THE LOBBY - A "TRIVIAL" ELEMENT IN LIFT DESIGN

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ABSTRACT

Lift system design is based primarily upon the handling capacity of the equipment during a sample period of the morning up peak traffic condition. An integral part of the ability to feed people into the lift system is the lobby on each level, but particularly the one at the lower terminal, where the intending passengers mass while waiting to be conveyed. The design of the lobby does not form part of the lift installation, and in many cases, the lobby is designed by people not associated with the industry, with results detrimental to the system operation. This paper investigates problems arising from such a marriage, in some larger buildings.

1 THE LIFT LOBBY

Numerous publications have been written, and investigations made into the movement of people in buildings. Handling capacities of corridors, stairs and transportation equipment are well documented, and form a necessary part of the building design. Statutory requirements are used also in most countries to dictate the minimum standards for such buildings.

Lift lobbies in many countries do not have the same documentation or requirements. Some specific needs are evident, such as minimum access for wheelchairs and fire egress, otherwise the arrangement appears to be one for the greatest convenience to the designer. Often, this is the best "on paper" fit in a service core, and can result in inconvenience to the occupants of the buildings, particularly during periods of peak traffic.

Several lobby arrangements have been investigated in office buildings, in Sydney, Australia, to indicate the effects of their design on the overall lift system.

2 PASSENGER EXPECTATIONS

Persons wishing to use the lifts would expect to enjoy the quality of service for the particular type of building. This is expressed as hypothetical average passenger waiting times, indicative of the expected wait of the passenger from the time of arrival at the lift lobby, and the arrival of the next suitable lift. Using data that is available readily, the lift system can be designed to achieve a predetermined quality of service. This is the expected task of the lift system design engineer.

As indicated in CIBSE Guide D[1], and other related publications, an excellent service is one in which the passenger waiting interval (disregarding car loading) is 20 seconds or less; a good service has 20 - 25 seconds; a satisfactory service has 25 - 30 seconds; and so on, to poor and unsatisfactory systems.

Before considering the quality of service requirements, however, it is necessary to contemplate the lift installation from the view of a person entering the building for the first time. Doubtless each of us has experienced the difficulty, in the jungle of multi-zoned lift systems, of determining which bank of lifts served the required floor. Rarely are the zones indicated clearly, since there appears to be an architectural or interior design reluctance to "spoil" the decor of main entry lobbies by such mundane indication appendages.

Passengers expect to enter the next lift which arrives at the lobby. In many cases during the morning peak condition, the lift lobby becomes crowded, and they are not able to reach the desired lift before it is either filled, or departs partly empty. Such a lift system is, as a consequence, unable either to cater for the design service or satisfy the intending passengers, in these instances, through reasons outside the system design parameters.

Undoubtedly, the worst condition for lobby congestion, is that where the lower zone bank of lifts also serve the basements of the building. In this situation, people endeavour to leave the lifts at the lower terminal in order to travel in lifts to higher zones, while others are struggling to enter the cars from the crowded lobby. No traffic system yet invented can overcome such design limitations.

3 LOBBY DESIGN

Lift lobbies may be designed with a variety of objects in view, other than those associated directly with the use of lifts by passengers. They may comprise part of an ornate entrance to the building, or to a particular floor. There may be security, noise, fire or smoke isolation requirements in lobbies of some particular buildings. Each of these latter considerations, by providing restraints, will have a direct bearing on the quality of the lift service. For the process of this study, however, the special requirements are not considered specifically, other than to note their possible effect on the lift service.

Conventional lobbies will therefore be considered here. These encompass arrangements where the lifts are either in a single line or there are two banks of lifts facing each other. A deviation from these simple arrangements is one where lifts for separate zones are in single banks, with the back wall of a shaft facing the doors of the neighbouring group.

4 DESIGN PARAMETERS

4.1 Documentary Data

The theoretical requirements for lift lobbies are indicated, for example in Clause 2.4.3 of CIBSE Guide D[2], where preferred side by side and facing lift arrangements are shown; and Tragenza[3], who relates the crowding of the lift lobby to inefficiency in the lift service. Documentary evidence on the corollary, where the efficiency of the lift service is effected by the lobby environment, appears to be lacking. It is necessary only to stand, if one can, in the lobby of any restricted main entrance level of a large office building during the morning up peak condition, to appreciate the effect of a crowded lobby.

