Microclimate Performance in Different Urban Fabric in Mosul City

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Abstract

City of Mosul has a traditional urban core called old city, side by side with a modern fabric adopted by municipal authority since the rapid urbanization which the city had witnessed in the fifties of the last century, the traditional one characterizes with a compact and organic tissue introverted courtyard buildings built with a heavy thick masonry structure, while the modern is open geometric one with wide streets and extraverted buildings build with concrete.

This research aim to make a comparative study for the urban micro climate performance (air temperature and relative humidity) in the two deferent urban fabrics (traditional and modern), during both the hottest and the coldest period of the year, using the meteorological data as a reference for evaluating the performance. The way cities are planned and built is therefore important for the global energy use and environmental comfort. So it's important to study the relationship between urban form and outdoor climate. The preliminary results confirm that the climatic conditions are much more stable in the traditional city than in the modern part of the city, regarding both air temperature and relative humidity.

Key words: ***Urban, Microclimate, Fabric.***

الأداء المناخي الموضعي لأنسجة حضرية مختلفة في مدينة الموصل

الدكتور تركي حسن علي الدكتور بهجت رشاد شاهين

الخلاصة

لمدينة الموصل نواة تقليدية حضرية تدعى المدينة القديمة، وتتواجد جنبا الى جنب مع النسيج الحديث الذي اعتمدته السلطات البلدية منذ التحضر السريع الذي شهدته المدينة في خمسينات القرن الماضي، يتميز جزؤها التقليدي بنسيج عضوي متضام وبمباني متوجه نحو فناء ات داخلية مع بني انشائية سميكة وثقيلة، في حين يتميز جزؤها الحديث بنسيج هندسي مفتوح أي بشوارع عريضة وواسعة ومباني متجه نحو الخارج وببنى اشائية خرسانية. هذا البحث يهدف إلى إجراء دراسة مقارنة لأداء المناخ الموضعي في المناطق الحضرية (درجة حرارة الهواء والرطوبة النسبية) في اثنين من الانسجة الحضرية (التقليدية والحديثة)، وخلال فترتي الحر والبرد الشديدين من السنة، وباستخدام بيانات الأرصاد الجوية كمرجع لتقييم الأداء. ان طريقة تخطيط المدن وبنائها لهما دور مهم في الراحة الحرارية لساكني هذه المدن فضلا عن مجمل استخدام الطاقة. لذلك من المهم دراسة العلاقة بين الشكل الحضري والمناخ الموضعي للفضاءات الحضرية المفتوحة. النتائج الأولية تؤكد أن المؤشرات المناخية في المدينة التقليدية كانت افضل وأكثر استقرارا مما كان عليه في الجزء الحديث من المدينة، وعلى حد سواء فيما يتعلق بدرجة حرارة الهواء أوالرطوبة النسبية.

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1-Introduction

It is well known that the built environment modifies the climate. It has found that the geometry of buildings and properties of building materials have a strong influence on the urban climate. Parameters such as building density, height to width ratio of street canyon thermal admittance and color have a direct influence on the climate around buildings. This climate affects the comfort of humans at street level. It also influences the thermal stress on buildings and thus affects indoor comfort as well as energy use for heating and cooling [1].

It is possible to create a good urban climate through conscious urban planning and design. However, in most cases the climate is not sufficiently considered in the planning and design processes and as a consequence, many urban areas are uncomfortable. Whereas comfort and energy use on single buildings have been studied extensively, outdoor comfort and energy use in urban areas have had little attention [2].

City of Mosul has a traditional urban core called old city, side by side with a modern fabric adopted by municipal authority since the rapid urbanization which the city had witnessed in the fifties of the last century, the traditional one characterizes with a compact and organic tissue, introverted courtyard buildings built with a heavy thick masonry structure, while the modern is open geometric one with a wide streets and extraverted buildings build with concrete. City of Mosul has a hot dry climate summer and cool rainy winter, this research aims to make a comparative study for the urban micro climate performance (air temperature and relative humidity) in the two deferent urban fabrics (traditional and modern), during both the hottest and the coldest period of the year, using the meteorological data as a reference for evaluating the performance.

