OFFICE BUILDINGS FROM THE BOTTOM UP

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ABSTRACT

The building system most subject to abusive comment by occupants is the lift installation. For most, the lift service impact is in the area between the main entry lobby and each particular working level. Basements are considered commonly as an appendage, and often provide a means of cost cutting at the design stage, when the lift provision to them is reduced to the minimum allowable by regulation.

The purpose of this paper is to investigate basement requirements in typical office buildings, to indicate where the lift design often does not meet them, and where the overall system can be affected by the basement service.

1. INTRODUCTION

The lift installation, being a substantial portion of building construction costs, is generally one of the first areas to which developers and financiers look, with the intention of pruning costs to the minimum. The lift industry, particularly in times of economic uncertainty, is left with the problem of seeking to provide the best compromise solution to vertical transportation in the building, at the minimum cost.

This paper considers basement usage, and corresponding lift requirements; restrictions in basement service; and the overall effect on the lift installation, in typical office buildings.

2. DESIGN CONCEPTS

The main emphasis of lift design involves the passenger waiting time at the lower terminal, during a morning up peak condition, consequently basement service is looked upon often as a factor which interferes with the effectiveness of the system during that period. In some cases, the basement service is disconnected at that time; in many others, the system design is cut, to allow only for the absolute minimum number of lift cars required by regulations, to be able to serve the basement levels.

The needs of potential passengers during the up peak traffic condition are the same, whether they join the lift at the main terminal or at the basement; that is, they wish to arrive at their workplace in the minimum time. Passengers from either origin tend to work against each other, each causing a longer travel time for the other. This occurrence is well documented, however equally detailed solutions are harder to find. Similar delay periods can occur also during the down peak condition.

The specific needs, and status, of basement users must be taken into consideration, when designing for potential basement lift service. Executives with basement car parking privileges, may well consider that they have lift service rights over the less fortunate, who use the normal entrance lobby. On the other hand, the building management may endeavour to use the lift system as a measure of control of persons and vehicles leaving the building during periods of very high traffic flow.

The most unfortunate result of these requirements is that they tend to detract from the apparent effectiveness of the lift design, and continually, these influences are allowed to override the design of lift systems, often to the detriment of the industry, and its reputation.

3. AUSTRALIAN STATUTORY REQUIREMENTS

Most countries, and in many cases, separate states, have their own particular requirements for lift installations. Australia has now adopted a national standard 'Building Code of Australia', designed to bring the whole continent into a common line. Although the reference to lifts takes up only five short sections, formal variations to the Code exist for both New South Wales and Western Australia.

In essence, the requirements of the Building Code, as modified for New South Wales, include the following:

- For a building which has an effective height of more than 25 metres, at least one passenger lift, which is an emergency lift; or where there are two or more lifts, at least two passenger lifts, which are emergency lifts; to serve each storey of the building.

- The emergency lifts must be contained in at least two separate lift wells.

- Emergency lifts need not serve the topmost storey of the building if it comprises plant area only.

In the above requirements, an emergency lift is one which is connected to a standby electrical power system, and includes a stretcher facility comprising a minimum clear interior area of 600 mm wide x 2000 mm long x 1400 mm high above the floor area. This means that one, or more, such lifts are required to serve all floors, including basements.

4. REFERENCE DATA

In his book, "Vertical Transportation: Elevators and Escalators", G. R. Strakosch considers the serving of basements to be a problem, but does not offer any real solution to it. He divides the basement service into either more or less than 33 per cent of the critical traffic on the lifts, suggesting in the former case that time allowance should be made, while in the latter that consideration should be given to relocating the dispatching terminal to the basement.

G. C. Barney and S. M. dos Santos, in "Elevator Traffic Analysis Design and Control" express concern at the disruption to the lift performance caused by basement service, and recommend either that such service be seriously restricted, or a separate basement lift service be used.

