Cycle Lifts – Meeting The Future Demand

Adam J Scott

Sweco UK Ltd, 1 Bath Road, Maidenhead, BERKSHIRE, SL6 4AQ, UK

Keywords: Bicycle, cycle, lift, demand.

Abstract. Recent changes to planning policy in many major cities, allied to a growing awareness of the need to address our sedentary lifestyles, is driving the need to design buildings to accommodate more and more bicycle spaces. In large commercial developments in London, this can lead to a need for more than 1000 bicycle spaces, which often are located at basement levels. From a circulation perspective this creates a need to move people and their bicycles between street level and the bicycle storage facility. Sometimes this is achieved with a ramp, or adapted stairs, but often lifts are required.

There is currently limited guidance on design benchmarks for lifts whose primary purpose is the movement of bicycles and their riders. What are acceptable waiting times? What is an acceptable queue length? How much space does a bicycle and accompanying rider occupy? How large does a lift need to be to accommodate two cycles and riders, or three cycles and riders. This paper explores the current guidance and proposes additional benchmarks for consideration when designing cycle lifts.

1 BACKGROUND & CONTEXT

Throughout a growing number of developed countries there is an increase in people's awareness of the need to protect ourselves from the insidious creep of our convenient sedentary lifestyles and unhealthy diets. Obesity and its associated poor levels of fitness and health are the number one cause of early death in many developed countries. This has led to governments focusing on affordable steps to improve the health of the nation and encouraging the use of bicycles has formed part of this strategy in the UK and particularly in London.

Cycle use fell sharply in the late 1940s as the affordability of the car came within more and more people's reach. Recently however that declining trend has started to reverse, and some traffic counts suggest that the number of miles cycled in 2017 (3.27 billion) is around 29% above the figure for 1997 [1] as shown in Fig. 1 below.

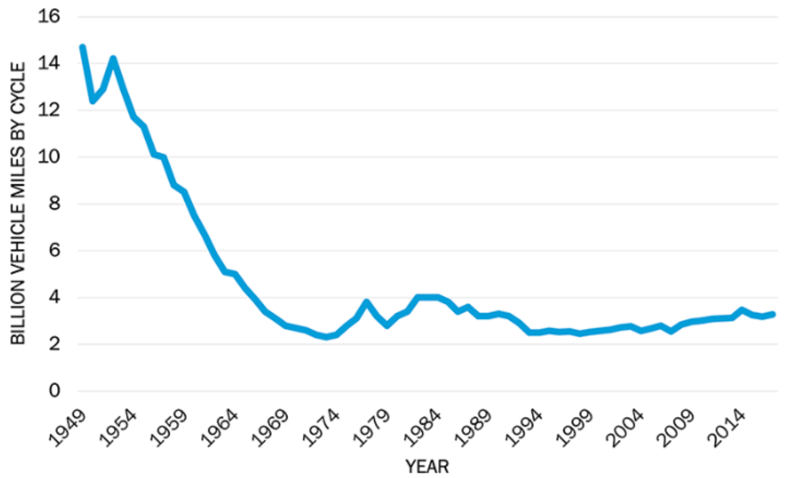

Figure 1: Cycle Use in Billions of Vehicle Miles 1949-2017 (GB)

In London however the increase is far more significant; around 27,000 people cycled across central London in 1977, compared to 184,000 in 2016, almost seven times as many [1], as illustrated in Fig. 2 below.

