17 Mechanical transportation

Learning objectives

Study of this chapter will enable the reader to:

1. understand the principles of passenger and goods transportation within and between buildings;
2. discuss the applications of passenger lift systems;
3. know the speeds and carrying capacities of lifts;
4. know how lift systems are controlled and used during the outbreak of fire in a building;
5. know the principles of electric motor and hydraulic lifts;
6. know the principles and carrying capacities of escalators and passenger conveyors;
7. understand the importance of lift shaft and motor room ventilation;
8. recognize the builder's work required for a lift installation.

Key terms and concepts

Introduction

The mechanical transportation of people and goods is an energy-using service which needs the designer's attention at the earliest stages of building design. Standards of service rise with expectations of quality by the final user and with the provision of access for disabled people.

The principles of transportation systems are outlined and reference is made to movement between buildings. Their energy consumption may be low, but the electrical power requirement is significant for short periods. Integration with other services, fire protection, means of escape and correct maintenance are of the highest importance.

Transportation systems

The mechanical transportation of people and equipment around and between buildings is of considerable importance in relation to the degree of satisfactory service provided. Increasing usage of computer networks, internet, digital communications will gradually reduce travel requirements. Cost-effective and energy-efficient transportation will always be in demand. Walking and cycling are supreme of personal low-cost mobility for the majority of the population. City express cycle lanes for aerodynamically enclosed human-powered vehicles can be provided with present-day technology for cruising speeds of 45.0 km/h. Tunnels and covered above-ground routes could be used for conventional bicycle traffic on large building developments or around towns. When the total concept of global sustainability is thought about, alternatives to consuming highly refined forms of primary energy, as electricity, must be considered.

Permanently installed energy-consuming systems in use are as follows:

Lifts

Passenger lifts are provided for buildings of over three storeys, or less when wheelchair movement is needed. The minimum standard of service is one lift for each four storeys, with a maximum walking distance of 45.0 m between workstation and lobby. Higher standards of service are provided in direct proportion to rent earning potential of the building and prestige requirements.

The peak demand for lift service is assessed from the building size, shape, height and population. Up to 25% of the population will require transportation during a 5-min peak period. Congestion at peak travel times is minimized by arranging the lift lobbies in a cul-de-sac of, say, two lift doors on either side of a walkway, rather than in a line of four doors along one wall.

Computer-controlled installations can be programmed to maximize their performance in a particular direction at different times of the day. Each lift car can be parked at an appropriate level to minimize waiting time. Two lifts of 680 kg carrying capacity, 10 people, provide a better service than one 1360 kg, 20-person lift. The large single lift would run only partly loaded during the major part of the day, with a resulting decrease in efficiency and increased running cost. One of the smaller lifts could be parked for long periods to reduce costs. The advantages of using two smaller lifts may be considered partly to outweigh the additional capital and maintenance costs.

Car speed is determined by travel distance and standard of service. Buildings of more than 15 storeys may have some high-speed lifts not stopping for the lower 10 storeys. A 49-storey tower in the City of London has double-deck cars serving two reception floor levels simultaneously. Sky lobbies are halfway up and near the top of the tower; non-stop service is provided in both lower and upper sectors between the main lobbies, at a speed of 7 m/s, intermediate floors being served with lower-speed stopping lifts. Travel from basement car parking to the main street lobby is usually a dedicated low-speed service.

Car speeds for various travel distances are shown in Table 17.1.

Car speed is chosen so that the driving motor can be run at full speed for much of the running time to maximize the efficiency of power consumption. Starting and accelerating power is greater than steady speed energy use, as it is with a road motor vehicle. Deceleration during braking dissipates the momentum gained by the car and counterweight in friction-generated heat, lost to the atmosphere and into the lift motor plant room at the top of the shaft. The overall speed of operation is determined by the acceleration time, braking time, contract speed (maximum

Table 17.1 Design lift car speeds.

Floors	*Car speed (m/s)*
4	0.75
9	2
15	3
Over 15	5–7

car speed), speed of door opening, degree of advance door opening, floor levelling accuracy required, switch timing and variation of car performance with car load.

