Maximum Lift Car Loading Accepted by Passengers in High-Rise Office Buildings: Does Data Support the 80% Rule?

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Abstract. When conducting lift traffic analysis, one of the key modelling choices is passenger capacity: the limit on the number of passengers in a lift car. A widely used convention in the lift industry is the 80% rule, according to which lifts are assumed to be loaded to no more than 80% of their rated capacity. However, the interpretation of this rule varies across practitioners and methods. Lift car loading is likely influenced by multiple factors, such as cultural norms, traffic conditions, rated capacity, and the building segment. Although the 80% rule is a recurring topic in professional discussions, published measurement data remain scarce.

For this study, automatic passenger count data from 34 office buildings were analysed. Some buildings included multiple lift groups, resulting in a total of 52 lift groups. The measurements were conducted in Europe, Asia, the Middle East, Oceania and North America. The results indicate substantial variation in the upper bounds of lift car loading across regions.

1 INTRODUCTION

Lift safety standards define the maximum available car area for a lift with a particular rated load [1,2]. To board a lift, passengers require sufficient free space to satisfy their physical needs as well as cultural or personal preferences. If the serving lift already carries several passengers, waiting passengers need to decide whether to board the lift or wait for the next one. Lift traffic experts' assumptions regarding the maximum number of passengers accommodated by a lift, i.e., *passenger capacity*, have a significant influence on the validity of lift handling capacity calculations and simulations, affecting the functionality and the value of the building.

It was observed already in the 1960s that passengers do not usually fill lifts to their rated capacities [3]. Dr. Barney, the well-known pioneer of lift traffic planning, suggested using 80% design capacity in lift traffic calculations [4]. Dr. Barney encouraged applying this 80% loading factor to the probable capacity, which is estimated by dividing the lift floor area by the area per person and is usually different from the rated capacity. She considered passenger capacity (P) not as an absolute maximum number of people in a lift car at any given moment but as an average. More recent research [5, 6] supports the use of an 80% capacity factor in lift traffic analysis but also points out that it is not the absolute maximum.

Different practitioners justify the 80% limit in several ways. It can be justified on an area basis; typically, no more passengers can fit in the lift due to the limitations imposed by safety standards. It can also be justified by assuming a Poisson passenger arrival process and applying rules of thumb derived from queuing theory. Some lift traffic experts apply both approaches, leading to approximately a 64% car loading limit compared to the rated capacity, depending on lift car size. The larger the rated capacity, the less space is available per person when comparing rated capacity with the lift car area permitted by safety standards. 80% car capacity factor can also be seen either as a pre-set parameter in calculations and simulations, or as an outcome of simulations [e.g. 6, 7, 8].

Different definitions, or interpretations of definitions, of passenger capacity may cause additional confusion. ISO 8100-32:2020 (Chapter 6.5.3) [9] provides two different definitions for passenger capacity depending on whether the analysis is based on a calculation method or a simulation method. The standard defines P_{calc} as the *average* number of passengers in the car at the departure from the main entrance floor, and P_{sim} as the *maximum* number of passengers in the car during simulations. These definitions are not problematic if they are used consistently in the formulae giving the relationship between the rated capacity and passenger capacity. The interpretation problem comes from a note that is on the same page as the definitions in the standard. The note states: "In simulation, the car can load to more than the average, represented by P_{sim}." This raises the question: is P_{sim} the average or maximum? This distinction is critical when determining the correct multiplier (F) in an equation describing the relation of rated capacity (Q) and passenger capacity P_{sim}:

$$P_{sim} = FQ. \quad (1)$$

If P_{sim} is interpreted as an average that can sometimes be exceeded, a multiplier of max 0.8 should be used. If P_{sim} is interpreted as the maximum that is never exceeded, a maximum multiplier of 1 can be justified. Smaller multipliers can be required depending on building segment and other case-specific considerations. In equation 1, rated capacity Q can be replaced with the area-based maximum number of persons if an area-based approach is preferred.

