Elements of Elevatoring

NBC 2005 Guidelines to Preliminary Design of VT Systems

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Presented at the

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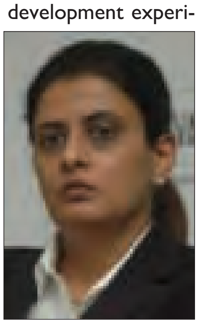

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Earlier this year, I had the privilege of visiting one of the new office complexes in Mumbai. I was impressed by the triple-height lobby, vertical garden and overall grandeur of the place. My expectations went up with every step I took. So, it was a huge letdown when I turned into the elevator lobby and bumped into a long queue of people waiting for the lifts.

I first thought that some of the lifts were out of service, but I was wrong. I also noticed that the lift at the far corner seemed to have its doors open, so I inched my way to it. I looked up to see the words "Directors Only" with a uniformed guard next to the lift. Even as I looked, the guard suddenly clicked to attention, and a solitary passenger entered the lift and was immediately whisked away. The reaction of the people in the queue varied from indifferent shrugs to pure fury.

The "Directors' Lift" silently advertised the status of the project's vertical-transportation (VT) design – it had been inadequate to begin with, and the problem was compounded by removing one of the lifts from general service. This brings to the fore the importance of planning the VT system at an early stage of the project; a poor VT configuration can kill the best of projects.

NBC 2005 provides two basic parameters to determine the preliminary design of a VT system in a building – quantity of service and quality of service. NBC 2005 Part 8, Sec 5-6.2.3 defines the quantity of service as a measure of the passenger-handling capacity of a VT system:

> *"It is measured in terms of the total number of passengers handled during each five-minute peak period of the day. A five-minute peak period is used as this is the most practical time over which the traffic can be averaged."*

The handling capacity is calculated as

$$H = \frac{300 \text{ X } Q \text{ X } 100}{T \text{ X } P}$$

where H = handling capacity as a percentage, Q = average number of passengers carried in a car, T = waiting interval in seconds, and P = total population to be handled during the peak period.

According to NBC Part 8, Section 5-6.2.4, "Quality of service is generally measured by the passenger waiting time at the various floors." The waiting interval is calculated as T = RTT/N, where T = waiting interval in seconds, N = number of lifts, and RTT = round-trip time (the average time required by each lift to take one full load of passengers from the ground floor, discharge them in various upper floors and come back to the ground floor for fresh passengers for the next trip).

RTT is the sum of time required in the following process:

a) Entry of passengers on the ground floor
b) Exit of passengers on each floor of discharge
c) Door closing time before each starting operation
d) Door opening time before each discharging operation
e) Acceleration periods
f) Stopping and leveling periods
g) Periods of travel at full rated speed between stops, going up

Continued

h) Periods of travel at full rated speed between stops, going down

Some of the assumptions made in the calculation for RTT are:

- Pure up-peak traffic
- That all floors are equally populated
- Constant inter-floor distances over all floors
- That rated speed is achieved for a single-floor jump
- That passengers arrive at constant intervals and are served by lifts arriving at constant intervals
- That the elevators are all making the same "average" round trip of the building.
- That dispatch interval, loading interval and door dwell times are negligible
- That average passengers carried equals 80% of the rated car capacity

It is clear that we can calculate the interval between car arrivals at the main terminal (ground) floor, not the passenger waiting times at the various floors. It is also clear that average waiting time (AWT) does not equal interval. In an ideal situation, AWT is one-half of the interval. In reality, the relationship between waiting time and interval depends on how busy the elevators are and on the extent of car loading.

During non-peak hours, the elevators may be idle for some time. This would increase the interval as calculated by the RTT equation, even though the AWT could be as low as zero. This is because, on average, passengers are likely to be serviced by an elevator immediately upon registering a call. The situation is reversed during the peak period. As traffic increases, people arrive faster than they are being taken away, and every elevator leaves the main terminal at maximum loading. The system "saturates," and long queues begin to form. People have to wait for the next elevator to get on, and hence, AWT increases exponentially. However, interval barely changes, because elevators continue to cycle around the building at a constant rate, irrespective of the queues at the main terminal floor.

The relation between AWT and interval has been approximated by experts:

- For car loads less than 50%, AWT = 40% of interval (*CIBSE Guide D*, Chapter 3).
- For car load = 80% of rated capacity, AWT = 85% of interval (*CIBSE Guide D*, Chapter 3).
- According to George R. Strakosch, AWT is approximately 55-60% of interval.
- Barney's results suggest AWT ~ $[0.4 + (1.8\ P/RC - 0.77)^2]\ INT$, where *RC* is the rated car capacity, and car loads are 50-80%.

However, for car loading exceeding 80%, AWT increases substantially and, in theory, would be infinite at 100%. Simulation can be used to obtain more definitive values for AWT.

To conclude, the conventional approach to design assumes that passengers arrive at a constant rate and are serviced by lifts arriving at constant intervals. In reality, the passenger arrivals and lift departures are random. The randomness produces queues and long waiting times at higher levels of car loading. As we normally analyze traffic at peak levels, minor variations in design can make a massive difference in passenger waiting time but minimal change in interval.

The National Building Code (NBC) provides the basic guidelines for the preliminary lift design that could probably be refined for further detailing (Table 1). While it is important that preliminary lift design is carried out at an early stage in the project, it is also very important that appropriate parameters are used to determine the design instead of assuming ideal traffic patterns. As NBC 6.1.1 notes, "In view of the dynamic situation, it is recommended that computerized software is used for Traffic Analysis Study."

Table 1

NBC 2005 Part 8, Section 5, Clause 6 – Scope for Improved Design Parameters	
6.2.2 Population Assumption – 5 m^2 per person for general office buildings for speculative development	Per person area will change depending upon the plan layout – open/cellular, quality of accommodation – prestige/standard/speculative and occupancy type – single/sector/mixed tenancy. Guidelines can be drawn out for different criteria.
6.2.4 **Quality of service** *Acceptable Interval* *20-25 sec. – Excellent* *30 to 35 sec.– Good* *34 to 40 sec. – Fair* *45 sec. – Poor* *Over 45 sec. – Unsatisfactory*	A more comprehensive table can be provided ensuring there are no gaps/overlaps.
6.2.4 **Quality of service** For residential buildings, **longer intervals** should be permissible	"Longer interval" needs to be clarified and values can probably be set depending on the segment – luxury, middle income, low income.
6.2.9 Interval-passenger waiting time at various floors $T = \frac{RTT}{N}$	Using this formula, Interval can be calculated at main lobby level. Average waiting times cannot be calculated at various floors. Since the code is already looking at average waiting time as the parameter for quality of service, some guidelines regarding average waiting times can be set.