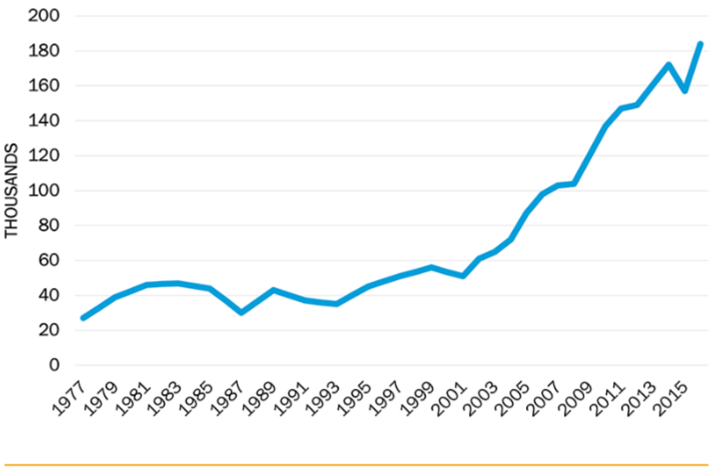

Figure 2: Long-term trends across the Central London Cordon 24-hour weekdays, both directions, 1977-2016

2 PLANNING

The design of buildings within London needs to demonstrate compliance with the London Plan [2], an established set of design principles governing the development of the City. In the foreword of the latest Draft London Plan (2019), the Mayor of London Sadiq Khan comments,

"I also see the London Plan revolutionizing the way we get around our city - enabling a boom in active travel, with walking and cycling becoming the primary, default choice for millions of Londoners because we have made it far easier and safer."

Whilst this approach is focused on the development of London, the trends it is establishing and promoting are being seen in many other cities both in the UK and overseas, and in many cases being adopted in varying forms into formal planning design requirements.

Policy T5 of the new draft London Plan provides requirements for cycle parking, a key element in removing barriers to cycling and creating a healthy environment in which people choose to cycle. One is unlikely to use a bicycle regularly unless there is a secure, safe and convenient place to store it.

The policy requires cycle parking to be fit for purpose, secure and well-located. The right amount of cycle parking for a site or area would be at a level that:

- Meets existing baseline demand
- Meets the potential demand generated by the existing and proposed land uses in the area
- Ensures there further is allowance for spare capacity (ideally, at least 20 per cent)

Development should provide cycle parking in accordance with the minimum standards based on Gross External Area (GEA) [3] set out in Table 10.2 of the plan, headline extracts from which are shown below in Table 1.

Table 1: Draft London Plan – Cycle Parking Requirements (Extract)

Class of Development	Long-stay (e.g. residents or employees)	Short-stay (e.g. visitors or customers)
B1 Offices	1 space per 75 m^2 GEA (higher standard) [*] 1 space per 150 m^2 GEA (standard)	First 5,000 m^2 GEA: 1 space per 500 m2 Thereafter: 1 space per 5,000 m^2 GEA
C1 Hotels	1 space per 20 bedrooms	1 space per 50 bedrooms
C3/C4 Dwellings	1 space per studio or 1 person / 1 bedroom dwelling 1.5 spaces per 2 person 1 bedroom dwelling 2 spaces per all other dwellings	5 to 40 dwelling: 2 spaces Thereafter: 1 space per 40 dwellings
[*] – Locations with high cycle usage currently identified as justifying a higher provision of cycle parking. Central and inner London boroughs plus others.		

Cycle parking should also permit easy access for disabled cyclists who may be using adapted cycles, as well as providing appropriate facilities for other non-standard cycles such as tricycles or bicycles with trailers.

Cycle parking also needs to be designed in accordance with the guidance contained in the London Cycle Design Standards.

3 DESIGN GUIDANCE

The London Cycle Design Standards [4] is another established guidance document setting out the requirements for effective design to meet the requirements of the London Plan, whilst also defining current best practice for all. Its guidance draws on the experience of many practitioners from around the world, and its recommendations have application outside London.

The standards contain some specific requirements relating to vertical transportation, but in doing so create further questions. Step-free access to cycle parking is a fundamental requirement of the standard and note is made that this:

"…may require provision of shallow ramps or lifts large enough to carry all types of cycle."

The standard does then provide some guidance on what type of lift should be large enough to carry all types of cycle, stating:

"To accommodate all types of cycle, lifts should have minimum dimensions of 1.2 by 2.3 metres, with a minimum door opening of 1000 mm."

