A Study on the Characteristics of Road Landscape for 3D Design Developing Process

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Abstract. Due to Asia’s economic growth and industrialization, there has been a growing interest in road landscapes recently. In the meanwhile, aesthetic aspects in road design are becoming more and more important as 3D design technology advancing. With a view to the above, designers must consider both the structural engineering and the aspect of aesthetics when conceiving new urban roads blueprint. Much more in-depth studies are expected to focus on the aesthetics of roads by utilizing 3D design technology. In light of this, this study was centred on the landscape preferences of road in modern cities from the perspective of building height and planting type alongside. The main results of the study were summarized as follows: The images of H:W=1:3 and H:W=1:1 were more highly preferred than the rest seven images on the grounded that the lower buildings seemed to have better correspondence with the surroundings. And the image of planting with 7.5 meter-interval received the highest evaluation for visual preference on account that this interval provides road landscape with a visual image of stability. In conclusion, this study results illustrated that ratio of building height to road width and the planting interval on footpath were the crucial elements in landscape design. Furthermore, this study also make efforts to present a methodology for 3D design development.

1. Introduction

1.1. Research Background and Purpose

Due to economic development and recent rise of many nations in Asia, regional governments in Asia are increasingly interested in urban landscape. The cityscape consists of a variety of elements. Among these factors, roads play an important role in urban landscape. When designing roads, experienced designers would consider two aspects: structural engineering and aesthetics. Despite of the importance of road landscape, the road aesthetics in design hasn’t been studied a lot up to now. More researches are called to analyze the aesthetics of roads so as to optimize road landscape during the design phase. Existing theses have formerly only suggested guidelines for design based on visual preference, but it has been as yet no research on the practical process of landscape design [1]. In response to this, this thesis analyzed the visual preference of urban roads to present theoretical foundations about road landscape using 3D design technology. Furthermore, this research hoped to present a methodology for
3D design developing process, to some extent.

1.2. Literature Review

The existing studies on road landscape were overwhelmingly conducted by the researchers from developed countries; prominent studies have not been found in developing countries. Additionally, most of the current studies on this topic were about structural stability and structural mechanics. Chen Yiling etc. (2015) analyzed the difference between the urban road landscape design and the highway landscape design [1]. Shin Jae Yun etc. (2014) analyzed the preference depending on street planting types and visual characteristics on Dongdaegu-ro located in Suseong-gu, Daegu Metropolitan City [2]. Jeong Dae young etc. (1996) figured out visual character and preference of roadscape for the main entrance road in Chongju [3]. Suh Joo Hwan etc. (1999) focused on exploring the relationship between the index of shape and the factor of perception about road landscape [4]. Almost all research about road landscape showed that the shape of the street trees and background were important factors in the image and visual preference of road landscapes. Background plays an especially significant role in visual preference, and more research is needed from the point of diversified backgrounds in the future. The background is comprised of a variety of factors, including buildings. So, this study surveyed the landscape preferences according to the height of the building and planting type.

2. Theoretical Background

2.1. Building Height

The height of the surrounding buildings along a road affects visual preferences. The ratio between the height of a building and the width of a road is particularly distinct within road landscape. If the height of a building is called H and the width of the road is W, then the ratio between the height of the building and the width of the road is \( H/W \). If \( H/W \) is higher than 1, the closed image of the road increases and if \( H/W \) is lower than 1, the open image of the road increases [3]. So the ratio between the height of a building and the width of a road is an important factor in determining the image of the road (figure 1).

![Figure 1 H/W Ratio](image1.png)

2.2. Planting Type

Planting is an indispensable component of the road landscape. Among such factors related to the planting, the interval between plants affects the image of space. Generally, the interval between plants is greater than 4.8 meters and less than 10 meters [5]. These intervals should be determined by considering both the engineering and aesthetic aspects (figure 2).

![Figure 2 Planting interval](image2.png)
3. Research Method

3.1. Selection of Background
This viewpoint should be the road’s landscape surroundings along with the road itself, as observed from the centre of a road, where the road landscape can be seen clearly by drivers. The background was chosen as a typical road view for drivers when driving. In addition, this research chose viewpoint on road, selected as a prospect point on the road landscape as seen from the center of the road.

