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Applied Research Article

Investigation of the Oppressiveness of Tall Building Scapes: Architectural Variation and Vegetation

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ABSTRACT: The uncontrolled growth of tall buildings in contemporary cities has caused numerous visual and psychological issues for urban citizens. This study's framework examined the combined effect of architectural and vegetation variations on the scape of tall buildings and the oppression imposed on citizens. The architectural changes of the tall building included form (rectangular, stepped and pyramidal), gap (in single building (without gap, small and large gap) and between buildings (middle, sides and middle and sides)), console (1, 2, 2,5, 3, 3.5 and 4 m), and setback (1, 2 and 3 m) of the building from the base. Vegetation changes also included the distribution of different tree species on the façade and the positioning of the trees within each species. To assess the impact of architectural and vegetation changes on oppression, the method was based on the framework for assessing the oppressiveness of tall buildings and people's opinions. In conclusion, vegetation demonstrated a significantly greater reduction in perceived oppression compared to architectural modifications. The results of examining the architectural scenarios showed that as the pyramidal form of the building increased and the gap between the single tall building (or between tall buildings) widened, citizen-imposed oppression decreased. Also, as the console of a tall building decreased to less than 2.5 m and the setback increased to more than 2 m, the oppression decreased significantly. Also, the results showed that using concentrated and horizontal vegetation at the base and shaft of tall buildings has effectively reduced oppression (Compared to other vegetation change scenarios).

Keywords: *Tall Building, Architectural Variation, Vegetation, Urban Perception, Oppressive Environments, Environmental Psychology.*

INTRODUCTION

Stress is taken to be one of the main factors affecting mental health, and one of the main factors causing it is the environment (Evans 2003; Halpern 2014).On the one hand, during daily activities, the physical, psychological, and social strength of individuals is reduced and needs to be recovered (Hartig, 2007; Hartig 2004; Lindal & Hartig 2013), and on the other hand, living in today's dense and crowded cities can, in turn, expose citizens to stress and adversely affect citizens' mental health (Knoll et al., 2015; 2018), As environments are not only defined by their physics, in addition to their physical aspects, they have psychological effects. They are a psychological milieu (Bond et al., 2012). Some qualities of the urban environment stimulate certain areas of the human brain (the brain's parahippocampal place area (PPA)), leading to duplicate stress (Stamps & Smith 2002) and weakening citizens' mental abilities. In contrast, some of the qualities of the urban environment can provide the opportunity to strengthen the psychological abilities (Psychological Restorativeness), having been diminished by the daily efforts of citizens, thereby improving the mental health of individuals (Hartig et al., 1997; Herzog et al., 2003; Hidalgo et al., 2006; Nasar & Terzano, 2010; Staats et al., 2010; Tyrväinen et al., 2014; White et al., 2010). The guidelines for design and urban planning in different regions have paid less attention to this issue. Therefore, paying attention to urban environments that revitalize citizens' Psychological states seems necessary in today's dense and high-rise cities (Lindal & Hartig, 2013, 2015). In urban environments where there are tall buildings in

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their setting, there are negative impacts of tall buildings on the environment and its citizens, including the sense of oppression and impact on people's health, congestion, crowding, and social and environmental disturbances (Ali & Al-kodmany, 2012; Asgarzadeh et al., 2010). In studies of tall building oppression (Asgarzadeh et al., 2009; 2010; 2012; 2014), oppression is a type of environmental stress (negative psychological pressure), with a continuous and hidden effect (Asgarzadeh et al., 2012) defined to occur in the event of a violation of personal space (Schmidt & Keating 1979) and indeed an imbalance between the status of the environment and the capacity of citizens. Despite increasing the usability of urban spaces, tall buildings can create oppression, be visually perceived by citizens, and impose stress and fatigue (Asgarzadeh et al., 2009; Hwang, 2007; Maki, 2006), which can have significant effects on the performance and concentration of individuals (Asgarzadeh et al., 2012). However, there have been limited studies on the oppression imposed by tall buildings on citizens; therefore, this became the basis of our research, and the impact of architectural and vegetation variation of tall buildings 'scape on the oppression imposed on citizens was examined.

Theatrical framework

Tall Buildings and Oppression

'Oppression' is the English equivalent of the Japanese word 'appakukan' (圧迫感) (Asgarzadeh et al., 2012). Studies in Japan have taken into account the negative psychological pressure of the domineering of large buildings (tall buildings) on citizens as an 'oppression' with a permanent and hidden effect. Oppression challenges the comfort, privacy, and mental health of citizens, as well as the psychological sustainability of cities (Asgarzadeh et al., 2009, 2012, 2014; Hwang, 2007; Zarghami et al., 2019). Despite the great importance of oppression, few studies have been conducted to address it in the literature of architectural and urban design:

Parameters of the physical shape of the building (solid angle and configuration factor) and equation of oppression were introduced in the first studies of oppression by Takei and Oohara (1977a, 1977b, 1978, 1981) as the main factor of oppression on individuals. This equation has also been studied and updated by subsequent researchers, including Hwang (2007), Hwang et al. (2009), and Asgarzadeh et al. (2012). Asgarzadeh et al. (2012) introduced the latest version of the oppression equation, based on the effect of trees (Table 1). The analysis in this study is the same equation.