This description however is somewhat unspecific. For example, it does not define:

- whether the minimum car size is 1200 mm (w) x 2300 mm (d) or vice versa?
- how many cycles with accompanying riders such a lift can realistically accommodate?
- what the minimum lift car size is for varying capacities of cycles and riders?
- what is the predicted demand pattern?

The Chartered Institution of Building Services Engineers (CIBSE) Transportation Systems in Buildings (2015) [5] is unusually silent on the issue of cycle lifts, a situation the author trusts will be addressed in the forthcoming 2020 revision.

The new 2019 British Council for Offices Guide to Specification [6] provides a little further guidance noting that cycle lifts are:

"Required where levels either above or below ground are provided with significant numbers of motorbike and bicycle spaces. The typical car configuration is at least 2300 mm deep with entrances on opposite sides…and the effect of water in the car and shaft should be considered."

But this still leaves much room for debate on capacity, demand and size.

4 THEORETICAL PERFORMANCE ASSESSMENT

In the experience of the author cycle parking is typically designed by architects in conjunction with transport consultants, and the latter is normally best placed to advise on both the loading capacity of cycle lifts and the predicted demand pattern. The latter will often vary according to the location of the building and the nature of its occupants.

The magnitude of theoretical demand can become very significant for larger developments. The requirements of the London Plan when applied to commercial buildings with hundreds, often thousands, of occupants, generates a requirement for hundreds, occasionally thousands of cycle parking spaces.

Ideally such cycle parking is located at street level but often this space is far too valuable to allocate to such a use, with retail or other such amenity being a far more attractive option for the developer. The cycle parking is therefore typically sited at a basement level, ideally at a single level with all associated facilities such as lockers showers and toilets.

Access is then preferably via ramps though the gradient of these are restricted by standard resulting in them often occupying an unjustifiable amount of valuable space and alternative access needs to be sought.

The viability of the so called "Dutch Stair" option (see Fig. 3), stairs with channels to the sides up and down which one runs bicycle wheels, has been questioned relatively recently and is not recommended, particularly where the vertical distance to be travelled exceeds one level.

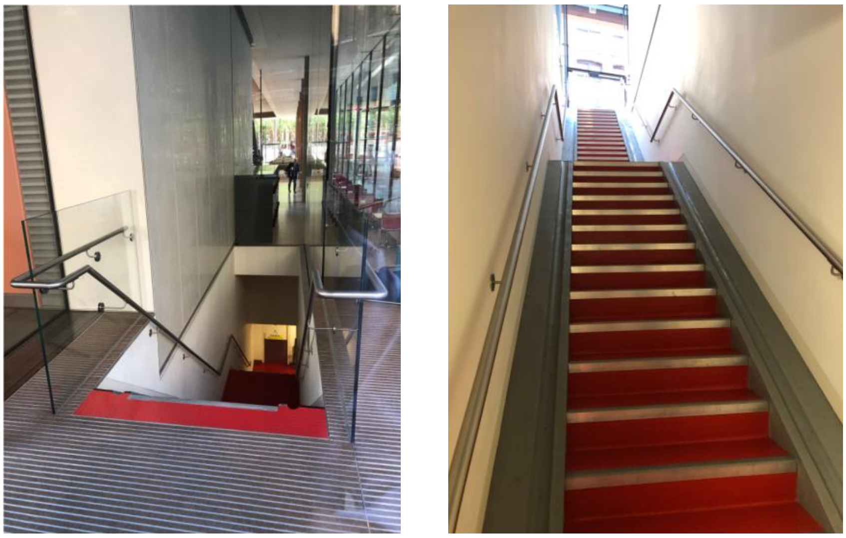

Figure 3: Cycle Access "Dutch Stair" (Central St Giles, London)

