IMPRESSION ANALYSES OF BUILDING FORM AND STREETSCAPE IN NIHONBASHI-CHUO STREET USING VIRTUAL REALITY

Streetscape Analysis which aims at creating unique streetscape using virtual reality

NORIO KOBA, KOJI KOIZUMI AND TATSUYA KISHIMOTO

Keio University, Yokohama, Japan.
{koba, koizumi, kishimoto}@sd.keio.ac.jp

Abstract. Recently in Japan, streetscapes have been changing by repeated deregulations and redevelopments. In this paper, the desirable building forms and facades in Nihonbashi is examined through experiments using the VR system. Firstly the changes of impression in three streetscapes whose buildings forms and height are different are investigated. Secondly, the difference in impression of facades in the cases they are seen in streetscapes or seen individually is examined. Thirdly analysing the correlation of physical components and unique facades, the relation between attractiveness of streetscape and building forms and facades is clarified. From these results, way of design to create lively, emotional and unique streetscape in Nihonbashi is suggested.

Keywords. super high-rise building, fa ade, redevelopment, streetscapes, Nihonbashi, Virtual Reality system

1. Introduction

Japanese urban streetscapes have been changing by frequent deregulations and redevelopments. However, in most cases, there are no guidelines in creating rich streetscapes, and Nihonbashi Central Street that traditional buildings create an impressive streetscape, Tokyo is not an exception.

Nihonbashi Central Street was deregulated in 2000, and construction of huge buildings which exceed the original limitation of 56m became possible. How the streetscape in Nihonbashi will change by deregulation has become one big problem. Another very important problem is how historical facades and newly designed facades should coexist. Newly designed fa ade is increasing in Nihonbashi by deregulations. It is now a task of convert the current streetscape to new Nihonbashi streetscape while keeping it unique. Therefore, it is necessary to clarify what aspects of facades make impacts on the streetscape.

Studies to systematise various streetscapes by the impression evaluation experiment of street space are reported by a series of paper by Funakoshi and Tsumita. Funakoshi and Tsumita analysed the psychological evaluation about various streets by questionnaire examination that uses Semantic Differential Method (SD Method) and factor analysis. Moreover, Funakoshi and Tsumita(1983) decomposed the street into physical components and analysed their quantity. Furthermore, Tsumita(2002) studied the structure of streetscape and the feature of the street through analysing the psychological influences that the physical elements of the street give to the street evaluation. These studies aimed to classify the features of each street and to clarify the evaluation structure.

On the other hand, evaluation experiments of the street space which use Virtual Reality (VR) or 3DCG have been reported. Matsumoto(1989) examined the effectiveness of a simulation system with CCD camera set in model space.

Onohara and Kishimoto(2004) proposed a VR system with a combination of Head Mounted Display (HMD) with three-axes gyro sensor device. Moreover, Koizumi and Kishimoto(2007)

applied this VR system in Ginza Central Street, and analysed the influence which the buildings heights and facades give to the impression of streetscape. This study is a sequel of these studies.

This study aims at clarifying the elements which changes the impression of Nihonbashi streetscape, and finding out the fa ade components which is preferable as Nihonbashi-like streetscape. These were clarified by two examinations using Virtual Reality (VR). The VR buildings and streets of the three models were created by making 3D CAD data based on the Geographical Information System data, and mapping the photograph of each fa ade to all the volumes. As a display device, we used a handy VR system which combines HMD with a three-axis gyro sensor.

2. Study Method

2.1. VR SYSTEM AND MAKING OF 3DCAD DATA

The VR image was projected onto displays, one for each eye. The images were projected on each display differs slightly according to the added Japanese standard parallax, 6cm. This enabled the examinees to see the images three-dimensionally. At the same time, the rotation of the head was transmitted to the workstation with the three-axis gyro sensor. Synchronizing in the direction of examinee's head, the VR image in the direction of the head was displayed.