In another study, Ohno et al. (2003) also described "oppression" by the solid angle of surfaces around buildings and trees. Additionally, a study by Hwang et al. (2007) found that assessing oppression in a single building and a group of buildings yielded similar results, indicating that the configuration factor is an effective physical factor in assessing oppression. In the case of a group of buildings, the observer's direction facing the building was also shown to affect the sense of oppression. Other studies by Asgarzadeh et al. (2009, 2010, 2014), conducted in Japan, noted the impact of trees (and view of the sky, and groundscapes) near tall buildings and the vegetation on their scape in reducing building oppression. Zarghami et al. (2019) research, which was based on the influence of form changes of tall buildings (such as height, width, and height-to-width ratio) on oppression, emphasized the appropriate correlation between the results of the oppression assessment framework and the citizens' surveys, highlighting the reliability of the equation and framework for assessing oppression in studies in this area and showed that in the construction of tall buildings with a height (H) of 60 meters and more (≥60 m (meters) high) and a width (W) of 15 meters and more (≥15 m wide) on streets with a width of 30 m or narrower, over-burden oppression is imposed on the citizens. There is a pressing need to optimize the layout of vegetation in landscapes and reduce building dimensions to alleviate the pressure imposed on citizens.

In a recent study, Saadativaghar (2023) also relied on oppression (in Iran) to develop a mechanism for better positioning of tall buildings (in a modern city) in terms of psychological effects on citizens (developed in Hamedan city).

According to the research, many physical variables influence this sense of oppression, which can be classified into two main parts:

1. "Studies on the effect of physical form and appearance characteristics of buildings on citizens–induced oppression": Variables examined in this section were a solid angle, width, height, height-to-width ratio, color, and texture of the building (Asgarzadeh et al., 2009, 2010, 2012, 2014; Hiyoshi & Takei, 1990; Hwang, 2007; Hwang et al., 2009; Takei & Oohara, 1977a, 1977b; Zarghami et al., 2019).
2. "Studies related to the effect of the setting characteristics of the building on citizens' perceived oppression": of the variables considered in this section are the view angles, the observer's distance to building and tree and solid angles of the sky, the

Table 1: Equation for calculating the oppression of building (Source: Asgarzadeh et al., 2012).

$\omega=\sum\{(\Omega_B-\Omega_{TCB})\Gamma^3\}$	
Ω_B: is the solid angle of the building façade	ω: is the oppressiveness
Ω_{TCB}: is the solid angle of trees covering the building	Γ: is the inverted distance of the viewer from the building complex

ground, the trees covering the building and the sky (Asgarzadeh et al., 2009, 2010, 2012, 2014; Hwang 2007; Hwang et al., 2009; Takei & Oohara 1978).

As noted, the impact of many aspects of form, morphology, and the greenscape in the studies of tall building oppression have remained neglected, so the present study relies on this gap knowledge focusing on the impact of both building physics (form and the morphological and physical features) and setting of the building layout, to examine the effect of architectural changes (general form, gap, console and setback) and the vegetation (type of distribution and position) of tall building scape on the oppression imposed on citizens. In previous studies of tall buildings, the visual and environmental impacts (such as shading) of these architectural variables (including gap, console, and setback from the street) have been addressed (Al-Kodmany, 2012; Stamps, 2002, 2005; Stamps et al., 2005). However, the effects of architectural and vegetation variation of tall buildings on oppression have only focused on examining the architectural parameters of height and vegetation parameters of street trees and green walls on buildings (Asgarzadeh et al., 2009, 2010, 2012, 2014), And little attention has been paid to other architectural variables and the diversity of vegetation distribution and the location of each type of distribution. Therefore, the goal of the present study is to investigate the effect of architectural and vegetation variations of the tall building scape on oppression.

MATERIALS AND METHODS

Calculation of the oppression of the tall building scape

- Procedure

Humans use a spherical field of view to understand their surroundings, which is less noticeable in rectangular images taken by ordinary cameras (Gutwin et al., 2017). In the present study, the human visual field (spherical field of view) became the criterion for action, so that spherical fish eye images, whose field of view is almost similar to the real common vision of both human eyes, were used to simulate vision from the surrounding environment, especially the imaging of building scapes.

In this study, based on the framework presented in the pioneering studies in this area (Asgarzadeh et al., 2012; Zarghami et al., 2019), the oppression coming from the form, physical features and vegetation of tall building scape can be calculated; the steps of this framework are as follows: 1. simulation of different modes of tall building form (general changes of building physics) and its setting; 2. Rendering a fisheye image of the building and its scape at that point; 3. Loading the fisheye image in the SPCONV (or GeoCity) software and determining the visual weight of the building form and its scape elements; 4. Calculating the oppression based on the visual weight of the building form and its scape elements, with the distance the observer is located relative to the building.

- Research Variables

Variable Related to Architectural and Vegetation Variation of the Tall Building Scape

Thus, based on the regulations of architecture, urban planning, and tall building construction code in the cities of Iran and the research proposals of experts in the field of urban and tall building scape, Scenarios related to the architecture and vegetation of the tall buildings scape were made feasible and simulated; these scenarios were:

a. The architectural changes of the tall building were classified into three categories: 1. The general form; 2. gap in the form of a single building or between buildings; 3. The console and setback in the form of the 2nd floor (Table 2).

b. Vegetation in the building scape, after consulting with urban landscape and tall building specialists, was examined in 4 types: horizontal, concentrated, vertical, and random types. In the continuation of the research, different locations of vegetation placement in each type were also analyzed (Table 3).

In all scenarios of this section, eight fixed and identical trees in different types of distribution and placement of vegetation on the façade (different species of tree distribution on the façade and position of the trees in each species) were used (Table 3).

