STUDY ON THE RELATIONSHIP BETWEEN THE VISIBILITY OF TOWER AS LANDMARK AND THE SURROUNDING BUILDINGS*

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1. Introduction

Nowadays, the construction of high-rise buildings and towers are becoming vast. Due to the physical characteristics such as: huge scale structures, unique shapes and also the position in the city, etc. direct effects on the urban landscape are unavoidable, especially in term of visual environment. These elements can become new landmarks of cities, since they have high degree of visibility and also monumentality effect due to the huge-scale. As a landmark means also that these elements can become a point of reference, since there is a tendency for people, who more familiar with city to rely increasingly on systems of landmarks for their guides[1]. Therefore, a hypothesis can be deducted that visibility becomes one of several important factors that affect how one physical element of urban landscape can become a landmark.

There are several factors that affect how one physical element of urban landscape to become a landmark ("Landmark-ability"), those are: Visibility (How many percentage of the landmark can be seen from one viewpoint quantitatively), View angle, Distance between the landmark and viewpoint, Street network pattern, Sequential view of the landmark. The Visibility factor is affected strongly by the surrounding physical elements, such as: height of the surrounding buildings, open spaces, width of roads and also the characteristics of the landmark itself (size- especially the height, shape and location in the city)

In this research, the visibility analysis of a landmark, focusing on huge-scale structure in the shape of a tower is carried out. Visibility here means how many percentage of the tower can be seen from one viewpoint quantitatively. It means the influences of other factors such as: the surrounding buildings, open space (including the roads) are considered in this analysis.

2. Aim and Methodology of Study

This study will focus more on the relationship between the visibility of the tower as landmark and the surrounding buildings, including the street network pattern. In other words, the aim of this study is to clarify how the visibility of a tower as landmark is affected by the height of surrounding buildings and the width of the street. The visibility of the tower as landmark here is under the condition of the viewpoint at the position of a pedestrian eye level looking at the tower. The viewpoints are distributed over each row of the street network around the landmark. Based on several different cases of the height parameter of the surrounding buildings, the visibility values distribution of the landmark for each case is calculated.

(1) 3-D (Three- Dimensional) Model, Visibility-Calculation Program

The square-grid of street network pattern is chosen for the 3-D model of the tower and the surrounding building, since it is a common street network pattern that can be found in most cities (Figure 2, 3). The model was developed using CAD software. The dimensions of the surrounding buildings and roads are set uniformly in size. Dimension of the surrounding building block and roads are shown in figure 3. Then by customizing the CAD[2] software, the program for calculating the visibility of landmark was developed. This program is based on the technique for converting 3-D models into 2-D drawings. By transforming the perspective views of the 3-D model (2-D drawing) from each viewpoints into a vector-image file-format (WMF, Windows Meta File), the visible area of the landmark for each viewpoints are calculated. The outline of the program flow for visibility calculation is shown in Figure 1.

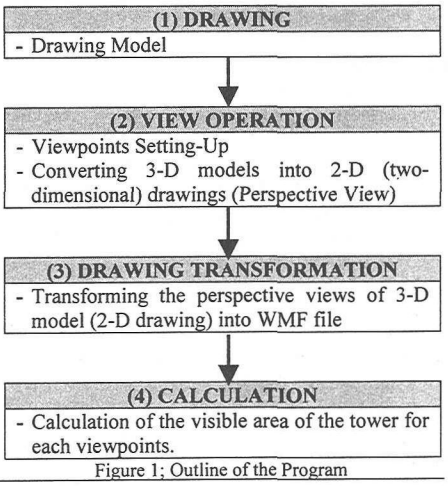

Figure 1; Outline of the Program

(2) Viewpoints

The viewpoints are set-up at the height of 1.6 m from the ground level, which is considered as position of the human eye (pedestrian viewer). As it is shown in Figure 4 & 5, the vertical distance between each viewpoint is set at 5 m apart and the positions are at the middle of the both sides of pedestrian path (VR; View-Right and VL; View-Left) and the middle of the road (VM; View-Middle). As it is shown in Figure 5, the nearest viewpoints rows to the tower are named VR-1, VM-1 and VL-1, until the farthest viewpoints rows of VR-11, VM-11 and VL-11, in which there are eleven rows in total. The sight line is set as a straight line with the direction of facing (looking) toward the tower (Figure 6).