Virtual street data was created on 3DCAD, by using two-dimensional digital map data and creating columns in the height of actual buildings using the building's footprints on the map. Building photos taken in Nihonbashi were trimmed and mapped on the created three-dimensional columns. Finally, arranging people, cars, streetlights, and signs appropriately around the buildings, the street space was completed.

The virtual street space data was taken into the VR system, and the system is set so that the transformation of viewpoint (walk through) is automatically done. The surrounding sound which was recorded in Nihonbashi was played in the experiment. By the walk through of the VR system and looking around in it, examinees could experience the street space in a condition that is much closer to reality.

We made three virtual street space models whose building forms were different to compare the difference in the environment of these streetscapes.

The virtual street models are as follows:

1) The current model (2006/05/30)
2) The 56m model: most buildings are adjusted to 56 meters.
3) The high-rise setback model: some buildings are rising greatly with its surface retreating from the medium rise to the top.

2.2. EXPERIMENT METHOD

Examinees experienced the virtual street space with HMD as an impression evaluation experiment. Route of the walking through is shown in Figure 1 by the arrow. The flow of the experiment was set as follows.

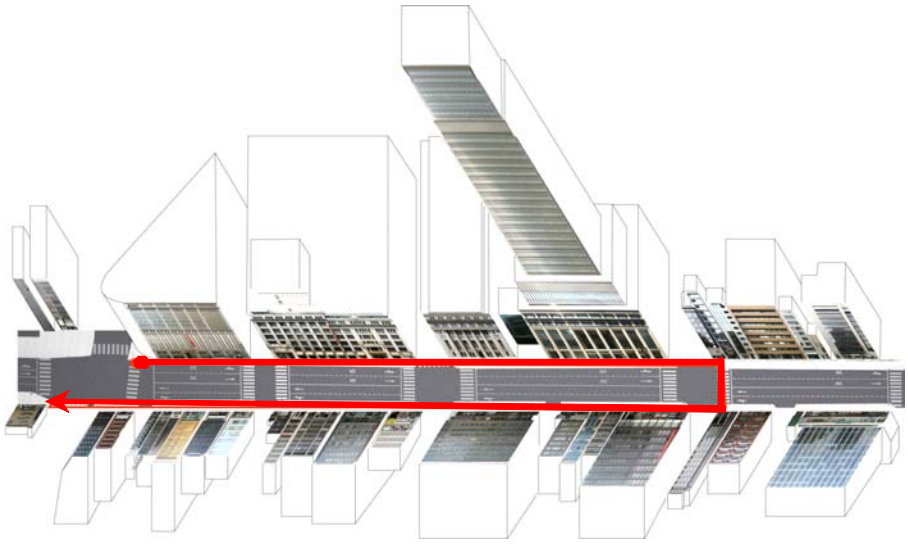

Figure 1. Route of the Walk Through

Step 1: Examinees experience the current model.
Step 2: Examinees evaluate the current model by answering a questionnaire.
Step 3: From the presented picture of the elevation of buildings (Figure 1), examinees pick out the building facades which they thought were impressive, Nihonbashi-like, or unfavorable by Indication Method.
Step 4: Projecting each building facade image to a large screen, examinees evaluate each fa ade which they picked up in Step 3 by answering another questionnaire.
Step 5: Examinees experience the 56m model.
Step 6: Examinees evaluate the 56m model by answering a questionnaire.
Step 7: Examinees experience the high-rise setback model.
Step 8: Examinees evaluate the high-rise setback model by answering a questionnaire

Here, examinees were thirty Keio University students. A questionnaire which was used in Step 2, 6, and 8 was sixteen adjective-pairs about the impression of the street using SD Method. Similarly, a questionnaire which was used in Step 4 was eighteen adjective-pairs about the impression of the individual fa ade using SD Method.

2.3. ANALYSIS METHOD

From the results of the experiment, three analyses are done.

In analysis A, the change of impressions caused by different form control regulations was analysed comparing the three street models. The form control that seems better in Nihonbashi was examined. In order to do so, impression of each model by factor analysis of evaluation experiment results was analysed (from step 2, 6 and 8).