This paper studies the maximum car capacity factors (CCF_{max}) measured in high-rise *office* buildings. The car capacity factor is defined as the ratio of the number of passengers in a lift car to its rated passenger capacity. In this article, the car capacity factor is not averaged over round trips, but the purpose is to find out the highest values that passengers accept at any time.

$$CCF_{max} = P_{max} \,/\, Q \quad (2)$$

2 FACTORS INFLUENCING MAXIMUM CAR LOADING

Several factors influence the point at which a lift is perceived as too crowded to board. These factors can include, for example, culture, time of day, waiting time, handling capacity, building segment, tenancy, gender distribution, number of floors, social group behaviour, personal accessories, lift group control, lift shape, and lift car size – the area per person varies with different rated loads and even lift cars with the same rated load can have different floor areas [5, 10, 11].

This article concentrates on the office segment, including single-tenant and multi-tenant offices. The dataset also includes one building that could be classified as an educational facility and one that could be classified as a parliament building. These were considered sufficiently similar to offices in terms of passengers' space requirements. Other building segments, such as residential buildings, hotels, hospitals, and shopping centres, were not included and would require further research.

The hypothesis is that people in Western countries tolerate lower levels of crowding in lifts compared to, for example, people in South-Eastern Asia. This difference may be partly explained by variations in average passenger size, as well as by cultural norms regarding personal space and acceptable density in shared environments. In addition, familiarity with high-density environments is likely to play a role. Practitioners in the field have also suggested that Northern Europeans may utilise lift capacity less efficiently than Southern Europeans.

Previous pilot research [5] indicated that higher car loadings would be accepted by passengers during lunchtime and evening peak than during morning uppeak. Therefore, this is now analysed using a larger dataset.

3 COLLECTED DATA

Data were collected using stand-alone sensor devices that were temporarily installed in the lifts. Using 3D camera technology and human detection algorithms, the sensors detected boarding and alighting passengers with an accuracy greater than 95%. The passenger counts were used to derive car capacity factors after each stop [5, 12].

Measurements were conducted on several continents: Asia, Oceania, Europe and North America. The European sample included buildings from Northern, Southern, Eastern and Western Europe. The Asian dataset consisted of measurements from the regions of Southeast Asia, East Asia and the Middle East. Most of the buildings had at least minor lift traffic challenges, as most of the data was originally collected to support customers in improving people flow in their buildings, although some buildings with good lift traffic were also included. None of the regions had only well-lifted buildings.

The data were collected between 2017 and 2025, but not during the COVID-19 restrictions or in the period following them, when passenger behaviour may have differed from normal conditions. Some of the buildings included several lift groups located in different zones. The zones may have differed significantly, effectively functioning like separate buildings with different tenants and traffic profiles, as well as different passenger behaviour. Some lift groups had only one day of measurement data, while others had up to 7 days of data. All the measurement days were weekdays. Lift car sizes included in the research varied from 8 to 26 persons rated capacity, according to a 75 kg per person standard.

Table 1 Overview of the measurements by region, including countries, number of buildings, lift groups and measurement days

Region	Countries	Measured buildings	Measured lift groups	Measurement days
Eastern Asia	China	2	3	5
South-Eastern Asia	Indonesia, Singapore, Malaysia, Philippines, Thailand	12	19	31
Middle East	Türkiye, UAE	5	5	6
Eastern/Central Europe	Poland, Serbia	2	2	4
Western Europe	France, Belgium, Netherlands	4	10	15
Northern Europe	Finland, Sweden	3	3	13
Southern Europe	Spain	2	3	6
Oceania	Australia	2	2	5
Northern America	USA, Canada	2	5	8
Total		**34**	**52**	**93**

4 RESULTS

One of the research questions is to determine the highest acceptable car capacity factors at different times of the day and in different regions or cultures. One challenge when analysing the data was that peak periods occurred at different times in each building, and direct averaging over timestamps would have flattened the peaks. On the other hand, maximum values can be affected by outliers or measurement errors.

To address this, the following approach was applied. For each lift and measurement day, the highest-loading 15-minute interval was identified separately for three peak periods: morning, lunch and evening. This ensures that peak conditions are captured regardless of their exact timing in different buildings.