The automatic control system should function in an upward collecting and downward collecting mode. Requests for service made sufficiently early at a lobby cause the car in that shaft to break its original journey instruction and stop. Computer controls are used to optimize the overall performance of the installation, by causing the nearest car to stop and to minimize electricity consumption.

In the event of a fire within the building, the central fire detector and alarm system signal causes all the lifts to run to the ground floor. Where the building extends out of the reach of conventional fire-fighting turntable ladders on vehicles, at least one of the lifts is designated as the fireman's lift. Its main features are the following:

1. platform area and contract load of at least 1.45 m^2 and 550 kg;
2. reaches the top of the building within 1 min;
3. has power-operated doors of not less than 0.80 m clear opening that are arranged to remain open at any floor;
4. has an overriding 'Fire Control' switch at the fire control floor level, to bring the lift under manual control of the fire officer. This switch brings the lift immediately to the fire control floor, which is the fire officers' entrance level; all other controls are made inoperative.

Goods lifts travel at a maximum of 1.0 m/s and have full width doors, sometimes at each end of the car. Accurate floor levelling, to within 5.0 mm, may be provided to facilitate smooth passage of trolleys carrying fragile goods, fluids or patients in a hospital. Passengers can use goods lifts but service is slow. A variable-voltage electrical or hydraulic power supply is used. Hydraulically operated lifts have the advantage of very quiet operation and low running costs. The only power-consuming plant item is a small hydraulic pump immersed in an oil tank. Goods lifts complete each journey instruction before accepting another. Door operation can be manual or automatic. Additional structural supports are needed for lifts with high carrying capacity and well-designed brakes. Non-metallic serrated inserts may be fitted into the grooves of the driving pulley (sheave) to reduce wear and increase traction.

Service lifts are small goods lifts with car floor areas of up to 1.20 m^2 and heights of less than 1.40 m. The serving level may be 0.850 m above floor level to coincide with the working plane. Documents, goods or food are carried at up to 0.50 m/s with a maximum contract load of 260 kg. Control can be manual or semi-automatic. Prefabricated service lifts can be installed in a day and require minimal builder's work. Controls and the electric driving motor can be at the base of the shaft and a chain drive used.

Service conveyors for document transportation combine horizontal and vertical movement. An installation in the City of London transfers documents throughout a bank complex using briefcase-sized carriages on a continuously moving railway track with sidings for loading and unloading.

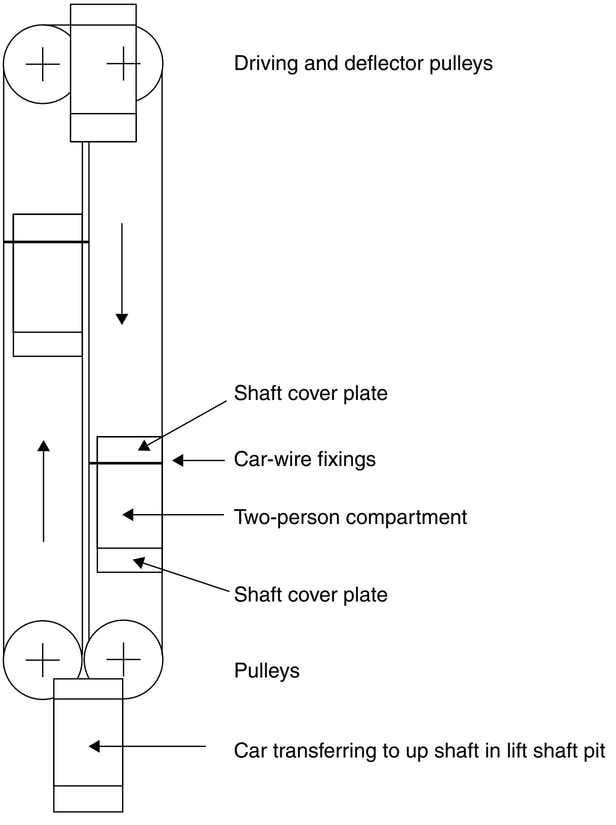
A tunnel connects buildings on either side of a street. The Post Office unmanned underground electric mail trains are another example.