In analysis B, unique facades in Nihonbashi were analysed. Evaluation examination result which examinees evaluated the impression of the individual facade was analysed by factor analysis (from step 3 and 4). Moreover, the correlation between impression of the facades which was seen in street and impression of the facade which was seen individually was analysed by canonical correlation analysis. Criterion variables were the number of buildings times being picked out (from step 3) by the thirty examinees as “impressive,” “Nihonbashi-like,” or “unfavorable,” and explanatory variables were the factor score averages of each facade (from step 4) clarified by the factor analysis.

In analysis C, the impression of the street by physical components of the facade was investigated, and the factors on the design elements of building facade which make the streetscape more impressive and unique were analysed. Physical components of facade which picked out were silhouette, texture, colour, and others, and they were further divided into several aspects. Silhouette of facade were divided into aspect ratio, height, width, and form. Texture were divided lattice, glass, wood, and concrete. Colour of facade were divided gray, yellow, blue, red, black, and white. Finally, signboards, decorations, and division of facades were categorised into others. The correlation between the physical components of the facade and the impression of the fa ade (from step 3, 4) was analysed by the canonical correlation analysis, and the influence each component gives to the impression of the fa ade was clarified.

3. Analysis of Impression Change in Streetscape by Difference of Form Control (Analysis A)

As a result of Analysis A, sixteen adjective-pairs were classified into five factors. The common factor of adjective-pairs was named in each group. (Table 1)

Adjective-pairs which had a strong relation with Factor 1 were “Conspicuous-Inconspicuous,” “Showy-Plain,” “Characteristic-Common,” “Prosperous-Lonesome,” “Complex-Simple,” “Entertaining-Not Entertaining,” and “Bold-Delicate.” The common factor name was decided as “Liveliness” in streetscape. Adjective-pairs which had strong relation with Factor 2 were “Light-Heavy,” “Spacious-Oppressive,” “Bright-Dark,” and “Open-Close.” Therefore, the common factor name was decided as “Openness” in streetscape. Similarly, we decided third common factor name as “Emotionality,” fourth factor name as “Orderliness,” and fifth factor name as “Beauty.”

TABLE 1. Factor loading matrix of impression on street

Adjective-pairs	Factor 1 Liveliness	Factor 2 Openness	Factor 3 Emotionality	Factor 4 Orderliness	Factor 5 Beauty
Conspicuous-Inconspicuous	0.846	-0.020	0.153	0.026	-0.105
Showy-Plain	0.685	0.167	-0.155	0.090	0.218
Characteristic-Common	0.673	-0.141	0.343	0.000	0.194
Prosperous-Lonesome	0.642	0.224	-0.015	-0.115	0.241
Simple-Complex	-0.563	-0.268	-0.249	0.251	0.043
Entertaining-Not Entertaining	0.486	0.226	0.260	-0.115	0.465
Bold-Delicate	0.393	-0.338	-0.159	-0.109	-0.030
Light-Heavy	0.114	0.800	-0.104	0.136	-0.034
Oppressive-Spacious	0.258	-0.709	-0.186	0.144	-0.141
Bright-Dark	0.305	0.638	0.021	-0.074	0.396
Open-Close	0.195	0.619	0.250	-0.121	0.163
Tasteful-Tasteless	0.150	0.091	0.791	0.085	0.097
Luxury-Cheap	0.123	-0.030	0.679	0.198	0.099
Uniform-Not Uniform	-0.006	0.035	0.133	0.793	0.179
Continuous-Discontinuous	-0.059	-0.134	0.140	0.671	-0.181
Beautiful-Not Beautiful	0.035	0.267	0.484	0.338	0.596
Sum of squares at factor loading	3.009	2.367	1.787	1.409	1.016
Contribution of factor (%)	18.806	14.794	11.166	8.805	6.347
Cumulative contribution (%)	18.806	33.601	44.767	53.572	59.919