In CIBSE GUIDE D, Part 3 "Planning and selection of equipment and performance of transportation systems", the authors expressed concern at the limitation in the number of lifts to basements as a cost reduction. They indicate that, as well as creating passenger confusion, basement service can add 15 to 30 seconds to the round trip time during the up peak traffic condition, also they iterate a suggestion by J. Nahon in "Traffic Analysis for Small Scale Projects", that, where there are several basements, a similar calculation could be used as for the service above the main terminal, and the resultant figures combined to give an overall round trip time.

The Elevator World "Guide to Elevatoring" (whatever that word can really be construed to mean), merely suggests that alternative lift service to basements can save as much as 15 seconds per trip.

Lama, the general lift design computer programme distributed by ACADS, the Australian computer aided design service, suggests the disconnection of basement service during up peak traffic periods; adding that if this can't be done, then their programme allows for a basement stop every third round trip.

Programmes either obtained from, or discussed with, manufacturers appear to provide a simple add-on to the basic calculation, or disregard basements altogether.

These references would appear to indicate that the effects of basements are considered to be either too insignificant, or too difficult to calculate, and they are construed as being unworthy of special consideration.

5. BASEMENT USAGE

Basements in office buildings are used generally for car parking; storage; electrical substation and main switchboard, communications main frames; hydraulic services and fuel storage.

Facilities there, other than car parking, do not require substantial, if any, public involvement. They are not considered to be significant for the purposes of this study, since there is neither regularity of usage, nor a normal need for swift access to them. For car parking, the local council normally sets the minimum number of car spaces required in each new building, to limit the need for external public parking.

Some buildings are designed with the upper basement utilised as a restaurant, and this can create special lift traffic problems, particularly during lunch-time peak conditions. Evening usage of the restaurant should cause little disruption to office traffic, since the majority of office employees have left the building before the restaurant is due to open.

Late lunch traffic to the restaurant can cause sufficient lifts to be engaged in serving the basement as to provide an inferior service to employees endeavouring to return to their offices after their lunch break.

Not all members of staff, in a typical office building, are able to park their cars in basements, consequently it is more common that the users will be important members of staff. They are considered to be entitled to that privilege since their time is valuable, and their tasks justify the convenience provided.

Restriction to vehicular traffic flow is automatic on both entry from, and egress to, the roadway, due to the limited access provided generally to the basement, by the building design. Build-up of that traffic can occur at times of peak movement, not only outside the building in the morning, but also inside during the evening, and this may be a cause of frustration to time conscious executives.

The use of basements, as a consequence, provides the potential to create a high level of annoyance in the users. This would be increased even further by such irritations as incorrectly parked vehicles blocking, or occupying, their reserved places. Persons subjected to these influences are well primed to vent their anger on the lift system, during a long wait for a lift to take them to their office levels.

These frustrations, in the morning peak traffic condition, are matched by people at the main lower terminal, waiting for lifts which are serving the basements, and which either by-pass that terminal because they are already full, or may stop, but when substantially full. The lift lobby can become overcrowded, and under these circumstances, people who are in a hurry, annoy those around them, by trying to push past them to catch the next lift. It appears that, with a crowded lobby, the next lift to arrive is always the one furthest from those who need it most.

In such circumstances, the lift system can be seen to be the cause of peoples' discomfort, and may be, as a consequence, severely criticised by its users. Measures taken to reduce criticism from one group always appear to work against the interests of the other passengers.