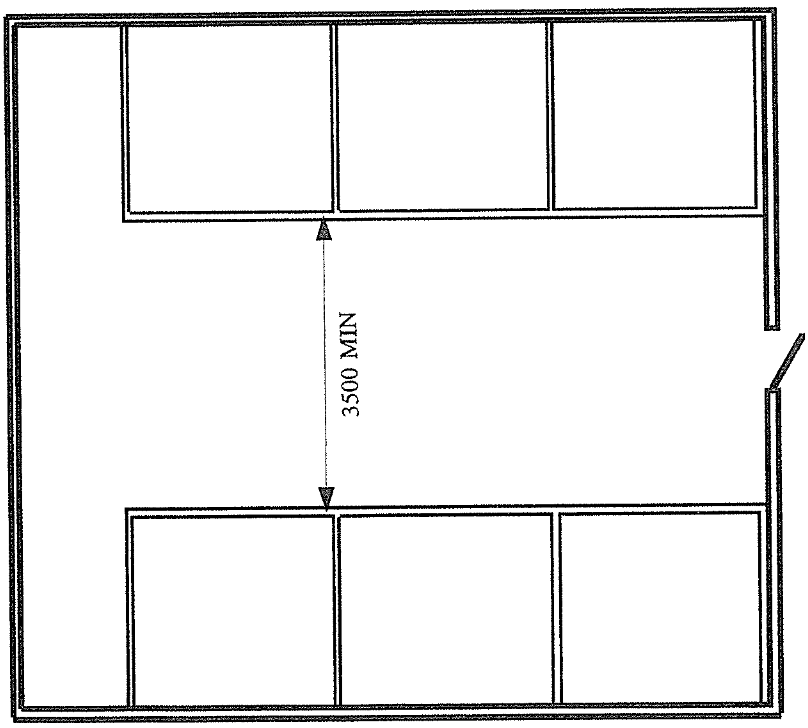

Figure 1 - Typical Otis Well and Machine Room Plan, Multiple Shafts Opposite

Marmot[4] carried out a study at the University of Sydney on twenty multistory office buildings, in order to establish an empirically based model of lift lobbies. She found that basic relationships exist between the lobby areas and the building population, lobby areas and the number of lifts, and the number of lifts and the total office area. She concluded that those relationships should be developed further, before any assessment could be made of lift lobbies **in terms of lift system performance**. No additional paper has been seen in evidence of this matter being considered further, and it appears that it has been left to lie on the shelf, as someone else's problem.

4.2 Restricted Lobbies

Doubtless for machine room layout convenience, as indicated in Figure 1 on the previous page, the Otis Elevator Company, has indicated a minimum dimension of 3500 millimetres between the lobby side of the lift well walls for facing shafts in their standard layout data sheets.

Australian architectural convention endeavours to restrict this dimension to 3000 millimetres, to minimise the service core, and to allow the maximum possible area for letting. This can create a double edged sword, since the corresponding larger office area involves a greater number of occupants, who require greater service provisions. If these are inadequate dissatisfaction can be created, with consequent long term empty space potential, and a possible downgrading of the value of the building for leasing purposes. This required dimension appears to have derived from the manufacturer's desired machine room extension for a single bank of lifts, as indicated in Figure 2.