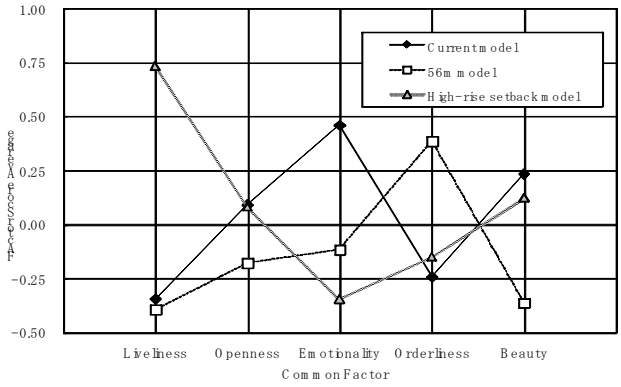

Figure 2. Change in factor score average by difference of height control.

Figure 2 shows the factor score averages of the three street models.

According to the factor score averages, the characteristics of the current Nihonbashi streetscape are Emotionality and Beauty. It can be said that Emotionality and Beauty are important factors in Nihonbashi.

When looking at the 56m model, factor score of the Orderliness increases but points decrease in other factors. Here, it can be said that straight and unnatural skyline is unfavorable in Nihonbashi streetscape.

In the high-rise setback model, Liveliness increases greatly but Emotionality decreases remarkably. Openness, Orderliness, and Beauty do not change, although buildings became considerably larger than the current model. Therefore, it can be said that building surface retreating from the middle layer is effective in upkeeping the points of the three factors.

By comparing the three models, it can be said that the issue of Nihonbashi streetscape is to find a way to create liveliness without reducing emotionality.

4. Impression of facade

4.1. ANALYSIS OF THE UNIQUE FACADES IN NIHONBASHI (ANALYSIS B)

As a result of Analysis B, Eighteen adjective-pairs were classified into four factors by the factor analysis. The common factor of adjective-pairs was named in each group. (Table 2)

Adjective-pairs which had a strong relation with Factor 1 were “Beautiful-Not beautiful,” “Luxury-Cheap,” “Tasteful-Tasteless,” “Heavy-Light,” and “Complex-Simple.” The common factor name was decided as “Emotionality” in streetscape. Adjective-pairs which had a strong relation with Factor 2 were “Conspicuous-Inconspicuous,” “Impressive- unimpressive,” “Characteristic-Common,” “Showy-Plain,” and “Bold-Delicate.” The common factor name was decided as “Impressiveness” in streetscape. Similarly, we decided third common factor name as “Liveliness,” and fourth factor name as “Transparency.”

These results and the number of buildings picked out were analysed by canonical correlation analysis.

Table 2. Factor loading matrix of impression on facades

Adjective-pairs	Factor 1 Emotionality	Factor 2 Impressiveness	Factor 3 Liveliness	Factor 4 Transparency
Beautiful-Not beautiful	0.851	0.137	0.059	0.031
Luxury-Cheap	0.821	0.259	-0.065	0.019
Tasteful-Tasteless	0.799	0.263	0.127	-0.272
Light-Heavy	-0.541	-0.062	0.445	0.386
Simple-Complex	-0.368	-0.203	-0.260	0.306
Conspicuous-Inconspicuous	0.211	0.778	0.021	0.228
Impressive- unimpressive	0.295	0.771	0.127	0.027
Characteristic-Common	0.439	0.651	0.172	-0.087
Showy-Plain	0.154	0.518	0.431	0.179
Bold-Delicate	0.158	0.420	0.016	0.315
Entertaining-Not entertaining	0.340	0.223	0.603	-0.058
Prosperous-Lonesome	-0.066	0.338	0.578	0.159
Hard-Soft	0.351	-0.010	-0.507	-0.021
Interesting-Uninteresting	0.427	0.275	0.489	-0.124
Oppressive-Spacious	-0.006	0.099	-0.450	0.018
New-Old	-0.247	0.152	0.004	0.805
Transparent-Opaque	0.077	-0.003	-0.037	0.636
Bright-Dark	-0.008	0.287	0.295	0.542
Sum of squares at factor loading	3.329	2.622	2.006	1.901
Contribution of factor (%)	18.497	14.569	11.141	10.560
Cumulative contribution (%)	18.497	33.065	44.207	54.767

