LIFT TRAFFIC ANALYSIS

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Users Expectation on Vertical Transportation

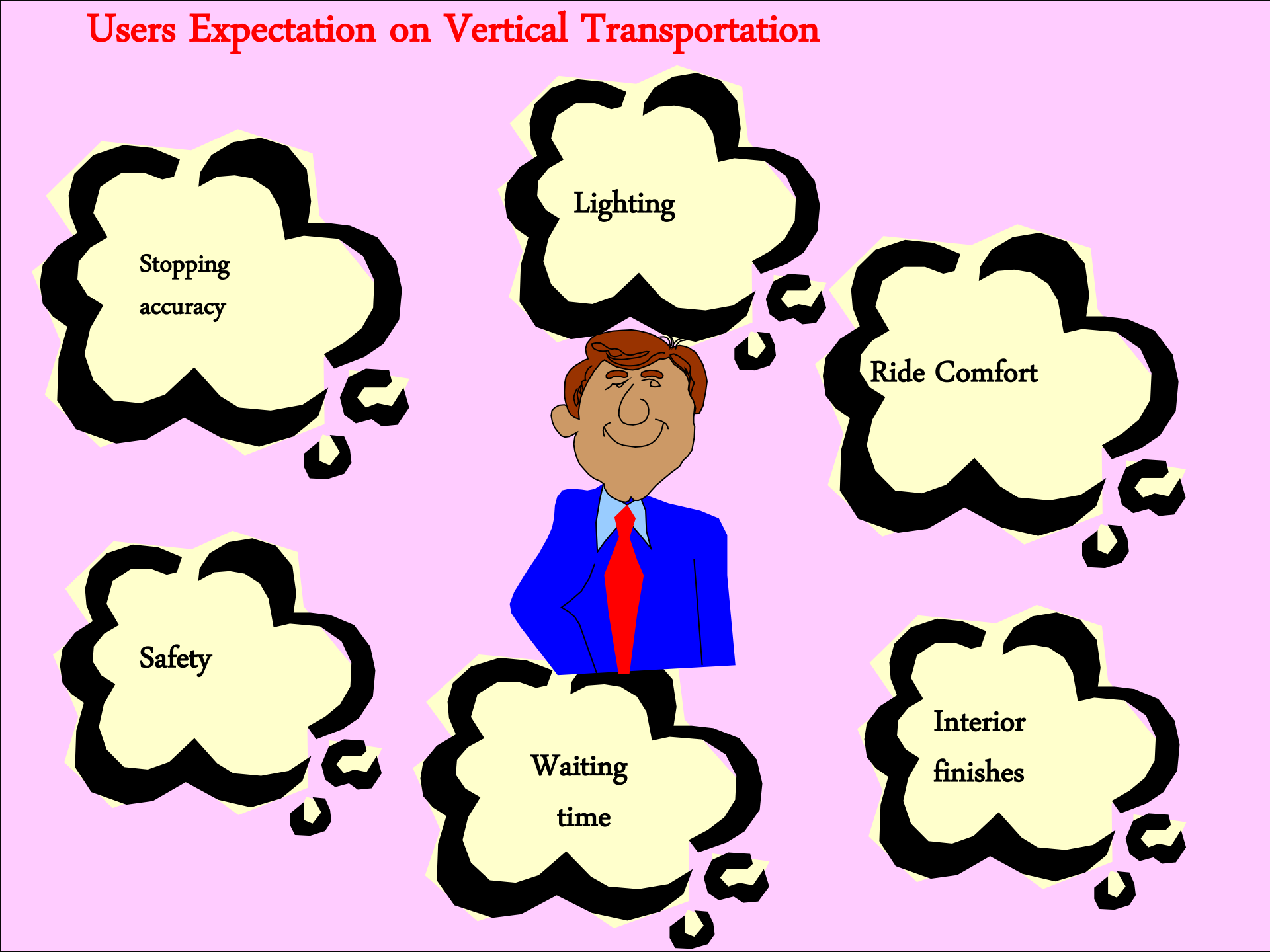


TABLE 1

LIFT SELECTION - OFFICE BUILDINGS

No of floors >	UP TO 5 FLOORS			6 - 10 FLOORS			11 - 15 FLOORS			16 - 20 FLOORS		
** Area per floor (m^2)	No	Capacity (kg)	Speed (m/s)	No	Capacity (kg)	Speed (m/s)	No	Capacity (kg)	Speed (m/s)	No	Capacity (kg)	Speed (m/s)
500	3	900	1.6,	4	1,050	2.5	6	1,350	3.0	6	1,350	3.5
750	3	900	1.6	4	1,050	2.5	6	1,350	3.0	6	1,350	3.5
1,000	3	900	1.6	6	1,050	2.5	8	1,350	3.0			
1,250	3	900	1.6	6	1,050	2.5	8	1,600	3.0			
1,500	3	900	1.6	8	1,050	2.5						
1,750	4	900	1.6	8	1,150	2.5						