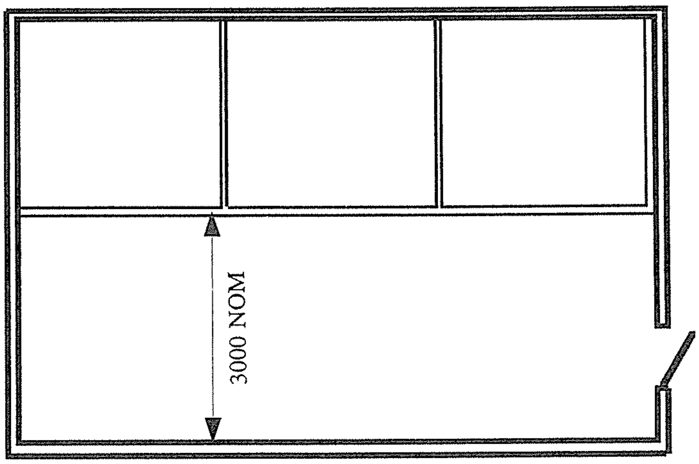

Figure 2 - Typical Otis Well and Machine Room Plan, Multiple Shafts in Line

The information provided in both Figures 1 and 2 derived from standard brochures provided by the manufacturer, however have been simplified to indicate only the issues related to this paper. Figure 3 on the following page has been developed from the same information, and visual evidence at the Northpoint Building in North Sydney, Australia, where the author spent several years of his working life, and learned to appreciate the trauma, and techniques used while having to live with restricted lobbies.

Due to the narrower space requirement for the machine room in the second example, it is obvious that any lobby provision, based upon this requirement would provide less space for waiting passengers, with the resultant possibility of crowding in times of peak traffic. This is the effect of the design of a system where the front of one bank of lifts faces the rear of the neighbouring bank, and the core has been laid out to take up the minimum space possible.

In situations where statutory limitations, excepting those that relate to fire access and egress, and to requirements for disabled persons, are not applied to lift lobbies, there is no reason, for them to be any deeper than the minimum required by the lift manufacturer for the lift machine room. The design of such a lobby has consequently little to do with the capacity of the system, the building population, or the grade of the lift system. Circumstances exist where building tenants have exacerbated this problem with upper level narrow lobbies served by a single bank of lifts, by stealing up to a metre of depth for the creation of enclosed and locked storage of archival material. Building management appears to have shown little interest or concern in such further intrusion into the available lobby space.

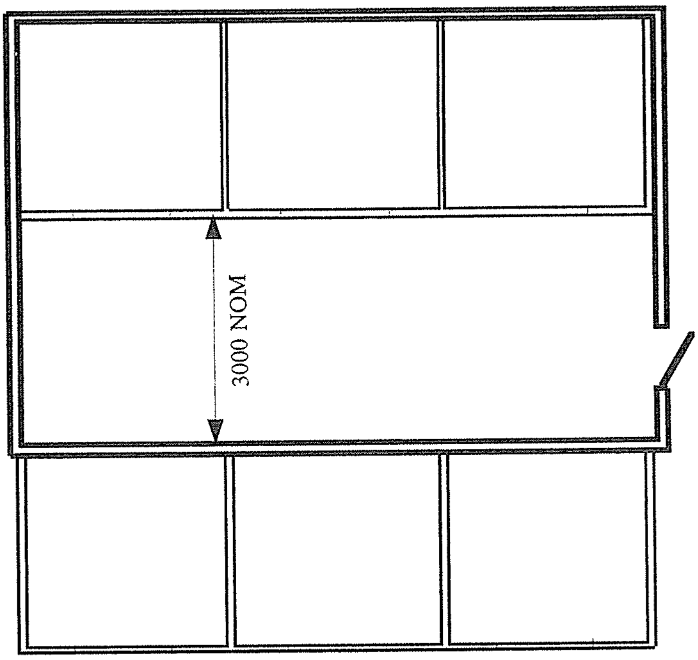

Figure 3 - Typical Otis Well and Machine Room Plan, Multiple Shafts Front to Back

4.3 Lobbies With Convex Shaped Lift Well Faces

Circular section buildings, as well as being difficult to divide up for office areas, can also create serious lobby problems. If the lifts are part of a central core, then they are designed generally around the core, facing toward the building perimeter. This arrangement creates the condition where all the lifts in a bank cannot be seen from any point in the lobby, and the doors of all zone banks are on the circumference of a round face. The advantage of this arrangement is the ability of the main lobby to accommodate a large number of waiting passengers, however this is outweighed by the disadvantages.

Substantial frustration occurs when a passenger reacts to the signal of an arriving lift, but by the time he has determined where it is, and reached it, the car has already left. The next arriving car in his zone at the terminal is, of course, at the other end of the bank, and a potential passenger, knowing he can't reach it before it leaves, in desperation makes for the twenty storeys of stairs to his office. The Australia Square building in Sydney, New South Wales, designed by the architect Harry Seidler, includes an example of such an "abomination" for lift passengers. The author's observation here is not intended as a criticism of the building as a unit, although it does mean to indicate dangers attending the design of a building based upon such a circular plan.

