Investigating Green Urbanism; Building Oppressiveness

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Abstract
There are both positives and negatives to constructing high-rise buildings in high population densities of large cities. The negative effect of oppressiveness (圧迫感) will be the focus of this paper. Oppressiveness is defined as the negative feeling resulting from being surrounded by high-rise buildings. Building oppressiveness when combined with other urban stresses contributes towards making compact cities unsustainable. In other words these negative psychological factors of the environment are barriers to achieving urban sustainability. Therefore it is important to find ways to mitigate the negative psychological effects of high-rise buildings in order to improve the benefits of compact cities. This research assesses the psychological effect of green building façades and trees in Tokyo while taking into consideration a real urban environment. Within the context of the goal of "Green Urbanism" this research also measures and compares the effect of these two different types of greenery on residents' psychology. The methodology consisted of two experiments that were conducted in the Hongo area of downtown Tokyo. The aim was to assess the effects of green façades and trees in terms of environmental psychology and compare them. The results showed that the effect of greenery on the façade of buildings is not as positive as the effect of a tree-lined street. Trees are significantly more effective in mitigating the perception of oppressiveness. The results are important for urban designers and government policy makers.

Keywords: green urbanism; landscape architecture; urban sustainability; environmental psychology; greenery

1. Introduction
High-rise buildings allow for higher densities in urban areas but at the same time there are many negative effects that at times outweigh the positive ones. The positive effects of high-rise buildings are found in economies of scale in terms of environmental, economic, and social activities. The negative effects include building oppressiveness, environmental pollution, health risks, social segregation, noise from traffic, fear of crime and crowding. Nevertheless, despite these psychological demands we live in an urbanized world with about 75% of the population living in dense developing urban areas (Habitat, 2001). Urban life in general and urban stress contributes towards making compact cities unsustainable.

The term "oppressiveness" (圧迫感) refers to cityscapes that feature high-rise buildings, which cause negative psychological pressure on residents. Matsuda (1995) argued that when evaluating urban space, the impact of surrounding buildings should be considered as psychologically unfavorable. In Japan, while researching a way to measure the oppressiveness of buildings Takei et al. concluded that the parameters of the physical shape of buildings are the driving factors of oppressiveness (Takei, et al. 1977, 1978). The physical variables which were evaluated in previous researches are: configuration factor (Hwang, 2007), solid angle rate (Takei, 1977), sky factor (Takei, 1977), visible area of the building, distance from the building (Takei, 1978; Hwang, 2007), color of the wall (Hiyoshi, 1990), texture, angles of view (Hwang, 2007) and the amount of trees (Takei, 1980; Asgarzadeh, 2009). Among the above indexes, Takei’s research concluded that configuration factor is the most effective explanation for oppressiveness. Furthermore, configuration factor and solid angle rate are closely mathematically related. This research will therefore focus mainly on the configuration factor and the solid angle rate. Takei theorized that the amount
of oppressiveness that can be withstood by people has a limit (Takei, 1981). Further research determined that the permissible value of oppressiveness is 8% of the building configuration factor. In the case of a building with a configuration factor of over 4%, the building should be considered as an influential element in the urban environment (Takei, 1978). So therefore buildings with a configuration factor of 4-8% have a significant impact on the urban environment. Hwang (2007), explained that oppressiveness in the city is influenced by distance and posited the formula O=Wr² in which O is the oppressiveness of a cityscape, W is solid angle and r is the distance. Hwang concluded that the closer the viewer is to a building, the more oppressiveness is sensed by them. In a mega city like Tokyo many buildings have a configuration factor of more than 8%. This oppressiveness is amplified by the fact that streets are very narrow in Tokyo, which makes it an oppressive compact city.

Oppressiveness is the result of 'compactness,' which is the key to achieving urban sustainability in terms of maintaining social, economic, and environmental resources (Banister, Watson, & Wood, 1997; Duany, Plater-Zyberk, & Speck 2000; Krier 1998). Compactness refers to an urban environment with the following main characteristics; mixed land use, densely packed buildings interspaced by roads, limited space for greenery, and a union of form and function (Jenks et al., 1996).

Compact cities are perceived to have a positive impact on social cohesion, equity, and accessibility (Duany et al., 2000; Krier 1998). They also have better economic viability in terms of infrastructure due to the cost saving from vertical usage (van den Berg et al. 2007). Therefore, even though the current forms of compactness prevent achieving sustainability in terms of environmental psychology it is not viable to reject urban compaction as achieved through a process of undifferentiated densification. Instead, we should look for solutions that combine the benefits of the compact city with psychologically beneficial use of greenery within the structure of urban form and thereby attain an effective usage of urban space. Therefore it can be said that these negative psychological factors stemming from high-rise buildings are one of the barriers to achieving urban sustainability.