NOTES:

** 1. Indicates the net usable building area. Normally, it is taken to be 80% of building gross area.

2. For selection within the shaded area, please consult the Mechanical Engineer.

3. Service lift may be provided for buildings having 6 or 8 lifts in a group.

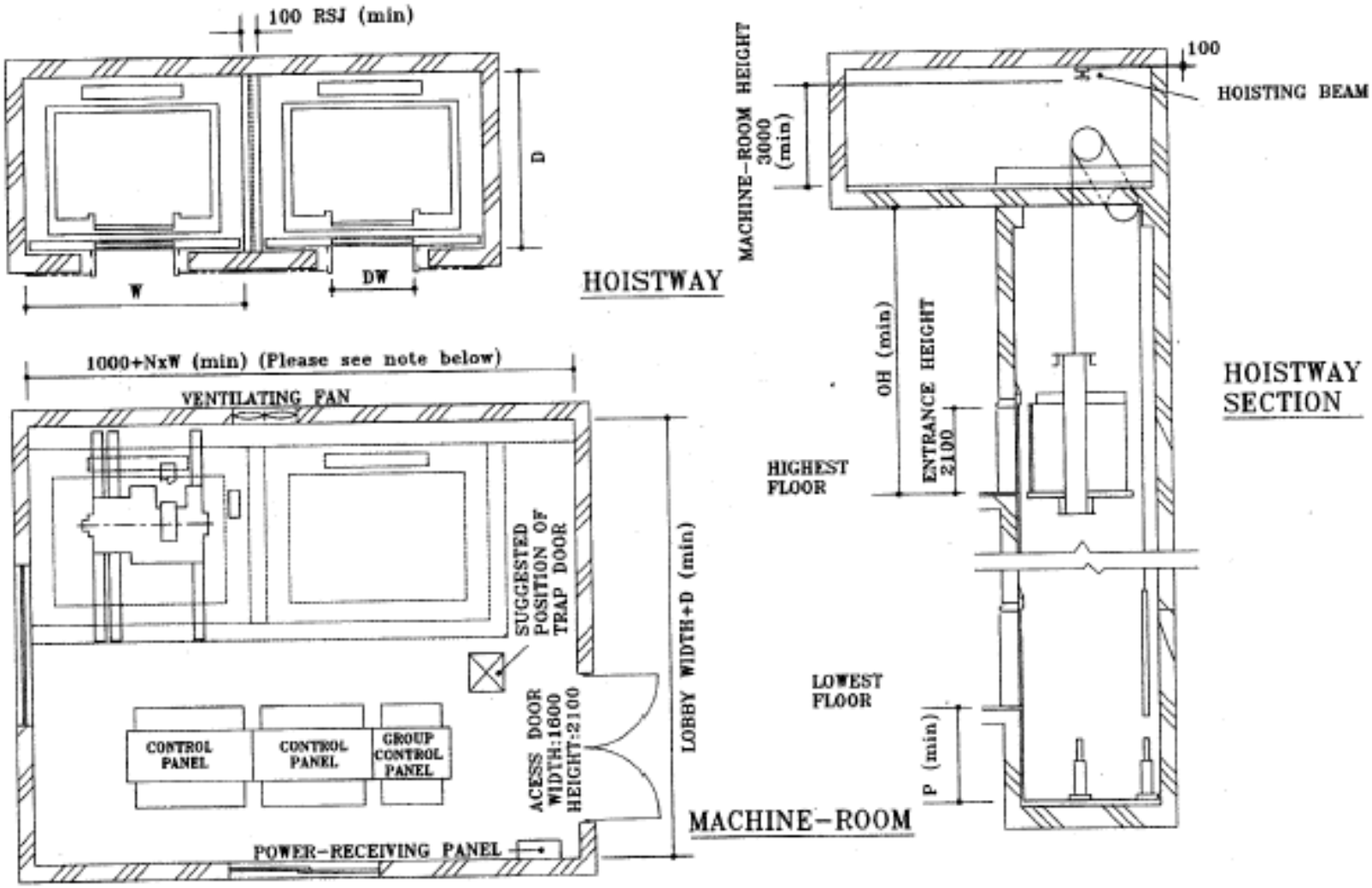
TABLE 2

LIFT SHAFT DIMENSION - OFFICE BUILDINGS

LIFT CAPACITY kg (person)	SPEED (m/s)	HOISTWAY DIMENSIONS (mm)				ENTRANCE DOOR DIMENSIONS (mm)	
		PIT DEPTH P	HEADROOM OH	WIDTH W	DEPTH D	WIDTH DW	HEIGHT DH
900 (13) and 1,050 (15)	1.6	2,100	5,100	2,100	2,300	900	2,100
	2.5	2,300	5,500				
	3.0	2,800	5,800				
	3.5	3,500	6,000				
1,150 (17) and 1,350 (20)	1.6	2,100	5,100	2,500	2,300	1,100	2,100
