Global Scientific JOURNALS

GSJ: Volume 10, Issue 5, May 2022, Online: ISSN 2320-9186
www.globalscientificjournal.com

VERTICAL MEANS OF CIRCULATION IN BUILDING

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March, 2022

Abstract

Circulation is an important influencing factor for the efficient functionality of a Building. In architecture, the concept of circulation refers to the way people move through, around, and between buildings or space. Circulation also refers to a way user interact with a building. This predominantly include spaces such as entrances, foyers, stairs, landing, lobbies, hall way, corridors, elevators, escalators, walkways, and so on. The size of a circulation space may be determined by factors such as; the type of use, the numbers of people using them, the direction of travel, crossing flows and so on. In complex buildings like hospitals or office buildings, signage or other forms of wayfinding may be necessary to assist people navigate circulation spaces. The purpose of the research is to derive the design guideline for circulation system in a faculty building. In this article, I will talk about vertical circulation, types of vertical circulation, and uses.

Keywords: Circulation, Vertical Circulation, Architecture

1.0 Introduction

Building circulation is a key organizing mechanism of layout and communication space as it connects exterior and interior areas and reflects the overall spatial organization of the building. The circulation system is often referred to as a "skeleton" that forms the supporting structure of the building. Thus, circulation reveals in a powerful way how patterns of space and configuration affect users through movement. Existing methods for circulation planning are based on analyses of the physical abilities of different user groups (physical strength, age, disabilities, etc.), which set architectural standards for the dimensions of ceilings, doorways, windows, steps, and the like (Neufert and Neufert, 2000).

Circulation in architecture cannot be over emphasized, it refers to the way users (people) move through and interact with a building. In public buildings, the use of circulation elements such as elevators, escalators, and staircases are of high importance, as they are positioned and designed to optimize the flow of people through a building.

2.0 What is Circulation

Circulation, as usually applied in architecture, is the movement of people between interior spaces in buildings and to entrances and exits. circulation includes lobbies, corridors, ramps, stairways, escalators, travelators and elevator. Circulation (movement of people) within interior spaces are of two types namely: Horizontal Circulation and Vertical Circulation. Specifically, this research work is on vertical means of circulation in building

3.0 Vertical Circulation

Vertical circulation is a system designed to help people move up and down within a building, so includes things like stairs, lifts, ramps, ladders and escalators which allow us to move from one level to another. Generally, for a functional design vertical circulations are very important both in normal use and in emergencies. In fact, location of elevators, ramps, escalators or stairs strongly influences the floor plan design, considerations should be given to the type of vertical circulation to be provided, the number of units needed, their locations, arrangement, and design.

3.1 Classification of Vertical Circulation Systems

Vertical circulation systems may be classified into two, Manual Circulation System and Mechanical Circulation.

- **Manual**
  1. Staircases
  2. Ramps
  3. Ladders
- **Mechanical**
  1. Elevators
  2. Escalators
  3. Travelators

3.2 Stairs

A stair is a set of steps arranged in such a manner as to connect one floor of a building to another. Stairs are designed to provide as easy and quick access to different floors. A staircase is an enclosure or room which the stair is located. The opening or space that contains the stair is known as a stairway.

