Pressurizing the cars of high speed express elevators

This possibility is often mentioned in articles about express elevators for tall buildings. The article in the July 2013 issue of ELEVATOR WORLD <A New World's Fastest: Shanghai Tower>, also refers to the pressurizing of cars and provides an interesting project to consider this topic. The express elevators for this tower may have a maximum contract speed of 18 m/s.

The article mentions that the Double Deck express elevators will reach contract speed after an acceleration period of 25 seconds and travel at full speed during 10 seconds. If we assume the deceleration period is also 25 seconds the total travel time to floor 119 (distance 565.4 meter) is 60 seconds. This time probably includes the time for door operation. A calculation with the usual standard rates for acceleration, deceleration, jerk, and times for door closing and opening, confirms that the 60 seconds Door to Door Flight Time (DDFT) is correct for the assumed contract speed of 18 m/s.

The air pressure at floor level zero will fluctuate in accordance with weather conditions; however, the air pressure on floor 119 will be about 58 millibars less because air pressure declines by about 10.2 millibars per 100 meter.

Time available for control of air pressure

The time available for a gradual reduction of car air pressure during an UP trip is the DDFT of 60 seconds, minus the time for door closing and opening, i.e. a period of 54 seconds. This means the car internal air pressure must be reduced by 1.07 millibars per second (58/54). This mode of air pressure control provides a car internal air pressure as if it is a <u>non-pressurized car</u> travelling at a constant speed of 10.5 m/s. During down trips the car air pressure must be increased by 1.07 millibars per second.

Passenger comfort

Airlines have undoubtedly investigated the affects of air pressure on passengers because gradually reducing air pressure in cabins and increasing it before landings is a standard practice. Airplanes usually have plenty of time for this procedure. For elevator passengers, the question is: "Which rate of change of car air pressure is safe and comfortable?" The author is under the impression that car speeds up to 12 mps can be tolerated by elevator passengers. If this assumption is correct, the pressurizing of the Shanghai Tower elevator cars enables a reduction of the DDFT. If the maximum elevator speed that can be tolerated by the general public is less than 12 mps the pressurizing of elevator cars is probably not attractive because it introduces a serious technical problem for minimal time benefits.

Complex technical problem

The article "A New World's Fastest: Shanghai Tower" mentions it may not be possible to use the maximum possible contract speed of 18 m/s. This comment is not surprising because the pressurizing of cars presents a complex technical problem that includes air-conditioning of the car interior. Also a sudden change of air pressure due to a technical problem would have to be considered.

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Conclusions

It is technically possible to realize a DDFT of 60 seconds to the Shanghai Tower Sky Lobby. It would probably be the first group of express elevators that controls the internal air pressure of cars to minimize flight times. To put this DDFT of 60 seconds in perspective please note that a contract speed of 12 m/s will increase the DDFT to about 70 seconds. For a contract speed of 10 m/s the DDFT will be about 73 seconds.

The Round Trip Times (RTTs) of the cars are positively affected by short DDFTs, however; the probably large cars of the express group under consideration cause long car loading and unloading times that negatively affect group performance. If we assume that the express group to floor 119 consists of four double-deck cars their Round Trip Times during heaviest simultaneous UP and DOWN traffic will be twice the DDFT of 60 seconds plus two 25 seconds periods for loading and unloading of 20 passengers per deck at each terminal, i.e. a total RTT of 170 s.

In this case the theoretical minimum average departure interval will be 43 seconds and the theoretical minimum average waiting time about 22 seconds. The maximum transport capacity of the group, per 5 minutes, will be: 282 passengers in both directions. The 25 s. for loading and unloading assumes the decks of the express cars have two sets of doors opposite each other and the loading doors open about 5 seconds after opening of the unloading doors, i.e. the car loading and unloading periods of 20 seconds each overlap by 15 seconds. In case the decks have only one set of doors the periods for car unloading and loading will be a least 20 seconds each. In this case the RTT will be at least 30 seconds longer.

The assumed four-large-car configuration is not the best possible optimum. An alternative group of SIX half-as-large triple-deck cars can be installed in the space required for four large double-deck cars. With a contract speed of 10 m/s and unpressurized cars (with two sets of doors per deck) this group will deliver average RTTs of 171 seconds (twice 73 s. + twice 12.5 s.) because the loading and unloading periods of 10 seconds each overlap by 7.5 seconds and total 12.5 s. In this case the departure intervals will be about 28.5 seconds (171 / 6) and average waiting times will be approximately 15 s. The maximum transport capacity of this group, per 5 minutes, will be: 316 passengers in both directions. With one set of doors RTT’s will increase by 15 s. to 186 s.

The 6-car configuration with small triple deck cars appears to be an attractive concept that reduces crowding at the main entrance and sky lobby floors, while substantially increasing service frequencies. The essential aspects of planning express groups and sky lobbies are described in Chapter 12 of your author’s book, “The planning and performance of groups of elevators“ published at website: elevatorgroupcontrols.com.

The author will greatly appreciate comments or questions from readers.

(This text has been published as an article in the November 2013 issue of Elevator World. After publication your author has added a further conclusion.)

A further conclusion

Concerning the time the time available for air pressure control your author wants to make a further comment. Please note that in case the sky lobby would have been positioned at a higher level, for example at 1000 meter, the Door to Door Flight Time (DDFT) of the elevators would increase from 60 to 84 seconds. The increase of 24 seconds is caused by the additional time required for the longer travel distance of 435 meters at the top speed of 18 mps.

In this case the air pressure differential of the sky lobby and floor zero will be 102 millibars (mb). The time available for a controlled reduction of air pressure will 78 seconds (84 less the time for door closing and opening). Consequently the controlled air pressure reduction in an UP going car should be 1.3 mb per second (102/78). For a car travelling at a constant speed of 10 m/s the air pressure reduction is 1.02 mb per second. A 1.3 mb reduction per second provides an internal air pressure as if it is a non-pressurized car travelling at a constant speed of 12.7 m/s. This rate of change of air pressure is probably not acceptable for the general public.

For the Shanghai Tower building the pressurizing of the cars of the express elevators may enable a modest reduction of the Door to Door Flight Time (DDFT) to and from the sky lobby. For sky lobbies that are positioned a few hundred meters higher the time saving will be shorter.

The author has doubts that the pressurizing of elevator cars offers a viable solution for improving the efficiency of express elevators. Groups with more and smaller triple deck cars are likely to be a more attractive solution.

It will be of interest to read in a future issue of Elevator World further news about the decisions in respect of the maximum contract speed, the pressurizing of cars, and the rate of change of air pressure that is considered acceptable for elevator passengers.

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