2-Background

Mosul urban fabric consists of two contrasting parts: the traditional Arabic-Islamic, organic urban pattern, called the old city, and the modern city with its gridiron urban pattern. One housing district in each part of the city was studied.

The first of them is Al-Makkaoui neighborhood in the old city, which is one of the most densely developed areas. Introverted courtyard buildings in two to three stories surround the narrow streets, which cut deep ravines through the city. The street network is irregular, which means that the buildings shade each other, there is a great variation of traditional building elements and a large number of building details provide shade at street level.

The second is Al-Malia neighborhood, located at the new part of the city, planned and built as a suburb with extroverted detached and semi detached two story single housing. The area has a regular pattern wide street planned for car ownership. This low density means both buildings and urban spaces are exposed to a great amount of solar radiation. Only a few trees provide shade for some facades and footways.

2-1-Research Problem

Different urban microclimates result in different urban shapes. This study seeks to define relevant parameters in traditional and modern housing areas, so it aim to make a comparative study for the urban micro climate performance (air temperature and relative humidity) in the two deferent urban fabrics (traditional and modern), during both the hottest and the coldest period of the year, using the meteorological data as a reference for evaluating the performance. The way cities are planned and built is therefore important for the global energy use and environmental comfort. Therefore, it is important to study the relationship between urban form and outdoor climate, in order to find combinations of qualities from both environments, to be used as a guideline for future housing development in Iraq, which would lead to increased comfort and lower energy use in urban areas.

3-Methodology

Measuring Points: In each neighborhood, several measuring points were studied. Measurements were made in two different street orientations, fig (1). In Almakkaoui the height to width (H/W) ratio of the street canyons varied between 4.25 and 3.64, whereas in Almalia the (H/L) ratios were 0.17-0.2. While the sky view factor (SVF) in Almakkaoui was between 0.056-0.061, whereas in Almalia the (SVF) was between 0.74-0.8.

For each measuring point, air temperature and relative humidity were measured in the middle of the street canyon, (1) m above street level. The instrument was protected from sunlight during the measurements. The measurements took place each hour per day from the sun rise to sun set, in summer (from 20th of July to 5th of August 2006) and winter (from the 20th of January to 5th of February in 2007). The measurements were made in one district at a time: seven days in one district followed by seven days in the other district.

All measurements were made with the testo-179-H2 instrument. The accuracy of the air temperature is ±0.5°C and 3% for the relative humidity

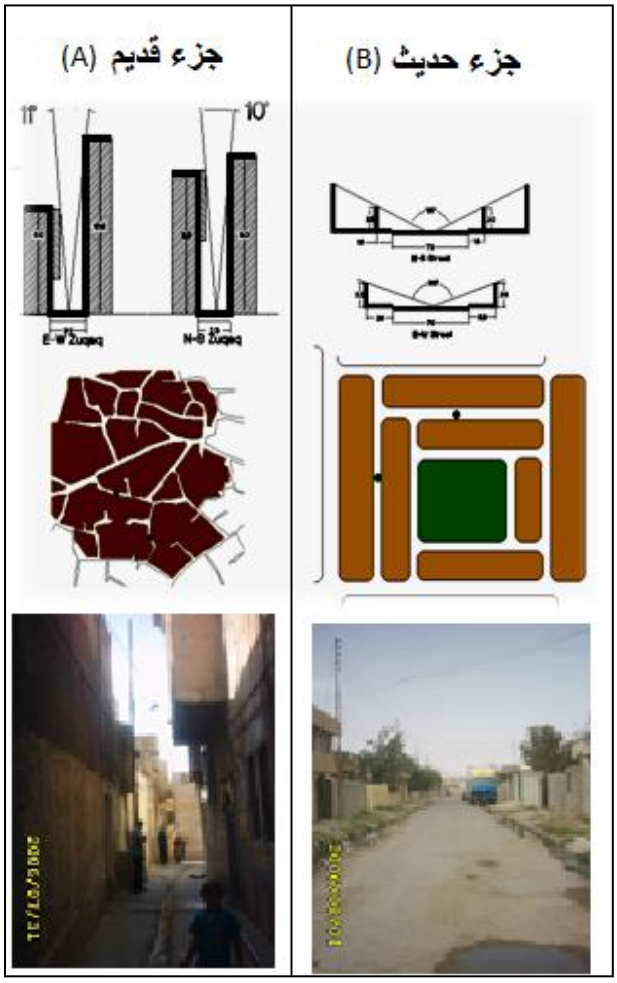

Figure 1. Measuring points in the traditional and modern urban fabric in Mosul city

4-RESULTS

The measurements can be divided in two category; air temperature and relative humidity.