6. SAMPLE CALCULATION FOR A BASEMENT SERVICE

"Life, like a lifts system, does have its ups and downs" (anon)

6.1. Assumed Data

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

Area per floor - 1220 m^2 nett
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

6.2. Calculations

(a) 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 $= \frac{176}{12} = 14.67$

Car size $= \frac{14.67}{0.8} = 18.33$, say 21 passenger

Total Travel = 12 x 3.3 m = 39.6 m

Rated speed should be 2.5 m/s (Table 3.7)

Transit time $t_v = \frac{3.3}{2.5} = 1.32$ seconds (Equation 3.4)

Single floor flight time $t_f(1) = 5.5$ seconds (Table 3.7)

Door operating times - $t_o = 0.8$ seconds, $t_c = 3.0$ seconds (Table 3.8)

Stopping time $t_s = t_f(1) - t_v + t_o + t_c$ (Equation 3.15)
= 5.5 - 1.32 + 3.8
= 7.98 seconds

H = 11.7, S = 9.2 (Table 3.5)

RTT = 2 x 11.7 x 1.32 + (9.2 + 1) x 5.5 + 2 x 16.8 x1.2 (Equation 3.3)
= 29.57 + 56.1 + 40.32
= 125.99 seconds

An up-peak interval of 25 seconds is required

No. of cars $= \frac{125.99}{25} = 5.04$ UPPINT $= \frac{125.99}{5} = 25.20$ seconds (acceptable)

UPPHC $= \frac{300}{125.99} \times 16.8 \times 5 = 200.02$ persons per 5 minutes (c.f. 176 required)

(b) UP SERVICE FROM BASEMENTS

Number of floors is 3 Using the same lift system as above, and allowing 2 stops per trip

Allow H = 3, S = 2, allow $t_{p(in)}$ to be 4.0 secs and $t_{p(out)}$ to be 1.5 secs (Clause 11.3.3.6)

RTT $= (2\,H\,t_v) + (S + 1)\,t_s + t_{p(in)} + t_{p(out)}$
= (2 x 3 x 1.32) + (2 x 7.98) + 4.0 + 1.5
= 7.92 + 15.96 + 5.5

= 29.38 seconds

Therefore: Total Round Trip Time for lift system
= 29 38 + 125.99
= 155.37 seconds, which would require the number of lifts to be increased to 7 to maintain the required 25 seconds up-peak interval.

(c) SEPARATE BASEMENT SERVICE

A separate lift service to the basements, allowing similar parameters, would have a lower car speed, since it would be serving only the three basements and the main terminal. Allow, from Table 3.7, a contract speed of 1.0 metre per second, similar door times to main lifts, and allow for all lifts to reach the main terminal at 80% of their capacity.

Therefore: $t_v = 3.3$, $t_s = 7.5$. Allow H = 3, S = 2.

RTT = 2 x 3 x 3.3 + (2 + 1) x 7.5 + 2 x 16.8 x1.2 (Equation 3.3)
= 19.8 + 22.5 + 40.32
= 82.62 seconds

But, from Clause 3.10.2, DNPINT is about 67% of the UPPINT, which is directly proportional to RTT. Hence, since a basement up-peak is the same as an above terminal down-peak condition, then we can consider the basement RTT to be 67% of 82.62, or 55.36 seconds. To provide a service reasonably close to the required 25 seconds interval, it would be necessary to provide at least two lifts. This would be a less expensive alternative to the extension of the main lift system, however may also be less convenient.

This exercise has indicated the difficulty of basement calculation, particularly where the number of basements fall below the minimum allowed in the tables providing values of H and S, where the calculation is required to be an inversion of standard down-peak formulae, and where significant assumptions have to be made for occupancy, transfer times, and passenger behaviour.

7. BASEMENT LIFT SYSTEMS

The understanding of the reasons for dissatisfaction with basement lift service in many buildings, necessitates consideration of a representation of the systems used.

A common system which should not be considered in depth is the old fashioned, single lift; either single or two button collective. It is used generally in small buildings, where control is minimal, and passengers expect it to provide a slow service, and to incur a long waiting time. This system causes little problem, because the occupants of the building do not expect anything more than what they actually receive. They even allow for it to break down on occasions!

Because they know that the lift design and system are not sophisticated, they expect most of the frustrations mentioned above, and are pleasantly surprised when the lift arrives before it is expected. It appears to be the sophistication of larger systems which may point to passenger dissatisfaction with the service.