From the observations within these peak intervals, the 99.5th percentile of car capacity factors ($CCF_{99.5}$) was calculated. This provides a robust estimate of the upper bound of passenger-accepted loading while excluding extreme outliers. Results should be interpreted cautiously for regions with limited sample sizes.

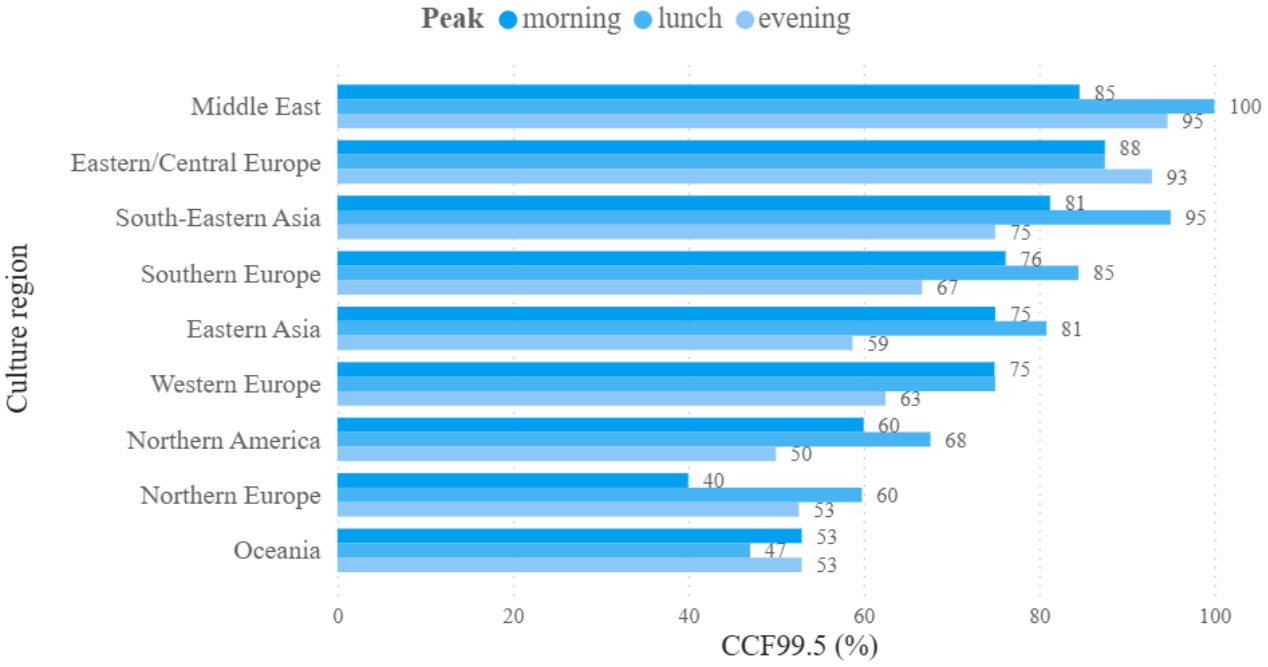


Figure 1 $CCF_{99.5}$ during worst morning, lunch and evening peak periods by cultural region

In addition to the detailed regional classification, a secondary grouping was constructed to improve statistical robustness. The alternative groups are Europe, Asia and Anglo-cultural regions. This complementary classification does not replace the original regional breakdown but provides a more aggregated perspective. However, this classification alone would be too coarse to capture meaningful variation in lift loading behaviour.

