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## Study on Sky View Factor of High-Rise Residences for Shrinking Cities in Japan

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### Biography

I am a doctoral candidate at the University of Kitakyushu of Japan, a second-class architect, and a member of the Architectural Institute of Japan (AIJ). Research interests include simulation-based studies on dwelling environments and approaches

that focus on compact city planning through information evaluation systems (specifically, the Geographic Information System).

### Abstract

This research presents an evaluation study on sky view factor of high-rise residences of an actual urban planning project in Japan. We compared high-rise residence plan with medium-rise residence plan and low-rise residence plan. Sky view factor and density of high-rise residences are analyzed in the end of this paper. Sometimes, building high-rise buildings are considered to be a kind of detriment to traditional view of city, because of the big sky view factor. But, in this study, comparing to other building types with the same bulk ratio, high-rise residence plan shows almost the same sky view factor value with the other plans.

This study is carried out in Yahatahigasi-ku, a ward in the city of Kitakyushu, Japan. The ward's land is characterized by steep slopes, which are inconvenient for aged people and reduce their outdoor mobility. Moreover, most of the ward's houses are over 30 years old, the average lifespan for houses in Japan. The quality of the houses is inadequate to the demands of modern life, perhaps explaining the area's inability to retain its youth. As a result, the shopping districts of Yahatahigasi-ku, prosperous in the 1950s and 1960s, are declining in proportion to the number of deserted houses.

Therefore, a development for urban regeneration is necessary to keep the activity and community here.

This goal can be achieved by the suggestion of new planning that adopting high-rise residences.

This research is also explores GIS design approaches as configured for an aging society. It discusses the important factors that flow into an urban design meant to address a declining population, such as the plot ratio, the mixing of commercial and residential spaces, and the placement of public facilities for the aged. We see here the importance of geographic information to urban planning. This paper will exemplify the importance of sharing informational evaluations to the urban planning process.

**Keywords:** super-high-rise residence; sky view factor; plot ratio; shrinking city; regeneration

## 1 Introduction

Aging society and the diminishing population are getting more serious in Japan, leading to related problems, such as the declining vitality of communities in most of the secondary cities. This tendency of the population and its structural change is supposed to continue in near future, thus makes the sustainable urban design urgent.

The industrial structure of Yahatahigasi-ku has totally changed over the last 50 years in tandem with changing lifestyles<sup>1)</sup>. In 1960 to 70, Kitakyushu supported Japanese rapid economic growth, through the aggregation of such material industries as the steel, chemical, metal and ceramic industries, which began when the government-managed Yahata Steelworks, the largest steelworks in Asia, which was founded in 1901. Yahatahigasi-ku, the biggest industrial area of Japan, was deeply affected by the changing times.

To accommodate employees, dwellings were built on the mountain around the industrial area. As employees aged, the inconvenient landform made it difficult for them to access the facilities near their houses. Young people are moving away in search of more comfortable residential environments, while few people move in (though the local population is increasing). Meanwhile, industrial styles have changed: factories are smaller, and some of the flat areas can be redeveloped.

Dilapidated dwellings in this area also pose a problem. Traditional wood dwellings constitute the majority of the street. The number of empty houses is increasing, though, especially in the steeply sloped area. An accurate average date of dwelling construction would enable an analysis of the ward's actual condition.

Yahatahigasi-ku had its glory days during the development of the West Japan Steel Factory from 1950 to 1960. The city's population was at its highest at that time. However, as the industry innovated, local residents began to leave. The current population of 60 thousand will decrease to 20 thousand in about 40 years. Though depopulation and collective aging are problems throughout Japan, the problem in Yahatahigasi-ku is particularly serious.

This study is an urban regeneration proposal plan for Yahatahigasi-ku, Japan. The proposal plan explores ways of solving the problems and providing residents with a better living environment. Compare the sky view factor with each building styles to countenance the proposal with high-rise residences in the aspect of landscape.

## 2 Inhabitant Migration Proposal

Figure 1 shows the designated migration-in promotion area, migration-out promotion area, and the buffer area. The study proposes an inhabitant migration from the sloped area to the flat area based on an examination of the aging population and the old dwellings on the slope as analyzed by the GIS. Many residences were built on the steeply sloped area. To solve the environmental problems produced by the steep slope, flat areas were chosen as the object region for inhabitant migration. The migration is expected to reduce the size of city and compact it, improving the efficiency of city services and facilities.