Oppression

In this research, to assess the oppression coming from the form of tall buildings and their scape vegetation at different distances from the observer to the building, the oppression equation was used: ω=Σ{(Ω_B-Ω_TCB) Γ^3

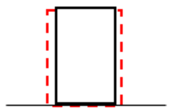
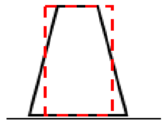
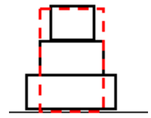
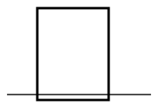
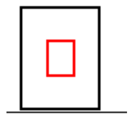
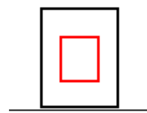
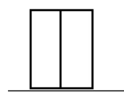
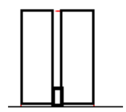
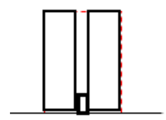
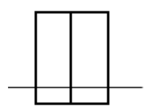
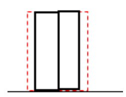
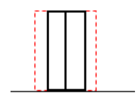
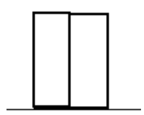
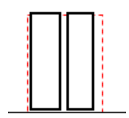
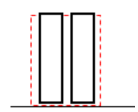
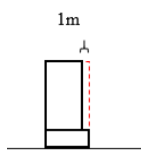
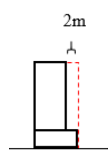
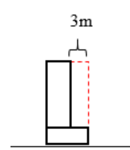
In this equation: ω is the oppression, Ω_B is the solid angle of the building façade in the view sphere (to understand the calculations of solid angle, refer to section 2-1-2-2-2), Ω_TCB Is the solid angle of trees covering the building in the view sphere, and Γ is the observer's inverted distance (perpendicular distance) from the building (Asgarzadeh et al., 2012).

Photography in Real and Simulated Environments

To take fisheye photos, we used a Nikon™ Coolpix 995 with a 0.21x fisheye converter FC-E8 in the real environment and a fisheye camera in 3D Max software (simulated environment). With the help of simulation and imaging experts, the virtual fisheye image adjustment was almost identical to that of a real camera and lens (converter).

In this research, the production of images similar to the real vision of Iranian citizens was the criterion for action, providing both real and virtual fisheye images. The approximate average height of Iranian men and women served as the basis, and the camera was placed at that height above the ground. Additionally, when selecting the camera location and preparing the photo, an attempt was made to choose a situation in which citizens encounter it daily, with buildings visible from that position.

Table 2: Image of various types of architectural changes in the tall building scape.

The type of architectural changes in the tall building	Image of architectural changes		
General form			
View	Elevation (rectangular)	Elevation (pyramidal)	Elevation (stepped)
Gap within a single building			
View	Elevation (non-gap in the building)	Elevation small gap (1/3 dimensions of the initial building)	Elevation large gap (1/2 dimensions of the initial building)
Gaps between buildings (gap in the middle of buildings)			
View	Elevation (non-gap between buildings)	Elevation small gap (1/3 dimensions of the initial building)	Elevation large gap (1/2 dimensions of the initial building)
Gaps between buildings (gaps in the (sides of buildings			
View	Elevation (non-gap between buildings)	Elevation small gap (1/3 dimensions of the initial building)	Elevation large gap (1/2 dimensions of the initial building)
Gaps between buildings (gaps in the middle and sides of buildings)			
View	Elevation (non-gap between buildings)	Elevation small gap (1/3 dimensions of the initial building)	Elevation large gap (1/2 dimensions of the initial building)
Setback from the property line (street) after the second floor			
View	Section	Section	Section

Continiue of Table 2: Image of various types of architectural changes in the tall building scape.

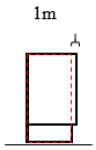
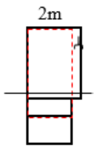
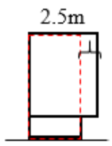
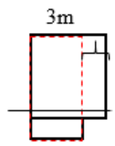
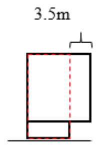
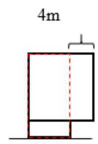
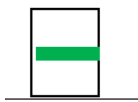
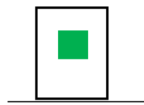
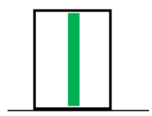
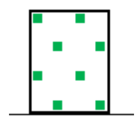
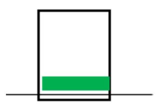
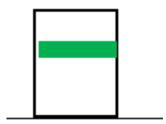
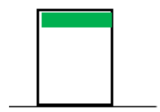
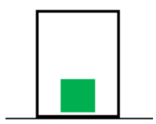
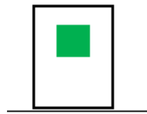
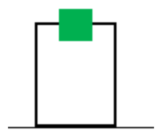
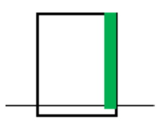
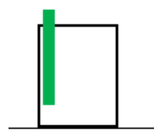
The type of architectural changes in the tall building	Image of architectural changes					
The console of the building on the second floor						
View	Section	Section	Section	Section	Section	Section

Table 3: Image of various types of vegetation changes in a tall building scape.

.Table 3: Image of various types of vegetation changes in a tall building scape				
Type of vegetation changes in the tall building scape	**Image of vegetation changes**			
Species of tree distribution on the façade				
View	Elevation (horizontal vegetation: 8 trees)	Elevation (concentrated vegetation:8 trees)	Elevation (vertical vegetation: 8 trees)	Elevation random) vegetation: 8 trees)
Horizontal vegetation at the base, shaft (middle), and top of a tall building				
View	Elevation (Horizontal vegetation at the base of a tall building: 8 trees)	Elevation (Horizontal vegetation at the shaft (middle) of a tall building: 8 trees)		Elevation (Horizontal vegetation at the top of a tall building: 8 trees)
Concentrated vegetation at the base, shaft (middle), and top of a tall building				
View	Elevation (concentrated vegetation at the base of a tall building: 8 trees)	Elevation (concentrated vegetation at the shaft (middle) of a tall building: 8 trees)		Elevation (concentrated vegetation at the top of a tall building: 8 tree)
Vertical vegetation on the right, middle, and left of the tall building				
View	Elevation (Vertical vegetation on the right of the tall building: 8 trees)	Elevation (vertical vegetation on the middle of the tall building: 8 trees)		Elevation (Vertical vegetation on the left of the tall building: 8 trees)

Additionally, the camera was positioned at a 30-degree angle with respect to the building (Asgarzadeh et al., 2009, 2010, 2012, 2014; Zarghami et al., 2019).