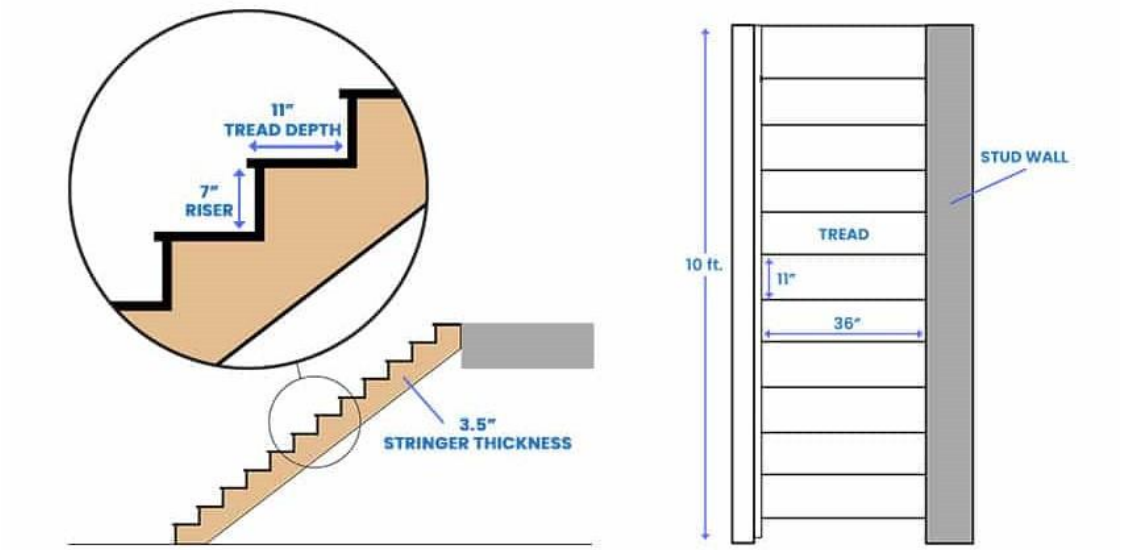

Figure 1: A straight-run stairs (source: designingidea.com)

3.2.1 Types of Stairs

Generally, stairs are of the following types

1. Straight stairs
2. Circular stairs
3. Curved stairs
4. Spiral stairs
5. Quarter turn stairs
6. Half turn stairs
7. Three quarter turn stairs
8. Geometric stairs
9. Bifurcated stairs and

1. Straight Stairs

Generally, these are the stairs along which there is no change in direction on any flight between two successive floors. sometimes it may be split into two or more than two flight by providing a landing between two flights.

2. Circular Stairs

A circular stair has no landings. Instead, the stairs are continuous, following the bend of the banister to make a striking architectural appearance. From above, circular stairs radiate from a circle with a single center of curvature and a large radius. While circular stairs do go around, they are more like normal stairs than a spiral staircase because the curve is more relaxed.

3. Curved Stairs

They have no landings and the stairs are continuous, curved stairs appear to follow a curve with two or more center of curvature. they have a much larger radius and typically do not make a full circle. Curved stairs add aesthetics to any office, home or public buildings. For this reason, they are almost always located at the entrance where they make the best first impression.

4. Spiral Stairs

Spiral stairs are similar to circular stairs except that the radius of curvature is small and all the stairs radiates around a center post and may be supported by the post.

5. Quarter Turn Stairs

The main feature of a quarter turn stair or L-shaped stairs is a 90-degree turn after a landing, then the stairs continue left or right. While the landing is commonly in the middle of the staircase, it can also be located closer to one end or the other.

6. Half Turn Stairs

These are type of straight stair which features a 180 degree change in direction. They can be dog legged and open newel.

7. Three Quater Turn Stairs

Three Quarter turn staircase changes its directions three times i.e., through 270° with its upper flight crossing the bottom one, in general, in this type of construction, a bigger open well is formed.

8. Geometric Stairs

The geometrical stairs are generally used in high class residential buildings. The stair is in the form of some curve, having all the steps as winders, radiating from the center of curvature of the curve. The hand rail of a geometrical stair, continues without interruption and without any angular turn- Considerable skill is required for fie designing and construction of a geometrical stair.

9. Bifurcated Stairs

Bifurcated stairs are also known as split stairs typically have a wide set of stairs starting at the bottom that ends at a landing partway up the flight. The stairs split at the landing into two narrower sets of stairs leading in opposite directions.

3.2.2 Material for a Staircase

1. Timber
2. Concrete
3. Steel

3.2.3 General Requirements of a Good Staircase

Below are the general requirements of a good staircase

Location of Staircase

- There should be easy access from all the rooms without disturbing the privacy of the room.
- In public buildings, stairs must be from the main entrance and located centrally.
- There should be a spacious and convenient approaches.
- Adequate provision light and ventilation from the exterior of the building.

With of the Stair

- The width of the step depends and varies with the type of building itself.
- The minimum width of a stair is 0.9m and 1800mm for public buildings.