Migration-out promotion areas are those with high slopes and high ratios of elderly—where there is, roughly, a level higher than 80m and a slope degree higher than 5. We propose to keep inhabitants from moving in and to encourage them to move out of this area.

Migration-in promotion areas are flat with convenient traffic and public facilities—where there is, roughly, a level lower than 40m and a slope degree lower than 3. In addition the areas where is anticipated to rich of these facilities in the further.

Buffer areas lie between migration-out promotion areas and migration-in promotion areas. Government offices and universities are situated there. Migration-out areas will become sparsely populated during the process of migrating-in. In the buffer areas, sparse landscape, community decay, and crime in streets full of abandoned houses could be alleviated by adding public facilities and encouraging more human interaction.

A high density of population and buildings is required to keep public facilities efficient. Inhabitants living in

migration-out promotion areas cannot access public facilities conveniently; meanwhile, those public facilities will decay as population density decreases. Sustainable city planning must compact city functions and increase population density.

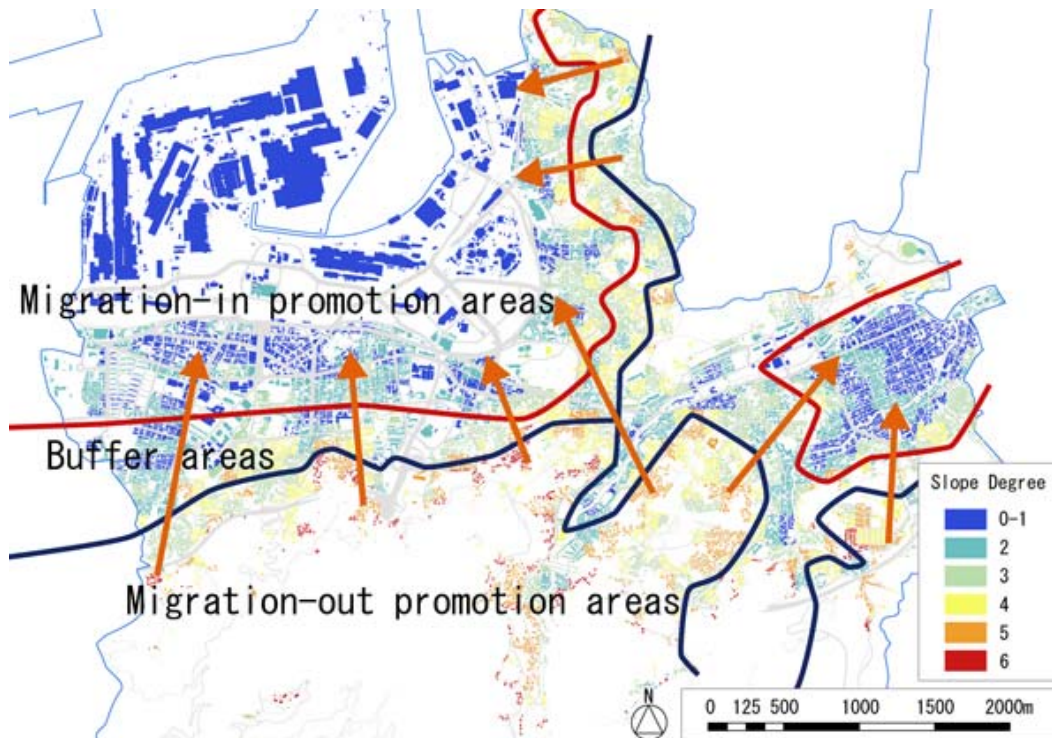


Figure1. Object region for inhabitant migration

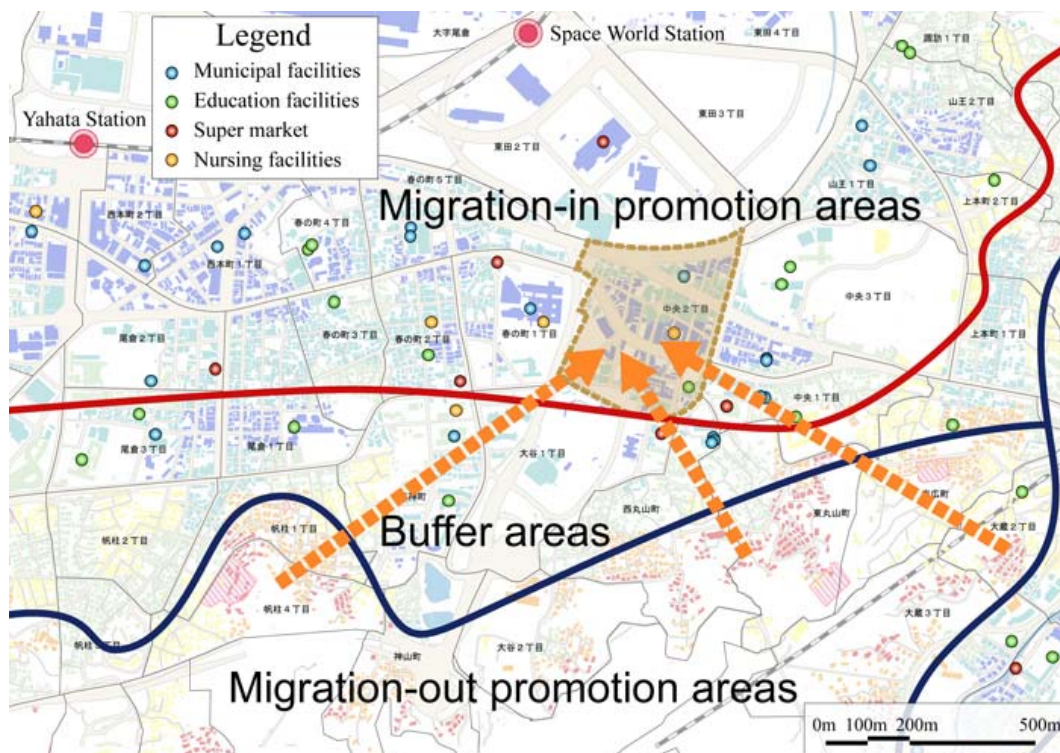
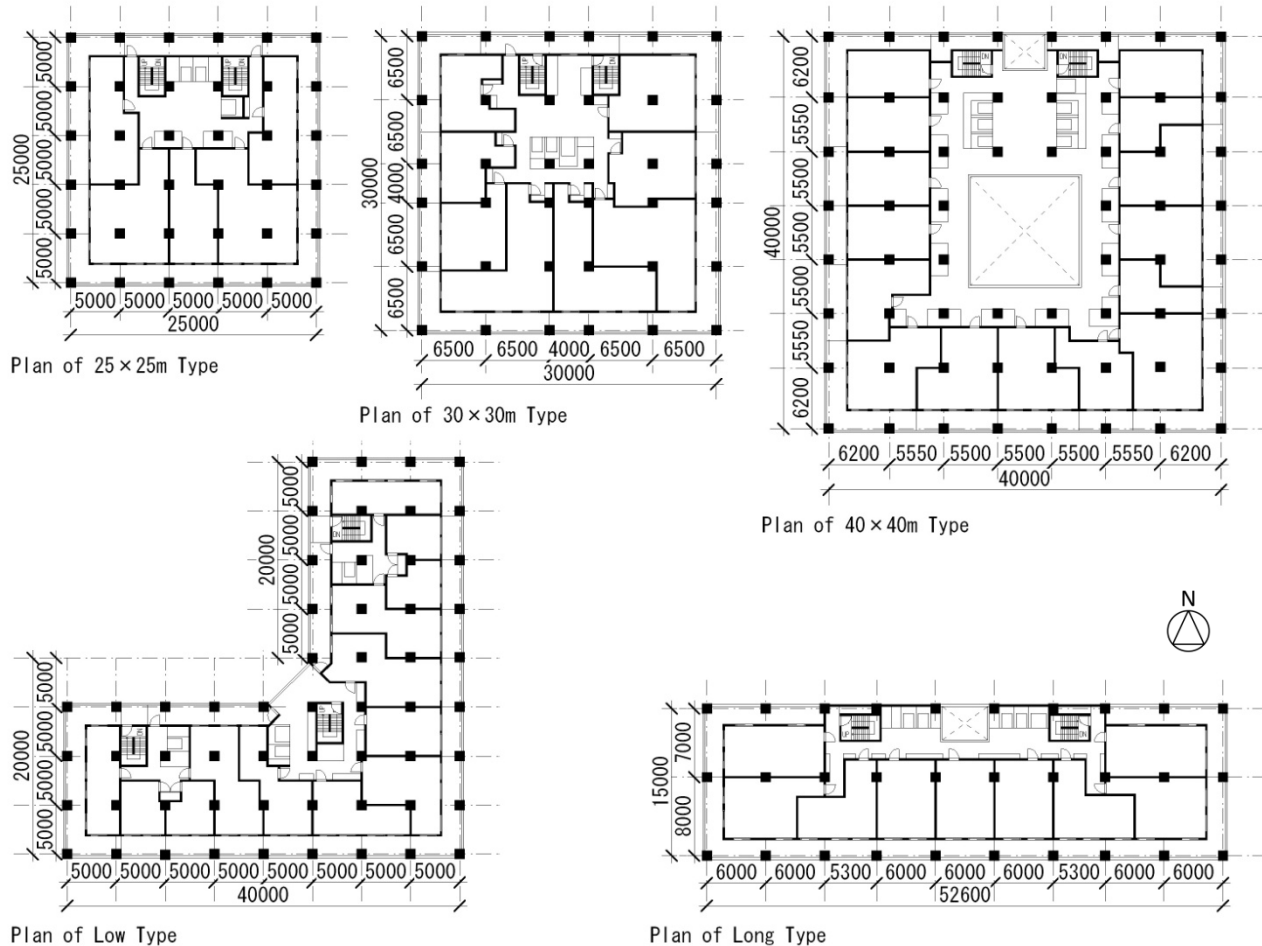


