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Study on Hours of Sunshine of High-Rise Residences

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\section*{Biography}

I am a professor in the University of Kitakyushu of Japan, doctor of engineering, registered architect of Japan, member of Architectural Institute of Japan (AIJ). Research interests are environment design of architectures, recyclable building, and urban planning concept of compact city, urban environment evaluation and suggestion.

\section*{Abstract}

This research estimated the influence of future super-high-rise apartment buildings by investigating the sunshine problem, which may present an environmental problem for future concentrations of super-high-rise residential buildings. We performed a simulation involving recent tendencies of actual conditions of super-high-rise residences in Japan. When super-high-rise apartment buildings are crowded together in the future, and building intervals are not taken into account to some extent, it turns out that sunshine on units at the lower part of the building do not get 4 In summary:
1. Super-high-rise residences in Japan are constructed with an emphasis on sunshine from the south side.
2. If the arrangements of buildings are moved 30 degrees to 45 degrees, there is a possibility that the sunshine conditions of the lower parts of super high-rise buildings would be improved.
3. In the case of 45 floor resideny complex, if there is a 150m interval for each building, the sunshine conditions would be acceptable. In such a case the population density is about 400people /ha.

Recently, construction of super-high-rise condominiums in Japan has increased. Especially in metropolitan areas, such as Tokyo, the construction of super-high-rise residences has escalated, with the number of completed super-high-rise residences expected to have exceeded 200 in 2003. It is clear that a forest of super-high-rise residences will be apparent in Japan in the near future, and there are already similar symptoms in the center areas of big cities in China and other Asian countries. This report pays attention to the residential environment of such super-high-rise residences, we examine sunshine hours of south facing dwelling units at each level of a high-rise building, assuming that many high rise-residences would be constructed in a limited area and caste shadows on other buildings. From this study we attempt to predict preferable allocations of super-high-rise residences and the possible population density in a city center.

\textbf{Keywords}: super-high-rise residence; residential environment; sunshine hours; density of population; shadow
1. Introduction

There are several reasons for the increase in super-high-rise residences in Japan. The desire to have a home in the center of Tokyo or other cities has been fuelled by the fall of land prices in city centers. Moreover, the necessity for better land-use in city centers and the recent city-center rehabilitation movement are encouraging the construction of super-high-rise residences. Further, super-high-rise residences are gradually being established as an accepted general form of a residence for ordinary citizens who are gradually beginning to recognize that a super-high-rise residence has special features, such as a superb view from upper floors or adequate security, which can not be attained in other housing forms. The technical progress represented by super-high-rise residences and the quality as a residential environment is highly appreciated. Thus, it can be expected in the future that the number of such constructions will increase in city centers.

We expect that a forest of super high rise-residences will appear in Japan in the near future. We thus examine the sunshine hours of south facing units at each level of buildings, assuming that many super high rise-residences will be constructed in a limited area, and cast a shadow on other buildings.

2. Characteristic of Super-high-rise Residences in Japan

Although a super-high-rise residence is generally defined as more than 20 floors, in this research we determine it as being more than 25 floors.

To understand the characteristics of a super-high-rise residence in Japan, we use data from the Building Center of Japan, of all the super-high-rise residences authorized from June 1993 to May 2001. The number of buildings having data available is 162. The contents of the data are lot area, building area, total floor area, standard floor plans, standard floor area, floor height, the number of EVs, completion years etc.

Fig. 1 shows the relation between completion year and the number of floors.

Many super-high-rise residences have been built recently and the rate of building residences of more than 40 floors has recently increased. The reason for there being few buildings in the 2004 bar is that all applications were not contained in the available data (to May 2001).

Fig. 2 shows the rate of buildings where units face only north only 4% of super-high-rise residences. This means that sunshine is still one of the very important issues for each unit of high-rise residences, the same as for ordinary houses.

