

# VISUAL GEOMETRICAL ANALYSIS OF OUTDOOR SPACE STRUCTURE AROUND RAILWAY STATION BUILDINGS

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## 1. Introduction

Railway transportation systems are becoming more important and efficient in the daily life. Furthermore, station buildings are hosting best and latest achievements of railway technologies. In Japan, railway stations in large cities have been rebuilt and extended several times. This results in complicated indoor and outdoor spaces which evoke feelings of confuse and disorientation in the passengers.

The arrangement of outdoor spaces around station buildings has a great effect on accessibility and ease of use. On the other hand, the degree of visual access to the environment is an important physical setting variable that corresponds to the extent to which different parts of the environment are visible. Therefore, the objective of this study is to clarify the effect of different space structure patterns around railway station buildings on the degree of visual accessibility of the station. A parametric study of theoretical cases representing main space structure patterns around stations in the Tokyo metropolitan area was conducted. Station plaza shape and type of relationship to main street were considered as the main effective parameters. A quantitative analysis method is proposed for measuring the effect of these parameters on the degree of visual accessibility of the station building.

## 2. Outlines and Methodology

Visual accessibility is defined herein as “the degree of visibility or the possibility of vision provided through different space structure patterns around railway station buildings.” The issue is to clarify how the passenger passing through different types of space structure can visually access the station building.

Method of “Visibility Contour Lines Distribution”<sup>1)</sup>, has been proposed for measuring quantitatively the degree of visual accessibility from different viewpoints around station buildings. Figure 1 illustrates the method, which proceeds in four steps:

- Step 1:** The first contour circle is constructed (diameter = station length). Every point on this circle has a view angle of 90° and can see 100% of the station building facade.
- Step 2:** Successive contour circles are drawn having view angles ranging from 0° up to 180°.
- Step 3:** Intersection of the contour circles and radial lines drawn at 20° intervals define locations of the viewpoints around the station building. The degree of visual accessibility of these viewpoints was measured.
- Step 4:** Effective contour lines are obtained by joining points with similar degree of visual accessibility according to different spatial characteristics of cases.

In this study, “visual exposure” was used for expressing the visual accessibility, implying the portion of vision provided from the station building façade proportional to distance. Accordingly, relationship between distance from the station building and percentage of visible length can be used for expressing the results of different types of space structure.

The percentage of visible length is defined as the ratio between the visible length from any viewpoint (L1) on a visibility contour line to initial length of station (L) as shown in Figure 2.

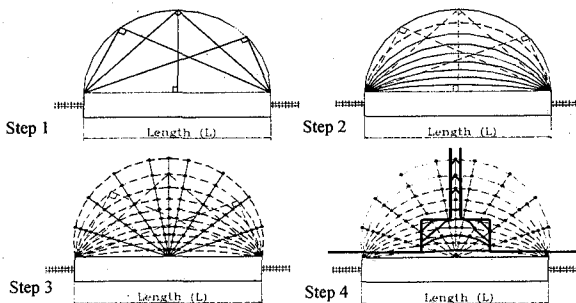


Figure 1: Steps of Visibility Contour Lines Distribution method

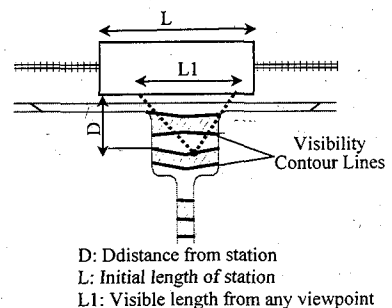


Figure 2: Variables of analysis

\*Keywords : space structure patterns, visual accessibility, visual exposure, visual inflation

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### 3. Study Analysis

In order to provide an intuitive comparison between the effect of different space structure patterns on the degree of visual accessibility of the station building, theoretical cases of study representing common space structure patterns in the Tokyo metropolitan area were constructed. The common patterns were obtained from analyzing 116 cases of study in the Tokyo metropolitan area<sup>1)</sup>. Accordingly, different types of space structure around station buildings could be analyzed. The obtained common space structure patterns are shown in table 1.

According to the importance of station plaza, the analysis considered the main space structure patterns providing plazas in front of the station building.