Figure2. The situation of public facilities

### 3 Proposal for High-Rise Residences on Tyuou Street

Five building types are to be compared: the void types (the  $25 \times 25$  m,  $30 \times 30$  m, and  $40 \times 40$  m types), the one-side gallery type (or the long type), and the traditional type (or the low type). Plan details for these five proposed building types are shown in Figure 3.

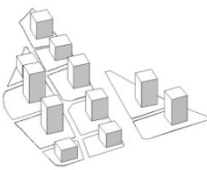
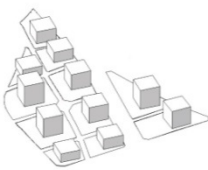
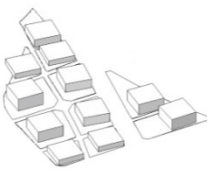
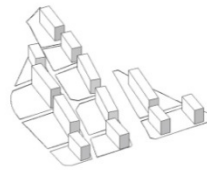
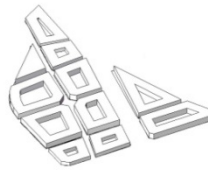
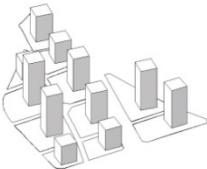
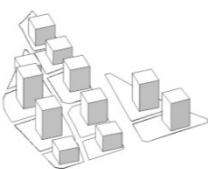
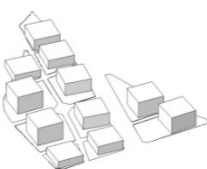
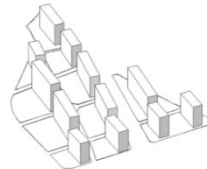
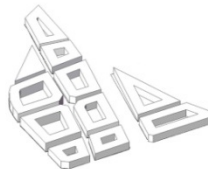

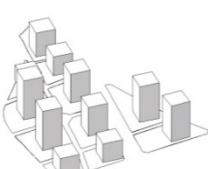
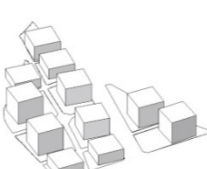
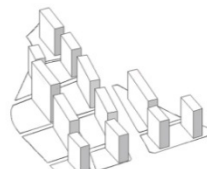