The Elizabeth House project in London illustrates the scale of the challenge for designers and the significance of some of the design criteria this paper has focused on. The development proposes more than 1,000,000 ft^2 (more than 90,000 m^2) of office accommodation with associated retail. By applying the draft London Plan guidance on total cycle parking numbers, the project's traffic consultant was able to utilize other design benchmarks and processes common to their particular discipline to define a peak demand profile for the cycle lifts, as shown in Fig. 4 below:

	Option 1 - 5 min profile		
	Entry	Exit	Total
07:00:00	30	1	31
07:05:00	34	2	36
07:10:00	33	2	34
07:15:00	38	2	40
07:20:00	44	2	46
07:25:00	44	2	46
07:30:00	49	2	51
07:35:00	51	2	54
07:40:00	62	3	65
07:45:00	54	2	56
07:50:00	54	2	56
07:55:00	63	3	66
08:00:00	51	2	54
08:05:00	58	3	60
08:10:00	56	3	59
08:15:00	55	3	57
08:20:00	43	2	45
08:25:00	50	2	52
08:30:00	47	2	50
08:35:00	45	2	47
08:40:00	32	1	34
08:45:00	36	2	38
08:50:00	27	1	28
08:55:00	24	1	25
09:00:00	21	1	22
09:05:00	21	1	22
09:10:00	18	1	19
09:15:00	11	1	12
09:20:00	11	0	11
09:25:00	11	1	11
09:30:00	8	0	9
09:35:00	8	0	8
09:40:00	8	0	8
09:45:00	11	1	11
09:50:00	8	0	9
09:55:00	7	0	7

	Option 1 - 15 min profile		
	Entry	Exit	Total
07:00	97	4	**101**
07:15	126	6	**132**
07:30	162	8	**170**
07:45	170	8	**178**
1 Hr	**556**	**26**	**581**
08:00	165	8	**173**
08:15	147	7	**154**
08:30	125	6	**131**
08:45	87	4	**91**
1 Hr	**525**	**24**	**549**
09:00	60	3	**63**
09:15	33	2	**34**
09:30	24	1	**25**
09:45	26	1	**27**
1 Hr	**143**	**7**	**149**

Figure 4: Theoretical Cycle Demand Morning Peak (Elizabeth House, London)

The theoretical demand is very significant, seeing at peak around 60 cyclists arriving in a 5-minute period, one every 5 s. The cycle storage is located at basement level 2, a nominal 10 m below street level and as such, this morning up-peak demand is a down-peak from a direction of traffic flow. Access arrangements such as ramps were considered during the design development but discounted from a space perspective in favour of dedicated cycle lifts.

A lift traffic simulation model was built to analyze lift performance when subjected to the theoretical demand pattern advised by the transport consultant. The simulation was run 100 times, for statistical accuracy, in order to assess the resulting theoretical performance, and to determine the optimum number and size of cycle lifts required.

Key to such analysis is the capacity of the lift in terms of the number of cycles and riders it can realistically accommodate. The simulation was based on capacities as shown in Table 2 below. The minimum clear internal dimensions required to accommodate two and three cycles and riders was determined by a transport consultant and adopted into the models accordingly.

Table 2: Cycle Lift Theoretical Capacity

Number of cycles and riders	Minimum clear internal car dimensions / area	Maximum Car Area / Rated Load acc. BS EN81-20 [7]
Two	1400 mm (w) x 2300 mm (d) / 3.22 m^2	3.25 m^2 / 1425 kg
Three	2100 mm (w) x 2400 mm (d) / 5.04 m^2	5.00 m^2 / 2500 kg

The lifts were configured with the parameters shown in Fig. 5 below.