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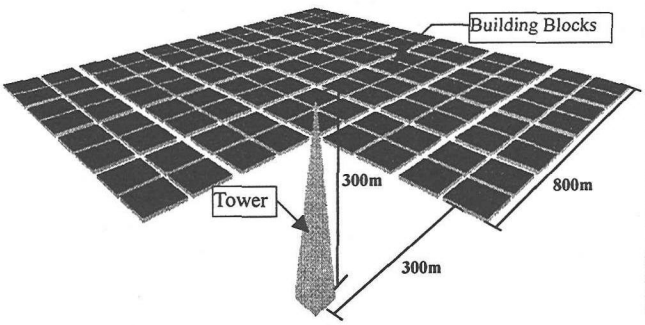

Figure 2; The 3-D (Three Dimensional) Model

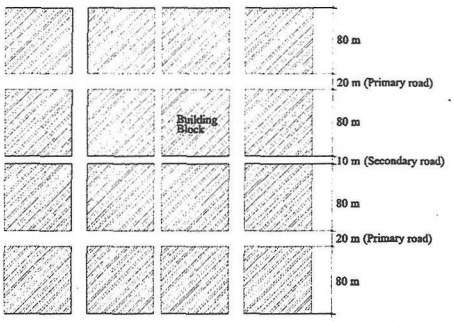

Figure 3; Dimension of the Surrounding Blocks

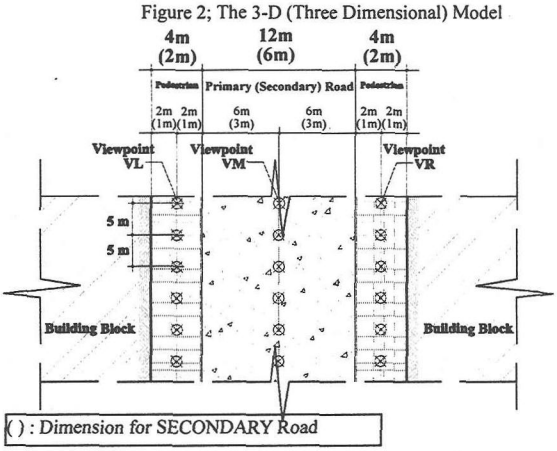

Figure 4; Dimension of PRIMARY & SECONDARY Road

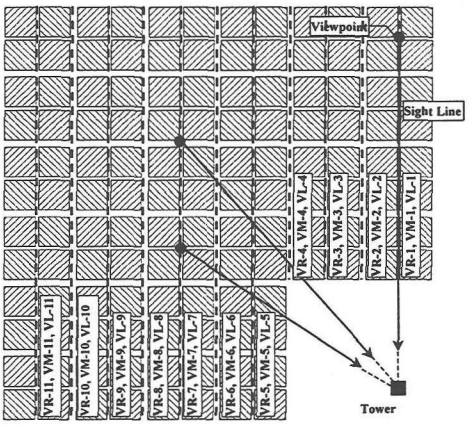

Figure 5; Position of Viewpoint Rows

(3) Study Cases

Four different parameters of the height of the surrounding buildings are set at 3 m for one story building, 6 m for two stories, 9 m for three stories and 12 m for four stories building. Base on these conditions, four different cases of visibility analysis are carried out. The details of each study cases are as shown in Table 1.

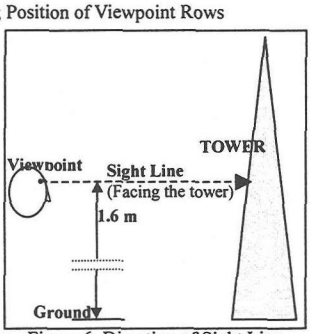

Figure 6; Direction of Sight Line

3. Results

The results of the visibility calculation are presented and analyzed in two ways, those are Graph of visibility value distribution (Figure 7) and Zone of visibility value map (Figure 8). For Graph of visibility value distribution which represents the visibility value distribution of each viewpoints in one row, the X-axis represents the distance between the viewpoint and the tower and the Y-axis represents the visibility value range between 0-100%. Then the viewpoints which have the same visibility value range are mapped in the Zone of visibility value.