The fisheye images (taken with these settings) were then loaded into SPCONV software (Fig. 1) to calculate the solid angle of the building and the tree covering the building. With the solid angles (building and tree) calculated from the photos, we could measure the sense of oppression. In the virtual fisheye images produced, the impact of architectural changes and vegetation overlaying the tall building was examined. In all these images, the observer's distance to the building was 65 m. The basis of the architectural changes, in the form of tall buildings, was the city's (Iran) architectural and urban regulations, the frequency of such changes in modern cities, and consultation with experts in the field of tall buildings.

Solid Angle

To measure the formal variations of the building and the vegetation that partly covers it, the parameter of solid angle was used for both elements, referring to the visual weight of the building and the vegetation (covering it). In other words, to calculate the solid angle of the building and its covering trees, real and virtual fisheye images were prepared (Nikon Coolpix 995 and its fisheye convertor 0.21x FC-E8 output images were fisheye images in approximate dimensions of 13 by 13 cm (1537 by 1536 pixels) (Fig. 1). In the present study, this method was used to calculate the solid angle of a tall building (and each of its formal and physical changes) and its covering trees (in different situations) (Asgarzadeh et al., 2012 and Zarghami et al., 2019) (Fig. 1).

Case Study

In this research, one of the many tall buildings constructed in recent years in the city of Hamadan was investigated. Specifically, a tall building located in the insurance square of Hamadan, with the final stages of its construction currently underway, was examined.

Validation of calculated oppression (oppression estimated by the framework) by people's oppressive perception of the tall building scape

- Procedure

For this purpose, on a sunny day (to reduce the climatic effects on the results), first from the same position and conditions (65 meters vertical distance and 30 degree angle of the camera (observer) to the top of building) as the fish eye images were taken (related to formal and vegetation scenarios of tall building scape), the normal images were taken with a 100-degree horizontal field of view and an 85-degree vertical field of view (the images were based on a field of view a person sees in a single sight). The output of this step was 34 normal images corresponding to 34 fish eye images (images related to formal and vegetation scenarios of a tall building scape) (normal images).

Then, 20 citizens (the same number of males and females) in Hamadan, all of whom were students of architecture and urban planning of Hamadan universities and had relative knowledge in the field of architecture and urban planning, with individual presence in the experiment room (a classroom with modified projection screen angle and a chair at the proper position for the observer), evaluated images displayed (images that correspond to a field of view a person sees in a single sight) on the screen (based on the psychological variables of oppressive perception, openness, and preference) (Asgarzadeh et al., 2012, 2014; Lindal & Hartig 2013, 2015; Zarghami et al., 2019)

- Reliability, Validity, and Statistical Analysis

After collecting participants' opinions and ensuring the

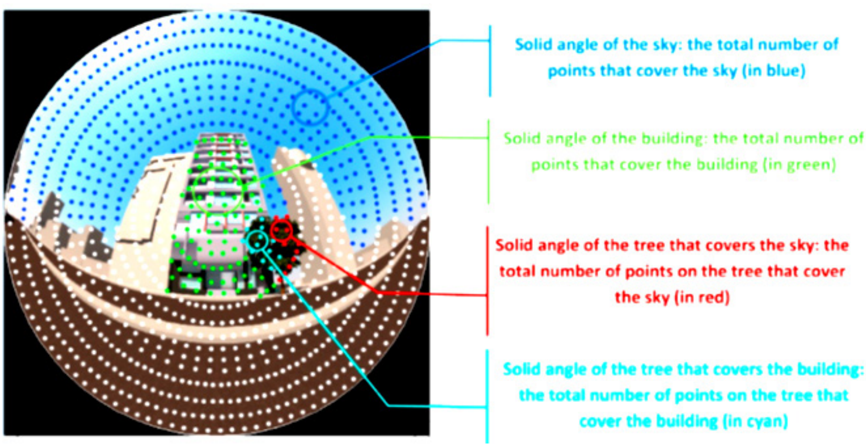


Fig. 1: The environment of SPCONV software and procedure of calculation of the solid angle of the building, the tree, and the sky (Source: Zarghami et al., 2019).

reliability (through Spearman-Brown reliability coefficient, based on researchers' recommendation for reliability, the minimum acceptable value of this coefficient should be 0.5 (Guilford 1954; Nunnally 1967)) and validity (based on the validity of simulated environments (color images) and Semantic Differential (SD) method: As recommended by the main researchers in the field of oppression, the validity of the use of a simulated environment that can be used as an alternative to the real environment and can provide a low-cost study of effective urban landscape changes in the pre-design stage with better control of environmental factors (such as traffic and noise) has been suggested in studies of oppression assessment (Asgarzadeh et al., 2009, 2010, 2012, 2014; Hwang 2007; Takei & Oohara 1981)) of the assessment technique, based on statistical analysis and graphical outputs in IBM spss and excell software, the results of oppressive perception (the amount of openness and preference) related to formal and vegetation scenarios of tall buildings scape were expressed based on citizens' opinions.

Finally, based on descriptive and inferential statistical analysis using IBM SPSS software, such as Pearson correlations, and graphical comparisons (Graphs) created with Excel software, the oppression was calculated based on the framework of oppression assessment and the perceived oppression (as well as the values of openness and preference variables) by citizens.

RESULTS AND DISCUSSION

Findings related to calculated oppression based on the research framework

•Findings Related to the impact of formal (architectural) Changes of Tall Buildings on citizen-imposed oppression

The results of the study of the effect of changes in tall building form (with equal façade area) showed that in tall buildings with rectangular, stepped, and pyramidal forms, the imposed oppression on citizens was the same.