Door Pre-opening Time (s)	0.50	0.50	0.50	0.50
Door Open Time (s)	2.00	2.00	2.00	2.00
Door Close Time (s)	3.00	3.00	3.00	3.00
Home Door Dwell 1 (s)	3.00	3.00	3.00	3.00
Home Door Dwell 2 (s)	1.00	1.00	1.00	1.00
Door Dwell 1 (s)	3.00	3.00	3.00	3.00
Door Dwell 2 (s)	1.00	1.00	1.00	1.00
Speed (m/s)	1.00	1.00	1.00	1.00
Acceleration (m/s^2)	0.50	0.50	0.50	0.50
Jerk (m/s^3)	0.80	0.80	0.80	0.80
Start Delay (s)	0.50	0.50	0.50	0.50
Levelling Delay (s)	0.00	0.00	0.00	0.00

Figure 5: Lift Parameters

The demand profile advised by the transport consultant was modelled as shown in Fig. 6 below. It should be noted that the traffic is predominantly down, but with some modest up component, and therefore slightly more onerous than simplistic pure down-peak traffic:

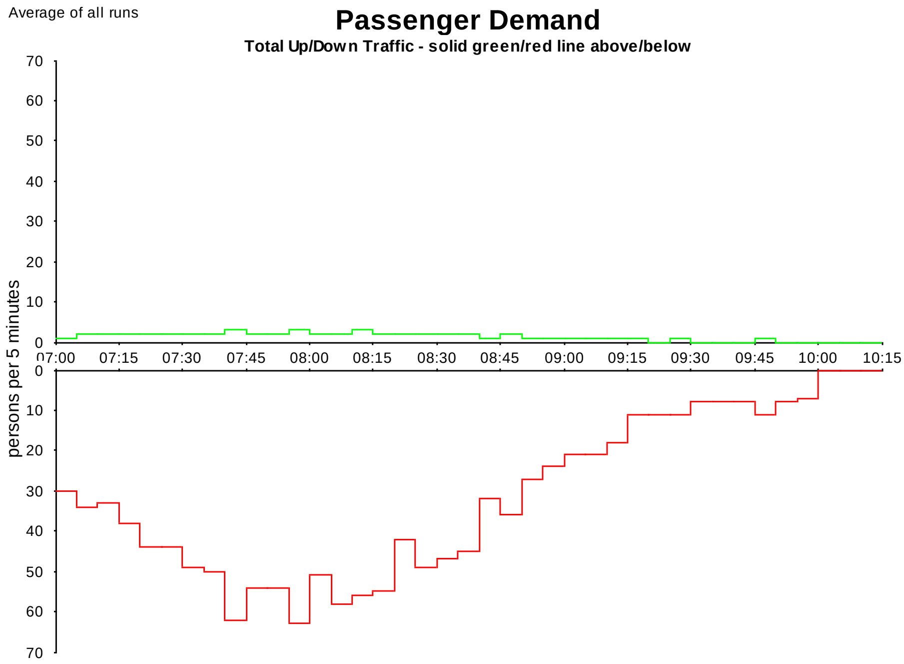

Figure 6: Theoretical Cycle Demand Profile (Elizabeth House, London)

Initially the simulation was run with the minimum car size required to accommodate two cycles and their riders, i.e. 1425 kg duty. A four-car group was assessed, and the average waiting time and queue length at the highest demand Ground floor were as shown in Fig. 7 and were clearly unacceptable. In this scenario the handling capacity of the lifts with an effective number of “passengers” (P) equal to two, is much less than the peak demand of 60 cycles and riders per 5 minutes.