Table 1; Study Cases

		Case			
		A-1	A-2	A-3	A-4
Height of : (m)	Tower	300	300	300	300
	Surrounding Building Blocks	3	6	9	12

(1) Visibility Value Distribution

In general as it can be expected, since case A-1 has the lowest of buildings' height (3m; 1-story building), the distributed visibility value are higher relative to other cases with higher buildings' height. But, the way of how the visibility values are distributed along the viewpoint path has different in characteristics.

For the viewpoints located at the viewpoints of VM-1 viewpoints (Figure 5), the visibility value along these viewpoints for all cases (case A-1 to A-4) is high, ranged between 90- 100% (Figure 7a). This means that most part of the tower can be seen continuously along this path, which is located on the middle of the street. Around 100% of visibility values are distributed around the nearest viewpoints to the tower, then the values are decreasing exponentially when the surrounding buildings are starting to obstruct the view to the tower, and then become almost constant until the farthest viewpoint. For the rows of VL-1 and VR-1 viewpoints, the distribution of visibility values has almost the same characteristic of that of VM-1 viewpoints, that is an exponential decreased of visibility values (smooth curve) and continuous visibility of the tower.

At the second row, both viewpoints of VL-2 and VM-2 rows have the same characteristic of visibility value distribution, that is a linear decrease of visibility value, but then almost constantly distributed. But when location of the viewpoints are

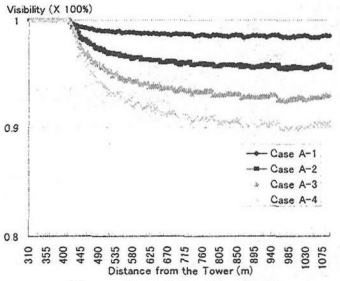

Figure 7a; VM-1 Viewpoint

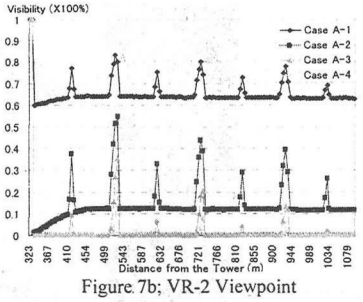

Figure 7b; VR-2 Viewpoint

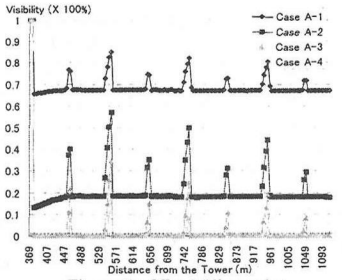

Figure 7c; VM-3 Viewpoint

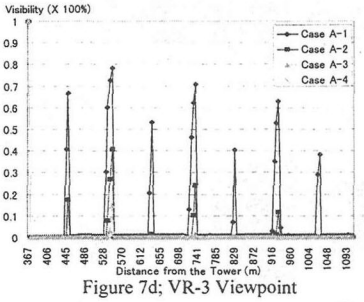

Figure 7d; VR-3 Viewpoint

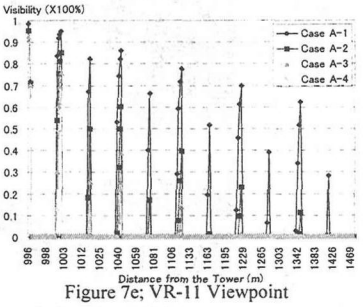

Figure 7e; VR-11 Viewpoint

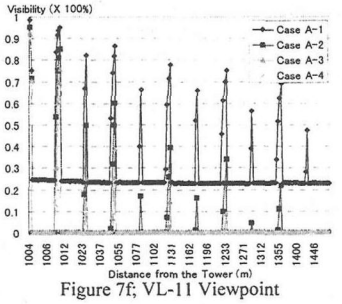

Figure 7f; VL-11 Viewpoint

Figure 7; Graph of Visibility Value Distribution

around the intersection, the visibility value is increasing (fluctuating). This is because the distance between the surrounding building blocks and the viewer is getting wider around the intersection, which caused the decreasing of the depth of invisibility[3] of the tower. But in case of VR-2 row (Figure 7b), a sudden drop of visibility value is observed and also the fluctuation of visibility value around the intersection is more obvious. This is because the viewpoints of VR-2 row are located at the right pedestrian-path side (Figure 4, 5), where the effect of depth of invisibility of the tower is higher than other viewpoints in the same row.