But in the building with the initial form the level of oppression was higher because the level of the basic form façade is higher than the three conditions studied (rectangular, stepped and pyramidal); In fact, by examining the context of the building and the possibility of forming of rectangular, stepped and pyramidal buildings whose surface (level) of connection to the ground is the same and with the shaft and top form changes (the surfaces of façade area are different), there is seen a difference in oppression, so that with the shaft and top of the tall building becoming narrower oppression is decreased (in this comparison, the criteria of equality the façade area of building has been ignored)

Examination of the gap changes in the single tall building also showed that in both small and large gaps, there was a decrease in oppression compared to the non-gap building, and this decrease was more pronounced with the increase in gap proportion.

The results of the study on the gap between buildings were presented in two parts: A. Creating a small gap between buildings (one-third of the initial building's dimensions). B. Creating a large gap between buildings (1/2 dimensions of the initial building).

The results showed that the creation of a small gap (one-third of 1/3 dimensions of the initial building) in the middle of buildings, compared to the placement of this small gap on the sides (dividing the small gap into two equal parts and placing them on the sides of buildings), has played a more effective role in reducing oppression.

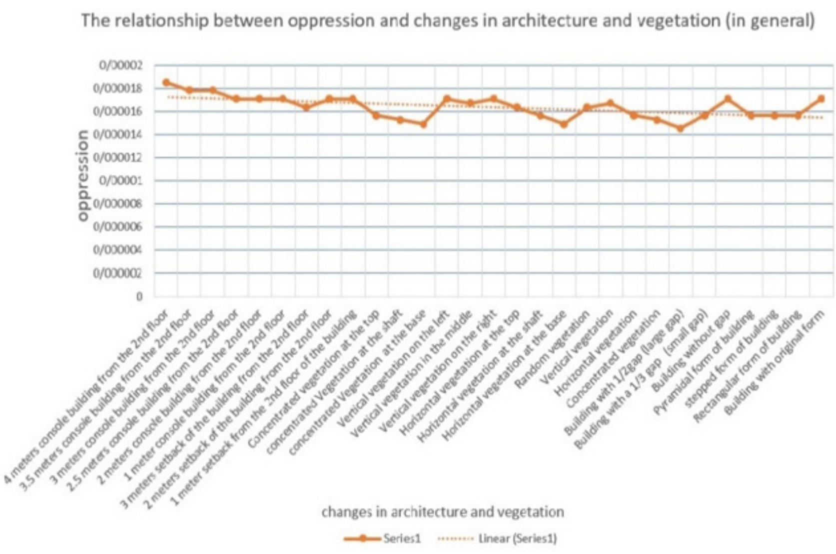


Fig.2: The relationship between oppression and changes in architecture and vegetation (in general).

The results show that the oppression imposed by a 1m and 2m setback of the building from the second floor is not significantly different. However, with a setback increase to 3 meters, a severe reduction in oppression is observed due to the decrease in the occupied volume of the human vision sphere by the building.

The results of a 2-storey building console (creation of a console) on oppression, showed that there was no change on the oppression with the 1, 2, and 2.5 m console of the building (and being the same with initial building oppression (in initial non-consoled building: the solid angle of the building minus the solid angle of the trees covering building was 4.7%)). However, in the three and 3.5-m consoled buildings, there was a slight increase in the oppression imposed by the tall building. In the tall building with a 4-meter console, the highest oppression is experienced.

• Findings on the effect of the vegetation of tall building scape on citizen-imposed oppression

Comparing tall buildings with vegetation random, horizontally, vertically, and concentrated in their façades, showing that the highest oppression occur in the buildings with trees scatted vertically and randomly while the lowest amount of oppression are from buildings in which trees cover concentratedly and horizontally the façade of the building (oppression from low to high, respectively, was observed in buildings with concentrated, horizontal, random and vertical vegetation).

In the following, the position of vegetation was changed in each vegetation type (horizontal, vertical, and concentrated). It was observed that the presence of horizontal strips of trees on the base of a building reduces oppression, followed by buildings with horizontal strips of trees in the shaft (middle) and at the top.

The study's results on the effect of vertical vegetation positioning change on the tall building façade also showed that vertical vegetation deployment on the left and right sides of the building reduced the oppression imposed by the building. However, they are less effective than vertically placed vegetation in the middle of the building façade in reducing oppression.

The study of the effect of concentrated vegetation positioning also showed that concentrated vegetation at the base of the building had the highest share, and vegetation concentrated at the top of the tall building had the least share in reducing the oppression imposed on citizens.

•Comparing the efficacy of architectural and vegetation changes on the tall building-induced oppression on citizens

Further on, R2 statistics (coefficient of determination) on architectural changes and vegetation changes in tall building scapes are discussed (in opposition). Overall, based on the R2 statistic, it was observed that the effects of vegetation changes on the tall building scape were more significant than those of tall building architectural changes on oppression (except for the relatively less vertical vegetation impact on oppression), albeit the effect of the gaps in the single tall building were significant and very close to the effect of vegetation changes of the tall building scape on oppression.

Findings Related to Calculated Oppression based on the Research Framework (Point-To-Point Comparison of Architectural and Vegetation Changes)

This section reviews the findings related to the point-by-point comparison of architectural changes and vegetation in relation to oppression. In this diagram, the building with a large gap imposed the least amount of oppression, and the building with a 4-meter console imposed the most oppression on citizens. Vegetation, except for the vertical mode, also had a significant positive effect on reducing oppression. Among architectural changes, the gap is the most important factor, and among vegetation changes, horizontal (and concentrated) vegetation is considered the most effective component in reducing oppression (Figure 2)

Findings related to determining the validity of oppression were calculated based on the research framework.