	2.5	2,300	5,500				
	3.0	2,800	5,800				
	3.5	3,500	6,000				
1,600 / 23	1.6	2,100	5,100	2,500	2,500	1,100	2,100
	2.5	2,300	5,500				
	3.0	2,800	5,800				
	3.5	3,500	6,000				

FIGURE 2

GENERAL PLANT ROOM LAYOUT AND DIMENSIONS FOR IN-LINE ARRANGEMENT



NOTES:

1. N in the expression equals to number of lifts in the bank

Lift Traffic Analysis

GENERAL CONSIDERATION

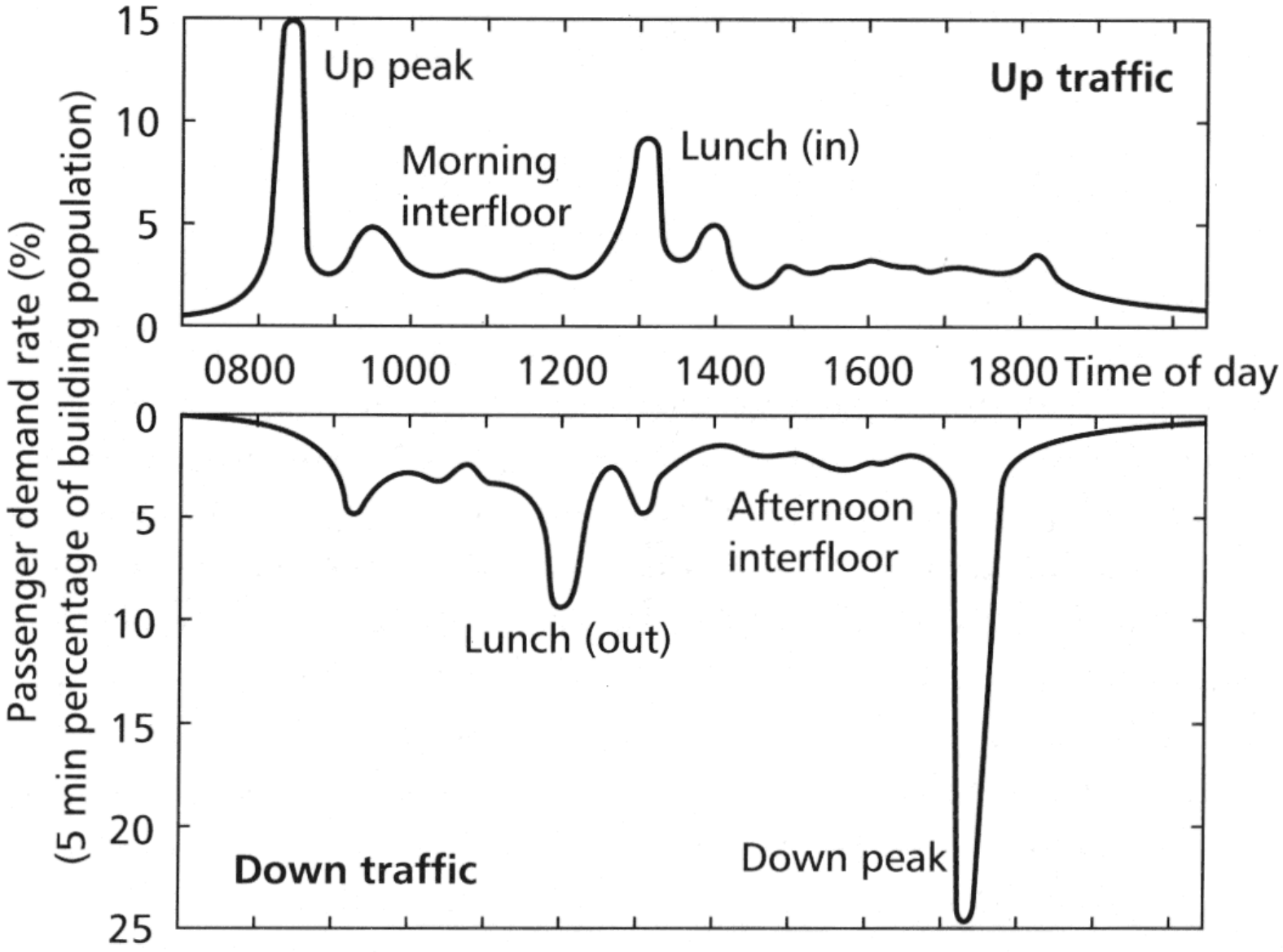
- Application
- Office building/Hospital/commercial
- Capacity & Nos. Of Lift
- Traffic and size of building
- Speed of lift
- Number of stops and traffic load
- Lift Doors
- Depends on application
- Number of stops/opening
- Depends on building height, applications