In order to construct the theoretical cases representing the main patterns introduced in table 1, design guidelines of railway station buildings<sup>2)-3)</sup>, basic theories of urban space design and prediction of traffic demand<sup>4)</sup> were implemented. A flow chart of the analysis is shown in Figure 3.

### 4. Parametric Study of Stations Cases

Many factors were found to affect the degree of visual accessibility. Accordingly, a parametric study of the cases representing main space structure patterns around station buildings in the Tokyo metropolitan area was conducted.

Anastasi<sup>5)</sup>(1936) found that the perception of the area of geometric figures having the same area varies according to their shape. Also, Sandalla and Oxley<sup>6)</sup> (1984) found that the area of a room was perceived as larger as the length/width ratio increased. The station plaza is basically considered to play the main role of a multi-functional node where, providing best space dimensions is of great importance. Therefore, the plaza shape was considered as one of the main parameters in the analysis.

It was found from analyzing different cases of stations around the Tokyo metropolitan area that type of relationship to main street characterizes the main physical relationship between the station building and surrounding street network. Accordingly, the type of relationship to main street in the different patterns shown in table 1 was considered as the second parameter in the parametric study.

The method of "Visibility Contour Lines Distribution" was applied on the constructed cases from very small up to large size stations and the degree of visual accessibility was measured for the different cases with changing the shape of the plaza for the different types of space structure patterns. Finally a grouping of the analysis results was conducted in order to clarify the effect of each of the parameters.

#### (1) Effect of plaza shape on the degree of visual accessibility

Three types of shapes were proposed, based on changing the ratio between width and depth (W/D) as shown in Figure 4. The assumed differences were found to affect the distribution of visibility contour lines within plaza limits.

The degree of visual exposure and consequently the degree of visual accessibility was also found to be different for each shape. Figure 5 illustrates relationships between distance and percentage of visible length for the three shapes among different size of stations. Plazas with large depth constrain the degree of visual accessibility as well as restrict traffic control and function distribution. Therefore, cases of stations having "rectangular shape" plaza with  $W/D = 0.5$  were found to provide low degree of visual accessibility. On the other hand, cases having "square shape" plaza were observed to provide better results for the different types of station size. The cases of stations having "Rectangular shape" plaza with  $W/D = 2$  were found to provide best degree of visual accessibility among the different types of stations especially in cases of large size stations as observed in Figure 5 (e, f). By increasing the width of plaza, larger amount of station frontage could be seen, thus, increasing the degree of visual accessibility. In addition, it provides good arrangement of traffic functions as well as creates gathering spaces and pedestrian accommodations. This implies the importance of square shape design in the design control of spaces around station buildings in urbanized area for providing better enhancement of the visual quality of the environment in front of the station.

Table 1: Main space structure patterns around stations in the Tokyo metropolitan area

orthogonal link to main parallel street	Binary orthogonal link to main parallel street
Binary link to main orthogonal street	Direct relationship to main orthogonal street