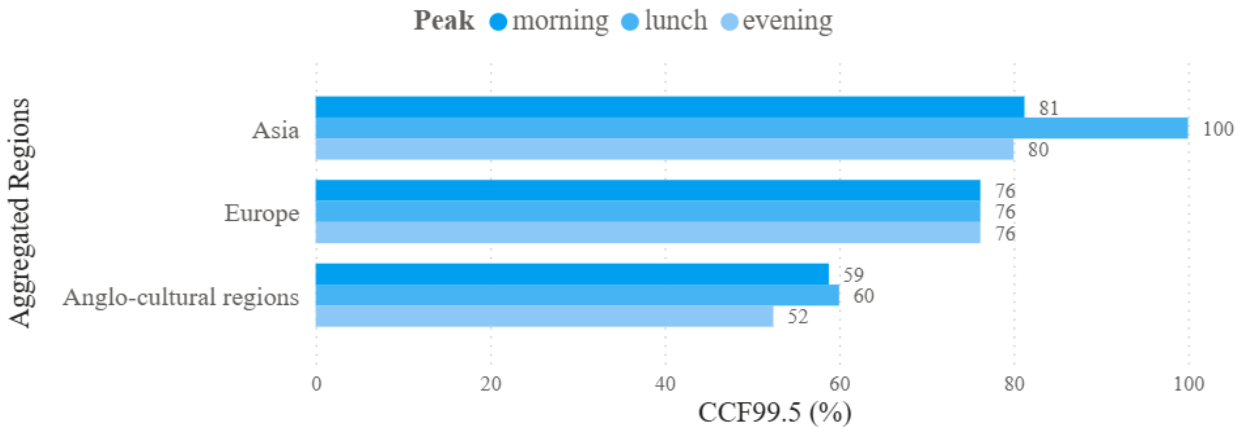


Figure 2 $CCF_{99.5}$ during worst peak periods by aggregated region

In Asia, the upper range of accepted car capacity factors appears to reach approximately 80% during morning and evening peak periods, and up to around 100% during the lunch peak. This reflects the upper tail of the observed load distribution rather than typical operating conditions. The higher values observed during lunch compared to morning and evening peak periods may be associated with increased traffic demand, longer waiting times, or a higher likelihood of passengers travelling in socially connected groups.

Across Europe, accepted car capacity generally remains below 80%. More detailed analysis reveals notable intra-regional variation, with Northern Europe demonstrating significantly lower loading levels. This observation is consistent with the authors' experience, although the sample size in Northern Europe is limited.

The lowest car capacity factors were observed in Anglo-cultural regions. Although the dataset did not include measurements from the United Kingdom, this pattern is consistent with industry practices in these regions. For example, British lift consultants often prefer area-based methods for defining passenger capacity, which typically result in lower car loading compared to mass-based approaches. Both approaches are permitted under ISO 8100-32:2020.

In addition to cultural reasons, regional differences are probably influenced by passenger sizes. CIBSE Guide D [11], which is commonly used in countries with strong British influence, presents passenger sizes varying from 0.14 to 0.24 m^2 per person in different countries. More precisely, CIBSE Guide D calls this the body area index. After the tables of body area indices, CIBSE Guide D presents an example of a body ellipse with an area of 0.21 m^2. This lets the reader understand that body area indices are body *ellipse areas*. It could be better clarified whether it is correct to divide lift floor area by the presented ellipse area. Passengers are not play-dough and cannot fill every corner of the lift efficiently. On the other hand, the example body ellipse seems to have a bit of tolerance, and the original body ellipse measurements have been done based on an adult male sample population. In practice, mistakes would not be big if lift floor area is simply divided by area per person without complicated ellipse packing analyses.

Figure 3 shows the distribution of car capacity factors across all observations, including non-peak periods. The majority of observations are concentrated at low load levels, reflecting typical operating conditions where lifts are only partially occupied. However, the presence of a long tail demonstrates that significantly higher load levels do occur, although relatively infrequently. This contrast highlights the difference between typical and peak usage: average operating conditions are dominated by low loads, whereas high load levels are rare but still operationally relevant.

Figures 4–6 show the corresponding distributions within the identified worst 15-minute peak intervals for morning, lunch and evening periods. Compared to the full dataset, the distributions are shifted towards higher load levels, as expected.

The most extreme car capacity factors over 130 % did not occur during any peak period. Those might be individual sensor measurement mistakes. Alternatively, the passengers involved may have been smaller than average.