Were it possible to locate the lift doors on the inside of the lift wells, facing toward the core centre, a more passenger friendly lift system may have eventuated, although this would have created, no doubt, crowding in the internal lobby. In addition, the services that exist in the core area would have needed to be located elsewhere, causing additional architectural concerns about the "clean line" design of the building.

Following observation of passenger movement in several buildings with a lift system having the doors on a convex wall, the author can find little to support such a design.

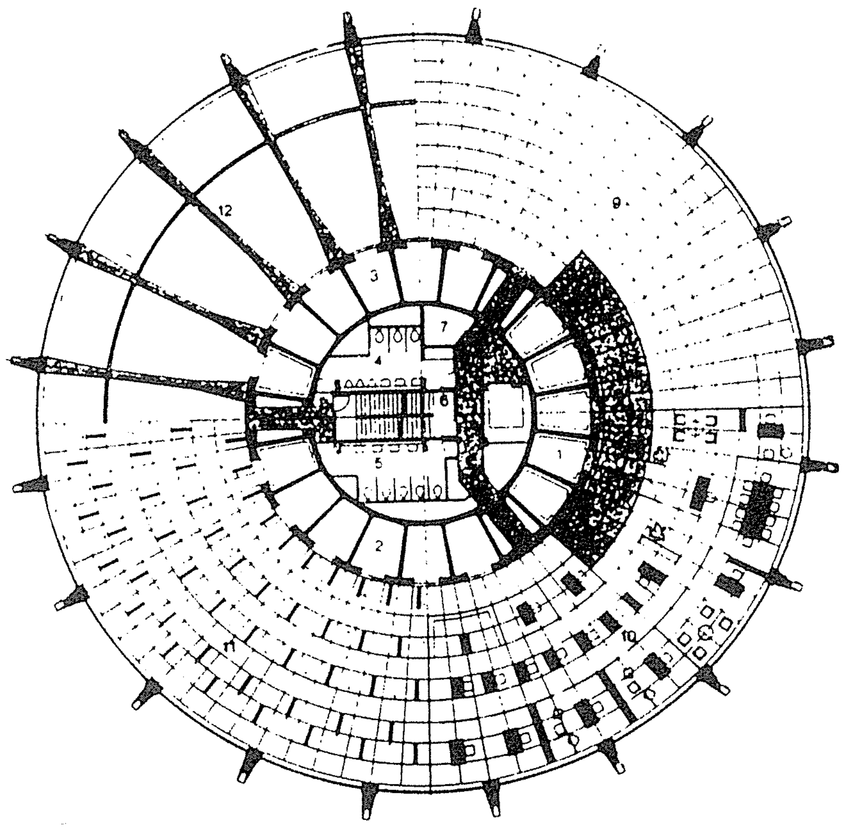

Figure 4 - Layout of the Australia Square Building Showing Convex Shaped Lift Well Face

4.4 Lobbies With Concave Shaped Lift Well Faces

Several examples exist of buildings in which the lifts are located on a large radius curved pattern at the end of a conventional entry lobby. This is an arrangement which appears to work extremely well, since the slight curvature provides a high quality visual impression, while maintaining a large assembly area, and easy access to the lifts.

Opinions given by occupants of such buildings support the suggestion that this style of lobby and car arrangement provides a perceived superior lift system to either the straight lobby or a convex layout, although the actual passenger waiting interval may be longer than that existing in a comparable but restricted corridor type lift lobby. The American Express Tower building, also in Sydney, and designed by the architect John Andrews, is an example of this arrangement.

This arrangement can create larger than normal lobbies at the upper levels of the building, and, as a consequence, would be uneconomical with regard to the maximisation of space available for leasing. It is a style more applicable to a high prestige building where tenancy considerations would be of lesser importance than an appearance of opulence.

5 LOBBY CAPACITIES

Table V, "Area per person to be allowed in various circulation areas", of the AJ Metric Handbook[5], indicates that the design area per person in an enclosed lift lobby should be between 0·5 and 0·65 square metres. This would be increased to up to 0·9 square metres per person where there is a cross-flow in the lobby.