Multicar systems in larger buildings always provide scope for variation in design and control. Two button collective systems, and variants thereof, allow, in the first instance, a choice of the number of lifts to serve the basements, in excess of the minimum number required by regulations.

From Australian experience with multicar systems, it is normal to see two cars only serving the basements, with the remainder terminating at the main entrance lobby. Unless special arrangements are included with the lift control system, intending passengers have to chance their luck, when requiring a lift from upper levels to the basement.

Lifts serving higher zones of multizone buildings rarely serve floors below the lower terminal, which is generally the ground floor, and passengers from those floors to the basement are forced to change lifts at that level. The resultant effect is further frustration, with descending passengers having to break their journey, and ascending passengers not only having to do likewise, but also having to force their way through a crowded lobby to that of the zone serving their required floor. Add the pressure of people trying to enter the lower zone lifts arriving from the basements, while these passengers are trying to leave it, and the ingredients are in place for a great start to the day.

The provision of a completely separate basement lift system from the lower terminal, with all upper level lifts terminating at that level, overcomes some of the crowd frustrations indicated in the previous paragraph. It does not solve any of the problems associated with time loss for executives entering and leaving the building, rather it adds to them, in that no one has a direct lift service from the basements to upper floors.

The basement considerations so far have not taken into account the Australian statutory requirement for emergency lift service to all floors of the building. It is true that passengers from basements can use emergency lifts directly between a basement and any upper floor, however this arrangement does involve some difficulties. Commonly, the lifts designated to serve all floors are the goods lifts, and these are considerably slower than the normal passenger lifts. They are also purpose built, and have the minimum of internal fit out, being used primarily for the carriage of large, heavy and awkward items. They do not create an ideal environment to impress potential clients, or customers.

8. BASEMENT CONDITIONS

An argument often voiced by building developers is the need to use the space under lifts for additional car parking in lower basements. There never appears to be sufficient space available in basements to cater for all requirements. We know that the provision of counterweight safety gear, to make such usage possible, is an expensive exercise, and try, consequently, to advise other means of achieving the space requirement. We also appreciate that the pit could be in excess of five metres deep for high rise lifts, and this cuts severely into basement space.

The developers may complain also about the parking spaces lost in front of lift entrances in basements. This is acknowledged to be a potential problem, however will always arise at any lift or stairway entrance, and the building design should not be so tight as to allow it to occur.

Regardless of the lift systems and arrangements used, there will always be a severe intrusion by the lifts into the basements of any building. As is applicable to upper floors, the developer should be encouraged to design with the lift requirements in mind, and include the most satisfactory lift system for the building, in the overall design.

Perhaps the most common, and indeed the most irrelevant comment from developers, is the high cost of additional lift entrances in the basements. We are all aware of the minute increase in the overall cost of a lift installation, caused by an additional entrance. This is an area that should be considered carefully, since the developer may be under a misapprehension.

Commonly, when excavating for lift pits, a full depth cut is made across the whole liftwell area, and a common pit floor is constructed. The reduction of pit depth, caused by lifts not serving basements, is created either by the provision of a false pit floor at, or a build-up of compacted fill to, the correct depth below the lowest floor served. The false floor, being a substantial structure, could be as expensive as the number of entrances, and associated equipment, that would be necessary to serve the basement floors.

The two major objections to basements being served by the main passenger lifts appear to be readily answerable. The space lost would be very little above that which would be available with lifts serving the main ground floor terminal only, and the cost penalty for the basement service is in a reasonable proportion to that involved with providing occupiable space beneath the lifts.

9. NUMBER OF BASEMENTS SERVED

In this particular exercise the number of basements served has not been stated, and the conditions vary depending on the number considered. The assumption has been the provision of two or three basement levels below the lower main terminal; obviously a single basement would not involve the ability to use space below the lift pit, whereas five or six basement levels may require it to be considered seriously.