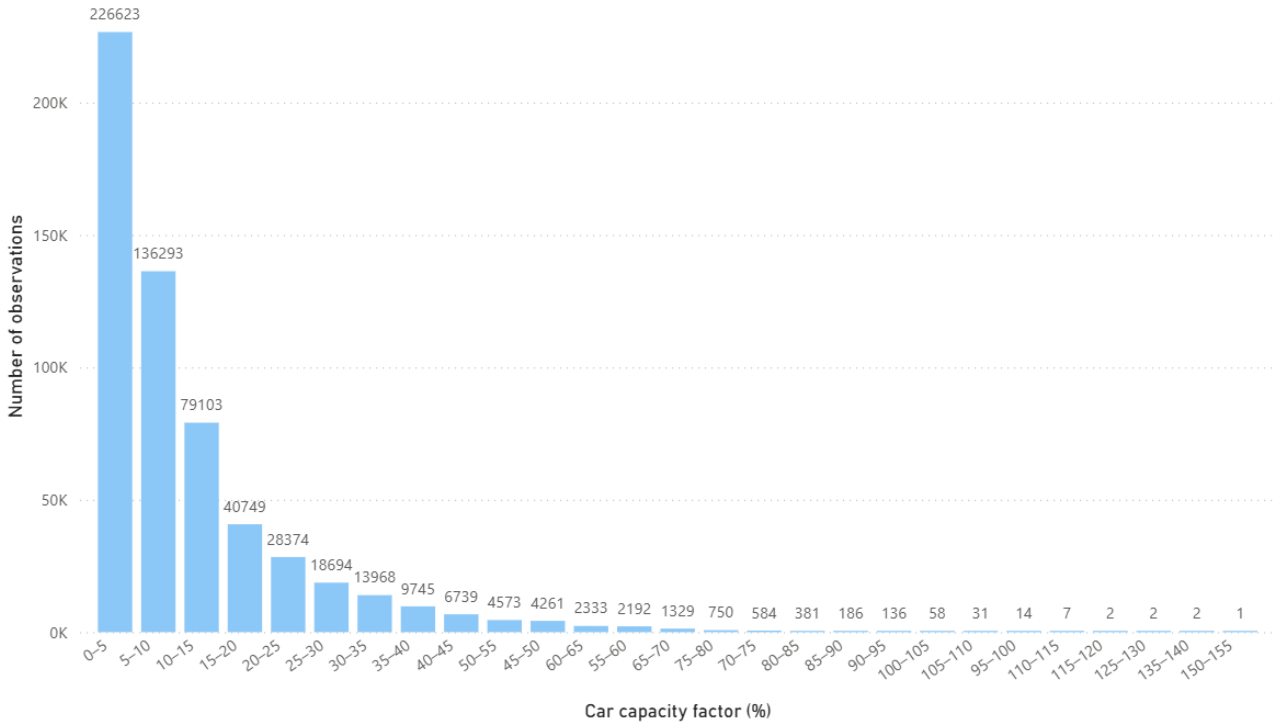


Figure 3 Distribution of car capacity factors including all time periods (also quiet times)