The concept of combining psychologically beneficial use of greenery and compactness has recently led to a new approach in landscape architecture called Green Urbanism (Beatley, 1999). The design solutions of this approach involve creative green infill options such as tree-lined streets and green building facades. The rationalization behind green building facades in the field of urban environment studies is as an energy saving element in building design which contributes to improved cooling and ventilation (Stec et al. 2005) through the provision of shade, reduction of emissions, and control of solar energy (Papadakis et al. 2001) as well as improvement of the thermal behavior of the building envelope (Eumorfopoulou et al. 2009).

The effect of green building façades on oppressiveness and openness has not yet been researched while the effect of trees located at the front of buildings has proved to be effective in reducing oppressiveness. A research project administered a door-to-door survey, which was conducted at residential buildings that had made progress towards mitigating the effects of oppressiveness through plants. The results showed that despite the high configuration factor of the building there were some responses that did not reflect the high levels of oppressiveness which often accompany high configuration factors. This was a surprising finding and it was theorized that the trees planted around the high-rise buildings mitigated oppressiveness by partially screening the view of the wall from the survey participants (Takei, 1981).

The replies in a 1978 residential survey led to the inclusion of a question that specifically addressed the mitigating phenomenon from 1979 onwards. The question aimed at discovering the effect of plants in alleviating oppressiveness. The question was accompanied by two pictures, on one side there was a picture showing a high-rise building with trees located at the front; only the top half of the building was visible. The other picture was of the same building but with no trees. The first year of administering the question (250 households were surveyed, and 209 responses collected) resulted in the finding that respondents attributed a feeling of peacefulness to trees. It was also found that as the amount of building visible through the leaves increases the mitigating effect also decreases (Takei, 1981). Takei et al. proved that the presence of trees situated around a single building does decrease oppressiveness (Takei, 1983). As the research was limited to a single building there is a need to expand research to discover the impact in a real urban environment, which is characterized by more densely packed buildings.

When considering a comparison between the effect of 'green building walls' and the effect of trees it is likely that urban residents will be more concerned about having more green spaces available than about the kind of greenery (see also Bonnes, Uzzell, Carrus, & Kelay). This idea is supported by Dutch based research that found that the relationship between self-reported health and the amount of green space was not affected by the type of greener (De Vries et al. 2003). On the other hand, other research found that residents had varying levels of satisfaction concerning different types of nearby greener (Kaplan, 1985). In this research the psychological effect of green building façades and trees lining a street in front of buildings will be assessed in Tokyo. This research takes into consideration the real urban positioning of trees, such
as distances and dimensions. The effect of these two different types of greenery on resident psychology will be compared with the aim of contributing to the approach of Green Urbanism's goal of improving the usage of greenery in terms of effectiveness.

2. Study Area

Hongo Street, which is located in the middle of Bunkyo ward in central Tokyo, was picked as the study area because of the following characteristics. First, because of the combination of some high-rise buildings, narrow sidewalks and Ginkgo trees located on the edge of the sidewalk closest to the streets. Second, because the average street width of 27.8m, which is about the average of Tokyo's urban streets. All these characteristics make Hongo Street a good sample to represent the normal/average streets of Tokyo for conducting this experiment (Fig.1.).

In the selected area of the street the sidewalk width is 2.7m and the average height of the Ginkgo trees is 13m. The average distance between each existing tree is 8m. In Hongo Street, most of the buildings are built based on the previous municipal rule of Tokyo, which did not allow construction of buildings higher than 31m. New buildings are fewer and higher; therefore it has traces of modern construction among the older city structure. In the chosen section of the street, the visible features are a building complex (M building located next to residential buildings), the sky, skyline and greenery. All features such as signs were eliminated (using CG) from the building’s façade. This particular section of the street was chosen because of its typical characteristics, which can properly represent the area. (Fig.2.).

3. Methods

In this research building configuration factor, tree factor and sky factor refer to the mathematical "Configuration Factor" value of building, sky and tree in the scenes of cityscapes, based on the viewing angle. These are the basic physical measurements of the cityscape utilized to conduct this research. The cityscape unit used for these measurements was defined based on the human field of view.