4-1-Air Temperatures

(1) - Summer: The air temperatures measured in the Almakkaoui district (in the old city) varied very slightly and steady in different hours of the day, with a Standard deviation 2.08-2.74 less than that one at Meteorological station 6.67. The minimum temperatures were 3.1-2.8°C higher than the "Meteorological station" for all measurement points all the days of measuring. The maximum temperatures were 8.9-8.3°C lower than the Meteorological station ones. The daily mean of air temperature was 4.9-4.5°C lower than the Meteorological station ones. No significant difference could be observed between streets of different orientation.

.The air temperatures measured in the district Almalia varied roughly during the hours of the day with a standard deviation 6.62 which is almost the same one at the Meteorological station 6.69-6.83. The minimum temperatures were 0.4-0.5°C higher than the ones measured at the Meteorological station. The maximum air temperatures were 2.3-2.6°C higher than the Meteorological station. The daily mean of air temperature was 1.59-1.63°C higher than the Meteorological station ones. As in Almakkaoui, no significant difference could be observed between streets of different orientation. Fig (2), Table (1).

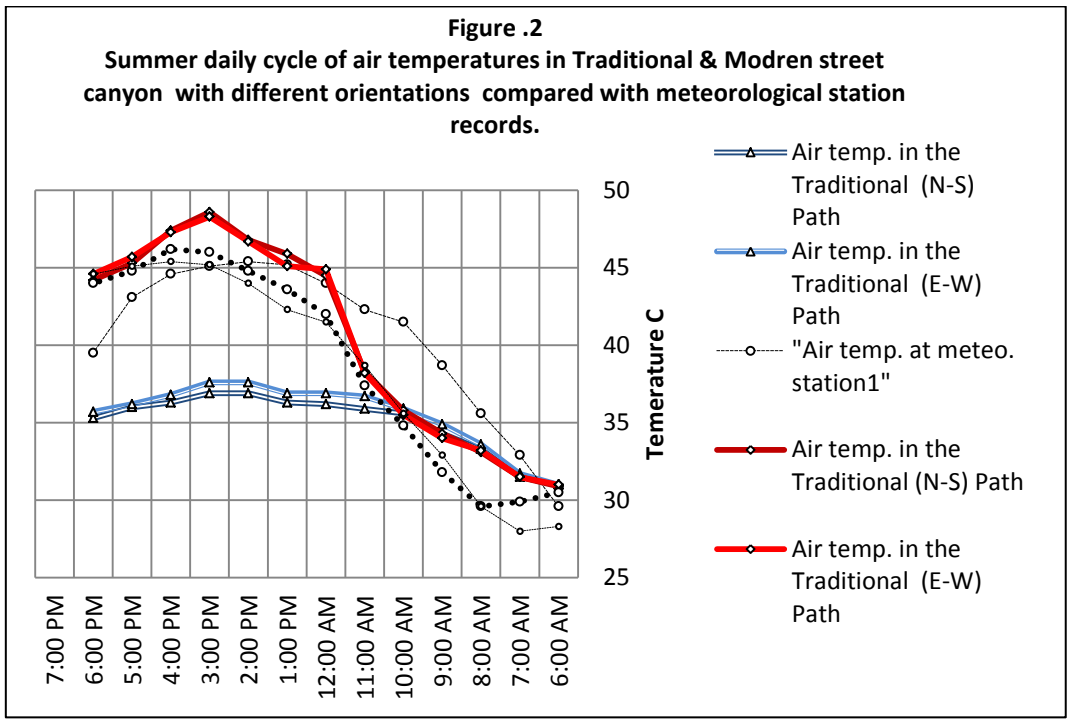

Table 1.Statistical analysis results of summer daily cycle of air temperatures

	Mean	Daily variance	Standard deviation
Air temp. in the Traditional(N-S)Path	34.8	5.6	2.08
Air temp. in the Traditional(E-W)Path	35.2	7.4	2.74
Air temp. at meteo. station	39.7	17.4	6.67
Air temp. in the Modern (N-S)Path	34.8	5.6	2.08
Air temp. at meteo. Station1	38.87	16.7	6.69
Air temp. in the Modern (E-W)Path	35.2	7.4	2.74
Air temp. at meteo. Station2	39.7	17.4	6.83