Paternoster

A number of doorless two-person lift cars travel continuously in a clockwise direction within a common vertical shaft. The principle of operation is shown in Fig. 17.1. This system is used in an office or an adult education building which requires regular inter-floor travel over short distances for normally agile people. A conventional passenger lift is installed alongside the paternoster for the carriage of more passengers, goods, children, the elderly or the infirm. Paternoster performance over more than about six storeys is limited by its low speed, 0.40 m/s. Its carrying capacity is 720 passengers per hour. A degree of acclimatization is needed for its use. Car spacing is 4.0 m. Chain drive from electric motors is employed. The driving motor, brake, gearing and control equipment is fitted in a machine room at the top of the shaft. Emergency stop buttons are at each floor level and are linked to an audible alarm.

Escalator

Escalators and passenger conveyors are primarily used where large numbers of passengers form surges at discharge times from offices, railway underground stations and airport terminals.



17.1 Paternoster lift.

Crowd flow, in plan, is similar to two-dimensional turbulent fluid behaviour and design for passenger routes can be regarded in a similar manner. Escalators provide suitable transport for all ages, laden or unladen. Their operating direction is reversible to correspond to peak travel times. Tread widths are from 0.60 to 1.050 m. For a given quality of service, they require less horizontal floor space than a lift. The angle of inclination is normally 30°, but 35° can be used for a vertical rise of less than 6.0 m and a speed of less than 0.5 m/s. Speeds of up to 0.75 m/s are permissible as this is the maximum safe entry and exit velocity.

Passenger conveyors

Passenger conveyors are moving pavements which can carry wheeled vehicles such as shopping or luggage trolleys, prams or wheelchairs. Distances of up to 300 m can be travelled at speeds of up to 0.90 m/s with an 8° slope. Combinations of grade, horizontal and up grade can be included, as in a road underpass. An S-shaped track overcame the limitation of entry and exit speed restriction on journey time by having its floor constructed from metal plates which slide relative to each other. The plates bunch together at the entry and exit curves of the track but spread out along the central straight which may be up to 1000 m length. Travel speed along the straight can be five times the entry speed. An electric motor of 19 kW drives the conveyor through a reduction gearbox and chain and 7200 passengers per hour can be carried. A concrete ramp forms the structural base for the entire conveyor. Emergency stop buttons are provided.

Driving machinery

The lift car and its load are partly balanced with a counterweight and this reduces motor power consumption. Motor power is used to overcome friction, acceleration, inertia and the unbalanced load during lifting. Power is transmitted to the traction sheave through a gearbox, two-speed or variable-speed motor driving sets, sometimes using direct current motors. The motor and driving sheave are mounted on a load-bearing concrete base at the top of the lift shaft. Considerable heat output is created and lift motor room natural or mechanical ventilation is essential plus in some cases, mechanical cooling from an air-handling unit, in hot climates.

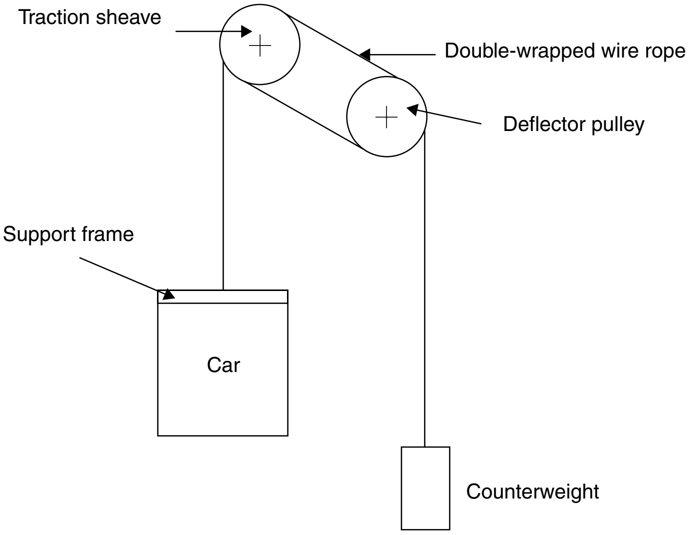
The wire rope configuration for higher-speed lifts is shown in Fig. 17.2.