Length

- The number of steps in a flight should be restricted to a maximum of 12 and a minimum of 3 steps.
- For more than 12 steps, an intermediate landing must be provided.

Pitch of Stair

- The pitch or slope of the stair should never exceed 40 degrees in any type of stairs, so that climbing of the stairs is less tiresome and dangerous.

Head Room

- The headroom or distance between the tread and soffit of the flight immediately above it, should not be less than 2.1m, so that a taller person can use the stairs comfortably.

Landing

- The width of the landing should not be less than the width of the staircase.

Winders

- The use of winders in a stair should be avoided and incase of use, if necessary, it may be provided at the lower end of the flight.
- They are dangerous and also increase the cost of construction.

Balustrade and Railings

- Balustrade and handrails should be provided for the safety of users.
- In a wide staircase, handrails should be provided on both sides.

Materials

- Materials for stairs should have sufficient strength to provide stability and resist impact
- Stairs should be constructed with a fire resistance and sound insulation material

The Dimensions of Stairs

- the dimensions of the riser and tread of each step should be of uniform dimension throughout the staircase and provides comfort to the user.

3.2.4 Components of a Staircase

a. Bluster – this are vertical member which is fixed between stairway to provide support to the handrail.
b. Balustrade – this refers to the combined framework of bluster and handrail.
c. Flight – the unbroken series of steps between the landing.
d. String – it is the inclined manner of stairs which supports the end of steps.
e. Going – the horizontal distance between the faces of two consecutive risers.
f. Handroll – this are inclined rail over the string, it is usually molded.
g. Headroom – vertical distance between noising of a flight and the bottom of flight immediately above is called the headroom.
h. Landing – A landing is a horizontal platform between two flights of stairs.
i. Nosing – The projection parts of tread behind the face of the riser.
j. Riser – a vertical member of the step that connects to treads.
k. Run – the length of stairs in a horizontal plane, which includes the length of landing.
l. Scotia – this is an additional finish that is provided to noising to improve the elevation.
m. Soffit – the under surface of a stair. Usually covered to a ceiling or finished with plaster.
n. Step – a combination of tread and riser.
o. Tread – the upper portion of a step.

3.3 Ramps

A ramp is a sloped or Inclined pathway used to provide access between two or more vertical levels (floor levels). It provides an alternative to stairs and facilitates the movement of wheelchair users, bicycles, people with mobility issues, and other wheeled vehicles. Ramps can be used both inside and outside of a building, they are frequently adopted for public buildings, such as rail stations, stadiums, office buildings, malls, schools and exhibition halls. In all cases, ramps should be constructed with a non-slippery surface.

Ramps are often expressed as a ratio. The rise may be set at a unit of one, so that, for example, a slope of 1:20 means that as each dimensional unit of height rises or falls, the dimensional unit of

length runs out by 20 units. A ramp that is too steep in slope will prove difficult for people to use and could even be unsafe, whilst a ramp with too shallow a slope can require excessive length. Width of ramps varies according to use, configuration and slope.