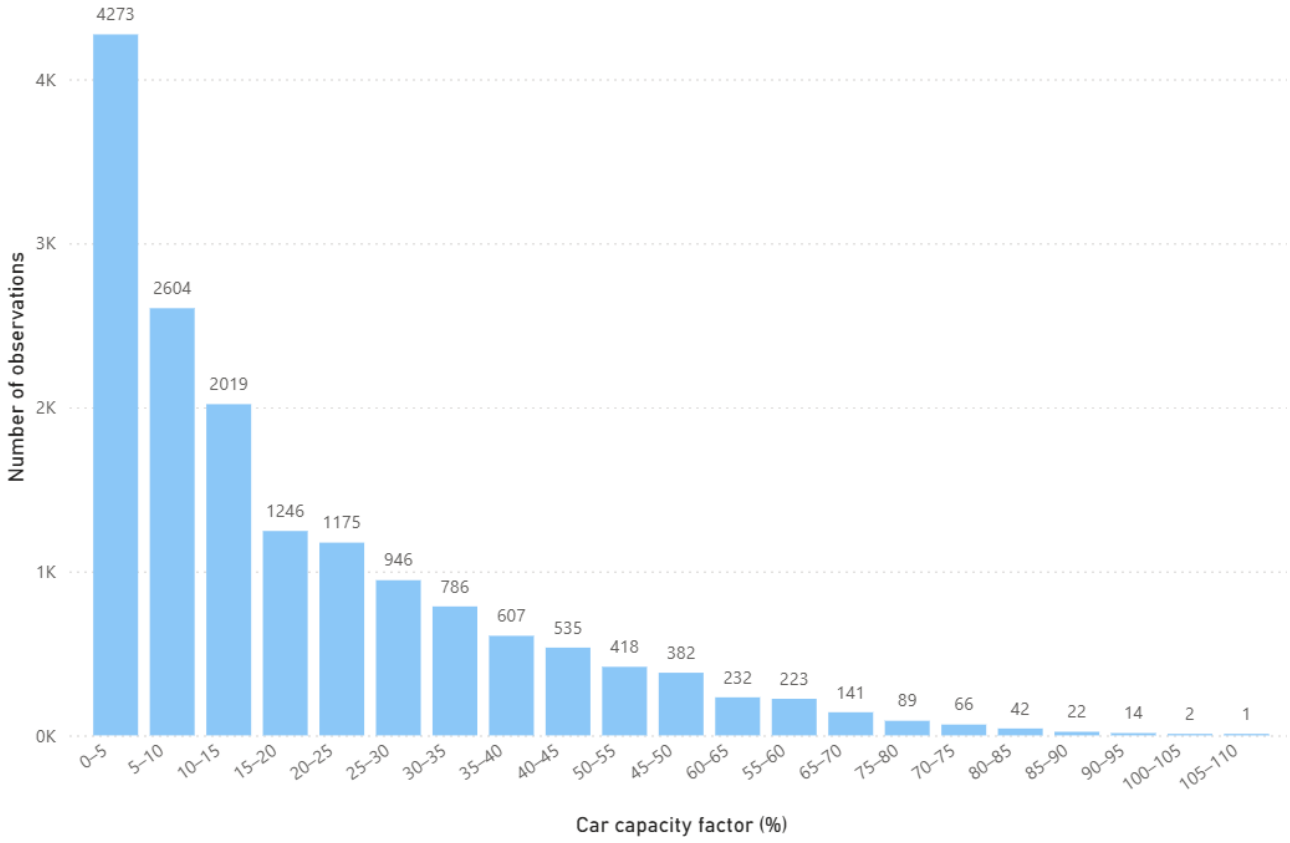


Figure 4 Distribution of car capacity factors during worst 15-minute morning peaks