In this section, the findings related to the effect of architectural and vegetation changes on the oppression of tall buildings' scape were verified through a separate survey based on citizens' opinions. The summary of the results of this comparison can be found in a past article by the authors (and appendix). To cite and trust the results of this separate survey, which was conducted with 20 participants evaluating 34 images based on psychological variables of oppressive perception, openness, and preference, it was first necessary to establish the reliability and validity of the measurement technique (Reliability and validity of the assessment). As noted in Section 2-2-2, the reliability and validity of simulated environments (color images) and the Semantic Differential (SD) method for image evaluation have been recommended by experts in previous studies on oppression. To calculate the reliability of the evaluation (assessment technique), the Spearman-Brown reliability coefficient was considered. For this purpose, participants were divided into two groups of equal size (10 participants each). Using IBM SPSS 21 software, Spearman-Brown reliability was calculated for each psychological variable by analyzing the average of the opinions from both groups. The values of this coefficient for the variables of oppressive perception, opening, and preference were 0.785, 0.903, and 0.904, respectively. Given that the value of this coefficient for all three variables is greater than 0.5, it indicates the reliability of the measurements. In the following, the results related to citizens' opinions on the impact of architectural and vegetation changes of tall buildings 'scape on three psychological variables of

Table 4: Descriptive statistics (Means, Standard Deviations, Min, and Max) and correlation matrix (Pearson correlations) for the variables in the analysis, based on 34 tall building view images.

	M	SD	Min	Max	1	2	3	4
Estimated oppression[a]	0000163072.	0000011436.	000012376.	000018564.	1			
Oppressive perception[b]	4.98	93627.	3.25	7.05	**482.	1		
Openness[b]	5.50	1.04242	3.35	7.55	**499.-	**896.-	1	
Preference[b]	5.48	1.07572	3.35	7.25	**463.-	**877.-	**945.	1

Note. The data in this table are based on 34 images rated by the participants (N = 20) and used as the unit of analysis. It should be noted that for each image, the average value of each variable was calculated based on the participants' opinions and used in the statistical analysis process.

a. In this part, to assess the oppression coming from tall building scape, the oppression equation was used: $\omega=\sum \{(\Omega_{B}-\Omega_{TCB})\Gamma^{3}\}$: In this equation, is the oppression, is the solid angle of the building façade in the view sphere, Is the solid angle of trees covering the building in the view sphere, and is the observer's inverted distance (perpendicular distance) from the building.

b. A 9-point scale was used for oppressive perception, openness, and Preference (for example, 1 = least oppressive perception, 9 = highest oppressive perception).

** $p \leq .01$

oppressive perception, openness and preference are described in two descriptive and inferential statistics: In the descriptive statistics section Means, Standard Deviations, Min and Max of each of the psychological variables were described (Table 4). In the inferential statistics section, after ensuring that the distribution of variables is normal (Kolmogorov-Smirnov test ($p> .05$)) and using analysis of Pearson correlations and graphs, the relationship between each of the psychological variables and each of the architectural changes and vegetation of the tall buildings' scape was examined. As can be seen in Table 5, the oppression calculated based on the oppression assessment framework (for any architectural changes and vegetation in the tall building scape) has significant and moderate correlation with psychological variables (oppressive perception, openness, and preference), as reported by citizens, and after viewing the images that have been evaluated. The results indicate a positive relationship between oppressive perception and estimated oppression, and a negative relationship between openness and preference and estimated oppression (oppressive perception). In other words, with the increase in the oppression of the tall building scape (estimated or perceived oppression), openness and preference for that scape have been reduced.

The results of the relationship between each of the psychological variables (assessed by citizens) and each of the physical variables and the vegetation cover of the tall building landscape also indicated the similarity of the results evaluated based on the research framework and citizens' opinions (second study) (Many details have been omitted due to the limited number of printable pages in the publication. For more details, see appendix of authors' past article).

Discussion

The combined impact of architectural and vegetation variation on the tall building scape's oppression of citizens was investigated in the present study. Suppose more studies are done in this aspect. In that case, the results of this study can provide guidelines for landscape (scape) design of tall buildings for architects and decision-makers interested in increasing mental health. In addition, in previous limited studies on the oppression imposed by tall buildings on citizens, the impact of limited architectural changes such as height, width, and height-to-width ratio on oppression has been examined (Zarghami et al., 2019; Asgarzadeh et al., 2012) and other architectural changes commonly used in cities, such as general form, gap, console and setback (from the base) of tall buildings have not been paid attention to. However, it should be noted that in other studies that did not consider the psychological effects of tall buildings and paid attention to the aesthetic and visual-perceptual aspects of tall buildings, the effect of variables such as building proportions (height, width and the ratio of the height of the building to the width of the passage), depth, setback, color, building materials, type of building openings, roofline silhouette (urban skyline), façade articulation, façade design type (classic, modern and simple), the size and position of the gaps in the walls (visual and physical permeability) and the coherence of street buildings on parameters such as openness, complexity, preference, fascination, pleasure, comfort, safety, enclosure, and arousal were examined (Alkhresheh 2007; Al-kodmany 2011, 2017; Heath et al., 2000; Karimimoshver & abrarasari 2014; Kim 2017; Samavatekbatan et al., 2016; Stamps 2005; Stamp et al., 2005). There have also been a few studies examining the impact of tall building scape vegetation on oppression, as well as that of front trees and green walls surrounding the façade on oppression (Asgarzadeh et al., 2009, 2010, 2012, 2014). Accordingly, little attention has been paid to the distribution of different species of vegetation on the façade, which is widely used in the scape of the tall building. In addition, in many studies related to the effect of vegetation covering buildings and vegetation around buildings, despite the psychological effects of tall buildings have received less attention, the focus has been on the impact of vegetation on parameters such as citizens` safety, perception and impression in public spaces, and there have not been paid enough attention to the diversity and location of vegetation in the scape of tall buildings (Avalone neto 2017; Harvey et al., 2015). This study aimed to fill these shortcomings, and researchers sought to achieve more comprehensive results that related the effects of architectural changes and vegetation of the scape of tall buildings on oppression (focusing on extracting criteria and code for the development of tall buildings) that were initially obtained through a computational framework of oppression and checked in a separate survey based on the opinion of citizens. The results of the second survey, based on the opinions of citizens, also largely confirmed the findings obtained using the computational framework of oppression (although exceptions are described in sections 2-3). But this study has limitations in addition to the merits (innovations) mentioned, so further studies in different areas, with other variables and laboratory and non-laboratory methods, are needed to validate further and complement the results. The following are some of the limitations that existed in the present study:

First, in the framework for calculation of the oppression, which, with further studies can be used as one of the complementary tools in the process of urban landscape design (especially urban landscapes that have been associated with tall buildings) to help designers and decision makers, fish eye images are used to simulate the real field of view of humans (the common field of view of both eyes) which is spherical. Even though in the preparation of fish eye images from the scape of tall buildings (tall building scape), attempts were made (in consultation with ophthalmologists and imaging specialists) to create conditions that are almost similar to real human vision, but the resulting fish eye images are also different from the real vision of humans and their perception of landscapes, which are among the main limitations of the present study. Therefore, to further the comprehensiveness of the method used in the present study, it is necessary to conduct studies in a real environment based on the actual psychological effects of citizens' encounter with tall buildings in the real environment and to evaluate the psychological effects of buildings, not only consider the perceptions of citizens based on the questionnaire technique, but also use other laboratory methods to evaluate the psychological effects of buildings (cognitive tests, nerve conduction tests (EEG and QEEG), skin conductance, heart pulsation, etc.)

Second, in the present study, computer simulation (using 3DS MAX) was employed to generate fisheye images to assess the feasibility of architectural and vegetation changes in the tall building scape in terms of the oppression imposed on citizens. However, it was attempted by consulting simulation and imaging experts that the fisheye imaging settings in the software are similar to those of a real fisheye camera and its lenses.

Third, in the present study, to further control the research, the observer's position was calculated to face the building perpendicularly and rotate 30 degrees from the top of the building. Therefore, in fish eye imaging (used in the framework of oppression assessment) and in showing normal images in the experiment room to participants (to measure the validity of research results), the participant's head is inclined upwards (screen was rotated 30 degrees from the vertical axis and toward the observer's head, which is tilted 30 degrees upwards) as the previous studies have emphasized the maximum oppression in this condition (Asgarzadeh et al., 2009, 2010, 2012, 2014; Hwang et al., 2007; Zarghami et al., 2019) (compared to situations where the observer encounters a tall building non-perpendicularly and with a direct view or a downward view) and previous studies emphasized on the fact that citizens usually turn their heads up in the face of tall buildings (Asgarzadeh et al., 2009). However, to make the results more comprehensive in this regard, as noted, studies from all angles of the observer's encounter with the building are needed (the observer's head does not necessarily have to be tilted upwards, and his view is direct, or the observer's view of the building is from the side and non-vertical angles).

Fourth, consulting with experts on tall building, reviewing architecture and urban planning regulations in Iran, and analyzing global experiences in tall building and green landscaping were the basis of the architectural and vegetation variations of the present study scenarios, for example, in the present study, small trees were used to study the vegetation of the tall building scape because small trees are one of the most common vegetation used in this study setting. Based on the studies of researchers in the present study and a survey of experts in the field of urban landscape, Small trees have a higher priority than flower boxes and green walls in this area. The small trees studied in this study could be installed on balconies or a rooftop (roof garden). They were approximately as tall as a one-story building (about 3 meters), with a canopy width of about one-third of the height, and the trunk and canopy (foliage) heights were approximately the same. They are cold-climate trees with a needle-like texture that remain green in all seasons, both hot and cold. Certainly, examining other plant and tree species (in various sizes) that have the potential to grow in other climates around the world could help complement the results of the present study.

Fifth, in this study and all the scenarios examined, first terraces were created on the walls of the tall building under study, and then small trees planted in pots were established on the terraces. Also, to reduce the impact of the guard rail (fence) in front of the terrace on the audience of the research, it is assumed (For the participants present in the experiment room) that a glass guard rail will be used in front of the terraces (to prevent the risk of falling on the audience and causing danger), which will almost only block the trunk and flowerpot of the tree and will not have a great impact on the audience's perceptual view (The use of small trees planted in pots and resistant glass guard rail (Durable glass railing) has been very popular in the context of the present study, especially in recent years. Still, reliance on pot-based trees is certainly one of the limitations of the present study, and future studies could focus on other types of trees and green roofs.

Sixth, the scenarios under study (to eliminate intervening variables) had a limited number. Therefore, considering the limited data and, in some scenarios, the categorical nature of the independent variables, the use of regression analysis was not the criterion and only the R2 component (which is the output of the Excel software chart) has been placed and reported in the charts (as in most previous studies in this field) and in the reported point-by-point analyses. This is a limitation of the present study (Because when the independent variable has a limited number and sometimes categories, inferential statistics (such as ANOVA and regression) are not applicable and meaningful, and the focus is solely on descriptive statistics).

In addition to the limitations mentioned above, due to the difficulty of the process of assessing the participants' perceived oppression in such studies (Like being in the experiment room for a long time, turning head and understanding scenarios), this study (like the limited studies that pioneered the present study such as Asgarzadeh et al., 2009, 2010, 2012, 2014; Zarghamei et al., 2019; Saadativaghar et al., 2024) was conducted in a limited statistical population and mainly with participants who had relative knowledge of architecture and urban planning. The participants in the present study were architecture and urban planning students who were familiar with the principles and criteria of urban landscape design. Still, in this regard, it is necessary to use simpler measurement methods so that comments from ordinary citizens can also be used to provide more accurate and comprehensive results.