With a single basement, it is rather irrelevant whether all lifts serve the basement, from a cost consideration, however in many cases, only the lifts required by statutory regulations are run to that basement. Multiple (five and more) basements are served generally by a lift system separate from the main passenger service, particularly where the upper part of the building is served by a multizoned system.

An intermediate number of basements (say,two to four) appears to create some areas of doubt in the minds of system designers, and particularly as the overall design appears to be more in the hands of the building designer, than with those of the better qualified lift designer. This has been addressed, in some measure, by the calculation in this paper.

Without concrete guidelines for basements, similar to those developed for lifts serving above the lower main terminal, lift designers appear to be giving way, often, to developers' hypothetical cost savings, at the expense of good system design.

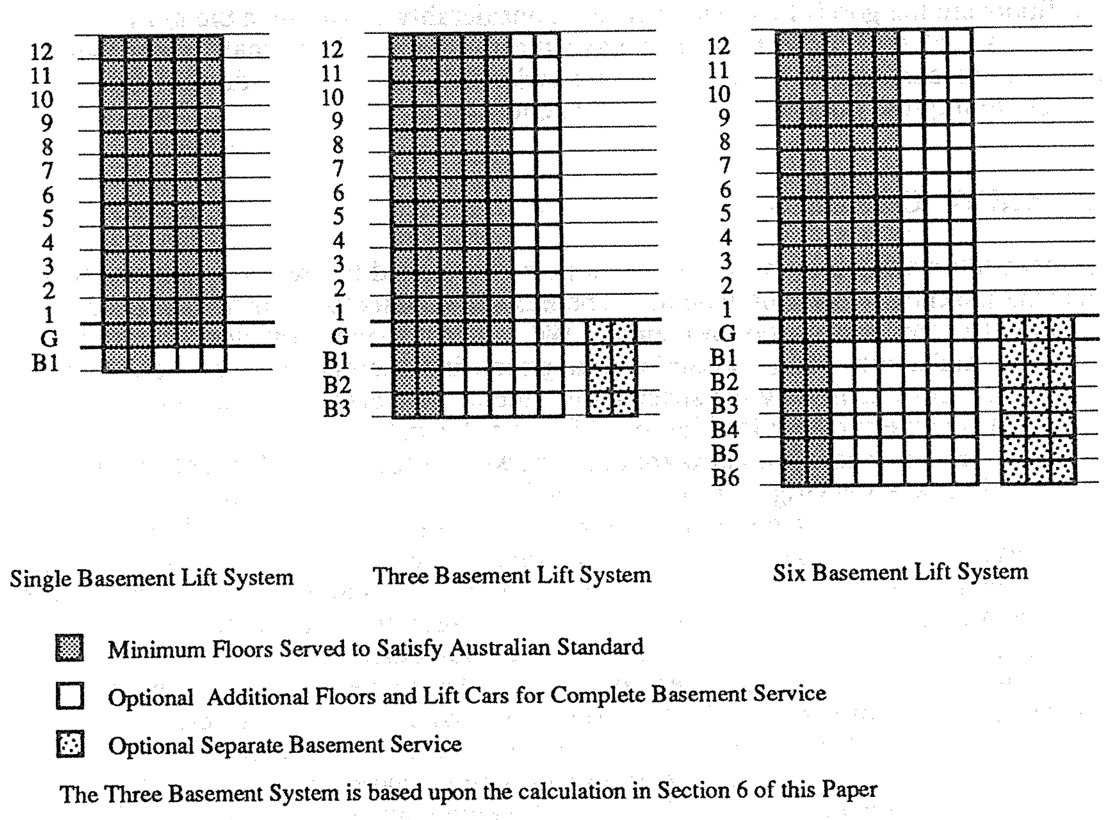

Figure 1: Lift Service - Possible Alternatives for Single, Three, and Six Basements

10. EFFECTS ON THE BUILDINGS

Initially, the cost savings gained by providing a substandard lift installation may help to convince the owner and developer that the building will be a viable proposition. As a consequence, the building design and construction will proceed, and the completed building will be occupied.