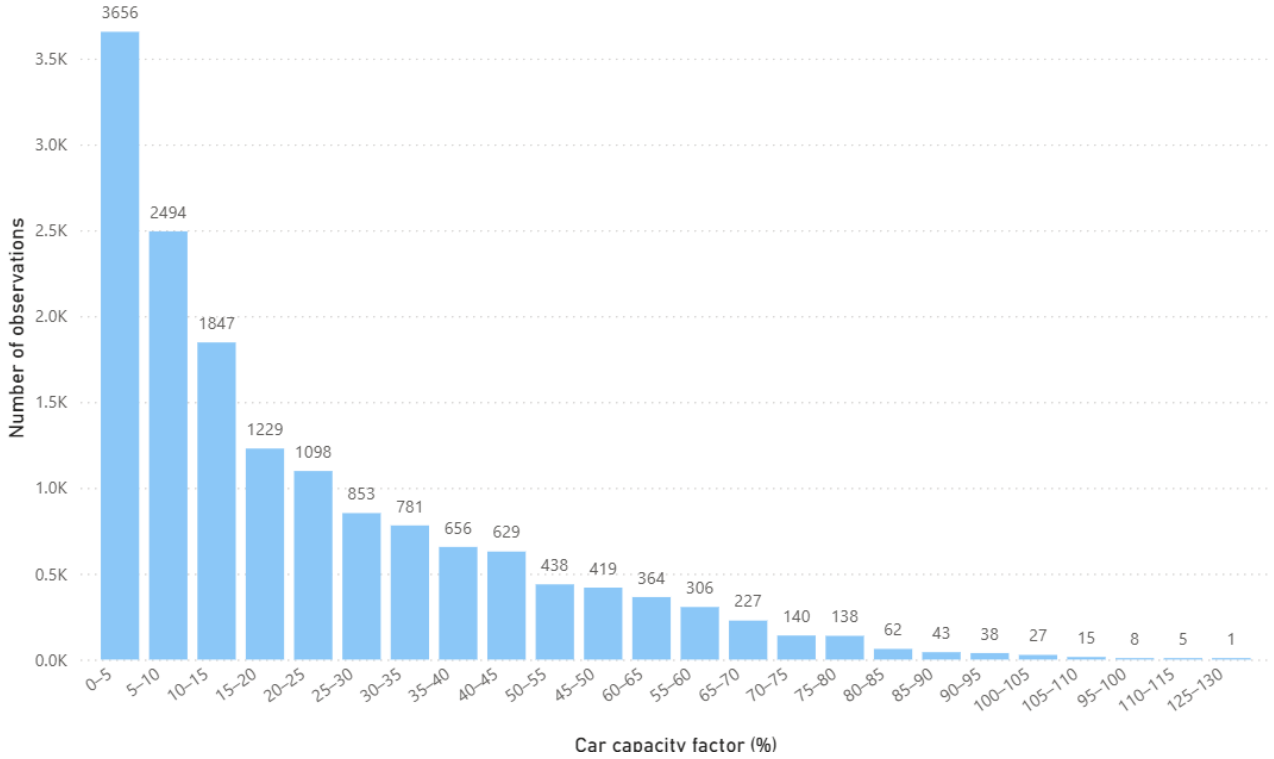


Figure 5 Distribution of car capacity factors during worst 15-minute lunch peaks

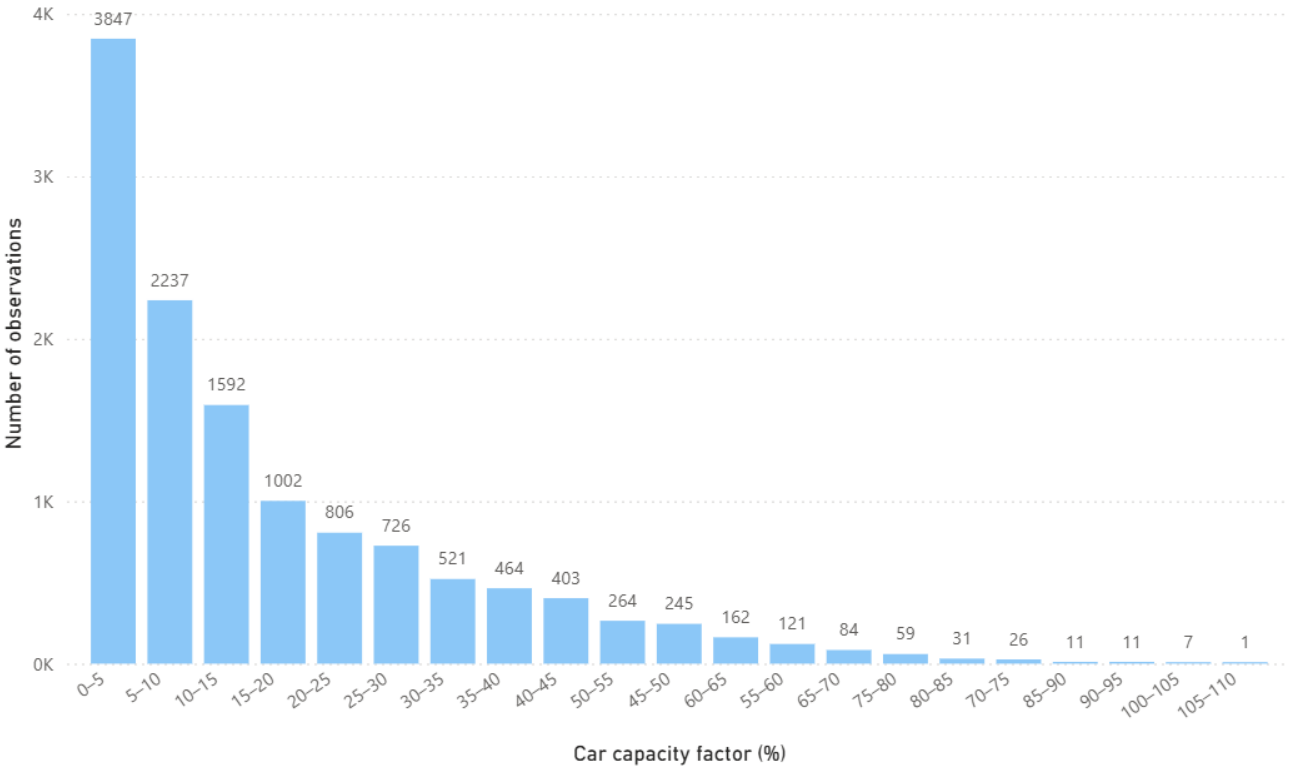


Figure 6 Distribution of car capacity factors during worst 15-minute evening peaks

The negative side of data being collected originally for other purposes is that the authors could not have affected what other data had been collected of the lift groups and buildings in addition to the sensor measurements. The authors have checked, for example, countries and building types, but data such as door parameters or lift floor areas are not available. These could have been beneficial for calculating handling capacity ratios or comparing loading against lift floor areas. Rough approximations could have been possible based on assumptions, but those could have been misleading also.

5 CONCLUSIONS

The results indicate substantial variation in the upper bounds of lift car loading across regions. High-percentile values ($CCF_{99.5}$) suggest that car capacity factors accepted by passengers can approach or reach rated capacity in certain contexts, particularly in Asian regions during lunch peak periods. In contrast, European regions exhibit more moderate car capacity factors, while Anglo-cultural regions show even lower car loading levels. The findings highlight that the upper envelope of car loading is strongly context-dependent.

The results suggest that assumptions regarding acceptable lift car loading should be region-specific rather than universal. The time of day also appears to influence car loading levels. Design approaches based on fixed or globally uniform capacity factors may fail to reflect actual passenger behaviour in different contexts, potentially leading to under- or over-dimensioning of lift systems.