Therefore, more studies need to be conducted, focusing on the above limitations (constraints) in different regions and replicating and developing architectural and vegetation scenarios.

CONCLUSION

The primary objective of the present study was to develop guidelines for the architectural design and landscaping of tall buildings to mitigate the impact on citizens. Therefore, using computer simulations, the tall building architecture and its vegetation were manipulated, and the effect of these changes on citizen-imposed oppression was measured through the oppression assessment framework and the opinions of the people. The investigation of the formal scenarios of tall buildings (based on framework and people's opinions) showed that, assuming a fixed cross-section width at the point of attachment to the ground, the narrowing of the shaft and top of the tall building relative to the initial rectangular tall building had a positive effect on decreasing oppression, which is almost consistent with the structural results in the design of tall buildings. The analysis of scenarios related to the gap of the tall building (based on framework and people's opinions) also showed that the create and increase in the gap of the single tall building (compared to single tall building without gap) and increase the gap between tall building (preferably gap in the middle of buildings) has reduced the oppression on citizens, consistent with the analysis studies of winds and statistic of tall buildings: In structural studies and wind analysis of tall buildings, the positive impact of thinning the tall building in shaft and top and gap of the single tall building (and gap between building) to reduce the wind pressure imposed on the building and more statics of structure have been paid attention to. However, the lack of pyramidal form variations in tall buildings and the gap in the design of tall buildings (as outlined in the Regulations for tall buildings) in the context of the present study and many other areas is strongly felt. In the cities of Iran, and according to the architectural and urban planning regulations, a building console is visible from the first and second floors. This was investigated in scenarios related to the console and setback of the tall building from the second floor. The results (based on the framework) showed that for the console, up to 2.5 m, there was no difference between the oppression of the consoled building and the non-consoled building, but after 2.5 m, the imposed oppression on the citizens facing the tall building increased, and this increase is more significant beyond 3.5 m. Citizens' opinion-based results almost confirmed this conclusion. However, there were exceptions: According to Citizens' opinion, with the increasing number of consoles, even at low values (such as those below 2.5 m), oppression increases; however, with the increasing number of consoles beyond 2.5 meters, the rate of preference and opening of the scape of the tall building has decreased. Combining the results of the study framework and people's opinions about the console showed that the creation of the console (especially in large quantities) increases the oppression imposed on citizens. In the case of the 2nd floor setback, the results (based on the framework and people's opinions) also showed that with a 1-meter building setback, there was no remarkable change in the oppression imposed by the building. Still, with the second-floor building setback by 2 meters or more, there was a remarkably decreasing oppression on citizens, which is rarely seen in the design of tall buildings (Especially in Hamadan and Iran). Concerning the effect of vegetation distribution variation on the façade of tall buildings on oppression, the results (based on the framework and people's opinions) also showed that horizontal and concentrated vegetation had the greatest effect on decreasing the oppression imposed by tall buildings, followed by random and vertical vegetation. In addition, the concentrated and horizontal vegetation in the lower (base) and middle (shaft) parts of the tall building has had a more significant role in reducing oppression (compared to the vegetation at the top of the tall building). As noted above, the effect of vertical vegetation on the tall building scape is slight.

In general, except for the impact of gaps in the single tall building (of architectural changes) on the oppression, which was very significant and very close to the effect of vegetation changes on the scape of tall building, the impact of vegetation changes on the scape of tall building has been more dramatic than that of architectural changes on oppression. Relying on the theory of attention restoration (ART) and Stress Recovery Theory (SRT), citizens of contemporary crowded and dense cities who suffer from attention fatigue due to the concentration of attention in the workplace After exposure to natural landscapes in the façades of Human-made buildings (and to a lesser extent architectural changes in line with the restorative environment) and natural environments, through being away the individual's attention from factors that disrupt visual health (being away), attraction to natural features that are compatible with human needs (fascination and compatibility), and perception of the visual openness of the place (extent) have led to the focus of the citizen's visual attention and reduced their stress. This process can ultimately promote mental recovery and reduce psychological stress (oppression), and consequently improve the well-being and mental health of citizens in the crowded, dense, and high-rise environments of today's cities. Although the present study is considered a case study, with the support of future studies and more detailed analysis, it can help designers and decision-makers choose the guidelines for architectural design and the landscape of tall buildings. Suppose future researchers conduct further studies to prove the results of the present study. In the field of extracting codes and criteria for tall building development from the present study, it is recommended that designers and urban planners use tapered forms (pyramidal, conical, stepped, etc.), use gaps in the building façade (to see the natural landscape behind the building, create visual openness for citizens, and reduce wind pressure on the building, which are consistent with structural and wind issues), reducing the amount of console the building façade and instead using setback on the building façade (from the base), as well as using more types of vegetation in the base and shaft areas of tall buildings (especially concentrated and horizontal vegetation instead of vertical and random vegetation on the building façade) to reduce the oppression from the tall building in cities. Adhering to such principles can significantly impact opening citizens' vision and better visual connection with these buildings (focal points) and landscapes, relieving them of the social and psychological tensions of today's urban life, reducing the stress imposed on citizens, and improving the mental health of citizens in crowded temporary cities with tall buildings.

AUTHOR CONTRIBUTIONS

p. Saadativaghar performed the gap of study, introduction, methodology, literature review, experimental design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. E. Zarghami performed the experiments and literature review, compiled the data, and prepared the manuscript. M. Karimimoshaver helped in the literature review and manuscript preparation. A. Ghanbaran performed the literature review

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CONFLICT OF INTERESt

"The authors have expressed no conflict of interest."

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