Lift Traffic Analysis

- Other Requirement
- Electrical switch boards and power points in lift motor rooms
- Ventillation fans and lightings in machine rooms
- Cat Ladders and power points in lift pits
- Structural openings in lift motor rooms, hoistways etc.

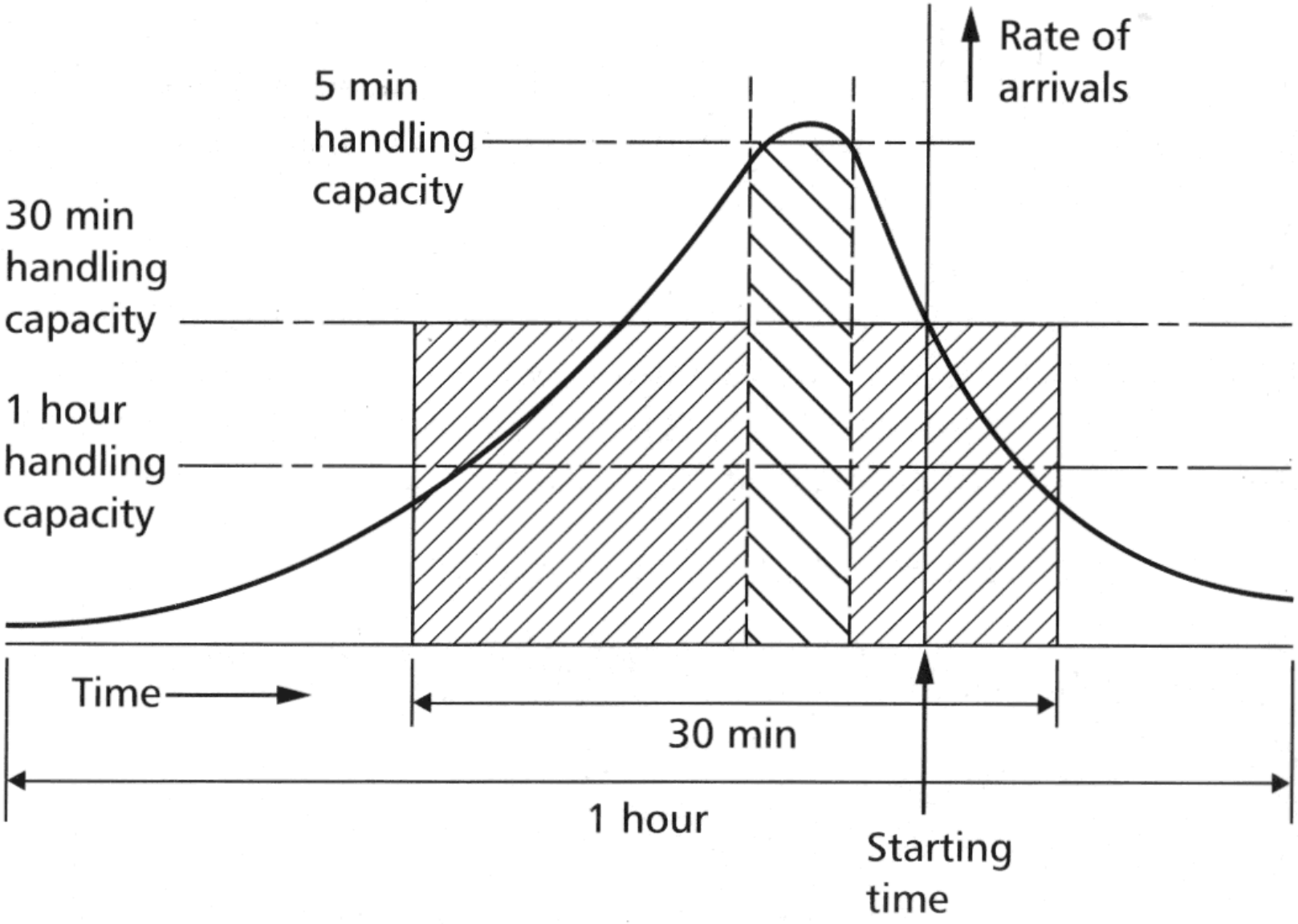
Lift Traffic Analysis

- **Assessment of demand**
  - Traffic patterns (in an office building)
    - Morning UP peak
    - Evening DOWN peak
    - Two-way traffic (lunch periods)
    - Interfloor traffic
    - Other considerations, e.g. 'Flexitime' attendance
  - Estimation of population (occupant density)
  - Estimation of arrival rate