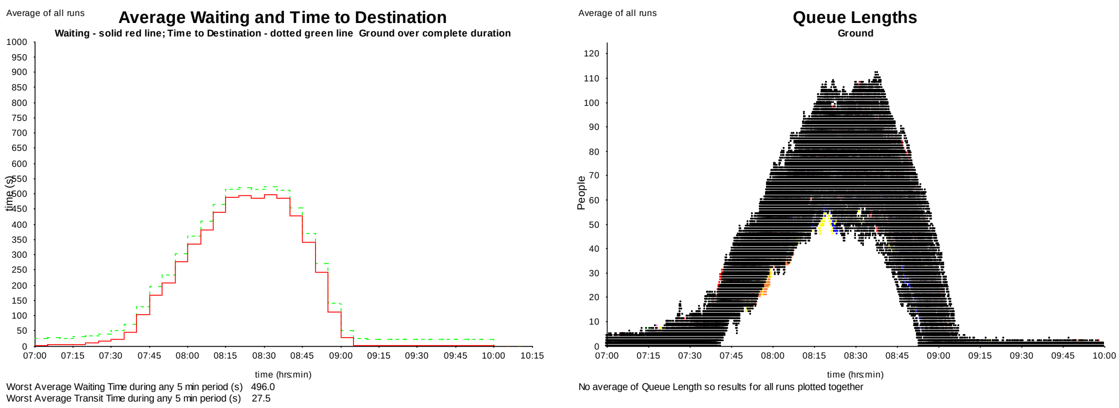

Figure 7: Predicted Average Waiting Time & Queue Length at Ground

The simulation was then run with 2500 kg duty cars capable of accommodating three cycles and their riders. The resulting average waiting time and queue length at Ground floor are shown in Fig. 8 below, and show a significant improvement when compared with the smaller lifts, and were considered acceptable:

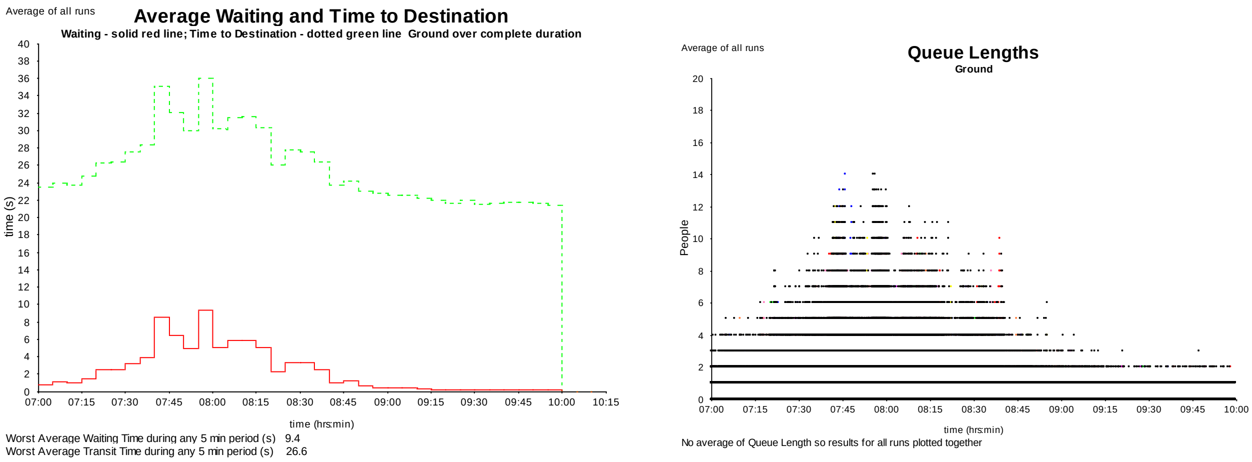

Figure 8: Predicted Average Waiting Time & Queue Length at Ground

In the author's experience, it is common for the limiting factor in cycle lift simulations not to be the average waiting time but the queue length, or more precisely the ability of the proposed lobby space to accommodate the queuing cyclists. Planning authorities are typically focused on ensuring that the predicted queues can be accommodated within the demise of the building and will not compromise circulation through adjacent public realm.

In the analyzed scenario the predicted peak queue of 12-14 cycles and riders will require a significant lobby space in which to be accommodated; if one assumes a "real-world" space requirement of 2.8 m^2 (1.2 m x 2.3 m) for a cyclist and rider, then the cycle lift lobby becomes a nominal 35 m^2. Care should also be taken to ensure the lobby does not include thoroughfares and circulation space to other demises within the building as this could cause disruptive conflict between pedestrians and waiting cyclists.

