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Assessing the Optimum Proportion of Outdoor Spaces of Educational Sites, College of Engineering in Erbil City as a Case Study

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Abstract

Many of Outdoor spaces (OS)s in the local existing educational institutional sites are narrow or wide, of inefficient degree of enclosure (DOE) and of reduced performance. Optimum proportion of OS in this paper is one that can ensure efficient performance of both the surrounding buildings and the OS itself, and also ensure minimum consumption of land, energy and material. DOE of OS in previous literature is associated only to the proportion of OS itself, whereas (DOE) in this paper is associated to other parameters in addition to proportion. They are; pattern of object configuration, permeability of vision of enclosing surfaces, and ambient environment. This paper attempts to establish a relationship between the DOE with the mentioned parameters, and to determine the optimum proportions of campus OSs for various uses. The site of the college of engineering in Salahiddin University is chosen as a case study to measure and record paper parameters with the help of a checklist. DOE evaluation of OS as a perceived performance is measured by the users for these OSs within a questionnaire. Results of this paper deduced the design criteria of the pattern and proportion of the physical objects forming the OS, that are capable to ensure anthropomorphic, healthy, sparing land consumption, and expedient outdoor environment for future campus developments.

Keywords : degree of enclosure, performance, configuration, permeability, consumption of land, environment.

1. Introduction

1.1 Nature of the problem

Optimum proportion of the outdoor space (OS) between buildings occupies a fundamental position to researchers, planners and architects. Lynch and Hack (Site Planning, 1984) describe the well-proportioned, simple and readable OS by "a powerful event". Beazley (Architectural Press, 1968) equalizes OSs importance with the interior of the buildings themselves if not more. Moughtin (Urban Design, 2003) recommends that OSs should be addressed to the environmental issues and the saving of scarce resources such as land, building materials, energy, etc. The distinctiveness of our local traditional towns, similar to many others, is as Dadson (The space between buildings, 1999) stated "the product of the juxtaposition of buildings to each other". It is the uniqueness of the OSs between buildings and their interaction, narrow in some places and widening out to form various public and private places. Since a human relationship with nature is inherent and biologically constructed, presence of OSs is crucial for him and for academic life (Ünlü et al., 2009; Fägerstam, 2012). A feeling of claustrophobia or agoraphobia that refers to the discomfort of "narrow" or "wide" spaces respectively is critical to determine the optimum proportion of OS. Strength of architecture and quality of OS is attributed to the configuration of physical objects defining an OS and to the coherence between them (Saxena and Sharma, 2013). Town context of Iraqi traditional architecture has experienced OSs proportion and revealed a comprehensive whole of both positive and negative OSs.

1.2 Importance of the subject

People live in outdoors as well as inside buildings; therefore the outdoor environment should be pleasant and comfortable (Saxena and Sharma, 2013). Main objectives of campus OS are to enhances the educational experience with outdoor informal learning, promotes the sharing of ideas, creative expressions and interaction across disciplines, supports and nurtures the physical and mental

health of students, faculty and staff, and to animates, invigorates and brings life to campus (UBC, 2009). OS defines a campus as much as buildings do. Cordiality of OSs is as important as buildings in shaping the image and livability of the campus. Objects and buildings should be placed so that they create usable and memorable OS rather than occupying space. The focus is less on architecture as stand-alone statements and more on the OS in between, giving form to the campus (Queen's University – Campus Plan). OS can leave a good impression upon the beholders, especially when it matches human proportion (Ferwati & Mandour, 2008; Wang, 2014), and when it is spatially contained by all physical objects rather than undefined open space or places between and around buildings (Hillier, 2002). The intrinsic importance of the subject is that OS can ensure an anthropomorphic arrangement satisfying the human sensation, control the internal environmental of surrounding buildings and the OS itself and minimizing consumption of scarce land area.

2. Statement of the problem

Although campus design history in developed countries has over 200 years, how to design campus OS is still relatively new concept to the design community (Cooper, 2000). "There is no doubt that there are OSs which feel 'right' or 'wrong' to us" as Dadson said (The space between buildings 1999). Recently many new designs of campus OS have been overlooked or treated as a leftover of buildings. It is noted in many project sites, if the OS does not comply with an efficient proportion, anthropomorphism quality of the OS and or its environment and the surrounding building indoor environment performance is reduced. When OS is too narrow; a pit sense and inefficient environment prerequisites are resulted. Adversely, when OS is too wide, there will be a missing of enclosure perception and waste of land. The majority of problems of OSs enclosure in many recent campuses are; wide or narrow enclosure, absence of clear configuration and definition, uncontrolled ambient local environment; cold in winter and or hot in summer.