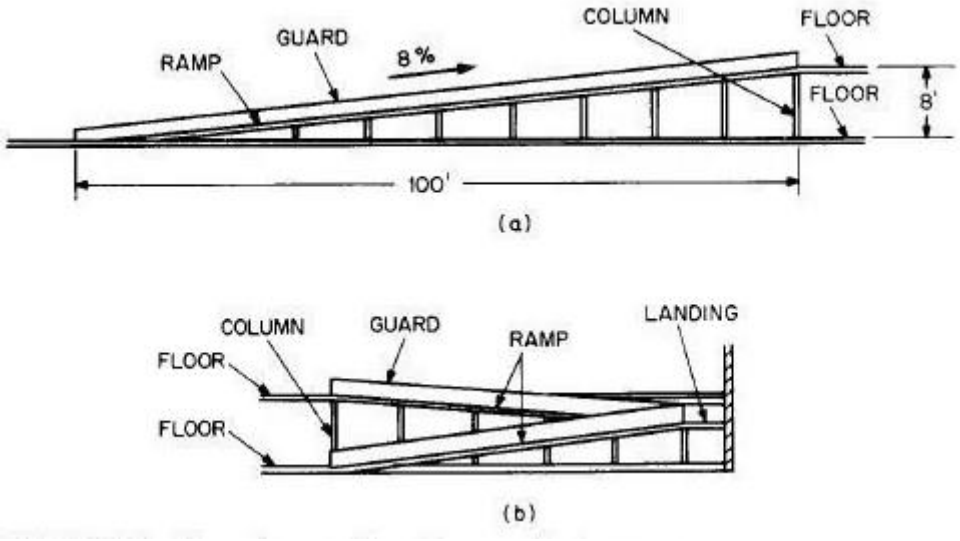

Figure 2: A Ramp (source: civilengineeringx.com)

3.3.1 Construction Requirements of a ramp

a. The length of the ramp should be long enough to provide gentle movement and the width should be enough to easily accommodate moving objects.
b. The ramp surface should be hard and non-slip.
c. An ideal ramp should have an identical ramp inclination at both the sides.
d. Landings should be provided every 10.00 meters for resting, at every change of direction and at the top and bottom of every ramp.
e. A protective handrail should be provided on both side of the ramp, it should be smooth and placed along the full length of ramp.
f. The minimum width should be 0.90 meter.
g. Ramp should not be too steep in slope, The minimum recommended slope of ramps is 1:20. Steeper slopes may be allowed in special cases.
h. The approach to the ramp should be clearly marked and free
i. The geometrical shape of ramp may be straight, zigzag, spiral, curve etc.

3.3.2 Material for Ramp Construction

- Concrete
- Wood
- Steel

Concrete is expensive, but it's a great choice for a permanent ramp, it should be finished with an anti-slip material or tiles. Wood is less expensive materials for ramp construction, but with a high maintenance cost. While steel must be galvanized to prevent rust and deterioration. Generally, ramps should be made of a non-slippery surface.

3.4 Ladders

A ladder is a device or equipment made up of repeating bars or steps (rungs) between two vertical or inclined lengths of metal, wood, or rope that is used to climb up or down an elevated surfaces.

Figure 3: a multi-purpose aluminum ladder (source: www.equalequip.com)

3.4.1 Types of Ladders

There are many different types of ladders based on the application and materials used in their construction.

a. Step Ladder
b. Twin step ladder
c. Steps stool
d. Straight Ladders
e. Platform Ladders
f. Extension Ladders
g. Folding Ladders
h. Multipurpose Ladder
i. Trestle ladders

3.4.2 Materials used for a ladder

1. Steel
2. Aluminum
3. Timber/Wood
4. Fiberglass

3.5 Elevator (Lift)

Elevator, also called lift are mechanical devices that moves passengers or freight between floor levels of a multistory building. Most modern elevators are propelled by electric motors, with the aid of a counterweight, through a system of cables and sheaves (pulleys), it moves vertically within a dedicated shaft that connects the different floor levels of the building.