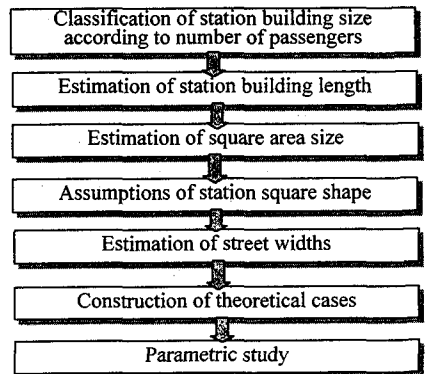


Figure 3: Flow chart of the theoretical analysis

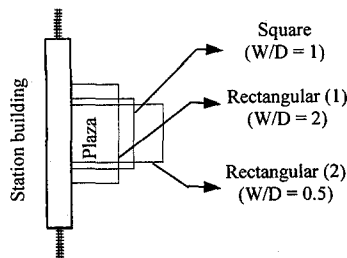


Figure 4: Assumptions of plaza shape

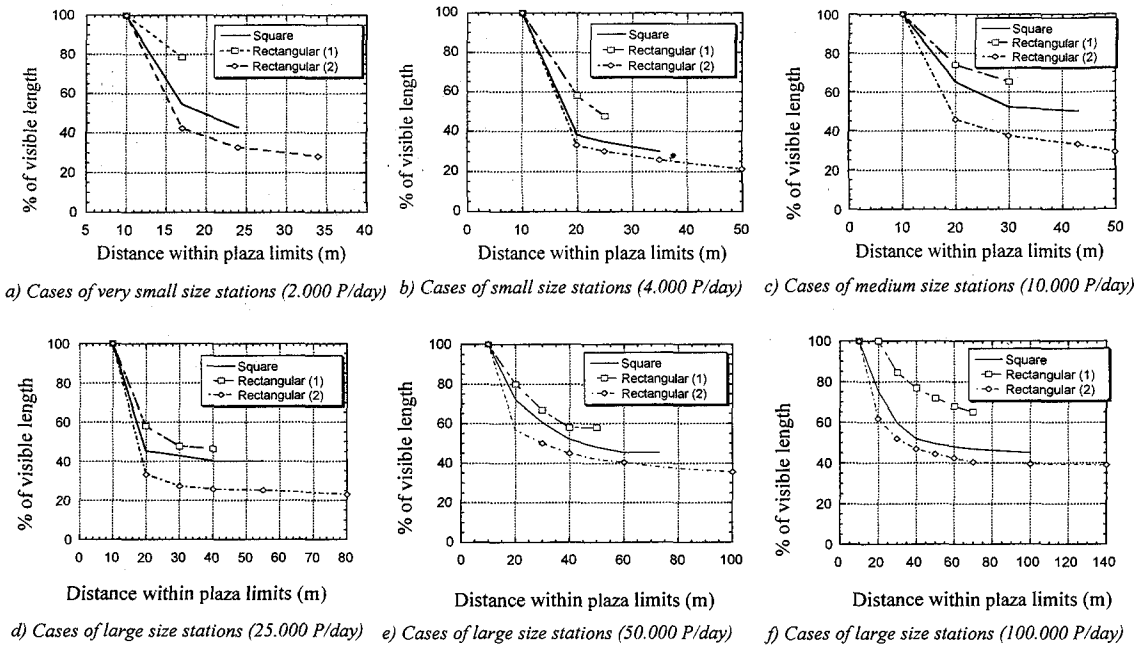


Figure 5: Relationships between distance and percentage of visible length for different types of plaza shape

## (2) Effect of type of relationship to main street on the degree of visual accessibility

Out of square limits, the type of relationship to main street can control the degree of visual accessibility of the station building. Therefore, the effect of each of the different space structure patterns previously shown in table-1 was discussed separately. Figure 6 through Figure 9 represent relationships between distance and percentage of visible length for different types of station size in case of square shape plaza. The results of the analysis are represented for the square shape plaza only, as the effect of square shape was discussed previously in section 1.

### a) Type of orthogonal link to main parallel street relationship

Cases of stations having square linked to main parallel street through a centered orthogonal link were found to provide high degree of visual accessibility as shown in Figure 6. It was clarified from the analysis results that such types of relationships provide open view within the limits of the plaza. Good degree of visual exposure could be maintained and station building can be considered as "vista" for the passengers coming from the main street.

### b) Type of binary link to main parallel street relationship

Types of space structure having square binary linked to main parallel street were found to restrict the degree of visual accessibility out of square limits as shown in Figure 7. For passengers using any of the binary links, the station is partially seen and becomes "off-vista". Consequently, the degree of visual exposure slightly decreases out of plaza limits. Therefore, identifying the station building and its entrance location is of great importance in such cases of space structure patterns.

### c) Type of binary link to main orthogonal streets relationship

Types of stations with square binary linked to main orthogonal streets were observed to provide poor degree of visual accessibility out of square limits compared with the other types. Mainly, visual exposure could not be maintained for limited distance from the station building especially in cases of very small and small stations as can be seen in Figure 8. Usually, several buildings separate the station from the links to main street. The station building is "not vista" any more. It is very difficult to perceive the station location from the main street. The plaza becomes a "sign" for the station. Accordingly, the design of plaza and arrangement of its elements becomes of great importance in signalling the presence of the station.

### d) Type of direct relationship to main street

Squares with direct relationship to main street are mainly affected by the main street width. This direct relationship to main street was found to increase the degree of visual accessibility within plaza limits as observed in Figure 9. Partial degree of visual exposure is provided and rail line is signalling the presence of the station location.