Fig. 3 shows directions of super-high-rise residences. In the lower introductory notes the square expresses the figure of super-high-rise construction plans, and the top direction is north. The portion of the thick line is the side to which many of the super-high-rise dwelling units face. According to the direction which many dwelling units face, high-rise residences are classified into six patterns. From the pie chart, 55% of super-high-rise buildings face south with a direction arrangement on an east-and-west axis. It is clear that super-high-rise residences in Japan are constructed with the emphasis on the sunshine from the south side.
3. Sunshine hours simulation
3.1. Precondition for the simulation

To perform a shadow hour simulation, we assumed that super-high-rise apartment buildings stood close together in the range of 500mx2000m (100ha) as a model site. We calculated the shadow hours of a dwelling unit on the south elevation of a super-high-rise residence at the center of the sequence of the No. 1 north side. The place was assumed to be in Tokyo (north latitude 35.41 degrees). The model shows:

- The 60th floor (200m high, standard floor: 30x30 m)
- The 45th floor (150m high, standard floor: 25x25 m)
- The 30th floor (100m high, standard floor: 20x20 m)

The building interval was changed by 50 or 75. 100, 150, 200, 250m. Moreover, angles were given to the arrangement of buildings to calculate how the shadow situation changes.

Three types giving incline changes to the arrangement of buildings are shown in Fig. 4. The basic arrangement of a building of 30 floors is at the left, incline at the 30 degrees is at the inside, and 45 degrees is at the right.

3.2. Shadow on the facade of a super high-rise residencies

Figs. 5 - 7 show how the shadow is caste onto a super-high-rise residence in this simulation. The figure on the left side is the shadow on a south facade; the right is the building arrangement plan at that time.

Fig. 5 shows the form of the shadow for the standard arrangement of the 30 floor building at different intervals from 50m to 100m. If an interval is wide, part of the shadow of 4 hours or more falls on a lower floor. In the case of 100m intervals, the shadow of 4 hours or more falls on the lower part under the 10th floor. In that case, the net population density is 294 persons / ha.

Fig. 6 shows the case of 45 floors with a standard plan. When the interval is 150m, the shadow of 3 - 4 hours falls on the lower half part of the building. The population density at this time is 389 people / ha.

Fig. 7 shows the case of the same 45 stories at a 30 degree-moved arrangement. When the interval is 150m, the shadow on the lower part became 1 or less hours. This is the effect of the 30 degrees movement. The population density at this time is 404 people / ha.
In this simulation, we measured sunshine hours at the point of 10 m, 30 m, 60 m, 90 m, 120 m, 150 m, and 180 m high. Here, we assumed that the case where sunshine was obtained for 4 hours (240 minutes) at the point of 10 m high is a good sunshine environment. Figs. 8-10 are the case of 30 story buildings in which the angles of arrangement differ. If the building interval is set to 100 m or more for a 30 story building in any arrangement, the 10 m high point gets more than 4 hours of sunshine. Fig. 11 shows the case of a standard arrangement of 60 floor buildings. In this case, if there is 150 m or more of interval, the 10 m point also gets more than 4 hours sunshine.

![Fig. 4 Three types giving incline changes to the arrangement of buildings](image)

![Fig. 5 Form of shadows with the standard arrangement of 30 stories buildings](image)

![Fig 6 45 floors with the standard plan](image)
Figs. 12-15 show the case of 45 floor buildings, and the intervals of the buildings differ. In this case, if there is more than 100m of building intervals, the 10m high point gets more than 4 hours of sunshine. Figs. 16 - 19 show the case of 60 floor buildings, and that the intervals of buildings differ. In this case, if there is a standard arrangement or the 30 degrees moved type, even if it is 60 floors with 150m intervals, 4 hours of sunshine are obtained at the 10m high point.
4. Conclusion

This research estimated the influence of future super-high-rise apartment buildings by investigating the sunshine problem, which may present an environmental problem for future concentrations of super-high-rise residential buildings. We performed a simulation involving recent tendencies of actual conditions of super-high-rise residences in Japan. Consequently, when super-high-rise apartment buildings are crowded together in the future, and building intervals are not taken into account to some extent, it turns out that sunshine on units at the lower part of the building do not get 

In summary:
1. Super-high-rise residences in Japan are constructed with an emphasis on sunshine from the south side.
2. If the arrangements of buildings are moved 30 degrees to 45 degrees, there is a possibility that the sunshine conditions of the lower parts of super high-rise buildings would be improved.
3. In the case of 45 floor residency complex, if there is a 150m interval for each building, the sunshine conditions would be acceptable. In such a case the population density is about 400people /ha.

5. References

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