The lift motor room must be maintained at between 10°C and 40°C by natural or mechanical heating and ventilation if necessary. This ensures a condensation-free atmosphere in winter and adequate motor cooling in summer. A smoke extract ventilation grille of 0.10 m^2 free area must be provided at the top of each lift shaft. Some noise is produced in the motor room and its escape from this area is limited by a vibration-isolating concrete machine base and the concrete construction of the lift motor room. The external noise level produced is considered in conjunction with nearby room usage to assess whether additional attenuation is required.

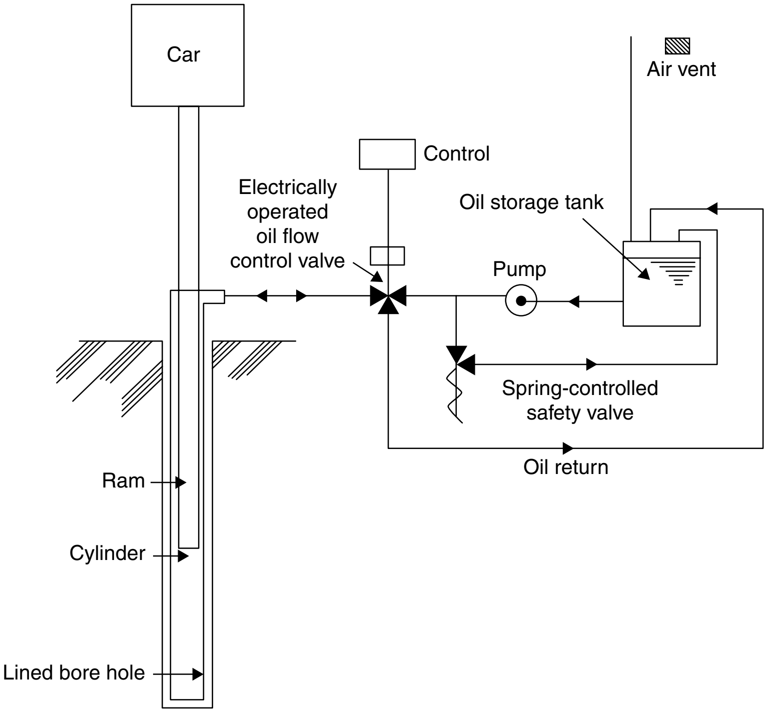
Air bypass holes, as large and as frequent as possible, cross-connect adjacent lift shafts to allow car-induced draughts to circulate with minimum restriction. An emergency electrical power generator is often installed so that, in the event of mains failure, one lift at a time can be run to the ground floor and the doors opened. One lift can then be made available for the emergency services and emergency lighting is provided.

Hydraulic drive is often used for lift speeds up to 1.75 m/s for passenger travel and goods lifts of up to six storeys. Alternative bore hole and rope drum drive operation principles are shown in Figs 17.3 and 17.4.

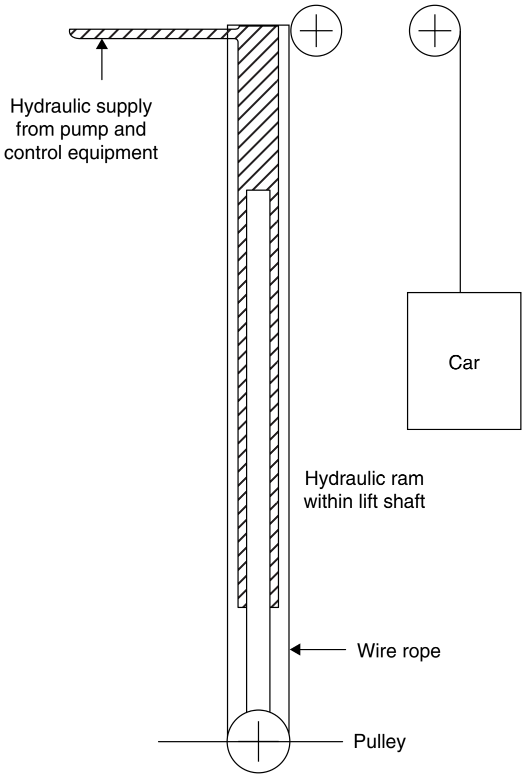
Service lifts can use an electric-motor-driven winding drum with a deflector pulley at the top of the shaft, a pulley on top of the car and the motor at the bottom of the shaft. This is less efficient than counterweighted designs but saves space and complexity.