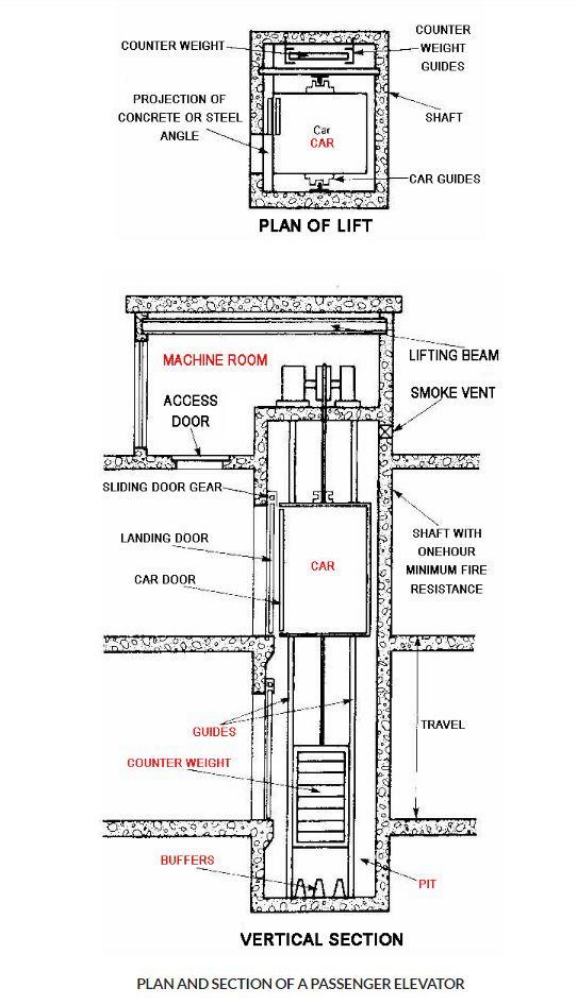

Figure 4: Plan and section of a passenger elevator (source: archi-monarch.com

3.5.1 Types of elevators used in buildings

A. The types of elevators based on function are:
   - Passenger elevator
   - Goods elevator
   - Service elevator

B. The types of elevators based on the working mechanism are:
   - Hydraulic elevators
   - Traction elevators
   - Machine-room-less (MRL) elevators
   - Vacuum home elevators

A. The types of elevators based on function are:

1. **Passenger elevator:** These are lifts provided in flats, residences, hotels, etc., for the transportation of passengers.
2. **Service elevators:** These are lifts used to carry goods along with people.
3. **Goods elevators:** These elevators are primarily used to transport goods, along with lift attendants, and persons for helping with the loading and unloading of the goods.

B. The types of elevators based on the working mechanism are:

1. Hydraulic elevators

Hydraulic elevator is one of the simplest type of lifts, supported by a piston at the bottom of the elevator to push it to different levels. An electric motor forces the hydraulic fluid (oil) to move the piston. They are slower in speed compared to traction elevators. They are used mainly for low rise applications of 2-8 stories, it can travel at a maximum speed of 200 feet per minute.

Types of hydraulic elevators

a. Conventional hydraulic elevators: They have a sheave that extends below the floor of the elevator pit. As the elevator descends, the pit supports the retracting piston. The approximate distance it can travel is 60 feet.
b. Hole-less hydraulic elevators: These types of elevators are similar to conventional hydraulic elevators; except they do not require a sheave or hole below the pit. The telescopic piston arrangement allows up to 50 feet of travel distance, while the non-telescopic piston allows about 20 feet.
c. Roped hydraulic elevators: These elevators use both ropes and pistons to move the elevator car. The maximum distance it can travel is 60 feet.

2. Traction elevators

Traction elevators are set in motion using cables or ropes that pass over a wheel connected to an electric motor. When the electric motor moves it sets the wheel in motion, this pulls the cable and lifts the elevator car to the required floor levels.

A machine room that houses the wheel arrangement is usually sit on top of the elevator or placed on the highest floor of the building. To make the elevator more efficient a counterweight is added to offset the weight of the car and the occupants. This way, the speed of the wheel and the rope coordination is achieved. This type of elevators can be used for floor levels up to 2000 feet.

Traction elevators are of two types:

a. Geared Traction Elevator: In this type, the wheel is driven by having a gearbox attached to the motor. These elevators achieve a travel speed of up to 500 feet per minute. The maximum travel distance offered by geared traction lifts is 250 feet.
b. Gearless Traction Elevator: In this type, the wheel is directly attached to the motor. It offers a speed of up to 2000 feet per minute and has a maximum travel distance of around 2000 feet. It is the top choice for high-rise buildings.

3. Machine-Room-Less (MRL) Elevators

MRL elevators can be traction or hydraulic elevators that do not require a dedicated machine room above the elevated shaft. Here, the machine sits in the override space. For any maintenance and repairs, the unit is accessed from the top of the elevator cab.

4. Vacuum (Air-Driven) Home Elevators

Vacuum elevators do not use any cables or pulley systems to operate. Instead, this elevator is a tube in a sealed vacuum arrangement operated by controlling air pressure. These are mostly used for residential applications for single to three passenger models (wheelchair accessible models).