3. Definition, configuration and classifying of the Outdoor Spaces

Main functions of the campus OSs are: firstly the social activities of students which include sittings, studying/reading, social assembly, eating and sport; secondly, the control of surrounding building internal environment by ensuring the prerequisites for appropriate internal performance of day lighting, ventilation, sun heating and view; and thirdly, transition of pedestrian and vehicles. The campus is the total environment composed of all "physical objects" with the combination of OSs between them. "Physical objects" In this paper, include building façades, plantation, shades, hill sides of topography, fences, retaining walls …etc. These objects and OSs, both act as an organized whole, and have a distinctive identity.

Three main types of OS configuration have been distinguished. Two sets of object opposite sides (parallel or rotated) form a linear extroverted OS with two directions sense, examples: pedestrian malls and streets; Figure 1-a, & pictures 1, 2 in Figure 2. Two or more sides of objects configured as a (U) shape form an extroverted OS with a single direction sense, example: plaza or green areas, Figure 1-b & pictures 3 in Figure 2. The three or more sides of objects forming introverted polygons (triangles, quadrilaterals…etc) are encompassing a field of space which is the strongest spatial definition; Figure 1- c & pictures 4 in Figure 2 if the configuration containing gaps, secondary zones within the OS will be created with a multi directional field (Ching, 2007).

4. Research objectives

Although much has been written about the degree of enclosure (DOE) of OSs, the variation of the former (DOE) had been attributed to a single variable: the proportion of the OS itself. This paper attempts to understand the forms of outdoor spatial-functional systems and monitor the parameters that affect their DOE in order to set an approach for the relationship between them (DOE and the parameters), and to determine the efficient proportion of campus OSs, which have not been addressed previously.

5. Previous researches and studies

Many researchers have studied the perception of OSs DOE, and attributed the latter to the proportion of the OS. It was extrapolated that the proportion (ratio of distance between buildings to its height) of (4:1) is the most suitable (Saxena and Sharma, 2013), and the ideal one (Buildings, n. d.) and agreed that with a proportion of (8:1), a loss of enclosure will be perceived (Saxena and Sharma, 2013). It is suggested that (4:1) proportion is the lower limit for creating a feeling of enclosure (Buildings, n. d.). Saxena & Sharma (2013) and a report (Buildings, n. d.) intuited that (6:1)

proportion is an intimate one. Manual of Miami-Dade (1999) recommended proportion of street width to wall height that can result a sense of enclosure and a positive human scale as follows: (1:1) as an ideal cross-section for pedestrian passages, (3:1) as an effective minimum for streets, and (6:1) as an absolute maximum. Differentials of the foregoing ratios may be due to various functional, environmental, social prerequisites and configurations of OS. These differentials justify additional local research.

6. Research variables

Although proportion plays an intrinsic role in the variation of (DOE) of OSs, this paper intended to investigate the effect of other independent variables in addition to proportion. They are; the configuration of enclosing objects, their facades permeability and the ambient environmental conditions of the OS. All these parameters are interrelated and interacted and work together to ensure a high quality whole; below, a brief description of each independent variable.

6.1 Proportion of the Outdoor Space

Spatial definition of the OS is a direct result of objects laid in the field of human vision and hence they are associated to human scale. The sense of spatial enclosure is related to the physiology of the human eye (Miami-Dade Manual, 1999). Within an OS, objects (much) below eye level are perceived as encompassing areas but not defining an enclosure (Ching, 2007, Lau et al., 2014). This is due to the fact that these objects fall below the horizon and occupy part of the field of ground. Objects occupying area within sky opening in the cone of vision will render a perceived sense of enclosure. Objects occupying more area of sky opening, more sense of enclosure will be perceived, (Figure 3).
Since the perception of OS enclosure is limited to parts of objects above eye level, a reference point for height measurement of OS in this paper is assumed as one meter above floor of the OS which represent the eye level height above ground of a sitting man. Distance between building's enclosing an OS measured at floor level is not always representing the effected sky opening. In this paper, distance (D) is taken between points of objects edge forming the opening to the sky when observed from a point in the middle of the OS. Hence, proportion of OS is measured by the ratio of the distance (D) between the foregoing objects edge to the height (H) between midpoint connecting these two edges and the observation point one meter above floor, as delineated in Figure 4.

6.2 Configuration of enclosing objects

This paper assumes that DOE of OS associates inversely with the percentage of opened sides around the OS. As an example, a courtyard OS configuration will be perceived as "narrower" than one-side open configuration of equal proportion.