On the third row (VL-3, VM-3 and VR-3 viewpoints), the fluctuation of visibility value around the intersection is more obvious than that of the second row. In case of VM-3 viewpoints, the average of almost 0 (zero) visibility can be observed in case A-3 and A-4 (Figure 7c). Moreover, in VR-3 viewpoints (Figure 7d) the average of almost zero visibility is found for all cases. Average of almost zero visibility for all cases (A-1 to A-4) are also found in other rows, those are VR-4 to VR-11 viewpoints (Figure 7e).

For other rows such as: VL-4 to VL-11 (Figure 7f) and VM-4 to VM-11, the distribution of visibility values has the characteristic of linear decreased then become constant value (or become zero visibility) with some fluctuation in the intersection area.

(2) High Visibility and Invisible Area (Figure 8)

a) High Visibility Area

The High visibility area here is represent by the area where the viewpoints has the Visibility value ranged between 80-100%, where it can be assumed that most part of the tower can be seen from the viewer.

In all cases, the 80-100% visibility area is observed at the street, which is located frontally to the tower (First row; VL-1, VM-1 and VR-1). As it can be observed from Figure 8a, in case A-1 (1-story surrounding buildings' height; 3m) the high visibility area are distributed till the farthest point from the tower. This is different from other cases where the high visibility areas are only found in the area, where the viewpoints are located frontally to the tower.

b) Invisible Area

Invisible Area here means the area or viewpoints where the Tower (Landmark) is invisible/ cannot be seen at all, or in other words from these viewpoints the visibility value of the tower is Zero.

As it is shown in Figure 8b, in case A-3 (surrounding buildings' height

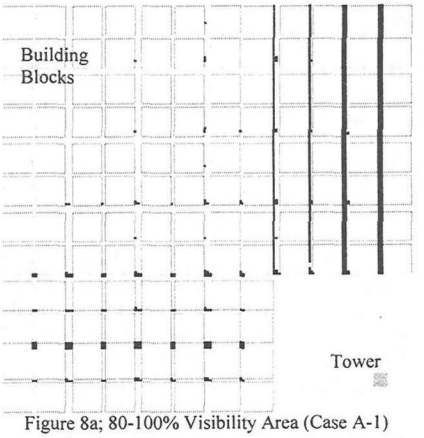

Figure 8a; 80-100% Visibility Area (Case A-1)

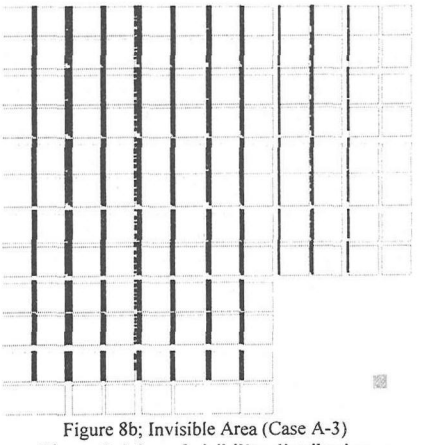
Figure 8b; Invisible Area (Case A-3)

Figure 8; Map of visibility distribution

= 9m) the viewpoints which has zero visibility are distributed starting from the third (VR-3) to the eleventh row. And it can be observed also the invisible area could not be found in the area near the intersection.

4 Analysis

It can be separated into two ways how the values of Visibility are distributed, those are gradual effect and strong effect. There two kinds of gradual effect, a smooth curve one (VM-1 viewpoints; Figure 7a) and a linear one (VL-2, VM-2 viewpoints). A strong effect here means a sudden drop of visibility value from being visible to become invisible (zero visibility), or in other words the landmark becomes disappeared from the view. This can be observed in Figure 7d.

There are three common patterns of how the landmark is being seen or the view patterns of the landmark, those are:

(1) Pattern A (Figure 9a)

The characteristics of this pattern are continuous visibility of the landmark and a gradual effect, which can be observed clearly from the viewpoints of VR-1, VM-1 (Figure 7a) and VL-1. The visibility values are firstly constant to a certain distance then increasing smoothly until reaches a 100% visibility, which makes sequential view to the tower as a vista.