17.2 Traction arrangement for a high-speed passenger lift.



17.3 Hydraulic lift drive.



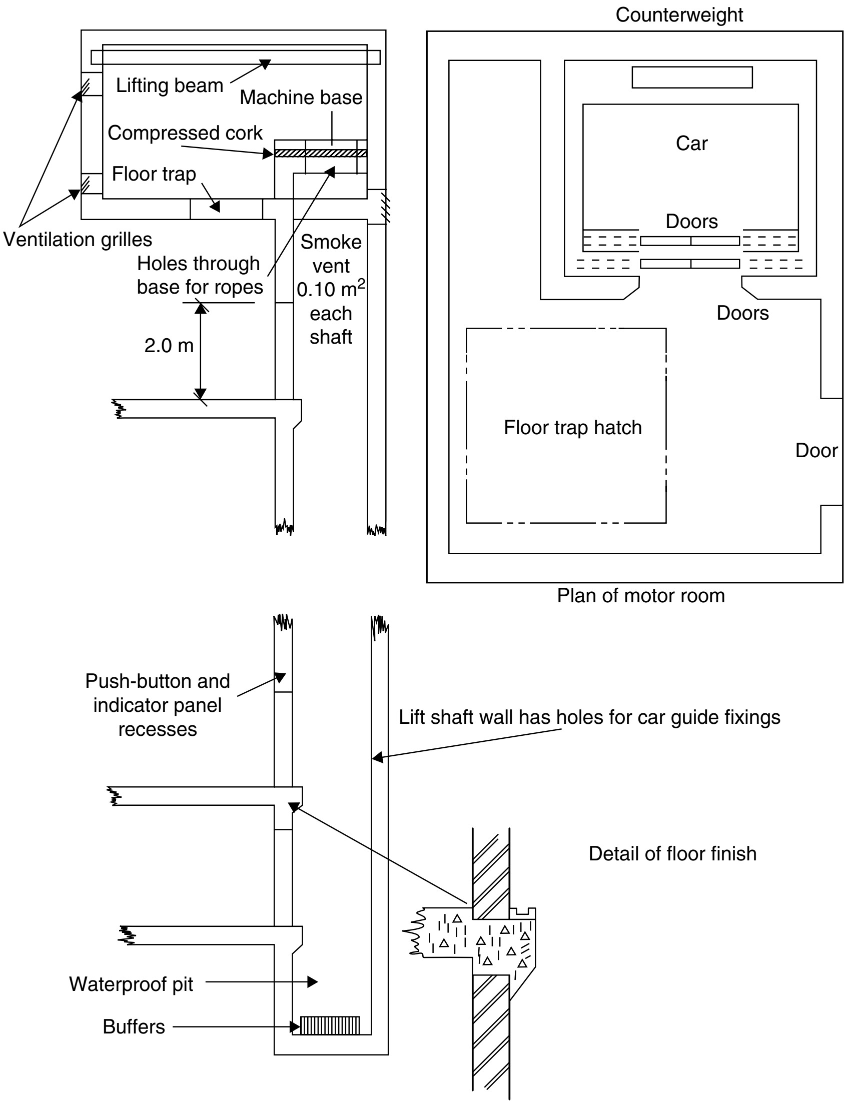
17.4 In-shaft hydraulic lift drive.

Each passenger lift car has a service hatch in its ceiling. When this is opened, an electrical interlock switch opens to prevent the lift from being operated while escapees or a maintenance engineer may be in the shaft. A mechanical extract fan is often fitted in the roof of the car.

A lift motor room has the following features:

1. a concrete machine base incorporating a vibration-isolating cork slab to separate its upper and lower parts;
2. motor and brake equipment bolted to the upper, vibration-isolated, concrete slab;
3. flexible armoured electrical cable connections to the motor;
4. lift motor main isolating switch close to the plant room door;
5. access hatch into the lift shaft;
6. electrical control panel, switches or digital;
7. lifting beam built into the structure;
8. adequate artificial illumination;
9. natural or mechanical ventilation;
10. 13 A power point;
11. locked door;
12. light-coloured walls and ceiling;
13. emergency telephone.

The main constructional features of a lift shaft and motor room are shown in Fig. 17.5.