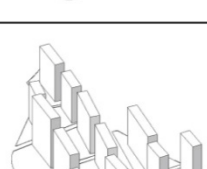

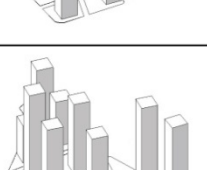
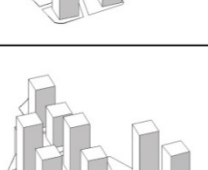
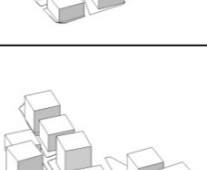
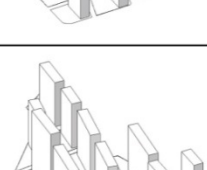
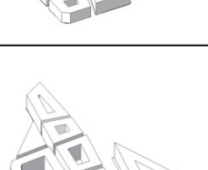


**Figure 3. Plan Details of the Five Proposed Building Types**

The maximum bulk ratio for the migration-in promotion area is 500%.<sup>2</sup> To achieve a residential building style that follows a sustainable urban design, we must consider the three functions of the building under the bulk ratio restriction: residence, residential service, and commerce. Tall buildings have been proposed in order to raise the density of the bulk ratio. Tall buildings are considered detrimental to cities, however, because of their effect on their sky views. To analyze the sky view factors of different building types with the same bulk ratios, we compare the sky view factors of four building types with four bulk ratio patterns. The building styles are shown in Figure 4.

The Japanese standard for bulk ratios does not include shared spaces such as galleries, stairways, and elevators. The ratio of shared space in these five plans is about 25%. Bulk ratios in brackets have been computed according to the Japanese standard.



		25 × 25m	30 × 30m	40 × 40m	Long Type	Low Type
Bulk Ratio	200% (150%)					
	300% (225%)					
	400% (300%)					
	500% (375%)					
	540% (405%)					
	665% (500%)					

**Figure 4. Images of Building Types**

Thirteen measurement points were set along Tyuou Street to measure its sky view factors. The results are shown in Figure 4. The sky views at point 5 (the black point in Figure 5) and the average sky view factors of all 13 points are shown in Figure 6.

As shown in Figure 6, each building type has different peculiarities. Slim buildings are taller than thick buildings but have the same bulk ratio. The high parts of tall buildings look small from ground level because of the long distances involved. Long-type and low-type buildings are wider than tall, slim buildings. They are lower, but their sky view factors are small, and they have the same bulk ratios. With a bulk ratio of 665%, the sky view factor of a low-type building is only about 18%.

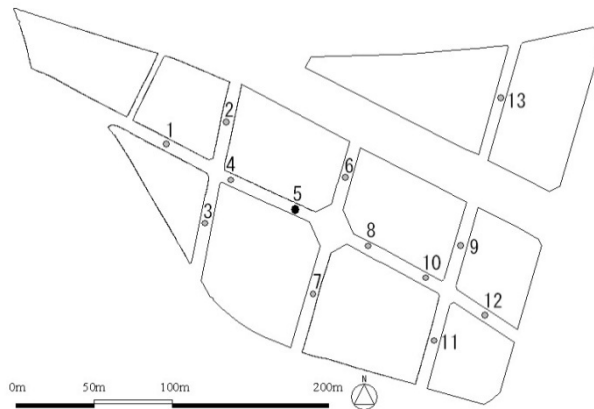
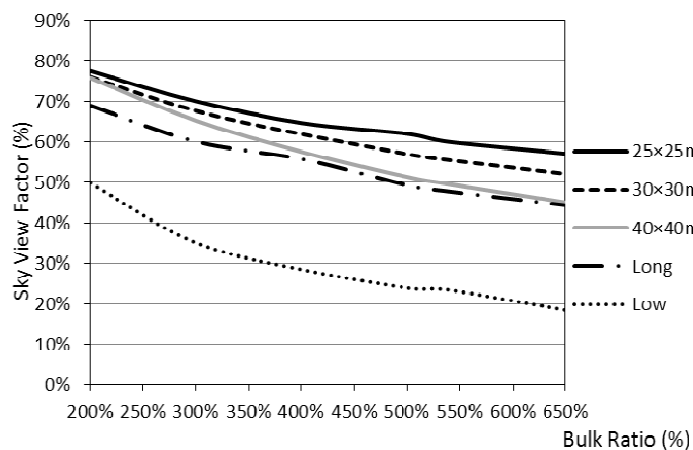