When the initial excitement of new building occupancy is over, and people consider unliked features, the difficulties with substandard lift service become a major problem to them. Time loss and inconvenience to staff can cause a company to look seriously at the possibility of moving to a better equipped building. When a city is oversupplied with office space, buildings with inadequate services are the ones which remain under-utilised, and lifts are a very noticable service.

Vacant office space is an extremely expensive commodity, both from the view of lost revenue, and from the reputation of the building. To attract tenants, the rental is reduced, and the initial purpose for the building may never be achieved. With less than intended income, less finance is available for building maintenance, the appearance starts to deteriorate, and the building is less attractive to potential occupants.

This is an overly dramatic example of the fate of a building with substandard services, but it is not unrealistic in times of economic recession, as is being experienced at the present time in many countries. Particularly relevant is the situation where the recession has followed a time of intense building activity, and many of the building tenants have ceased to operate. Potential tenants are in a strong position to find a building which satisfies all of their requirements, and it is the building which has the best available services, which will attract them.

Overly dramatic, perhaps, however it cannot be denied that people do find much to grumble at in substandard lift systems, and their concern can start right at the bottom of the building.

11. DESIGNERS' CONCERNS

The preceding clauses indicate some of the problems that may occur with the provision of a lift service to building basements. If it is acknowledged that a problem exists, it is necessary for us, as part of the industry, to consider carefully what we are going to do about it.

Perhaps the first consideration should be whether the problem is really sufficiently important to spend time and effort in reaching an acceptable solution. Indeed, could there be a single answer, or does the problem require a large variety of individual solutions, differing as the conditions and circumstances change?

A relationship between service above and below the main terminal has been addressed in Chapter 11 of CIBSE GUIDE D, and, as indicated in the calculations in Section 6 of this paper, may point toward an answer to the problem, particularly when it has indicated that some of the already printed assumptions may not be too far from the result calculated in that publication. This relationship does make a number of assumptions, including the number of floors, number of calls to each basement level, number of landing calls per trip, and the restriction of car calls to the basements during the up-peak traffic condition.

The assumptions of the above exercise may well exist for many buildings, however do not provide a basis for the consideration of all buildings with lifts serving basements. Earlier comment in this paper has shown instances where other factors must be considered, and where only a limited number of the lifts serve the basement at any time.

The designer should consider whether he requires all lifts in all zones to serve all basements, or whether it would be preferable to provide a separate basement service. Neglecting costs, it may be fair to ask how many lift system designers have given fair thought to this design consideration.

It would appear that design thinking has not always kept pace with the greater sophistication of control systems that is available today. The whole issue of lift service to basements needs serious rethinking, in the light of current development, not only in the control systems, but also in building usage.

Furthermore, does the designer have sufficient information at his disposal to make a fair assessment of the basement requirements, usage, and the type of lift system that would best serve the whole building? There is no reason, with the information available today, why he cannot design a most suitable lift system above the main terminal, regardless of whether he uses either a manual or a computer calculation.

The stage has been reached where a set of parameters, similar to those provided in Chapter 3 of CIBSE GUIDE D, should be established for lift services to basements. There should be no doubt in a designer's mind of what the system should comprise, and how it would fit into the overall lift design. This confidence would then be extended to architects, and other building developers, who may be more inclined to think of making the necessary space provisions, rather than how they could cut back the lift system, to allocate savings made to other parts of the building.

Experience has shown that, where the lift designer appears to be unsure of his ground, or is desparate to make a sale, then the developer has that designer, and as a result the industry, at his mercy. A tight developer, like the taxation assessor, is always ready to question hand calculated material, but can be swayed by a detailed computer printout. This is available for the main lift system, but is sadly lacking for the basements.