There were two experiments conducted both in the experiment room using generated photos of a typical urban building compound (M building and its surrounding residential buildings) and Hongo street, which was simulated in three-dimensional computer graphic software. These experiments were conducted in an experiment room in order to have better control of the conditions of the environment, in other words to eliminate unfavorable parts of the city environment that could have an effect on the results such as noise, signs, people and cars. Using this method, changing the physical parameters of the scene was possible such as changing the building height, and amount and type of greenery.

In these two experiments, scenes generated through 3D-CG modeling, using a wide-angle lens with FOV (field of view) of 100deg horizontal angle and 85deg vertical angle from the experiment buildings, were
projected onto a screen of the same size. These scenes comprised of the buildings front facade, while the breadth of the right and left of the screen was filled with the simulated facade of the high-rise building compound.

For the first experiment, photos were generated based on the following parameters; buildings of three different heights (15m, 30m and 60m), three different configuration factors (8%, 22% and 32%), trees with 15 different combinations, and three different distances from trees to viewer (1.2m, 10.2m and 19.2m). In Fig.3. the photo on the left shows the 15m high building and trees at 1.2m distance from the viewer. Trees at this distance were shown with 6 different configuration factors. The middle photo of Fig.3. shows the 30m high building and trees at a distance of 10.2m from the viewer. Trees at this distance were considered in 4 different configuration factors. The right photo of Fig.3. shows the 60m high building and trees at 19.2m distance from the viewer. Trees at this distance were displayed with 5 different configuration factors. Added to the above combinations were 3 photos of buildings with no trees in front of them, in total 48 images were generated for the experiment. In other words, two main factors were defined, height of building (3) and positioning of trees (15). The later consists of 3 distances and several configuration factors.

For the second experiment, photos were generated based on the following parameters; buildings of three different heights (15m, 30m and 60m); three different configuration factors (8%, 22% and 32%); green facades with 17 different combinations, in other words with different amounts of green blocking the wall from sight. The greenery patterns on the facade were developed based on three parameters:

1- Four plant allocations; only the upper side of the building, only the middle of the building, only the lower part of the building, random.
2- Two different amounts of green; 1/3, 2/3
3- Two different leaf densities; 1/2, 2/2 (Fig.4.)

Adding 3 photos of buildings with no trees in front of them, a total of 51 were generated for the second experiment. In other words, two main factors were defined; height of building (3) and plant ratio (16). Plant ratio consisted of 4 plant allocations, 2 each of different amounts of green area and leaf density.

In order to simulate a real situation in the experiment room, the vertical projection angle was considered to be 30 degrees when the observer faced the building’s façade against his horizontal line of sight (Fig.5.). This angle was maintained based on the human perspective in the urban environment. In other words, when facing the building, they appear to humans at a vertical angle and this gives a threatening impression.

The evaluation was based on selecting between adjective pairs with the SD/Semantic Differential method. This method is commonly used in urban landscape assessment studies and is a valid method to evaluate the degree of frustration and oppressiveness (Takei, 1981; Matasuda, 1995; Hwang, 2007). The above method was chosen for this experiment in order to find the relation between the sense of oppressiveness and physical parameters while also evaluating the oppressiveness of the cityscape. In the first experiment after viewing each scene the subjects responded to 9 questions in the pre-designed questionnaire. The experiment participants all had a basic knowledge of architecture. A total of 40 people, with equal distribution of males and females took part in the experiment.

In the second experiment, after viewing each scene the subjects responded to 9 questions in the pre-designed questionnaire. As with the previous experiment the participants all had a basic knowledge of architecture and an equal distribution of males and females. This experiment had 20 participants. The first experiment was conducted in August 2008 and the second in April 2009. The building configuration factor as well...
as the tree factor and sky factor were estimated using a fish-eye lens of 4.5mm 1:2.8 combined with SPCONV06 software (Fig.6.)

4. Results and Discussion

The findings of both experiments show that the perception of oppressiveness significantly increases as the building configuration factor increases (Chart 1). This result is in accordance with findings of Takei et al. (1981) and shows that when buildings grow higher and bigger, and therefore the configuration factor increases, it results in an increase in the perception of oppressiveness by people facing the building.

Since this is the first time to use the configuration factor to evaluate green façade, the second experiment is emphasized more throughout this paper. The results of the first experiment are used as a comparison. A factor analysis of experiment number two showed that three factors were involved in the experiment and all adjective questions were accordingly sorted and divided into three groups. The first group is called "Pleasing" and includes the following adjectives; "Natural", "Harmonic", "Beautiful", "Pleasant", "Like", "Bright", and "Light". The second group is called "Depressive" and includes the following adjectives; "Oppressiveness dissatisfaction", "Openness dissatisfaction", "Oppressiveness", and "Openness". The third group is called "Notable" and includes the following adjectives; "lots of greenery", and "remarkable" (Table 1.).