Finally, merits and demerits of the different space structure patterns could be clarified. Accordingly, some important points to be considered in future improvement or reconstruction could be revealed. The station building should express its identity as a railway station building either by building scale or design that increases its visual accessibility in most of the patterns. Also, providing landmark elements within plaza limits in visually appropriate location would be of great importance in signalling the station location besides of increasing its visual impact especially in cases where the plaza is binary linked to orthogonal streets. As rail line was observed to mark the station building in cases where plaza is directly open to main street, platform canopy becomes a very important factor in maintaining high degree of visual exposure if carefully designed.

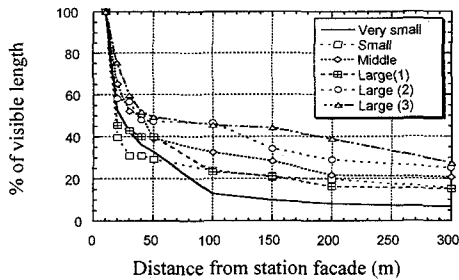


Figure 6: Relationship between distance and percentage of visible length for different types of station size in case of orthogonal link to parallel street

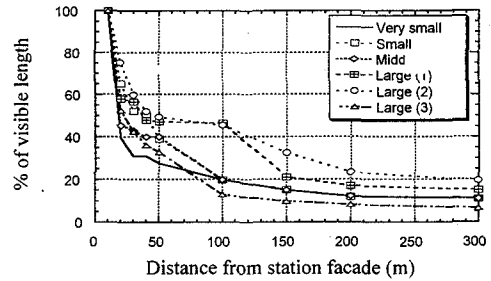


Figure 7: Relationship between distance and percentage of visible length for different types of station size in case of binary link to parallel street

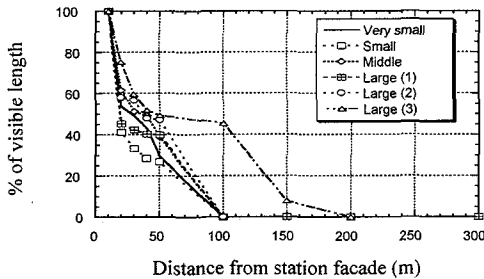


Figure 8: Relationship between distance and percentage of visible length for different types of station size in case of binary link to orthogonal street

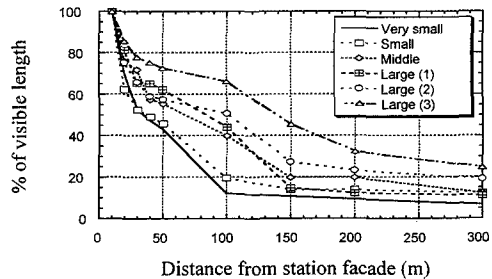


Figure 9: Relationship between distance and percentage of visible length for different types of station size in case of direct relationship to main street

## 5. Conclusions

This study focused on studying the effect of different space structure patterns on the degree of visual accessibility of the station building. A parametric study of theoretical cases representing common space structure patterns around station buildings in the Tokyo metropolitan area was conducted. Plaza shape and type of relationship to main street were considered as the main parameters. The applied quantitative analysis method of “visibility Contour Lines Distribution” showed effectiveness in clarifying the effect of these parameters on the degree visual accessibility.

It was revealed that the degree of visibility varies according to the shape of plaza even if the physical area is same. The results indicated that by increasing width/depth ratio, the station building façade was larger perceived and the degree of visual accessibility increased. Additionally, better arrangement of functions is provided. Type of relationship to main street was observed to have a great effect on controlling the visual accessibility out of plaza limits. Where, types of stations having plaza orthogonally linked to main parallel streets were found to provide high degree of visual accessibility. Thus, good degree of visual exposure could be maintained and station building is “vista” from the main street. On the other hand, binary links were found to decrease the degree of visual exposure and consequently the degree of visual accessibility.

In order to overcome the shortcomings resulted from some space structure patterns, emphasis should be given on improving some space elements design. The station building should express its identity. Also, providing landmark elements in a visually appropriate location would be of great importance in marking the station location as well as of increasing its visual impact. The study results are suggestive for future development of outdoor spaces around stations in urbanized areas.

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