CH. 21 – VERTICAL TRANSPORTATION

- ANSI/ASME code A17.1, Safety for Elevators, Dumbwaiters, Escalators and Moving Walks

HYDRAULIC ELEVATORS

- **Hydraulic elevator:** lifted by plunger or ram with oil as pressure fluid
  - Cylinder for the ram extended into ground depth the same as elevator heigh
- Speed is limited, slower than electrical elevators 25fpm – 150fpm
- Only for passengers and freight loads in 2-6 story buildings or 50'
- **Capacities:**
  - Single ram: from 2000lbm to 20,000lbm
  - Multiple ram: 20,000lbm to 100,000lbm
- **Holeless hydraulic:** telescoping plunger next to cab
  - Lifts by applying pressure to upper member of cab frame
- **Roller chain:** mounted over a wheel mounted on top of plunger w/ plunger mounted above the ground in the side of the shaft

ELECTRIC ELEVATORS

- **Electric elevator:** most common. Higher lifts and greater speeds
  - Precisely controlled acceleration and deceleration
  - **Traction elevators:** Cable suspended. Ropes draped over a sheave and attached to counterweight. Motor drives sheave which transmits lifting power
  - Counterweight is cab + 40%
- 250fpm to 1800fpm
- Capacities from 2000 to 5000lbm

Types

- **Gearless traction elevator:** uses DC powered motor directly connected to the sheave
- **Geared traction elevator:** slow speeds from 25fpm to 450 fpm
  - High speed DC or AC motor drives worm gear production assembly to provide slow sheave speed with high torque
  - **Flexibility:** many variations in gear reduction ratios, sheave diameter, motor speeds and roping arrangements

Roping

- **Roping:** arrangement of cables supporting the elevator
- **Single wrap:** rope passes over sheave once and connected to counerweight
- **Double wrap:** rope wound over sheave twice in high speed elevators for additional traction
  - More bends = shorter life
- 1**:1 roping:** when rope connected to counterweight where cable travels as far as car in opp dir
- **2:1 roping:** rope wraps sheave on counterweight and connects to top of the shaft, rope moves twice as far as cab
  - Requires less weight to be lifted ∴ smaller higher speed motor used
  - Desirable for speeds up to 700 fpm

Operation and Control

- **Operation:** the way the electrical systems for an elevator answer calls for service
- **Control:** method of coordinating all aspects of elevator service such as travel, speed, accelerating, decelerating, door opening speed and delay, leveling and hall lantern signals
- Operating systems coordinate elev response to signal calls on ea floor to minimize wait time
- **Single Automatic:** first automated system w/o single call button on each floor and single button for each floor inside car
  - Called if no one is using it
  - Passenger has exclusive use of the car until rip is complete

- **Selective collective operation:** most common, remembers and answers calls in oone direction then reverses. When trip complete, programmed to return to a home landing
- **Group automatic operation:** for large buildings with many elevators which are controlled with programmable microprocessors to respond

Safety Devices

- If power failure, brakes automatically applied
- Governor senses speed and if limit exceeded brake is applied
- **Rail clamp:** grips side rails
- Car buffers: stops motion if it over travels lowest stop
- **Safety edges:** movable strips on edge of door that activates a switch to reopen if something contacts it
- Photoelectric devices & proximity detectors serve same purpose
- Sensors under floor detect max weight reached thru deflection of floor
- If power failure all cars stop but codes require emergency power to operate at least one car
  - Code require if fire alarm activated all cars return to lobby w/o stopping ans switch to manual mode only operable by fire dept
- **Accessibility:**
  - Door opening 36"
  - Controls: 54" max for side approaches
    48" for front approaches
    must be designated by Braille and raised standard alphabet

ELEVATOR DESIGN

History

- Human, animal and water powered as early as 3rd century BC
- **Sir William Armstrong 1846:** inspired by hydraulic crane to invent the hydraulic elevator
  - 1870 hydraulic elevator began to replace steam powered elevator
- **Elishia Graves Otis 1853:** invented brake safety device
  - Due to increased safety allowed feasibility of high rises
  - **1900:** Otis co first introduced escalator
- **Werner von Siemens 1880:** first electric elevator

Capacity and Speed

- **Handling capacity:** number of people to be served, usually based on a 5-min peak period
  - Offices peak typ in morning
- Max number of passengers in car related to capacity in weight
- Recommended elevator speeds available based on the number of floors served and size of building

Number of Elevators Required

- Based on capacity and speed & elevator functions as door opening and closing time, delays and stops the average round trip time can be calculated and then handling capacity of the car in a given 5-min period can be determined
- Number of elevators required is then found by total number of people to be accommodated in a 5-min peak and dividing by capacity of one car.
- **Interval:** average wait time
  - **Diversified offices:** 30 – 35sec
  - **Hotels and apartments:** 40 – 70sec