Assuming a lift system comprising five or six standard 21 passenger lifts, as indicated in Figure 1 above, and used in the calculation in the following section. From Table VII, "Approximate dimensions of lift cars and wells for preliminary planning purposes" of the same handbook, the lift well width is 2540 millimetres, and there would be a 150 millimetres beam or wall between the wells. The total length of the lobby, assuming that the arrangement is two banks of three lifts in line facing, is:

$$3 \times 2540 + 2 \times 150 = 7920 \text{ millimetres,}$$
(plus the depth of both end walls).

From the information given in Figure 1, the distance between the walls of each lift bank is 3500 millimetres, which would provide a usable lobby area of 27·72 square metres. This would provide the space for a maximum of:

$$27{\cdot}72/0{\cdot}5 = 55{\cdot}44, \text{ or } 55 \text{ persons.}$$

Since space is required on both sides of the lobby to allow movement to the lift cars, the greater area per person is considered:

i.e. $27{\cdot}72/0{\cdot}65 = 42{\cdot}65.$

As a consequence, 42 persons can be accommodated in the lobby at any time, or were it subject to cross-flow traffic, at 0·9 square metres per person, only 31 people. This latter event would be most unlikely during a peak traffic period, since the block of people in the lobby makes the use of it impracticable for cross-flow traffic, unless that is the only means of access. Even then, from the author's personal experience, interference between cross-flow traffic and waiting lift passengers, creates an intolerable situation.

If the system of six lifts was changed to one with two separate banks of three lifts serving different areas of the building, as indicated in Figure 3 above, then the lobby width would be reduced to 3 metres, providing a useful lobby area of:

$$7{\cdot}92 \times 3{\cdot}0 = 23{\cdot}76 \text{ square metres.}$$

This would reduce the number of people able to be accommodated to 36, or 26 with cross-flow traffic. Interference would be intensified in this more restricted lobby, particularly as there would be only three lifts available to clear the lobby.

The condition would be exacerbated further if one bank of lifts served the basement during the morning up-peak condition. If the lower zone only of a lift system, or part of it, served the basement, then an already crowded main terminal lobby would be subjected to a number of passengers from the basement wishing to use lifts of another zone, forcing their way against the flow of people endeavouring to enter the lift.

It may be convenient, at this stage, to reconsider the lift system design which formed the example in the author's previous paper on basement traffic[6], in order to determine the relationship between the lift system and the lobby design, as well as the effect of the lobby on the lift system.

6 SAMPLE CALCULATION

6.1 Assumed Data

Using data, tables and formulae from Sections 3 and 11 of CIBSE Guide D,

Area per floor - 1220 m^2 net

Number of floors above main terminal - 12

Number of basements - 3

Population density - 10m^2 per person (Table 3.1)

Floor to floor distance - 3.3 metres throughout building

Required Interval is 25 seconds (Table 3.2)

6.2 Calculations

UP SERVICE FROM TERMINAL

1220/10 = 122 persons per floor

= 122 x 12

= 1464 persons total

At 80% occupancy, Population (Clause 3.3.5)

= 1464 x 0.8

= 1171.2

Arrival rate is 15%, hence Peak Arrival Rate (Table 3.2)

= 1171.2 x 0.15

= 176

Interval is 25 seconds (Table 3.2)

Number of trips in 5 minutes $= \frac{300}{25} = 12$

Number of persons per trip $= \frac{176}{12} = 14{\cdot}67$

Car size $= \frac{14{\cdot}67}{0{\cdot}8} = 18{\cdot}33$, say 21 passenger

H = 11·7, S = 9·2 (Table 3.5)

RTT $= 2 \times 11{\cdot}7 \times 1{\cdot}32 + (9{\cdot}2 + 1) \times 5{\cdot}5 + 2 \times 16{\cdot}8 \times 1{\cdot}2$ (Equation 3.3)

$= 29{\cdot}57 + 56{\cdot}1 + 40{\cdot}32$

$= 125{\cdot}99$ seconds

An up-peak interval of 25 seconds is required

No. of cars $= \frac{125{\cdot}99}{25} = 5{\cdot}04$ UPPINT $= \frac{125{\cdot}99}{5} = 25{\cdot}20$ seconds (acceptable)

UPPHC $= \frac{300}{125{\cdot}99} \times 16.8 \times 5 = 200{\cdot}02$ persons per 5 minutes (c.f. 176 required)

In the previous section, it was determined that 42 persons can be accommodated in the lift lobby for this lift system at any time. The lift cars could remove 16·8 persons every 25 seconds, or 40·32 each minute, which is in excess of the 35·2 persons as required by the initial calculation (176 for five minutes). It would appear then, that for this lift system, the lobby would be of a size adequate for the capacity of the lift system.