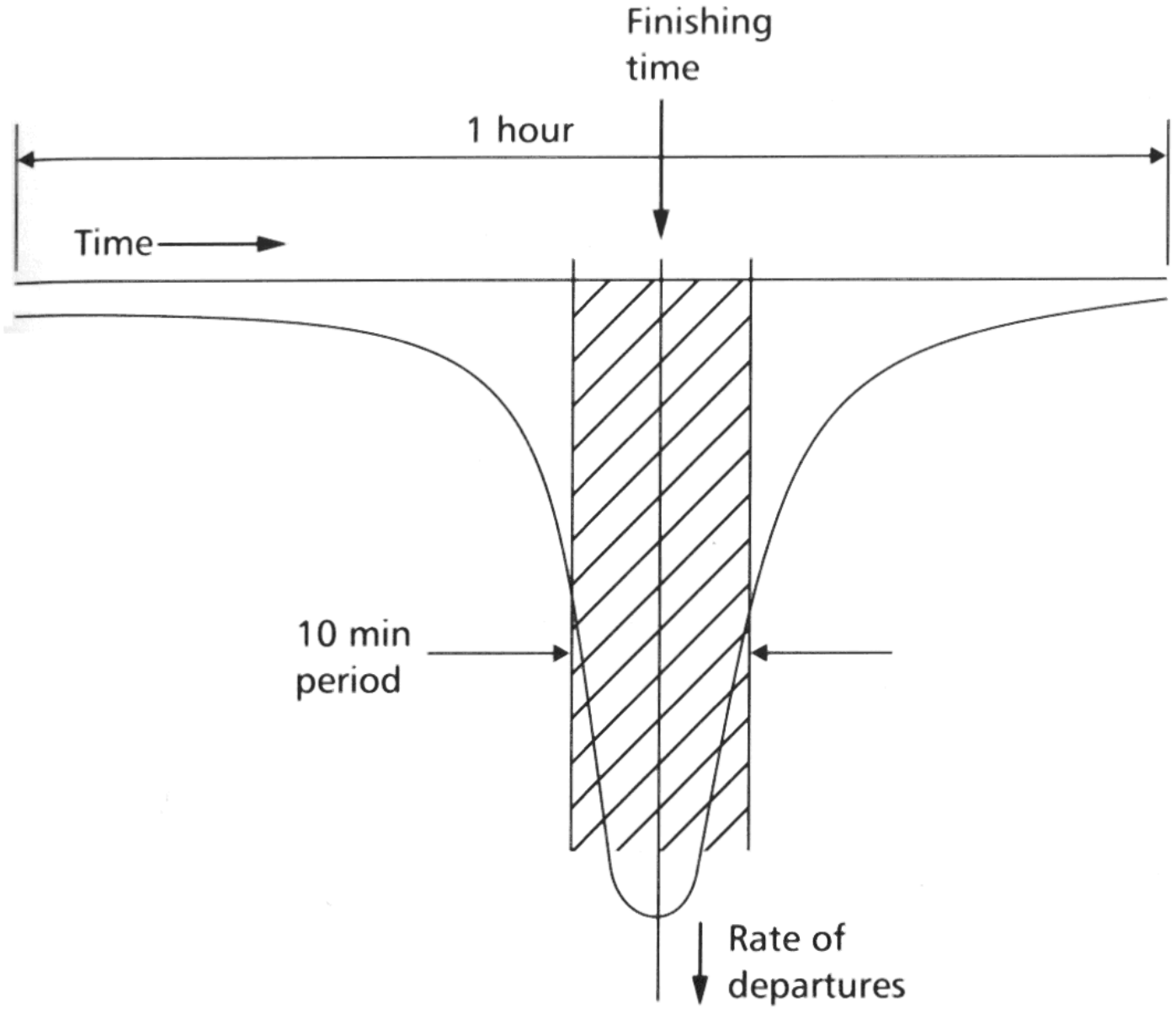
Traffic pattern in an office building

[Source: CIBSE Guide D]



Up peak traffic profile

[Source: CIBSE Guide D]



Down peak traffic profile

[Source: CIBSE Guide D]

Estimation of population

Building type	Estimated population
Hotel	1.5-1.9 persons/room
Flats	1.5-1.9 persons/bedroom
Hospital	3.0 persons/bedspace*
School	0.8-1.2 m^2 net area/pupil
Office (multiple tenancy): - Regular - Prestige	 10-12 m^2 net area/person 15-18 m^2 net area/person
Office (single tenancy): - Regular - Prestige	 8-10 m^2 net area/person 12-20 m^2 net area/person

* excluding patient

[Source: CIBSE Guide D]

Percentage arrival rates and up-peak intervals

Building type	Arrival rate (%)	Interval (sec)
Hotel	10-15	30-50
Flats	5-7	40-90
Hospital	8-10	30-50
School	15-25	30-50
Office (multiple tenancy): - Regular - Prestige	 11-15 15-17	 25-30 20-25
Office (single tenancy): - Regular - Prestige	 15 15-17	 25-30 20-25

[Source: CIBSE Guide D]

Lift Traffic Analysis

- Estimation of quality of service
  - **Actual average passenger waiting time (AWT)**
    - Time between the instant of passenger arrival until the instant of the actual arrival of the lift
    - Shorter the waiting time, better the service
    - But cannot be measured easily
  - **Interval of car arrivals at the main terminal**
    - Often taken to estimate the probable quality of service