6.3 Facades permeability of enclosing objects

Façades of an OS are permeable when vision of a beholder within the OS can penetrate through. Aligned dispersed plantation with wide gaps between, colonnades, raised floor buildings and roof shades compose permeable façades as shown in Figure 5. This paper assumes that DOE of OS associates inversely with the permeability percentage of surrounding façades. As an example, an OS surrounded by one or more permeable façade(s) will be perceived as "wider" compared to another one of equal proportion but of opaque façades. Plantations or colonnades can be perceived permeable when their objects (trees or columns) are so spread that not forming a complete barrier when overlooked from inside the OS. Appropriate spacing between these objects is relative to their volume and the vision angle of the beholder.

6.4 Ambient environment conditions of the Outdoor Space

Due to the high difference in temperatures of hot and cold seasons in Iraq, the sheltering from sun and the need to expose to, during the hot and cold seasons respectively is an effective parameter. This paper assumes that an OS completely shaded during winter will be perceived as "narrow", but perceived wider during summer if its floor is not shaded and exposed to a dominating sun. (Figure 6).

7. Methodology

Paper methodology for determining the optimum proportion for OSs for new developments can be summarized by establishing the mathematical relations between the proportion for OS and DOE through the following steps:

Firstly: evaluating the DOE of an existing set of OSs by a team of users.
Secondly: calculating the average value of DOE of evaluators for each OS.
Thirdly: Measuring physical dimensions of the same former set of OSs and calculating their proportion (D/H).
Fourthly: establishing the mathematical relations of the two variables (DOE, D/H) and plotting their curves for various cases of configurations.
Fifthly: extracting the optimum range of OS proportion that corresponds to the optimum range of DOE scale.
Explicating the methodology steps start with the investigation of OSs of a campus site of various proportion, configuration and quality by a panel of experts-users with the help of a checklist. Investigation includes observing, measuring and recording OSs characteristics connected to paper variables; DOE, physical proportion, configuration of enclosing objects, façade permeability, ambient environment, OS function, plantation capability, and privacy of surrounding buildings. All the parameters and their measurement are indicated in Table 1. DOE of OSs evaluation is devoted to the perception of the campus users. A scale of perception of the DOE of OSs has been developed, consisting of five ordinal ranks starting from "Extremely Wide" to "Wide", "Average", "Narrow" and "Extremely Narrow". A numerical value is given to each rank starting from (0.1) up to (0.9) with an increment value of (0.2) corresponding to the five values of the scale. Each intermittent rank will be extended by a value of (0.1) to both sides to transform it to a continuous scale starting from (0) to (1) with a range of (0.2) to each rank. (Zero) and (one) values represent the absolute of both, openness and enclosure respectively. The four steps of transforming the scale from ordinal to a continuous one are delineated in Figure 7. This transformation is adopted to ensure a meaning to the values of DOE between the original ranks resulted from the calculated weighted averages of the evaluation. Hence, the average value of (0.5) in the ordinal scale means the average of the optimum DOE and include all values of evaluation range between (0.4) and (0.6) as shown in Figure 7. The weighted average of DOE value of each of the (22) OSs to be calculated depending on the weighted values shown in Figure 7 to interpret qualitative values to quantitative ones.
The variation of DOE for the OSs as a dependent variable with the OS proportion as an independent variable will be plotted as curves for many cases to investigate the relation between and to find the local preferable proportion of OSs. The range of OS proportion that correspond to the optimum range of DOE scale (0.4 up to 0.6) are the anthropomorphic range and considered also optimum values, and will be extracted for many cases of variation. Values less than (0.4), or more than (0.6) refer to "wide" or "narrow" OS proportion respectively. Although value of (0.4) in the DOE scale is within the anthropomorphic part, it corresponds to a high proportion of OS and consequently results in more land consumption. While (0.5) and (0.6) of the scale refer to lower proportions and to relatively reduced land consumption. Hence the proportions of OS corresponding to (0.5) up to (0.6) in the DOE scale will be recommended and considered sustainable.

8. Site works

The site of the college of engineering has been selected for the study; a plan indicating all physical objects was prepared(see Appendix A). Twenty two OS positions of numerous proportion and configuration were chosen and numbered for evaluation. Because DOE is the sensation of OSs perceived by human being, evaluation was conducted by (47) students of the fourth year in the architecture department of the college of engineering in Salahiddin University on 15th April 2014. A second evaluation was recurred on 1st of June to investigate the effect of ambient environment variations on DOE. Evaluation was carried out by a questionnaire form, shown in Appendix B. In addition, all OS parameters are observed or measured and recorded with the help of a checklist during a walkthrough of the OSs by a panel of experts. Results are indicated in Appendix C.