One question was chosen from the first two groups as a better representative of each group (which has more adjectives). These were then compared with the results of the first experiment. The comparison is outlined and discussed in the following paragraphs.

Table 1. Factor Analysis of Subjective Questionnaire

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>First Factor</th>
<th>Second Factor</th>
<th>Third Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural/Unnatural</td>
<td>0.844</td>
<td>-1.155</td>
<td>0.216</td>
</tr>
<tr>
<td>Harmonic/Disharmonic</td>
<td>0.835</td>
<td>-0.263</td>
<td>-0.063</td>
</tr>
<tr>
<td>Beautiful/Ugly</td>
<td>0.798</td>
<td>-0.334</td>
<td>-0.034</td>
</tr>
<tr>
<td>Pleasant/Unpleasant</td>
<td>0.790</td>
<td>-0.432</td>
<td>-0.034</td>
</tr>
<tr>
<td>Like/Dislike</td>
<td>0.789</td>
<td>-0.425</td>
<td>-0.002</td>
</tr>
<tr>
<td>Bright/Dark</td>
<td>0.600</td>
<td>-0.524</td>
<td>0.047</td>
</tr>
<tr>
<td>Light/Heavy</td>
<td>0.596</td>
<td>-0.523</td>
<td>-0.141</td>
</tr>
<tr>
<td>Oppressiveness Dissatisfaction</td>
<td>-0.429</td>
<td>0.775</td>
<td>0.003</td>
</tr>
<tr>
<td>Openness Dissatisfaction</td>
<td>-0.130</td>
<td>0.705</td>
<td>-0.044</td>
</tr>
<tr>
<td>Oppressiveness</td>
<td>-0.458</td>
<td>0.702</td>
<td>0.104</td>
</tr>
<tr>
<td>Openness</td>
<td>0.361</td>
<td>-0.711</td>
<td>-0.010</td>
</tr>
<tr>
<td>Lots of greenery</td>
<td>0.147</td>
<td>0.139</td>
<td>0.837</td>
</tr>
<tr>
<td>Remarkable/Unremarkable</td>
<td>-0.114</td>
<td>-0.109</td>
<td>0.877</td>
</tr>
</tbody>
</table>

Eigenvalue                      | 4.536        | 3.246         | 1.473        |
Contribution rate                | 35.276       | 24.969        | 11.333       |
Cumulative Contribution rate     | 35.276       | 60.245        | 71.578       |
satisfaction improvement in oppressiveness perception. This building already has a low rating regarding oppressiveness.

In other words it does not dissatisfy people very much with its oppressiveness (Chart 4). Therefore this result is in accordance with previous research (Takei et al 1977). In that research Takei et al. called the oppressiveness of a building with 8% of configuration factor as "standard" and "permissible". Chart 4 shows the increasing effect of trees on mitigating oppressiveness dissatisfaction when the building is taller and has a larger configuration factor.

Based on this chart we can argue that the higher the building, the bigger the mitigating effect of trees concerning oppressiveness dissatisfaction. In all tested cases, 23% of the tree configuration factor brings the level of oppressiveness dissatisfaction close to the "permissible" level.

The same analysis was conducted with the data from experiment two. The results did not reveal any significant changes regarding the amount of oppressiveness dissatisfaction based on different building heights. That is to say, when the physical amount of greenery on the buildings’ façade changes - regardless of the greenery's allocation and density - there is no significant change in the amount of oppressiveness dissatisfaction. This result is slightly different from the results gained from the first experiment when testing the effect of trees in front of the building (Chart 5). When taking the greenery's allocation on the façade into account, a significant change is observed in the amount of oppressiveness dissatisfaction indicated by experiment participants (Chart 6). When the greenery factor increases in the lower part of the building, it has the biggest effect on oppressiveness dissatisfaction. Also increasing the greenery located in the middle of a building and random location show significant influences. The point is that increasing the greenery adds to dissatisfaction concerning oppressiveness. Adding to the greenery factor on the upper part of a building seems to have no significant effect on oppressiveness dissatisfaction. There is a possibility that greenery on the upper part of a building prevents the building from showing itself as an oppressiveness element and overcomes the dissatisfaction effect of greenery on the façade, so they neutralize each other and show no significant change in the amount of oppressiveness. If this is true, there could be a possibility that using greenery on buildings higher than 60m could change the scenario and make the buildings oppressiveness more satisfactory. This has not been researched yet and is a theory that is worthy of further consideration in the future.