    - A part of the evaluation of handling capacity
    - AWT $\approx$ 85% of the interval (assumed 80% car loading)

Lift Traffic Analysis

- Lift traffic calculations

(1) Based on classical formulae & results

- For the worst 5-min period during morning up peak

(2)Based on a discrete digital simulation of the building, its lifts and the passenger dynamics

Such as for down peak, two-way & inter floor traffic

Need to work at early design stage with architect or planner and the client to establish the lift system & its design criteria.

Probable quality of service in office buildings

Interval (sec)	Quality of service
20	Excellent
25	Very good
30	Good
40	Poor
50	Unsatisfactory

[Source: CIBSE Guide D]

Lift Traffic Analysis

Calculate up peak performance

- Determine round trip time (RTT)
  - Time for a single lift to make a round trip
- Select number of lifts (L)
- Determine up peak interval (UPPINT)
  - Such as, <= 30 sec (good)
- Determine up peak handling capacity (UPPHC)
  - During the worst 5-min (300 sec) of up peak

Lift Traffic Analysis

- RTT = $2\ H\ t_v + (S + 1)\ t_s + 2\ P\ t_p$
  - H = average highest call reversal floor
  - t_v = single floor transit time (s)
  - S = average no. of stops
  - t_s = time consumed when stopping (s)
  - P = average no. of passengers carried
  - t_p = passenger transfer time (s)
- UPPINT = RTT / L
- UPPHC = (300 x P) / (UPPINT x U)