3.5.2 Components of a lift

1. Car
2. Machine Room
3. Lift Well
4. Lift Pit
5. Shaft

3.6 Escalators

An escalator also known as a moving staircase is a transport device for moving people between different floors of a building. It has steps that carry people up or down using a conveyor belt and tracks, keeping each step horizontal for the passengers.

Escalators are used around the world to move pedestrian traffic in places where elevators would be impractical, such as shopping malls, airports, transit stations, hotels, and public buildings. Every escalator has a handrail attached which moves along with it for the support for the passengers.

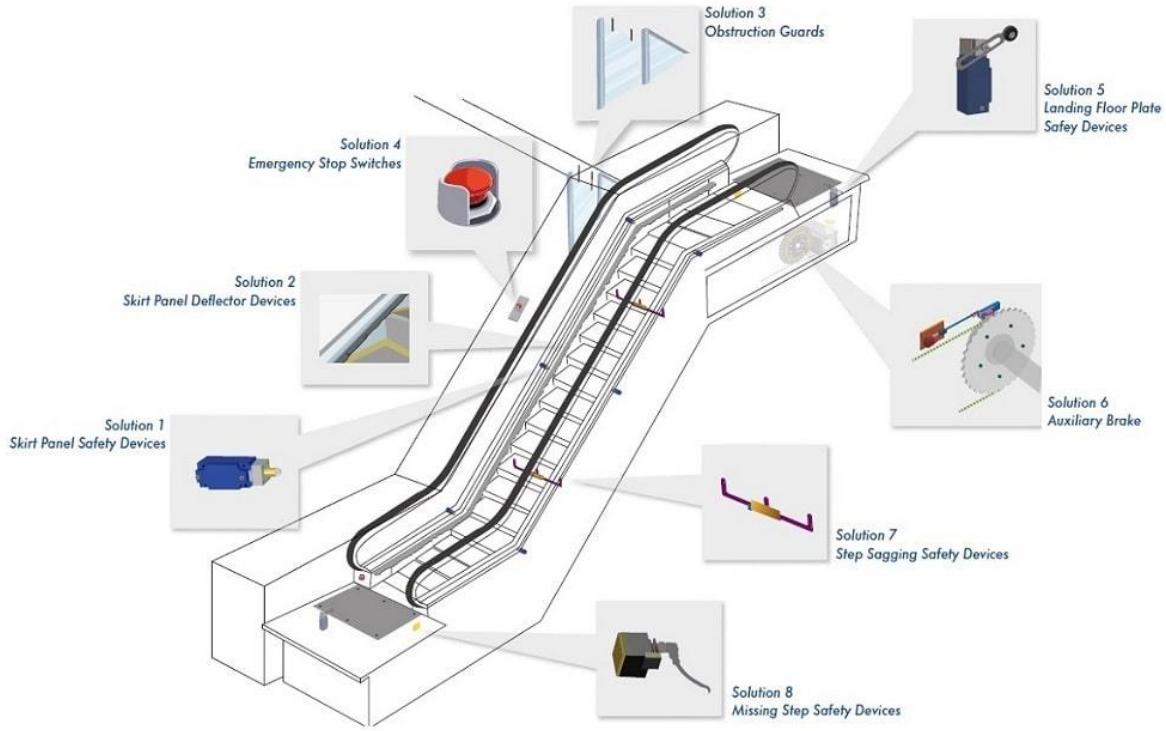

Figure 5: An Escalator (source: engineeringlearn.com)

3.6.1 Different types of elevators used in building

There are three basic configurations that are used for most common escalator systems:

1. Parallel
2. Crisscross
3. Multiple Parallel

1. Parallel Escalator

This type of escalator always faces in the same direction. The parallel escalators use more floor space, they are more expensive and less efficient than other types of escalator arrangements. They are mostly seen in metro stations and multilevel theaters. Also, they are suitable for buildings with heavy traffic flow in both directions.

2. Crisscross Escalator

Crisscross escalator easily moves people from one place to another place, it minimizes structural space requirements by "stacking" escalators that moves up or down in one direction, mostly used in department stores or shopping centers.