(2) - winter: The air temperatures measured in the Almakkaoui district (in the old city) varied slightly and steadily between different hours of the day, with a very small Standard deviation 1.74 less than that one at Meteorological station 4.18. The minimum temperatures were 4.93-4.6°C higher than that recorded at the "Meteorological station" 1.5°C. The maximum temperatures were 10.23°C slightly lower than the Meteorological station ones. But the daily mean of air temperatures were 8.68-8.83°C higher than the Meteorological station ones by 1.83-1.98°C. No significant difference could be observed between streets of different orientation.

In winter, the air temperatures measured in Almalia district varied slightly during the hours of the day with a standard deviation 2.17-2.57 but higher than that one at the Meteorological station 1.5. The minimum temperatures were 0.67- 1.07°C higher than the ones measured at the Meteorological station. The maximum air temperatures were 1.2-1.7°C higher than the Meteorological station. The daily mean of air temperature was 0.67-1.07°C higher than the Meteorological station ones. No significant difference could be observed between streets of different orientation for both types of districts. Fig (3), Table (2).

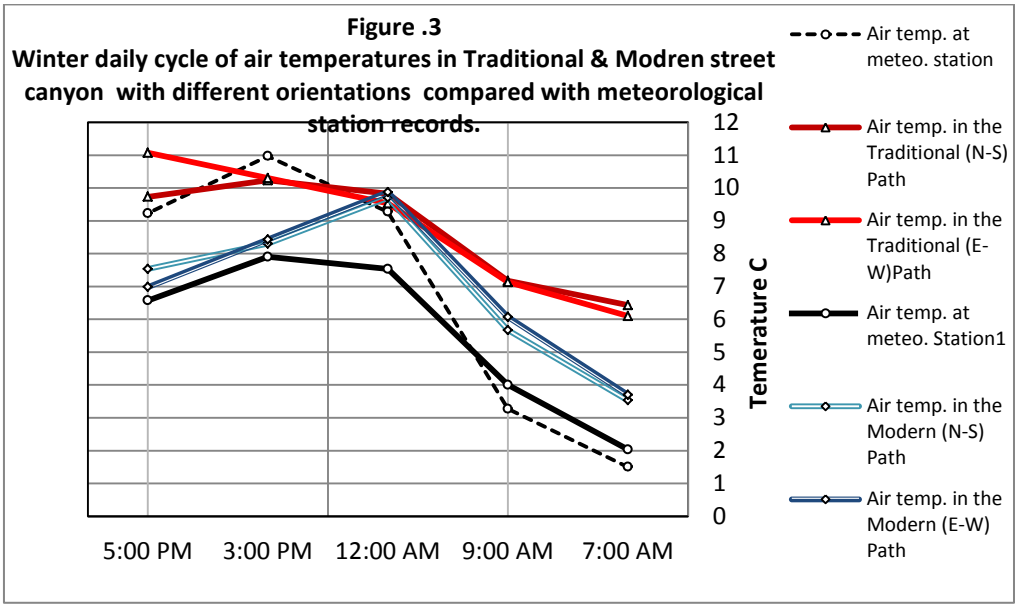

Table 2.Statistical analysis results of winter daily cycle of air temperatures

	Mean	Daily variance	Standard deviation
Air temp. in the Traditional(N-S)Path	8.68	3.8	1.74
Air temp. in the Traditional(E-W)Path	35.2	3.8	1.74
Air temp. at meteo. station	6.85	9.47	4.18
Air temp. in the Modern (N-S)Path	7.53	2.45	2.17
Air temp. in the Modern (E-W)Path	7.3	2.43	2.57
Air temp. at meteo. Station1	7.9	2.51	1.50