The analysis shows that increasing the trees or greenery in front of buildings significantly changes people's perception concerning the environmental quality factor – pleasantness. In the first experiment, analyzing data of the pleasantness of the environment, based on the buildings heights, shows significant improvements in the respondent's perception when they are facing a building that is 15m high (Chart 7). The same question was asked during the second experiment and the results show that increasing the greenery factor on the upper part of buildings does not have a significant influence on the perception of pleasantness. This result is also very similar to the results from the question concerning oppressiveness dissatisfaction.
The difference here is the change of greenery factor in "random" allocation, which here does not produce any significant differences while in "oppressiveness dissatisfaction" the change was significant. However, the change in greenery factor allocated on the lower part as well as the middle part of the building's façade, appears to have the biggest influence on the perception of pleasantness. Therefore, by increasing the greenery factor in these areas there is a significant decrease in the quality of the environment (Chart 8). That is to say, when greenery is placed on the facade of a building, it becomes a part of the building's exterior design and naturally will be compared against many other high-rise buildings with creative and beautiful designs. The results of this experiment only represent using greenery on the facade of buildings in a simple form. Notably, if greenery was involved in the building design process from the start then the result would most probably be different.

Significantly, based on the results of the second experiment, the effect of greenery on the top of the building is the best among all experiment variables but that does not mean it has a positive effect on oppressiveness. In fact, the placement of greenery on the top of the building had neither a negative or positive effect but when compared to other variables that cause a negative effect, it is ranked as the best choice.

5. Conclusion

The aim of this research was to measure the positive psychological effect of greenery placed on the exterior walls of buildings on decreasing oppressiveness in a real urban environment and compare this effect with the psychological influence of street trees in the front of the same building. So far greenery on the exterior walls of buildings has been researched in terms of its impact on improving the buildings energy efficiency and cooling benefits. In terms of urban environmental psychology, this research is considered to be the first to look into the influence of greenery on the facade of buildings in an urban environment.

The methodology of the experiments allowed oppressiveness to be measured in the scale of the urban environment through two controlled experiments, both conducted in an experiment room utilizing 3D-CG images of an existing cityscape. The questionnaire, filled out by 40 and 20 subjects in each respective experiment, was followed by empirical data analysis, which facilitated the comparison of the experiment results. The two factors compared were the effects of the tree factor versus the greenery factor. The greenery factor referred to greenery placed on the building's facade.

The results found that trees have a better effect on mitigating oppressiveness in the urban environment than greenery on the facades of buildings. The large difference in the psychological effect of greenery on the facade of buildings versus trees in front of the buildings in the street shows that the kind of plants is important. This finding is in accordance with Kaplan (1985) who found out that in his research, the residents of multifamily housing distinguished among different types of nearby greenery, which also resulted in different levels of residential satisfaction. These results contradict the findings of (Bonnes, Uzzell, Carrus & Kelay, 2007) who suggest the "more" green spaces we have the better and were less concerned about the types of greenery. The above researchers and De Vries (De Vries et al. 2003) say that any kind of greenery in the urban environment has almost the same influence on humans and that urban planners and designers should think of the quantity of greenery in urban areas rather than the kind, but the results of our experiments show the importance of considering not only the quantity but also the quality and type of greenery in the urban environment. Based on the results of these experiments, the type and the quality of greenery have an important influence on people's psychological perception.

When greenery is placed on the facade of a building, it becomes a part of the building's exterior design and naturally will be compared with many other high-rise buildings some of which have creative and beautiful designs. Please note that the results of this experiment only represent using greenery on the facade of buildings in a simple form. As previously stated, if greenery was involved from the start in the building design process then the result would most probably be different.

This research is another step towards the effort in environmental psychology to research the influence of greenery and streetscape trees in the urban
environment. These two experiments represent a contribution to efforts within the field to identify and quantify the driving factors of urban oppressiveness while also classifying their impact and importance. The data analyzed in this paper showed that despite the fact that there are many benefits in using greenery on the facades of buildings, it does not necessarily bring a positive psychological impact to the environment. These results will contribute to a better understanding of the complex urban environment and landscape.

Within this research there has been progress in analyzing the relationship between urban environment/landscape elements and human psychological health. Questions still remain about the effect of the design of greenery on building facades as well as different types of shrubs and the resulting effect on environmental psychology. Furthermore, these findings could be different from nation to nation, so further international research in various cityscapes is necessary to arrive at a more concrete conclusion. Further research in these directions is recommended. Successfully measuring the potential positive psychological effect of plants in urban areas is an essential step towards developing sustainable urban environments.

References