3.2. Selection of Type and 3D Design Simulation

| Table 1. 3D Design Simulation |
|-------------------------------|
| **Figure 3** Planting with 5 meter-interval (H:W=1:3) |
| **Figure 4** Planting with 5 meter-interval (H:W=1:1) |
| **Figure 5** Planting with 5 meter-interval (H:W=3:1) |
| **Figure 6** Planting with 7.5 meter-interval (H:W=1:3) |
| **Figure 7** Planting with 7.5 meter-interval (H:W=1:1) |
| **Figure 8** Planting with 7.5 meter-interval (H:W=3:1) |
| **Figure 9** Planting with 10 meter-interval (H:W=1:3) |
| **Figure 10** Planting with 10 meter-interval (H:W=1:1) |
| **Figure 11** Planting with 10 meter-interval (H:W=3:1) |

This study completed a total of 9 computer-generated road landscape simulation images using 3D computer programs such as Auto-CAD (Autodesk, 2005), SketchUP (Google Inc., 2007), and Adobe Photoshop CS (Adobe Systems, 2003). Simulation images depicted three ratios between the height of a building and the width of a road, featuring H:W=1:3, H:W=1:1 and H:W=3:1 types. The plantings were respectively divided at intervals of 5, 7.5 and 10 meters (figure 3-11). A survey was then conducted by simulation produced from driver perspective [2]. These types were appropriate for road designs that can fit into this site, and thus were chosen for this experiment. Road shape was drawn
according to the most common floor plan. Other elements of each simulated image, such as color and material, were kept constant (Table 1).

3.3. Selection of Survey Group and Method of Analysis
This research was conducted five times via survey from March 3rd, 2019 to May 10th, 2019. The size of all images was 210×297mm equally [6-7]. 60 students, who are the graduate students in Seoul national University and Konkuk University in South Korea, responded in the survey [6-7]. All students were landscape architecture majors. In addition, in order to analyze the differences in preference between the driving and non-driving groups, the subjects were sampled into 30 people who were driving and 30 people who were not driving. Before the survey began, each student were reminded of the evaluation method. The assessment time was 8 seconds. This survey asked an important question about visual preferences of the road landscape [6-7]. The evaluation of the visual preference used the 7-point likert scale. Statistical analysis, such as descriptive analysis, f-test, t-test [6-7], were conducted by employing such statistical programs like Excel and KESS (Korean Educational Statistics Software). This research also used two-way analysis of variance and Duncan’s test (post hoc tests) to analyze preferential differences based on the variation of the building height and planting type [6-7].

4. Results and Discussion

4.1. Visual Preferences on a Road Landscape

| Landscape            | Average | Standard deviation | F-Value | Significant probability | post hoc tests a=0.05 |
|----------------------|---------|--------------------|---------|------------------------|----------------------|
| Planting with 5 meter-interval | H:W=1:3  | 3.82               | 1.32    |                        | b                    |
|                      | H:W=1:1  | 3.78               | 1.22    | 8.322                  | 0.001                |
|                      | H:W=3:1  | 3.46               | 1.12    |                        | c                    |
| Planting with 7.5 meter-interval | H:W=1:3  | 4.22               | 1.38    |                        | a                    |
|                      | H:W=1:1  | 4.16               | 1.34    | 12.324                 | 0.002                |
|                      | H:W=3:1  | 3.92               | 1.26    |                        | a                    |
| Planting with 10 meter-interval | H:W=1:3  | 3.94               | 1.32    |                        | b                    |
|                      | H:W=1:1  | 3.88               | 1.76    | 9.148                  | 0.003                |
|                      | H:W=3:1  | 3.72               | 1.46    |                        | c                    |

The research also included conducting a study on visual preference on a road landscape. The results were summarized as follows: Significance level of results is less than 0.05. These significant differences of visual preferences on a road landscape can be measured to a given confidence level according to significant probability. As a result, in planting with 7.5 meter-interval, images of H:W=1:3 and H:W=1:1 were more highly preferred than other images. In planting with 5 meter-interval, images of H:W=1:3 and H:W=1:1 also received high evaluation for visual preferences. In planting with 10 meter-interval, image of H:W=1:3 received high evaluation for visual preferences. Because low buildings seem to have a good correspondence with the surroundings. And, the image of planting with 7.5 meter-interval received high evaluation for visual preferences. This was because this interval gave the road landscape a visual image of stability. The above results suggested that the variation in visual preference of road landscapes was profoundly linked to the ratio of building height to road width and planting interval on footpath. At the same time, this research conducted a Duncan test (post hoc tests) to analyze what the difference in landscape was according to the ratio of building height to road width and planting interval on footpath. As a result of the post-hoc tests, significance level of results was less than 0.05. The landscape preferences had significance according to the ratio of planting interval on footpath.
building height to road width and planting interval on footpath. The image of H:W=1:3 and the image of H:W=1:1 and the image of H:W=3:1 in planting with 7.5 meter-interval obtained similar evaluation performance in visual preferences. Furthermore, the H:W=1:3 image in planting with 5 meter-interval and the H:W=1:3 image, the H:W=1:1 image in planting with 10 meter-interval acquired similar evaluation in visual preferences. Afterward, the H:W=1:1 image in planting with 5 meter-interval and the H:W=3:1 image in planting with 10 meter-interval got paralleled performance in visual preferences. To sum up, visual preferences would change along with the building height and planting type (Table 2).