3. Multiple Parallel Escalator

Multiple Parallel are two or more escalators together that works in the same direction all the time. It is mandatory to have a moving handrail in an escalator that keeps pace with the movement of the steps. The direction of movement remains the same throughout which can be controlled by a person according to the requirement or even automatically. The main purpose is to carry people and move from one place to another place as well. It helps to save time because it covers a long space.

3.7 Travelators

A travelator is a conveyor mechanism that helps transport people across longer horizontal or inclined distances in a faster and easier manner than walking would. A travelator may also be known as a moving sidewalk, moving walkway or autowalk. Just like the escalators, people stand, or walk on the travelator as its conveyor walkway rolls along. They are often installed in pairs to keep opposite flows of people all moving their designated direction.

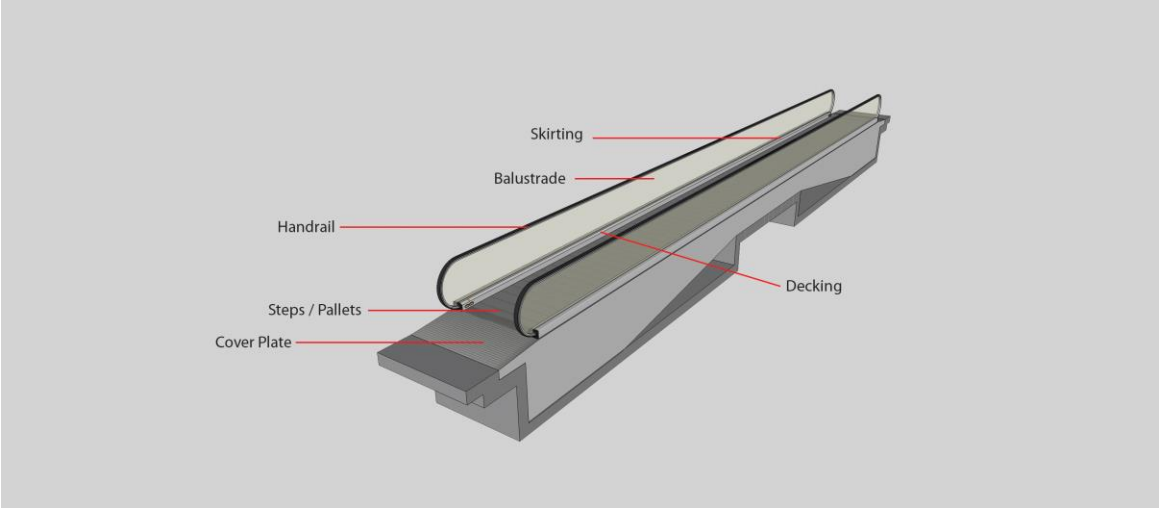

Figure 6: A Travelator (source: Sharplifts.com)

3.7.1 Different types of elevators used in building

Travelators come in one of two basic styles.

1. Pallet type
2. Moving belt

1. **Pallet type moving walkways** – are built from a series of connected flat metal plates that are joined together to form a walkway. This type of moving walkway has a metal surface, though some models have a rubber surface, tread bonded on top of the metal plates for extra traction.

2. **Moving belt walkways** – are essentially human conveyor belts. Moving belt walkways are generally built with mesh metal belts, which is a rubber surface over metal rollers. The walking surface may have a solid feel or a bouncy feel.

4.0 Design Constraints

Factors affecting the choice of vertical mode of circulation in buildings:

1. Volume of traffic
2. Height to be reached
    - Above 4 floors elevators are necessary
    - Escalators work only between two floors but can be placed one above another
3. Availability of space
4. Usage pattern
5. Convenience required

5.0 Conclusion

The idea of movement through space is one of the central themes in architectural theory, design, and practice. Circulation is a key factor in organizing a building layout, and hence is of interest for the architects to consider the users of the building. For instance, disabled people, as well as people with prams and push-chairs, young children and some older people, have particular difficulties in dealing with an environment designed for non-disabled people. It is important that these problems are recognized by the architect and full weight is given to finding ways to remove the barriers that prevent these people from leaving an active life. Generally, circulation provides free flow and ease of movement of people withing a building and its environment, hence the purpose of circulation should be maintained in every design.

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