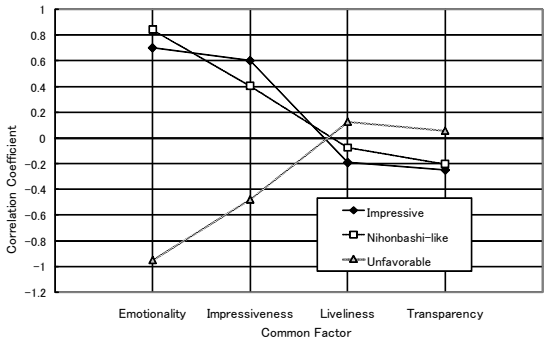

Figure 3. Correlation of impression on facades

Figure 3 shows the result of the canonical correlation analysis.

According to the result, impressive facades were rich in Emotionality and Impressiveness in Nihonbashi. Similarly, Nihonbashi-like facades similarly are rich in Emotionality and Impressiveness. Both of them lack in Liveliness and Transparency. Conversely, unfavorable facades lack in Emotionality and Impressiveness, and are rich in Liveliness and Transparency.

Furthermore, comparing the correlation coefficient of the impressive facades, the Emotionality value was higher than the Impressive value. Therefore, it can be said that buildings with high Emotionality can be impressive in Nihonbashi streetscape, although it may not be impressive when seen individually.

Nihonbashi-like facades and unfavorable facades have opposite tendency. Therefore, it can be said that non Nihonbashi-like facades are unfavorable in Nihonbashi. In Nihonbashi, facades that are low at Emotionality and Impressiveness are not suitable.

4.2. ANALYSIS OF INFLUENCE THAT PHYSICAL COMPONENTS GIVE TO IMPRESSION OF FACADES (ANALYSIS C)

As a result of Analysis C, first, the influence which the physical components give to the impression of facade of buildings in Nihonbashi streetscape is analysed. Criterion variables were the number of buildings picked out by the thirty examinees, and explanatory variables were physical components of facades.

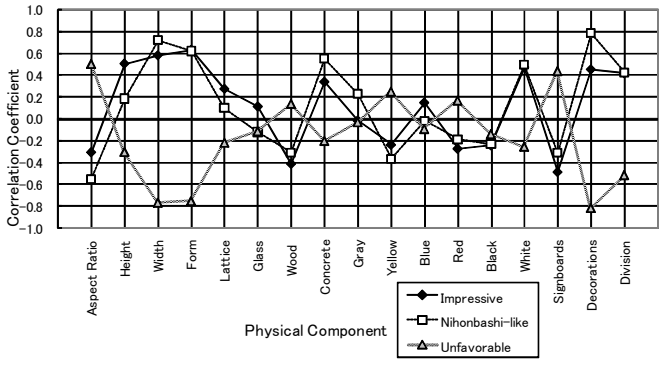

Figure 4 .Correlation between physical components and impression (on street)

Figure 4 shows relations between physical components and evaluation of facades in Nihonbashi streetscape.

According to Figure 4, impressive facades in Nihonbashi were high, wide frontage, not rectangular, mainly made of lattice and concrete, mainly white, decorative, and with no signboards. Similarly Nihonbashi-like facades were wide frontage, low aspect ratio, not rectangular, mainly made of concrete, mainly white, not mainly yellow, decorative, and have detailed surface. Finally, unfavorable facades were narrow frontage, high aspect ratio, rectangular, mainly yellow, less decoration, and have rough surface with many signboards.

Secondly, the influence which the physical components give to the evaluation of individual fa ade is analysed. The factor score averages of each facade in Analysis B are set as criterion variables. Also physical components of facades are set as explanatory variables.