Location and Lobby Design

- Min two elevators except in smallest applications so one available if one being serviced
- Easy to see all hall lanterns from one point (important for barrier free design)
- Never more than eight cars in a group or more than four cars in a line
- Taller and larger elevators to serve all floors increases proportion of shaft area to floor area increases beyond economic levels
  - It becomes impossible for single elevator to serve more than 12 – 15 floors w/o exceeding acceptable waiting and total travel times
  - **First method:** divides number of elevators into banks that serve zones
    - Shafts still take up significant space
  - **Second method:** sky lobby concept: intermediate lobbies travel from ground to intermediate where transfer to local cars
  - **Third method:** stacked or double decked elevator cabs
    - Serve even and an odd floor. Entry at two levels

Doors

- **Single speed center opening:** faster passenger loading than side opening
- **Two speed side opening:** Two leaves. telescope past each other
- Two **speed center opening doors:** four leaves.
  - Min width is 42" but 48" better which allows two people to pass

Machine Rooms

- Best located directly above hoistway and must provide space for motor, sheave, break, controller board, speed governor, floor selector mechanism and motor generator
- Abut as wide as hoistway and from 12' to 16' deeper than hoistway
- Min ceiling 7'-6" to 10'-0"

Accessibility

- Car must be self leveling to within 1/2" of floor landing
- Lobby **call buttons**: 42"
- **Hall lantern:** visible and audible signals
  - 72" and 2 1/2" min is smallest dimension
- **Braille character floor designation:** 2" high on both jambs and mounted 60"
- 5sec min notification between time when lantern is visible and when directional sound is heard
  - one tone = "up"
  - twice = "down"
- 3sec min for doors to remain open
- **Car control buttons** between 35" – 54"
- **Clear door width**: 36"

FREIGHT ELEVATORS

- **Freight elevator:** designed to transport equipment and materials
- **Elevator codes classification:**
  - A, B, C1, C2 and C3
    - **Class A:** general freight, no item can exceed 1/4th the rated capacity of the elevator
      - Rating cannot be less than 50 lbm/ft^2
    - **Class B:** used for motor vehicles loading
      - Rated at not less than 30 lbm/ft^2
    - **Class C:** industrial truck loading
      - Rated at 50 lbm/ft^2
- **Freight elevators common capacities:** 25000lbm to 8000lbm
  - Multiple ram hydraulic lift up to: 100,000lbm

ESCALATORS

- Rated by speed and size
- **Speeds:** Range from 90 – 125 fpm
  - **Industry speed:** 100fpm
  - **Other speeds:** 120 fpm (for transportation and sports facilities)
- **Sizes:** 32 (tread width = 24"), 40 (tread width = 32") and 48 (tread width = 40")
- B/c 40" size does not increase capacity of a 32" escalator in actual use, the two most common sizes are 32 and 48
- **Treads:** 16"
- **Risers:** 8"
- **Clearance:** 7'-0"
- Actual capacity is less than theoretical maximum capacity b/c under crowded conditions, people space themselves every other step on 32" models and on an average of every step on 48" models
- **Capacity:**
  - 32"model = 2300 people per hour
  - 48"model = 4500 people per hour

STAIRS AND RAMPS

- Stairs most basic types of vertical circulation
- Stairs classified into two broad categories
  - **Utilitarian purposes:** exit stairs
  - **Monumental stairs**
- When circular stair have smaller radius than required by code, they are classified as winding stairs
- Circular stairs, the inside smaller arc cannot be less than twice the width of the stair. If it is, considered a winding stair
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Exit Stairways

- Completely enclosed
- In buildings four or more stories in height, must have 2hr rated walls
- Buildings less than four stories (including mezzanines) 1hr rating

Requirements for All Stairways

- **Serving an occupant load of more than 50:** min 44" or Occupant load X .3 or .2 (greater)
- **Serving an occupant load of less than 50:** min 36"
- **Handrails** may project 4 1/2"
- If accessible means of **egress:** min 48"
- **Risers** min 4", max 7" (R-2: max riser = 7 3/4")
- **Treads** min 11" (R-2: min tread = 10"
- Winding, circular and spiral used as exits in R-3 occupancies
- L**andings** at top and bottom
  - Min width = width of stair, but need not exceed 48"
- **Max distance between landings** is 12' vertically
- **Handrails:** both sides, intermediate required fo all portions of stairs for egress are within 30"
  - Stairways wider than 5' must have intermediate
  - Top = 34" – 38"
  - Must extend not less than one tread beyond top and bottom riser
  - Ends must be returned
  - 1 1/4" – 2" dia, easily gripped and 1 1/2" between it and wall
- **Nosing:**
  - 1/2" radius max
  - 1 1/4" max projection
  - 1/2" radius w/ 60° angle to a max projection of 1 1/4"