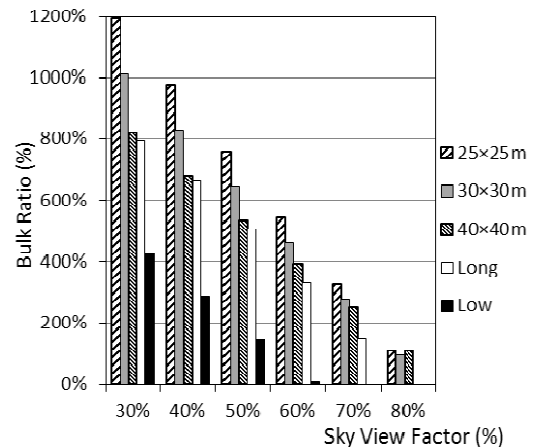
Figure 5. Sky View Factors' Measurement Points

		25 × 25m	30 × 30m	40 × 40m	Long Type	Low Type
Valk Ratio	200% (150%)					
		77.46%	76.01%	75.80%	68.84%	49.74%
	300% (225%)					
		69.95%	67.55%	65.19%	59.97%	34.97%
	400% (300%)					
		64.64%	61.87%	57.53%	55.75%	28.42%
	500% (375%)					
		61.93%	56.98%	51.25%	49.21%	23.81%
	540% (405%)					
		59.89%	55.48%	49.46%	47.69%	23.32%
	665% (500%)					
		57.09%	52.03%	45.00%	44.28%	18.37%

Figure 6. Sky View at Point 5 and Average Sky View Factor of All 13 Measurement Points



**Figure 7. Average Sky View Factors**



**Figure 8. Calculated Relationship between Bulk Ratio and Sky View Factor**

Figure 7 shows a comparison among average sky view factors. The sky view factor of slim buildings ( $25 \times 25$  m) is the highest, and that of low-type buildings is the lowest, with both types sharing equal bulk ratios. With a bulk ratio of 665%, the sky view factor of the  $30 \times 30$  m type building is 9% lower than that of the  $25 \times 25$  m type building. The factor of the  $40 \times 40$  m type building is 14% lower than that of the  $30 \times 30$  m type building. That of the long-type building is 2% lower than that of  $40 \times 40$  m type building, and the sky view factor of the low-type building is 59% lower than that of the long-type building.

The sky view factor of a slim building ( $25 \times 25$  m) decreases slightly as its bulk ratio increases. The sky view factor's rate of decrease for buildings with a bulk ratio of between 200% and 665% is 26% for  $25 \times 25$  m type buildings, 32% for  $30 \times 30$  m type buildings, 41% for  $40 \times 40$  m type buildings, 36% for long-type buildings, and 63% for low-type buildings. This occurs because floors added to slim buildings are far from eye level whereas floors added to low-type buildings are nearer.

The data on average sky view factors and bulk ratios were analyzed using the regression analysis method. Through it, we calculated the relationship between bulk ratio and sky view, which is shown in Figure 8. To gain an equal sky view factor, the bulk ratios available for buildings will depend on the building types. In this study, to achieve 30% of the sky view factor, the available bulk ratios for the  $25 \times 25$  m building type can be up to nearly 1200% but will be about 428% for the low type. Constructing tall slim buildings is the best way to preserve the sky view factor and increase density at the same time.

## 4 Conclusions

This paper discusses an urban regeneration proposal plan for Yahatahigasi-ku as a case study. The proposed regeneration area, Tyuou Street, was assigned to the analysis using GIS. To increase the residential density and bulk ratio of the regeneration site, five building types are compared and analyzed. The results indicate that the sky view area is not significantly hindered by tall, slim buildings. High-rise residences should be introduced into this area in order to address its shrinking population.

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