9. Work, test, analysis and results

The variation of DOE to the proportion (D/H) of the (22) OSs is plotted as scattered points using Excel program. First degree linear and exponential correlations between the scattered points ware probed to find the most fitting relation. Correlation values of 0.76 up to 0.79 for the linear relation for many cases of variation were released compared to values of 0.89 up to 0.96 for the exponential correlation which shows relatively more reliable correlation. By adopting the exponential correlation, many cases of variation of DOE to OS proportion has been studied. Paper hypothesis concerning values of average height (H) of objects were tested to find the most compatible correlation in the variation of DOE to proportion, whether it is the measure

from floor or one meter above, as it is assumed in this paper. Although results show almost equal values of correlation of (0.9 and 0.89) with no preference, the paper adopted its suggested value due to the reasons explained in item (6.1) of this paper.

Generally, the curves show manifest results of OSs campus proportion in parity to previous works. OSs of (4:1) average proportion (spacing to building height) acquire an optimum perceived DOE, while OSs of (8:1) and (2:1) proportions are of "Wide" and "Narrow" DOE respectively. Proportions higher than (8:1) and lower than (2:1) are of "Extremely wide" and "Extremely narrow" DOE. The variation of DOE to OSs proportion as a general case which include all paper variables shows that the optimum range of DOE (minimum, average and maximum) are corresponding to OS proportion of (3:1), (4:1) and (5.5:1) respectively, (Figure 8). Optimum DOE for introverted OSs with or without one side open shows also a similar relation to the general case, (Figure 9). The reason of parity is that these OSs (the introverted) comprise the majority of OSs of the paper, (17) of (22). Optimum range of DOE of extroverted OSs (of 2 sides opened) shows descent proportion of (2.6:1), (3.6:1) and (5:1) as minimum, average and maximum respectively, (Figure 10); while optimum proportion of the case of one-side open OSs have ratios of (2.8:1), (4:1) and (5.6:1) respectively which is higher slightly than the extroverted cases as shown in Figure 11. All foregoing results evince the effect of configuration on the DOE of OSs which agree with the paper hypothesis.

Cases of introverted OSs with permeable side(s) as illustrated in (Figure 12) show parity of DOE variation with the introverted OSs of no permeable sides which is against the paper expectations. The paper relates that, to the closeness of plantation objects that lead to low permeability of these façades. They were manifested as an opaque wall and abolish the possibility of "see-through".

The paper probed the effect of the ambient environment conditions of OSs on DOE by evaluating the latter at two different dates; 15th of April and the 1st of June. A disparity in values of DOE between the two dates has been noticed which agree with the paper hypothesis. Results in Figure 13 show that OSs of proportion less than (2:1) is perceived as narrower during cold season than hot one, while OSs of proportion more than (2:1) show the reverse. The paper recommends carrying out evaluations at mid of both hot and cold seasons to study the variation more precisely.

Regarding the proportion for OSs required to control ambient and surrounding building internal environment, all the deduced proportions are accepted since they exceed the minimum environmental prerequisites of buildings of (2:1) proportion. Since land saving is a must for sustainable developments, mid ratios of the range of optimum proportions revealed in the results is adapted as the most efficient and recommended. A minimum ratio in the range of optimum proportions is also recommended due to its intensive land saving relative to the other alternatives. The highest ratios in the range of proportion is accepted but not recommended due to its relative intensive land consumption. Table 2 indicates all the foregoing cases.

10. Discussion

Although the curves show a manifest correlation between the paper variables range from (0.89) up to (0.96), it reveals some deviation from the perfect correlation that can be attributed to two reasons. The first is the imperfection that may reduce the precision of the measurement due to the limited ranks of the DOE ordinal scale. Nevertheless, the paper recommends the scale due to its simplicity and infallibility that can guarantee an exact perception of the evaluator and hence avoiding mistakes may occur in an extended scale. The other reason of deviation is that the cases of OSs of extreme proportion (Extremely wide and extremely narrow) are limited in number, in the site under study, compared to OSs of other ranks. These two deviations can be diminished in next work by increasing number of evaluators and number of OSs of various configurations.