7 LOBBY INEFFICIENCIES

The above calculation and finding does, of course, assume a constant arrival rate of passengers over the five minute up-peak period, but observations have shown that this does not occur in practice. The indication is that people tend to arrive in groups, due no doubt to a variety of reasons, such as the concurrent arrivals of public transport, traffic conditions, or merely the close proximity to the normal start time. Examination of confined lift lobbies indicates that at times during the up-peak period, a lobby of the size in the previous example, although appearing more than adequate in theory, will not have the capacity for the number of people arriving, and intending to use the lift system, during that time.

Crowd crush occurs near to the doors of the next arriving lift, and the lifts, as a consequence, can take longer than the normally allowed time of 1·2 seconds per passenger to load[7]. The determination of that time in the CIBSE Guide is based upon human behaviour, shape and type of the car entrance, the building type and the characteristics of the passengers, but does not appear to consider the effects of crowding in the lobby.

With cross-flow, crowding and inconvenience often is even worse, due to the conflict of intention of the different lobby users, and people getting in the way of each other. This is particularly noticeable in buildings where there is no alternative path for people other than through the lift lobby. Although a most undesirable access and lobby design, it does occur in practice, unfortunately, with some development buildings designed with minimal cost as the prime consideration.

Most programmes and calculations on lift traffic design encountered by the author do not appear to take any account of the crowding of lift lobbies. The ACADS lift program "Lama", distributed by the Australian Computer Aided Design Service, however, appears to be one of the rare examples of a calculation which does take some, although general, account of problems in lift lobbies. The operating manual issued by the service for that program, includes the following paragraph:

> " **2.12 Inefficiency Factor**
>
> Should the lift lobby be narrow or the lift cars a shape which restricts passenger movement or the lift doorways are fitted into very thick walls it would be reasonable to allow an increase on loading and unloading times, typically 10%."[8]

It can be seen that, although some allowance has been made in this program for a general range of variations to normal expected usage, the appearance is of a simple arbitrary percentage time addition to allow for such eventualities. No further definition is provided; it seems as though the program developers were endeavouring to "cover their backs" against what may have been indicated as a problem area.

As with most design systems, the emphasis appears to be upon the purity of the lift system, rather than the problems encountered by the passengers under adverse conditions. It is evident that lift systems operate less efficiently where there is a restricted lobby, and allowance should be made in all programs and calculations for this.

8 OBSERVATIONS

Lift lobbies of the space restricted form were observed both during normal and morning peak operation, and car loading times were recorded during each of these periods. The actual waiting intervals of random passengers were taken, in an endeavour to determine a relationship between them. The process was repeated in buildings with unrestricted lobbies, in order to establish whether the longer loading times were a result only of lift system inefficiency, as suggested by Peter Tragenza, or if the lobby arrangement had a major effect on those times.

Initial findings were to a great extent inconclusive, since they varied between similar buildings within a particular type. The arrival of intending passengers varied considerably, to the extent that the limited number of samples taken for this exercise could not be considered as a fair overall indication of a normal condition. In one building surveyed, modification of the lift system commenced during the investigation period, with the result that one lift in each bank, or 25% of the installation, was disconnected from the system. With apologies to W. S. Gilbert, a researcher's lot is not a happy one.[9]

Some circumstances were evident very quickly. With the exception of a very few aggressive individuals, people did not use through lobbies as a pathway during peak periods, preferring to find an alternative route.

It was common for intending passengers to be pushed to positions very close to the landing doors with crowded lobbies, causing a "plug and burst" situation when the lift doors opened. A crush delay was created immediately after the doors opened, followed by a push of people into the lift as the crush sorted itself out. In many instances, due to the momentum of the push, the car became overcrowded, and passengers had to leave the car before it would be able to start. A delay was caused beyond the normal loading time of the lift, which would have had an adverse effect on the round trip time of that particular car, and consequently the passenger waiting interval.