5 CONCLUSIONS & RECOMMENDATIONS

Cycle usage is increasing and is to be encouraged. The legislative environment requires a growing provision of facilities aimed at facilitating the use of bicycles.

Whilst there are some design guidelines for cycle lifts, they would benefit from further development and the inclusion of more specific and detailed guidance. CIBSE is currently well positioned to provide such guidance with the imminent publication of the 2020 update.

Demand from cycle usage, at least theoretical demand, can be very significant. Bicycles are bulky objects that quickly absorb lift capacity. The resultant cycle lift requirement can occupy a lot of valuable space and should be considered carefully at an early stage of design planning.

Formal guidance documents such as CIBSE Guide D should provide recommended criteria for designers. The following are proposed for consideration:

- Cycle lift capacities to be assessed in accordance with Table 1
- Average passenger transfer time of 2 s in each direction, i.e. 2 s to load and 2 s to unload. This figure is proposed as a reasonable average expectation but is a predicted value that would benefit from real-world surveyed data to confirm or refine.
- Utilize through car arrangements wherever possible in order to minimize transfer times and interference.

- Ensure lobby design provides sufficient space to accommodate the predicted queue length whilst delivering an average waiting time of no more than 40 s. The expectation is that the queue length and the size of lobby required becomes the defining limit and satisfying this should lead to a satisfactory theoretical performance
- Ideally locate all cycle storage and associated facilities (e.g. lockers and showers) at a single floor level to maximize the performance of the lifts.
- Consider the effect of water ingress to both the lift car and lift well.

The author would also encourage a real-world study of cycle lift usage, particularly the average capacities observed for varying car sizes. Such a study could be done in conjunction with transport planners so that the basis of their criteria for defining the peak demand pattern could also be challenged and ratified or refined accordingly.

REFERENCES

[1] Department for Transport, Road traffic statistics. Retrieved from www.gov.uk/government/organisations/department-for-transport/series/road-traffic-statistics (2019, June 13)

[2] Draft London Plan – Consolidated Suggested Changes Version July 2019. Retrieved from www.london.gov.uk/what-we-do/planning/london-plan/new-london-plan

[3] Royal Institution of Chartered Surveyors (RICS), Code of measuring practice, 6th edition. RICS, London (2015).

[4] London Cycle Design Standards. Retrieved from content.tfl.gov.uk/lcds-chapter8-cycleparking.pdf

[5] Chartered Institution of Building Services Engineers (CIBSE) Guide D Transportation Systems in Buildings (2015)

[6] British Council for Offices Guide to Specification 2019. Retrieved from: www.bco.org.uk/Research/Publications/BCOGuideToSpec2019.aspx

[7] BS EN81-20 (2014) Safety rules for the construction and installation of lifts — Lifts for the transport of persons and goods Part 20: Passenger and goods passenger lifts (BSI, 2015)

BIOGRAPHICAL DETAILS

Adam J Scott BEng (Hons) CEng FCIBSE MIMechE

Adam started his career in the lift industry 28 years ago with Otis in London, UK. After twelve years working in construction, service, modernization and new equipment sales, he moved into the world of consultancy with Sweco (formerly Grontmij and Roger Preston & Partners) and has subsequently worked on the design of vertical transportation systems for many landmark buildings around the world.

Adam is the current Chairman of the CIBSE Lifts Group and of the CIBSE Guide D Executive Committee. He is the current codes and standards representative for the CIBSE Lifts Groups and sits on the British Standards Institute MHE4 technical committee. He is also a member of the BCO vertical transportation technical peer review committee. Adam is currently also the UK nominated expert for WG7 dealing with the accessibility standard EN81-70.