084, it means this storage location is at the fourth layer of the model A shelf no.8 in the fifth floor of building no.1. All the storage location addresses is shown in the table D.1 the storage location address of the appendix D.

Storage location addresses must be marked at the noticeable place in storage location and the type and sequence no. of storage equipment must be marked at noticeable place in storage equipment.

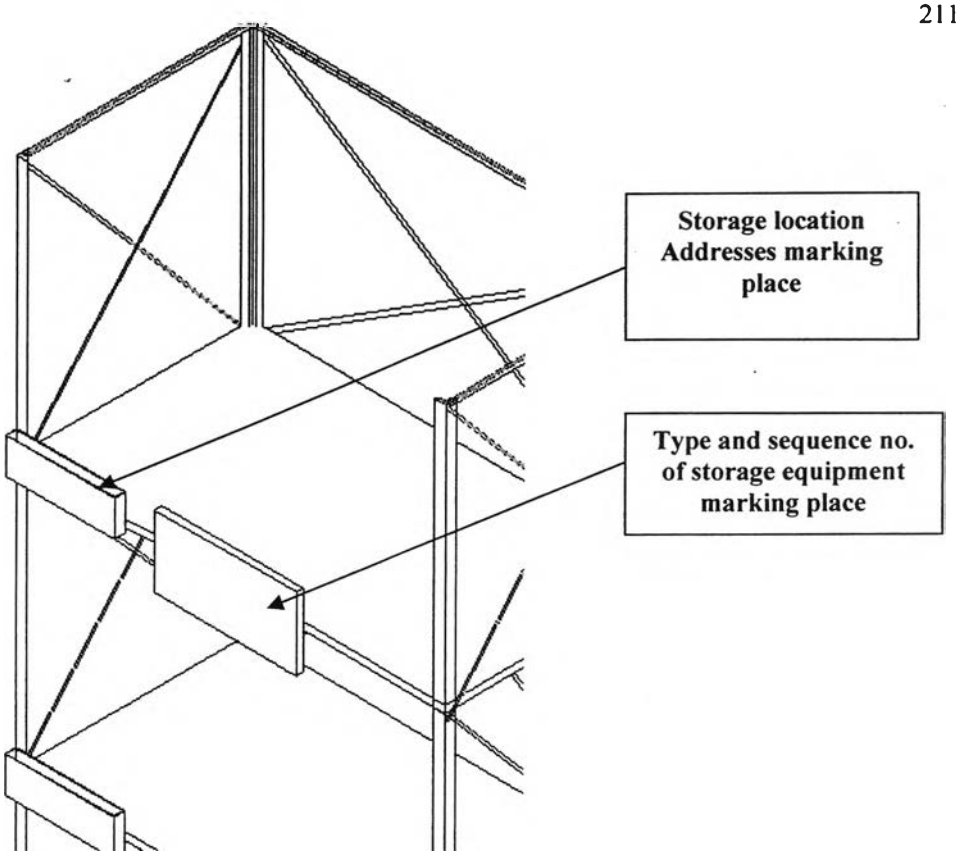


Figure 4.87-Sample of storage location mark place

From the fig. 4.87, the storage location addresses that are marked came from the storage location addresses code and the storage type code and the sequence no. of storage location code that is marked in each storage equipment came from the 3rd and 4th code in table 4.24.

These addresses represent the storage location address so the operator could identify the storage location accurately.

After the placement of identifiers on both product and physical locations creates an infrastructure by which product and it move can be tracked. The next step is bonding together an item number and the location(s) where that item is located.

4.4 Cost evaluation of improvement of infrastructure and equipment

The new warehouse management improves the warehouse from the infrastructure of warehouse to the warehouse operation. However, to implement the new warehouse management need investment from the company and this topic presents the estimated cost of implementation the new warehouse management into the wholesaler's warehouse.

4.4.1 Cost of infrastructure improvement

From the definition the fixed obstacles of the warehouse in 4.1, there is fixed obstacles in storage area improvement that need to be done to improve warehouse efficiently in term of space utility and material handling.

The storage area that must be improved in the building no.1 is 5th floor and the 6th floor. The storage area that must be improved in the building no.2 is the floated, the 3rd floor and the 4th floor. After the contractor has been invited to visit the warehouse and discuss about the plan to improve the infrastructure of the warehouse, the contractor estimated the cost to do it around 100,000 baht.

4.4.2 Cost of equipment improvement

There are 2 type of equipment in the warehouse that must be improved in implementing the new warehouse management.

4.4.2.1 The material handling equipment

The new warehouse management needs the material handling equipment that is determined to use in this storage area. The type of the material handling equipment that is determined to use is the steel platform truck with 6" rubber wheels 24"X48" platform and it is required 2 hand trucks to do activities in this warehouse. The price of it is 370 US dollar or 15,000 baht per unit. This data comes from the official website of the advanced handling services material handling company (http://www.advancedhandling.com). Then the cost of the material equipment is 30,000 baht.

4.4.2.2 The storage equipment

The size of the storage location in storage equipment should fit the size of the items to be stored so the new warehouse management requires various type of storage equipment. The model and quantity of storage equipment has been discussed in topic 4.1 already then the supplier has been invited to discuss about the specification and material of these storage equipments. The supplier had informed the price of each model following this:

Type	Quantity	Price/Unit (Baht)	Total
Rack model A	1	3,000	3,000
Shelf model A	62	3,500	217,000
Shelf model B	90	5,500	495,000
Shelf model C	7	7,000	49,000
		Total Cost	**764,000**

Table 4.25- Price of storage equipment

As a result, the total cost of storage equipments is 764,000 Baht. Then the total cost of the warehouse equipments is 794,000 Baht.