Lift Traffic Analysis

- Parameters in RTT equation
  - Average no. of passengers (P)
    - P = 0.8 x rate capacity of lift car
  - Average highest call reversal floor (H)

$$H = N - \sum_{i=1}^{N-1} \left(\frac{i}{N} \right)^P$$

  - Average no. of stops (S)

$$S = N \times \left(1 - \left(1 - \frac{1}{N} \right)^P \right)$$

$$H = N - \sum_{i=1}^{N-1} \left(\frac{i}{N} \right)^{P}$$

- $H = N - \sum_{J=1}^{N-1} \left(\sum_{i=1}^{j} \frac{U_1}{U} \right)^{P}$

- N = Number of floors above terminal floor to
- be served by the lift system.
- U = Total population in the building
- U_1 = Population at floor

$$S = N \times \left(1 - \left(1 - \frac{1}{N} \right)^{P} \right)$$

- $S = N - \sum_{i=1}^{N} \left(1 - \frac{U_1}{U} \right)^{P}$

- N = Number of floors above terminal floor to
- be served by the lift system.
- U = Total population in the building
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Lift Traffic Analysis

- Parameters in RTT equation (cont'd)
  - Single floor transit time, $t_v = d_f / v$
    - d_f = average interfloor distance (m)
    - v = contract (rated) speed (m/s)
    - For a lift serving an upper zone, an extra time to make the jump to/from the express zone to the main terminal must be added:

$$\text{RTT} = 2\,H\,t_v + (S+1)\,t_s + 2\,P\,t_p + [2\,H_e\,t_v]$$

    - H_e = number of average height floors passed through to reach the first served floor of the express zone

Lift Traffic Analysis

- Parameters in RTT equation (cont'd)
  - Time consumed when stopping

    $t_s = T - t_v = t_f(1) + t_c + t_o - t_v$

    - T = floor-to-floor cycle time (s)
    - $t_f(1)$ = single floor flight time (s)
    - t_c = door closing time (s)
    - t_o = door opening time (s)
  - Floor cycle time (T) has the most effect on RTT
    - Can be used to judge the quality of service
    - For a good system, T = 9 to 10 sec

Minimum Door Opening Times

Panel arrangement	Door Size	
	0.8m	1.1m
Side Opening	2.5s	3.0s
Centre Opening	2.0s	2.5s

Minimum Door Closing Times

Panel arrangement	Door Size	
	0.8m	1.1m
Side Opening	3.0s	4.0s
Centre Opening	2.0s	3.0s

Guide to selection of lift contract speed

Contract Speed (m/s)	Lift Travel (m)
< 1.00	< 20
1.00	20
1.50	30
2.50	45
3.50	60
5.00	120
>5.0	>180

Lift Traffic Analysis

- Parameters in RTT equation (cont'd)
  - Passenger transfer time (t_p)
    - Vague to define
    - Depends on:
      - Shape of lift car
      - Size and type of car entrance
      - Environment (commercial, institutional, residential)
      - Type of passenger (age, gender, purpose, etc)

Lift Traffic Analysis

- Assumptions of RTT equation
  - Average no. of passengers
  - Passengers arrive uniformly in time
  - All floors equally populated
  - All cars load to 80%
  - Rated speed reached in a single floor jump and interfloor height are equal
  - Other operating time (like dwell time) ignored
  - Traffic controller is 'ideal'

Lift Traffic Analysis

- Average passenger waiting time (AWT)
  - Average time an individual passenger waits at a floor before being able to board a lift
    - Not dependent solely on UPPINT
    - Also affected by the average car load and the arrival probability distribution function
  - Some design criteria for different traffic patterns have been derived empirically based on the simulation method (see *CIBSE Guide D*)

Lift Traffic Analysis

– Basic simple criteria

- Average waiting time is 30 to 60 seconds. Common users expectation.
- Average Max 5 stops per lift.
- Max travel time for the lift to return to ground floor from highest floor is 60 seconds. Therefore, lift speed is set based on this criteria.
- 20% of floor population weight is equal to about 80% of the per lift capacity. Per person weight is 68Kg.

Lift Traffic Analysis

Expectation/ Building	Waiting Time	Lighting	Ride Comfort	Interior Finishes	Stopping accuracy	Safety	Door Opening/ Closing (Noise)	External Appearance
Flat	High	Low	Low	Low	Low	High	Low	Low
Hospital	High	High	High	Low	High	High	Low	Low
Public Bus Station	High	Low	Low	Low	Low	High	Low	Low
Office/Commercial Building	High	High	High	High	High	High	High	High
VIP Offices	High	High	High	High	High	High	High	High
Private Use	High	High	High	High	High	High	High	High
Factory	High	High	Low	Low	High	High	Low	Low

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