11. Conclusion

The importance of this paper lies in its attempts to recognize the independent variables creating the physical characteristics of the OS; proportion, objects configuration and façade permeability. In addition, it investigates the effect of these attributes on the human sensation of enclosure, on the OS ambient environment and the internal environment of the surrounding buildings. The paper deduced the criteria to these physical attributes of the OS, capable to ensure anthropomorphic, healthy, sparing land consumption, vivid and expedient environment to the outdoor human activities.

Also, it manifests the unitary of physical objects with the OS entity as positive and negative substances composing a whole. Both, physical objects and the OS entity should be concurrently created during the design stage. This paper advantages, can be summarized by its manifesting of the OS proportion parameters and establishing the quantitative relations between which can lead to elaborated design in new developments.
Although this paper studied the OSs of a campus, it recommends extending similar researches to investigate the optimum proportion for various local urban OSs such as residential, commercial, and administrational sites. It is expected that local OSs proportion values may differ from previous works in other countries due to their specific social and environment characteristics.

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تقديرالتناسب الأمثل للفضاءات المفتوحة في مواقع المؤسسات الجامعية - كلية الهندسة في جامعة صلاح الدين حالة للدراسة

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المستخلص :
لوحظ أنَّ العديد من الفضاءات المفتوحة في مواقع المؤسسات الجامعية المحلية واسعةٌ لا تؤمّن درجة كافية من الإحتواء ، أو تكون ضيقة بحيث ينخفض أداءها . تفترض هذه الورقة إنَّ التناسب الأمثل لهذه الفضاءات المفتوحة يمكن أنْ يؤمّن أداءً كفؤاً لكل من الفضاء المفتوح والأبنية المحيطة به ، ويؤمّن أيضاً الحد الأدنى من استهلاك الأراضي والطاقة ومواد البناء.
تتغير درجة الإحتواء في البحوث السابقة تبعاً لتناسب الفضاء المفتوح حصراً ، بينما حدَّدَتْ هذه الورقة إضافة لذلك عوامل أخرى تتغير تبعاً لها درجة الإحتواء وهي : نمط ترتيب الأجسام المادية كالأبنية المحيطة بالفضاءات المفتوحة ، ونفاذية النظر للسطوح المحددة لهذه الفضاءات ، وبيئتها الدخلية . تهدف هذه الورقة الى إستخراج العلاقة بين درجة إحتواء الفضاء المفتوح ومتغيرات البحث لغرض تحديد التناسب الأمثل لهذه الفضاءات المفتوحه.
تمَّ اختيار موقع كلية الهندسة في جامعة صلاح الدين لقياس وتسجيل متغيرات البحث . تمَّ قياس درجة الإحتواء للفضاءات المفتوحة تبعاً لتقويم مستخدمي تلك الفضاءات وإدراكهم لأداءها وذلك عن طريق استخدام الإستبيان . إستُدِلَّ في نتائج الورقة عن معايير تصميمية لنِسَب الأجسام المادية التي تحدد الفضاءات المفتوحة وأنماطها التي يمكن بواسطتها تأمين مقاييس إنسانية و صحية وإقتصادية في إستهلاك الأرض وبيئة ملائمة للمشاريع الجامعية في المستقبل

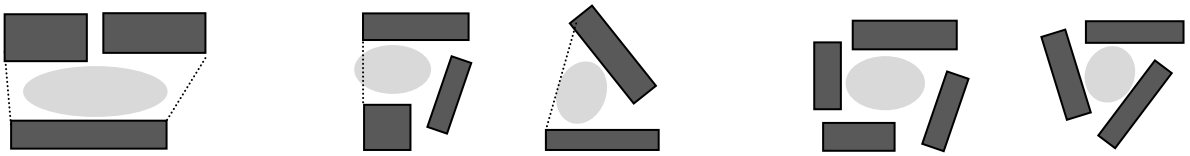
الكلمات المفتاحية : درجة الإحتواء ، الأداء ، الهيئه ، النفاذيه ، استهلاك الأراضي ، البيئه .

Table 1. Investigated parameters of OSs (Source: researchers)

Parameter	**Measurements**
Degree of Enclosure	**Extremely wide, wide, Average, narrow, Extremely narrow**
OS proportion (D/H)	D, H
Pattern of Enclosure	**Courtyard, one-side open, Two opposite sides open**
Permeability	**Number of permeable sides**
Ambient environment	**Sun during winter, Shade during summer.**
OS Function	**Student's activities, Pedestrian or vehicular access, Car parking, Green separating buildings, Service yards, Left area.**
OS plantation capability	**All seasons, Summer only**
Privacy of buildings	**Efficient, Low**

Table 2. Range of optimum proportion (D/H) of OSs of optimum (DOE), (Source: researchers).