17.5 Constructional features of a passenger lift shaft.

Questions

1. Explain how transportation systems are employed within and between buildings to assist the movement of people and goods. Include details of the main characteristics of the systems, their performance and costs.
2. Explain with the aid of sketches, drawings or illustrations from the internet how high-speed electrically driven lifts operate and where they are used.
3. Give examples of mechanical transportation systems used in buildings. Take photographs of installations available to you if permission is granted. Use the internet and manufacturers resources to illustrate current practices.

4. Comment on improvements which might be made in the current designs mechanical transportation systems used in buildings.
5. Explain with the aid of sketches, drawings or illustrations from the internet how goods and hospital lifts operate and where they are suitable.
6. Suggest some probable future developments that may occur for mechanical transportation systems used in buildings, giving reasons.
7. Discuss the statement, 'Having machines to move people through buildings contributes significantly to obesity and lack of physical fitness.'
8. Compare the use of primary energy to operate mechanical transportation systems used in buildings with alternatives and comment on the differences.
9. Discuss the statement, 'Having tall buildings where vertical travel can only be accomplished by consuming primary energy is not sustainable.'
10. Explain with the aid of sketches, drawings or illustrations from the internet how hydraulic lifts operate and where they are suitable.
11. Visit a lift motor room in a large building, with the permission of the building manager. Photograph, report and draw a detailed description of the installation, room space dimensions, control cabinets, motor and drive arrangement, ventilation and temperature control systems.
12. Use a lift system in a building where you have permission to enter, and measure the typical round trip time for a journey from the entrance foyer to the top of the building and back to the foyer. Record the number of stops, passengers carried, type of lift system and time taken by the door systems. Comment on the quality of service provided.
13. Visit an escalator system, with the permission of the building manager if it is not a public facility. Photograph (if possible), report and draw a detailed description of the installation, space dimensions and suitability for the application. Comment on the quality of service provided.
14. Sketch, draw or illustrate from the internet and publications how drive systems for mechanical transportation systems work. Clearly show their principles of operation, how they use primary energy and where they impose loads on the building structure.
15. List the builder's work associated with lift installations. Show by means of sketches or drawings where these items will be located and how they will be performed by the construction team. At what stage of the building will the lift installation be constructed and how will it be achieved?
16. Which are correct about escalators? More than one correct answer.

    1. Run continuously.
    2. Reversible in flow direction.
    3. Stop and start frequently to save energy.
    4. Require electrical drive.
    5. Provide sloping and horizontal travel.

17. Which are correct about lifts? More than one correct answer.

    1. Lift capacity is designed to move the whole population of the building in or out within a 10-min period.
    2. Number and speed of lifts in an office building are designed to match the likely inflow of people into their building.
    3. Need negligible maintenance.
    4. Lift cars have to be air-tight.
    5. Lift cars have an access hatch.

18. Quality of a lift service is determined from:
    1. Number of passengers carried in each car.
    2. Highest car speed attainable.
    3. Round trip time for one lift divided by the number of lifts available.
    4. Passenger comfort.
    5. Quietness of the lift system.
19. Which are correct about lift motor rooms? More than one correct answer.
    1. There aren't any, all components are within the lift shafts.
    2. The motor sits on top of each car and has a pulley at the top of the shaft.
    3. Electrical lift motor room is situated at the top of each lift shaft.
    4. Hydraulic lift motor room is at the base of the lift shaft.
    5. Lift motor rooms are always halfway up the lift shaft.
20. Lift and escalator installations:
    1. Lift systems can be added to the building design after important design decisions have been agreed.
    2. Escalators are just motorized stairways and do not need much design work.
    3. Lift systems are an after-thought in the overall concept of the building.
    4. Transportation systems do not cost much.
    5. Mechanical movement systems for the building's occupants are critical to the success of the project.
21. Transportation systems:
    1. Allow people to become unfit; we should walk.
    2. Are not essential for several categories of buildings and building user.
    3. Allow rapid movement around large sites.
    4. Do not need much energy to operate.
    5. Need no maintenance.
22. Where could a double-deck lift system apply?
    1. Combined goods and passenger lift cars.
    2. Commercial buildings of around 20 stories.
    3. High-speed long-travel lifts.
    4. Low-speed short-travel lifts.
    5. Hospitals.