The concept of car capacity factor could be more explicitly defined as an outcome of lift traffic analysis rather than a fixed design assumption. It may be difficult to determine a single global standard loading limit. However, a requirement to present car capacity factor as an analysis outcome could be incorporated into standards and guidelines. Some practitioners already present it in their lift traffic analysis results, and some guidelines [e.g. 11] encourage presenting it. However, other practitioners do not consider car loading levels to be a service criterion alongside waiting time and time to destination. It would be valuable for this requirement to be incorporated into the global lift traffic standard ISO 8100-32.

This does not mean that there would be no physical limits. In practice, lift car area and passenger sizes define the maximum passenger capacity. This maximum value could be used in lift traffic *simulations*. In the *calculation* method, a factor of 0.8 should also be applied. Regional differences are partly taken into consideration if area per person is defined correctly for every region. In addition, lift consultants can specify other context-dependent multipliers. These should be described and explained in lift traffic analysis reports.

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BIOGRAPHICAL DETAILS



Tiina Laine is a senior expert in People Flow Planning team and has been working for KONE Major Projects since 2008. In her role, she analyses people flow in high-rise buildings and other complex buildings. In addition, she trains the KONE network of People Flow Planning experts and advises them in challenging building projects to find optimal people flow solutions for customers. Laine holds a Master of Science (Tech.) degree from the Helsinki University of Technology, Department of Mechanical engineering (2007).



Mirko Ruokokoski graduated from the Department of Engineering Physics and Mathematics at Helsinki University of Technology in 2008. Currently, he is finishing his doctoral thesis at the Systems Analysis Laboratory in the School of Science at Aalto University. He joined KONE in 2012 and is currently an Engineering Lead in R&D.