Figure no.	Case of outdoor space	No. of points	Range of optimum proportion (D/H)		
			Minimum recommended	Average recommended	Maximum not recommended
8	**All**	**22**	**2.9**	**4**	**5.5**
9	**Introverted and one side open**	**17**	**3**	**4.2**	**5.7**
10	**Extroverted (two sides open)**	**6**	**2.6**	**3.6**	**5**
11	**Introverted of one side open**	**11**	**2.8**	**4.1**	**5.6**
12	**Introverted of permeable side(s)**	**6**	**3**	**4.3**	**6**

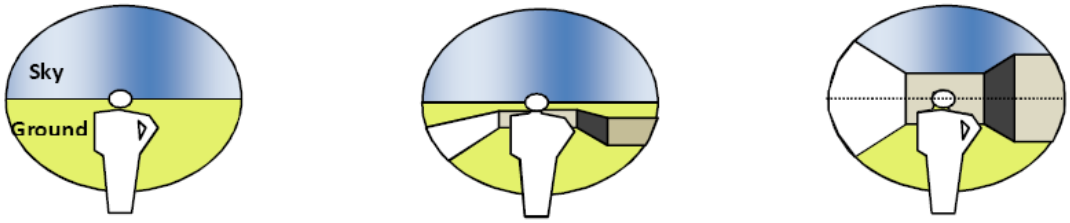


1. a : Two- sides **1. b :** One- side **1. c :** Courtyard: all-

Figure 1: Types of OS configuration, (Source: researchers).

1 2 3 4

Figure : 2 Pictures 1 & 4 (Yang, 2007); Pictures 2 and 3 (by the researchers).

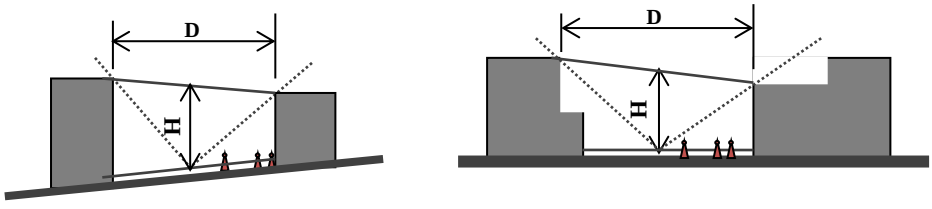


Two perceived fields; ground and sky.

No definition of enclosure for. objects below eye level.

A sense of enclosure for objects above eye level.

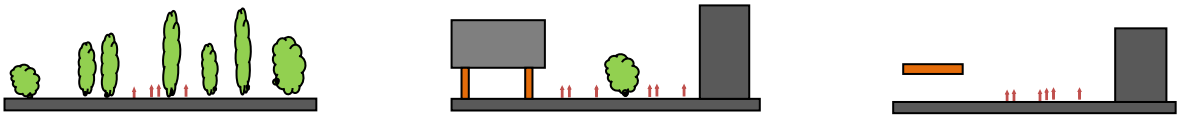
Figure 3 : Spatial definition of the OS in the field of human vision, (Source: researchers)



4-a) D = Distance between façades

4-b) D ≠ Distance between façades at ground

Figure 4 Definition of distance and height of OS, (Source: researchers).

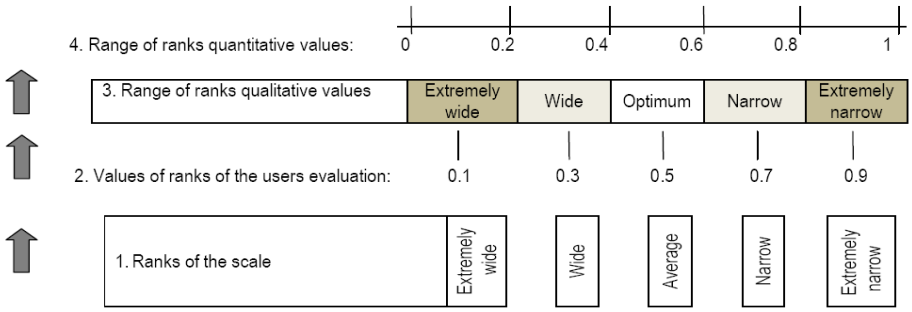


Plantation (front view). Raised floors (section view). Shades (section view).

Fig. 5: Permeable Surfaces, (Source: researchers).