4.2 Visual Preference’s Variation According to Driving
This research conducted a study on the difference of visual preference’s variation according to driving through T-test. T-test was used to find the difference between the road landscapes of preference with the data of factor score [7-8]. The results were summarized as follows: Significance level of results was less than 0.05. T-value was a minus sign about images of H:W=3:1. T-value was a plus sign about images of H:W=1:3 and H:W=1:1.

Table 3. Visual Preferences According to Driving

| Landscape                  | Subject  | Average | Standard deviation | t-Value | Significant probability |
|----------------------------|----------|---------|--------------------|---------|------------------------|
| Planting with 5 meter-interval | H:W=1:3  | Driver  | 3.88               | 1.14    | -1.214                 | 0.016 |
|                            |          | Non-driver | 3.76              | 1.26    |                        |      |
|                            | H:W=1:1  | Driver  | 3.80               | 1.36    | -0.416                 | 0.012 |
|                            |          | Non-driver | 3.76              | 1.18    |                        |      |
|                            | H:W=3:1  | Driver  | 3.40               | 1.22    | -1.214                 | 0.022 |
|                            |          | Non-driver | 3.52              | 1.38    |                        |      |
| Planting with 7.5 meter-interval | H:W=1:3  | Driver  | 4.30               | 1.14    | -1.624                 | 0.018 |
|                            |          | Non-driver | 4.14              | 1.18    |                        |      |
|                            | H:W=1:1  | Driver  | 4.18               | 1.26    | -0.412                 | 0.014 |
|                            |          | Non-driver | 4.14              | 1.18    |                        |      |
|                            | H:W=3:1  | Driver  | 3.86               | 1.04    | -1.216                 | 0.018 |
|                            |          | Non-driver | 3.98              | 1.32    |                        |      |
| Planting with 10 meter-interval | H:W=1:3  | Driver  | 4.02               | 1.44    | -1.638                 | 0.016 |
|                            |          | Non-driver | 3.86              | 1.12    |                        |      |
|                            | H:W=1:1  | Driver  | 3.91               | 1.36    | -0.614                 | 0.018 |
|                            |          | Non-driver | 3.85              | 1.18    |                        |      |
|                            | H:W=3:1  | Driver  | 3.64               | 1.22    | -1.626                 | 0.022 |
|                            |          | Non-driver | 3.80              | 1.34    |                        |      |

In H:W=1:3, the preference of drivers was higher than that of non-drivers. In H:W=1:1, the preference of drivers was higher than the preference of non-drivers. But, in H:W=3:1, the preference of non-drivers was higher than that of drivers. The reason for these results was that the low building served to broaden the driver’s horizons. Based on the analysis of visual preference’s variation, there was a difference in landscape preference according to the ratio of building height to road width and planting interval on footpath. In conclusion, the results illustrated that the ratio of building height to road width and planting interval on footpath were also important elements in the landscape design. When designing the road, the ratio of building height to road width and planting interval on footpath should be regarded as important points and reflected as such in the design (Table 3).
5. Conclusion
Due to Asia’s economic growth and industrialization, recently there has been a growing interest in road landscape. This study surveyed the landscape preferences of road landscapes, which was a special type from the angle of the ratio of building height to road width and planting interval on footpath. The main results were as follows: Images of H:W=1:3 and H:W=1:1 were more highly preferred than other images, because low buildings seemed to have better correspondence with the surroundings. And, the image of planting with 7.5 meter-interval received high evaluation for visual preferences, due to this interval brought the road landscape a visual image of stability. In H:W=1:3, the preference of the driver was higher than the preference of non-drivers. In H:W=1:1, the preference of drivers was higher than the preference of non-drivers. In H:W=3:1, nevertheless, the preference of non-drivers was higher than that of drivers. The reason for these results was that the low building served to broaden the drivers’ horizons. In conclusion, the results illustrated that ratio of building height to road width and planting interval on footpath were vital elements in landscape design. There are also other various elements on roads which show an obvious influence on the visual preference of the road landscape. But the results in this research only consider the three most essential factors, which were the ratio of building height to road width and planting interval on footpath, thus more research needs to be prepared and expected to get better and more accurate results in the field of road landscape in the future.

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