4-2-Relative Humidity

(1) - Summer: Almakkaoui district has a higher and more stable relative humidity (Standard deviation 7) than Almalia (Standard deviation 11), the daily means of the RH at Almakkaoui were 35%-31% whereas at Almalia was 24% for both deferent orientation streets, and the traditional district had recorded a higher mean RH than the Meteorological station by 7% in contrast to the modern district which recorded lower than the Meteorological station by 2%. There was a small difference could be observed between streets of different orientation for the traditional district only. Fig (4), Table (3).

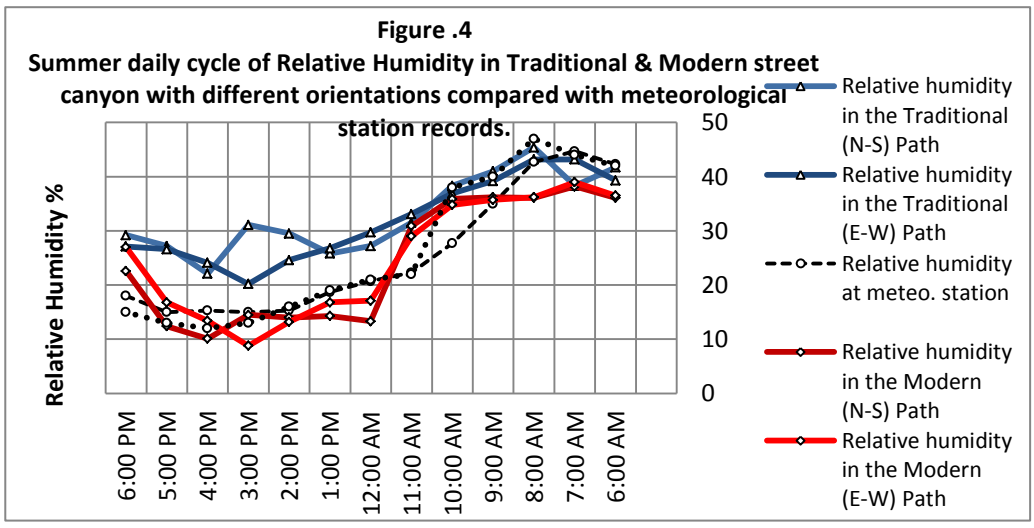

Table 3.Statistical analysis results of summer daily cycle of Relative Humidity

	Mean	Daily variance	Standard deviation
Relative Humidity in the Traditional (N-S) Path	35.2	53.2	7.3
Relative Humidity in the Traditional (E-W) Path	31.37	58.75	7.66
Relative Humidity at meteo. station	39.7	129.8	11.4
Relative Humidity in the Modern (N-S) Path	24.2	130.047	11.404
Relative Humidity in the Modern(E-W) Path	24.53	127.414	11.288
Relative Humidity at meteo. Station1	26.30769	183.73	13.555

(2) winter: In comparison with the Meteorological station the traditional district (Almakkaoui) relatively has a higher and more stable RH (Standard deviation 4.4-4.9) than Almalia (Standard deviation 9), the daily means of the RH at Almakkaoui were 58%-57% lower than the Meteorological station by 7%, whereas at Almalia was 65% lower than the Meteorological station by 8-9%. No significant difference could be observed between streets of different orientation for both types of districts. Fig (5), Table (4).

Figure .5
Winter daily cycle of Relative Humidity in Traditional & Modern street canyon with different orientations compared with meteorological station records.