6-a) Completely shaded OS during winter perceived "narrower". 6-b) Sunny OS during summer perceived "wider"

Figure 6 Effect of ambient environment conditions on DOE, (Source: researchers).



Caption of Appendix C : Site measurements of OSs dimensioning and the DOE of users evaluation.

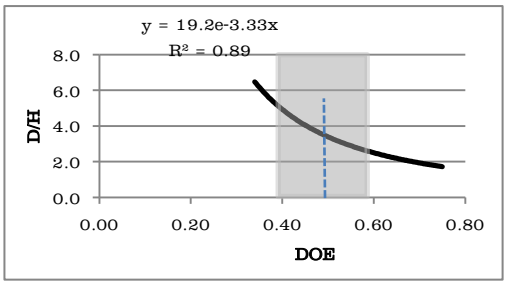


Figure 8 Variation of DOE and D/H of OSs of all cases.

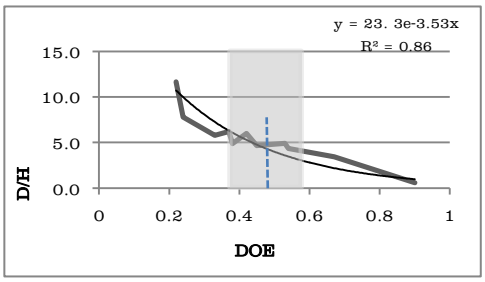


Figure 9 Variation of DOE to D/H of introverted and one side opened cases of OSs.

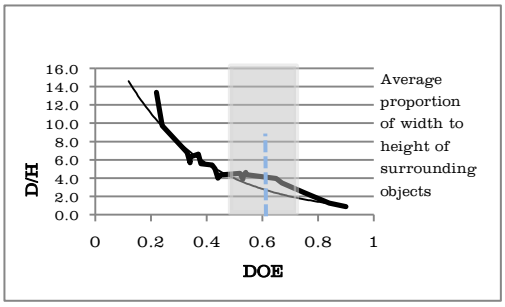


Figure 10 Variation of DOE to D/H for extroverted cases of OSs.

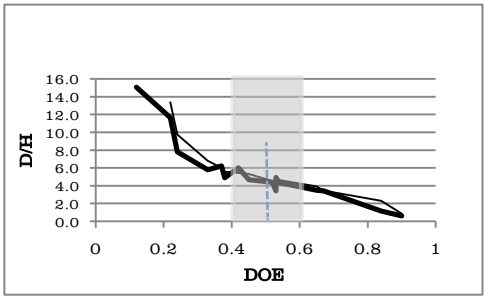


Figure 11 Variation of DOE to D/H for introverted OSs of one side open.

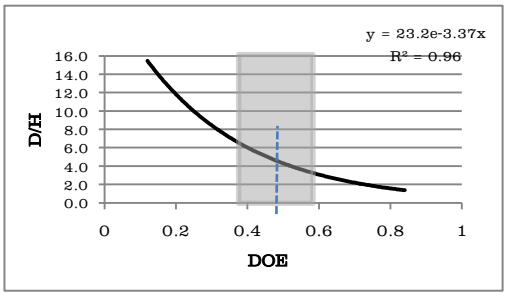


Figure 12 Variation of DOE to D/H of introverted permeable different OSs with side(s).