If the space taken by a properly designed lift system to basements, is the cause of the building needing to be extended by an additional basement, then so be it! Developers, for many years, have argued against the need for substation space requirements of Supply Authorities, and in almost all cases, have lost. They have learned to accept the requirements of such authorities, who do, admittedly, enjoy a great deal more "clout" than we, mere mortals. Without such regulatory power, we should aim at re-educating these developers, because the lift industry will gain in the long run, particularly if agreement of requirements can be achieved on an international scale.

The greatest barrier to such agreement within the industry, is the lift company which is prepared to offer a substandard lift installation, in order to make a sale. In the long run, this will create circumstances where the installation is a bad advertisement for the company and also, in the worst circumstances, cause the company to be barred from some future tendering for a period of time. At best, the installation will bear the brunt of user criticism, however the designer, and the installation lift company, will be well removed from the scene, having passed the problem, together with the maintenance, to anyone prepared to accept it.

12. THE NUB

In this paper, questions have been raised on the design of lift systems for office buildings which include basements. What is accepted as a fair sample of expert advice has been examined, and the measure of agreement and variance indicated.

With the advancement in control technology, and the increased use of microprocessors, it is reasonable to accept that the control for any system can be varied almost at will. If a lift system is designed with all cars serving the basements, then the control can be programmed to provide the best possible service for both basement passengers and normal terminal passengers. No decision would be necessary as to the removal of cars from the system to provide, say, optimum up-peak service from the terminal.

If one considers the problem of cost, then the industry can surely make it worthwhile for the building developer by including the additional basement openings at an absolute minimal cost. In this manner the lift system designer will have some control over his finished product, and will not be forced into the present arrangement of having to make the best of a bad design. There do not appear to be many office buildings in which the space below lifts, which terminate at the ground floor, is utilised purposefully.

It should be asked whether a separate lift system for basements is an acceptable alternative to an overall system, when the cost difference between additional floors served by a series of necessary lifts is compared with the cost of the additional lift system. The inconvenience to the building occupants, caused by the need to change lifts between basement and office level, must also be considered as a system disadvantage.

Assuming that a total lift service to all basements may be a desirable ambition, it would be then necessary to determine a reasonable traffic analysis, which may equate with observed traffic patterns. This may derive from existing data, but could require some rethinking.

Perhaps the most important consideration is whether the exercise is really worth the time and effort required to resolve it. Is the industry really concerned with the impact of its product on the general public, or is it content to develop on established lines? Is it reasonable to blame a bad lift system on the building developer, or the lack of project funds?

13. CONCLUSIONS

The lift installation, and the lift designer, both have been subjected to much abuse by the public, and misuse by many building developers. The development of technology for lift systems above the lower terminal level has done much to solve that situation, and to indicate clearly problems which will eventuate if established parameters are not met.

Unfortunately, the same has not been the case for lift systems below that terminal, resulting in a conglomeration of arrangements, very few of which give real satisfaction. This investigation has indicated several of these and related them, but has shown that they do not provide the complete answer.

This paper has demonstrated that it is immaterial which formula, or group of formulae one uses, if it has not been established which lift system will best serve the basements, in conjunction with the rest of the building.

Further investigation must be carried out on the service to basements, in order that clearly defined parameters may be established, similar to those for lift services above ground. Only on such a strong base will a fully acceptable lift system be provided.

14. BIOGRAPHICAL NOTES

The author, Craig Pearce, obtained his Diploma in Electrical Engineering from what is now the Caulfield campus of Monash University, Melbourne, Australia, in 1961, and spent the following 30 years in Consulting Engineering, much of which was involved with lift system design. In 1990, he was invited to lecture part time in Vertical Transportation in a new Building Services post graduate course to be established at the University of Sydney. He also joined the course, and was the first graduate of it, as Master of Design Science (Building Services) in 1992. In November 1991, he joined the university staff 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 is currently endeavouring to encourage interest in lift systems design, and to educate under-graduate architectural students on the importance of services in building design, while attempting research toward his Ph.D.

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