(2) Pattern B

Same as pattern A, the characteristics are continuous visibility, but the increase of the visibility is in linear-gradual effect. This can be observed from VM-2 viewpoint and VL-2 to VL-4 viewpoints.

(3) Pattern C (Figure 9b)

Pattern C has the opposite characteristics of the Pattern A, which are Un-continuous visibility and a strong effect. The visibility value of the landmark from most of the viewpoints is 0% (view 1 and 5 in Figure 9b), then it increased sharply when the position viewpoints are reaching the intersection of roads. This pattern can be seen from VR-5 to VR-11 viewpoints (Figure 7e).

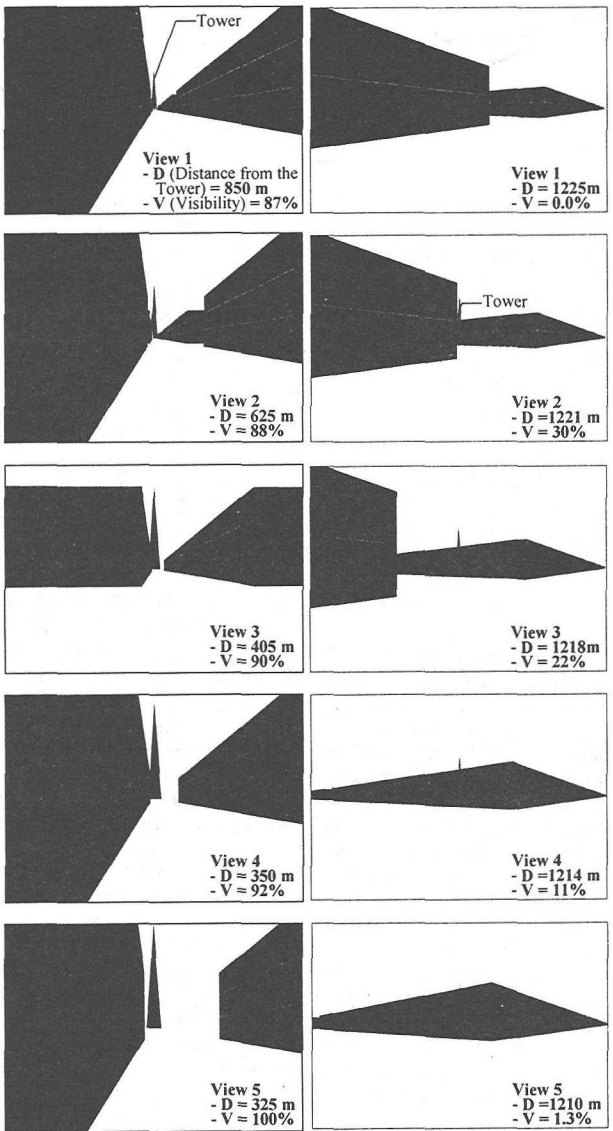

Figure 9a; Pattern A Vista View *Figure 9b; Pattern C*

Figure 9; View Patterns

5. Conclusions & Consideration

(1) The study shows that there is a close relationship between the visibility of a landmark and the physical characteristics of the surrounding buildings (height of buildings), including the road as open spaces (width of road). It can be observed that visibility values of viewpoints around the intersection of roads are increasing quite sharply, as it can be observed by a fluctuation of visibility values in the graph of visibility value distribution in Figure 7.

(2) This study is applied in an ideal condition where the street network are pure square-grid and the height of the surrounding buildings and also the width of roads are uniform. It needs to consider other factors, such as: random street network, the existence of tress and signage boards, etc., in order to make the result of the study is more comparable to the actual condition of most cities.

REFERENCES

1) Lynch K.; The image of city, The MIT Press, Cambridge, Massachusetts, 1960
2) Kubota Y., et al.; Development of an intelligent CAD system for visual design of a bridge in a landscape, Research report of Dept. Civil & Environmental Eng., Saitama, 1977
3) Higuchi T.; The visual and spatial structure of landscapes, The MIT Press, Cambridge, Massachusetts, 1983