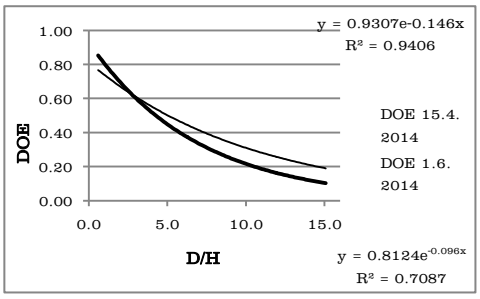
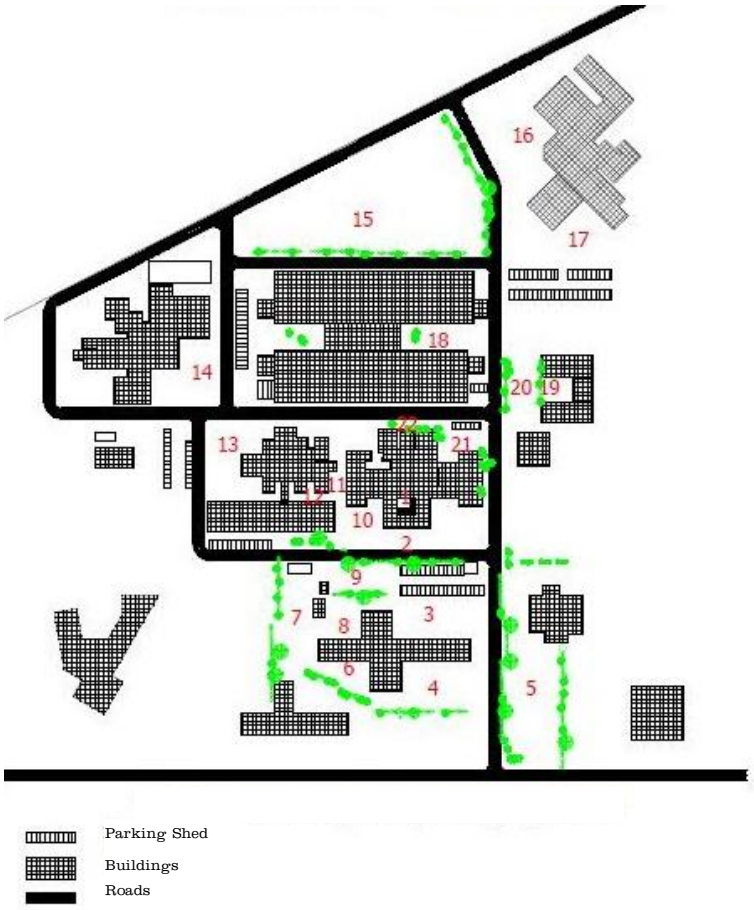
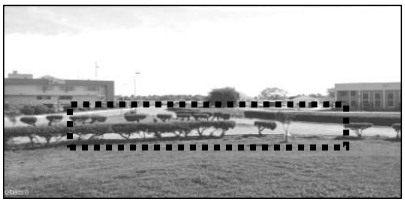


Figure 13 Variation of DOE to D/H of OSs at two different ambient environments.



Appendix A : Top view of the Engineering College of Salahiddin University indicating the investigated outdoor spaces by their number.

Appendix B: A sample of the questionnaire for evaluation the 'Degree of Enclosure of outdoor spaces" that carried out by the 4th year student of Architecture, 2013-2014.



Tick one of the five cells for each space

Degree of Enclosure	1. Extremely narrow	2. Narrow	3. Average	4 Wide	5. Extremely Wide
Outdoor Space No. 1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
Student name					

Appendix C: A record of the measured and observed parameters of the investigated outdoor spaces.

OS no.	DOE	Configuration	Number of permeable sides	OS Width (D) (m)	Average reference height (H). (m)	OS Function	D/H
15	0.12	introverted	2	98	6.5	Car parking	15.1
5	0.22	One side open	0	35	3	Garden and Student assembly	11.7
14	0.24	One side open	0	39	5	Outdoor terraces and Green belt	7.8
3	0.33	One side open	0	26	4.5	Green separating buildings	5.8
17	0.34	extroverted	0	28	5	Street and Green belt	5.6
16	0.34	extroverted	1	35	5	Street, walk path and Green belt	7.0
13	0.37	One side open	0	28	4.5	Green separating buildings	6.2
4	0.38	One side open	1	22	5	Green separating buildings and walk path	4.4
9	0.42	One side open	1	18	3	Garden	6.0
2	0.43	extroverted	1	22	5.5	Street and Student assembly	4.0
7	0.44	extroverted	1	22	5.5	Pedestrian path and Green	4.0
21	0.45	One side open	0	21	4.5	Green separating buildings	4.7
8	0.52	introverted	1	22	5	Green separating buildings	4.4
6	0.53	introverted	0	17	5	Green separating buildings and walk path	3.4
10	0.53	One side open	0	32	5.5	Green separating buildings and walk path	5.8
18	0.54	One side open	0	13	2	Pedestrian path and street access	6.5
20	0.54	extroverted	1	22	5	Student assembly	4.4
1	0.65	introverted	1	14	4	Pedestrian access	3.5
19	0.67	One side open	0	12	3.5	Green separating buildings and shade	3.4
11	0.75	extroverted	0	10	7	Left area	1.4
12	0.84	introverted	0	8	7	Left area	1.1
22	0.9	One side open	0	3	5	Left area	0.6

Notes
1. All OSs are sunny during winter except number: 1, 11, 12, 19, and 22. OSs number 1, 2, 5, 8, 9 and 18 ensure sun shading during summer.
2. All OSs are suitable for plantation during both seasons except number: 1, 12, and 22.
3. All OSs ensure privacy to the interior except number: 1, 11, 12, 19, and 22.