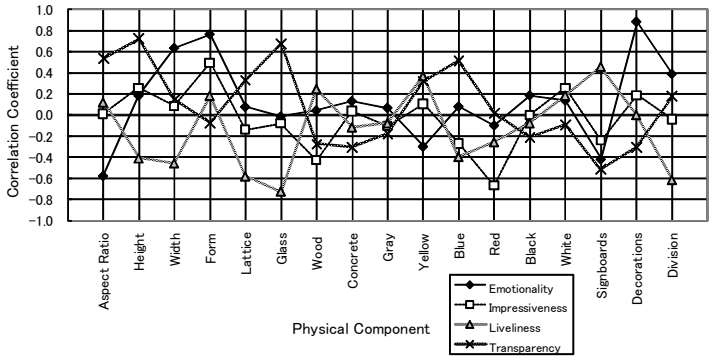

Figure 5 .Correlation between physical components and impression (on each facade)

Figure 5 shows relations between physical components and evaluation of individual facade.

According to Figure 5, emotional facades were wide frontage, not rectangular, and decorative. Impressive facades were not rectangular, and decorative. Lively facades were low, low aspect ratio, not mainly made of lattice and glass, mainly yellow, and have rough surface with many signboards. Finally transparent facades were high, high aspect ratio, mainly made of glass, and mainly blue and yellow.

By the two analyses above, it can be said that the facades which are wide, not rectangular, decorative, and have detailed surface with no signboards are suitable in Nihonbashi. On the other hand, the facades which are narrow, high aspect ratio, less decoration, and have rough surface with many signboards are not suitable in Nihonbashi.

5. Conclusions

From the three analysis results, we clarified important knowledge to form Nihnobashi-like unique streetscape as follows.

By analysis A, it can be said that the current Nihonbashi streetscape is rich in Emotionality and Beauty, but lack in Liveliness and Orderliness. On the other hand, straight and unnatural skyline is unfavorable in Nihonbashi streetscape. Furthermore, building surface retreating from the middle layer is effective to create Liveliness without reducing Openness. Finally, the issue of Nihonbashi streetscape is to find a way to create liveliness without reducing emotionality.

By analysis B, it can be said that impressive facades and Nihonbashi-like facades are rich in Emotionality and Impressiveness. Furthermore, buildings with high Emotionality can be impressive in Nihonbashi streetscape, although it may not be impressive when seen individually. Finally, in Nihonbashi, facades that are low at Emotionality and Impressiveness are not suitable.

By analysis C, it can be said that the facades which are wide, not rectangular, decorative, and have detailed surface with no signboards are suitable in Nihonbashi. On the other hand, the facades which are narrow, high aspect ratio, less decoration, and have rough surface with many signboards are not suitable in Nihonbashi.

References

Funakoshi, T., & Tsumita, H.: 1983, A Study on Psychological-analysis on Street Space, *Journal of Architecture, planning and environmental engineering*, **327**, 100-107.

Tsumita, H.: 2002, Analysis of “Figure” and “Ground” on Street Spaces by the Psychological and the Indication Method, *Journal of Architecture, Planning and Environmental Engineering* , **554**, 189-196.

Matsumoto, N., Kuno, K., Taniguchi, H., Yamashita, Y., and Seta, S.: 1989, Development of the Simulation Medium for Perception and Judgment of Architectural Space, *Journal of Architecture, Planning and Environmental Engineering*, **403**, 43-51.

Onohara, Y., and Kishimoto, T.: 2004, The Possibility of Streetscape and Space Evaluation Using the VR System by the Combination of Head Mounted Display and Gyro Sensor, *Journal of Technology and Design*, **20**, 279-284.

Onohara, Y., and Kishimoto, T.: 2005, VR System by the Combination of HMD and Gyro Sensor for Streetscape Evaluation, *CAADRIA'05, India*, 123-128.

Koizumi, K., and Kishimoto, T.: 2006, Study on Impression Changes According as Change in StreetUsing Virtual Reality, *IAPS 19 Conference Proceedings on CD-ROM, ENVIRONMENT*.

Koizumi, K., and Kishimoto, T.: 2007, Streetscape Analysis which Aims at Creating Unique Streetscape Using Virtual Reality, *Journal of Architecture, Planning and Environmental Engineering*, **613**, 151-158.