In other instances, in the same lobbies, people would be prevented by the crush from reaching the next available car, which would leave partly empty, and appeared to add a further extension to the passenger waiting interval for the system.

Some aspects appeared to show some promise for future study. The apparent similarity in car loading between lobbies of relatively unrestricted size, and lobbies with multiple lift shafts opposite, is an example. Both arrangements seemed to provide a relatively free flow of passengers to the lift cars, a feature which was not apparent with the more restricted lobbies which had a bank of lifts facing a blank wall opposite. It was in such lobbies that the problems of crush were evident.

An explanation may be that psychological influences are in play in such circumstances. People feel, when they are forced to stand near to a back wall by a crush of their fellows, that they are remote from the lift system, and later arrivals will deprive them of their turn to use the lifts. They tend to push through the waiting passengers to improve their position.

This does not appear to occur in open lobbies, since there is always plenty of space, and the waiting passengers feel more comfortable. Similarly, with multiple lift shaft opposite lobbies, the "periferal" passengers at the rear of the lobby are immediately in front of the lift bank on that side, hence do not feel threatened. The natural feed of a crowd in multiple lift shaft opposite lobbies is along the centre of the lobby, which provides the intending passengers with a choice of direction in which they wish to migrate.

The conditions seem to change when the lift traffic demand is light. There is no change to the user expectations with an open lobby, however passengers feel equally comfortable with multiple lift shaft opposite lobbies. Some discomfort is experienced with lobbies with multiple lift shafts opposite, since there is often little reference point to the next car arriving, and the passenger can experience difficulty in getting to the next arriving lift in time, much as has been found with the convex faced lobby.

9 CONCLUSIONS

The investigation into lift lobby arrangements have shown that the form of lobby can effect the performance of the lift system. Despite the almost complete lack of negotiation by building developers with the lift industry, lobbies are created with which the lift designer has to contend. In many instances, the marriage works well, and this is to the credit of the industry; however there are several examples where the lobby does not appear to suit the lift system at all. It is in these areas, some of which have been indicated in this study, that the industry should be able to make its requirements clear, to the ultimate benefit of all parties.

Areas in which further research would be advantageous have also been indicated, and it is intended that these should be followed up, in order that a clearer picture of the relationship between lifts and the lift lobbies may be obtained.

10 REFERENCES

[1] CIBSE Guide D (1993), *Transportation Systems in Buildings*, p 3-4.
[2] ibid, p 2-6.
[3] Tragenza P (1976), *The Design of Interior Circulation: People and Buildings*, Crosby Lockwood, London, pp 8, 12 and 17.
[4] Marmot A and Gero J S (1974), Towards the Development of an Empirical Model for Elevator Lobbies, *Building Science Vol. 9*, Pergamon Press, London, pp 277-288.
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[6] Pearce C M (1993), Office Buildings from the Bottom Up, in G C Barney, *Elevator Technology 5,* IAEE Publications, Stockport, pp 68-77.
[7] CIBSE Guide D (1993), *Transportation Systems in Buildings*, p 3-11.
[8] ACADS (1992), *Commercial Lift Design LAMA, Version 2.1, Reference Manual,* p 6.
[9] Gilbert Sir W S (and Sullivan Sir A S) (1879), "When a felon's not engaged ---", Act 2, *The Pirates of Penzance.*

BIOGRAPHICAL DETAILS

The author, Craig Pearce, obtained the Diploma in Electrical Engineering from what is now the Caulfield campus of Monash University, Melbourne, Australia, in 1961, and Master of Design Science (Building Services) at the University of Sydney, Australia, in 1992. He spent 30 years in Consulting Engineering in several countries, much of which was involved with lift system design. In November 1991, he joined the staff of the University of Sydney as a lecturer, developing and co-ordinating the vertical transportation, communications, and electrical services courses, fundamentally in the post graduate area of the Department of Architectural and Design Science, of the Faculty of Architecture. He lectures also at the University of Newcastle in New South Wales, Australia.