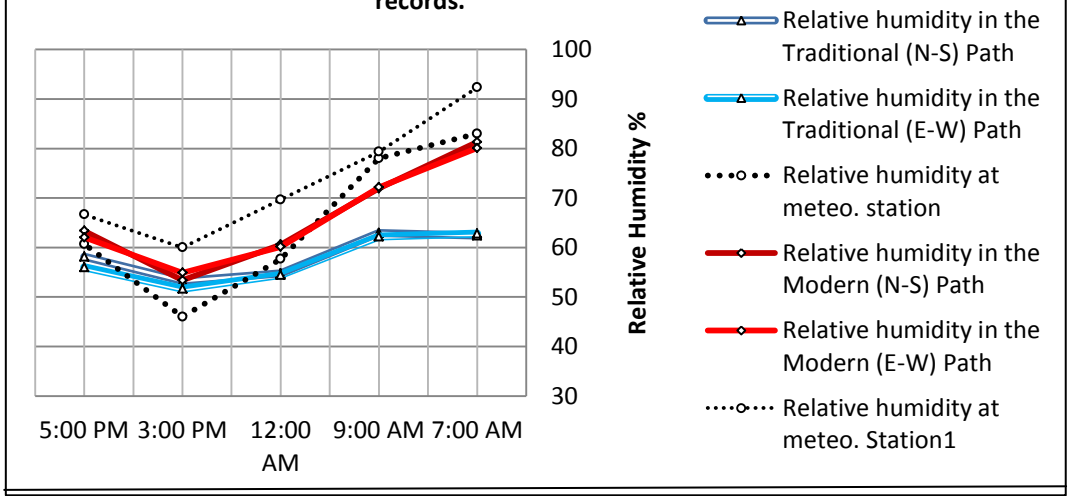

Table 4.Statistical analysis results of winter daily cycle of Relative Humidity

	Mean	Daily variance	Standard deviation
Relative Humidity in the Traditional (N-S) Path	58.31	19.19263	4.3809394
Relative Humidity in the Traditional (E-W) Path	57.43	23.72697	4.87103377
Relative Humidity at meteo. station	65.07	231.61	15.219
Relative Humidity in the Modern (N-S) Path	65.41	86.34239697	9.292060965
Relative Humidity in the Modern (E-W) Path	64.40	79.39999015	8.910667211
Relative Humidity at meteo. Station1	65.41	86.34239697	10.14243725

5-Conclusion

1) As measurements did not take place at the same time in both neighborhoods, the results by no means give a complete picture of the climate. However, the measurements indicate great differences in climate between the extremely dense old city and the very open urban tissue of the modern one. These differences are believed to be a combination of several factors, all of which are related to the urban fabric geometry. These factors include solar access; Outgoing long wave radiation; Thermal storage; Wind shelter.
2) In the modern district the heat island phenomenon is clear with higher temperatures than reported from the Meteorological station outside the city.
3) During daytime, however, the two neighborhoods show totally different behavior. In the densest part, of the old city the air temperature is normally lower than the Meteorological station temperature whereas it is higher in modern district. One explanation to this is that the sun does not penetrate down into the narrow street canyons; and most of the sunshine is reflected by the light colored roofs. Furthermore the dense and heavy structure of the city reacts very slowly to temperature differences.
4) In general, the climatic conditions are much more stable in the old city than in modern part of the city regarding both air temperature and relative humidity, which is play an important role in the physical comfort of the pedestrians. The stable climate in the traditional canyon is partly attributed to the large mass of the traditional area. The ratio between the total surface of walls and street and the air volume in the canyon is considerably higher in the old city. Hence, a large part of the increased air temperature during daytime will be absorbed by the canyon surfaces and not released until the night, which reduces diurnal swings due to its high thermal inertia, the old city withstands sudden climatic changes better than modern area.
5) To get less solar access, it may be preferred to use a high H/W ratios (and lower SVF), which leads to lower daytime air temperatures and more shade at street level. Through the using of a narrow street networks, and allowing people (designers) to build until the front edge of their plots instead of the frontal garden, and having a cantilever over streets space. Fig. (6). This can be achieved if we modify the traditional Arabic house.
6) Using the traditional building materials (stone), which have greater heat capacity than the modern ones (sold concrete blocks).
7) To get wind shelter, it may be preferred to avoid using straight line streets, and using other configurations, like T, L, U, zigzag shapes for the local street type, and cul-de-sac for the minor local street type.

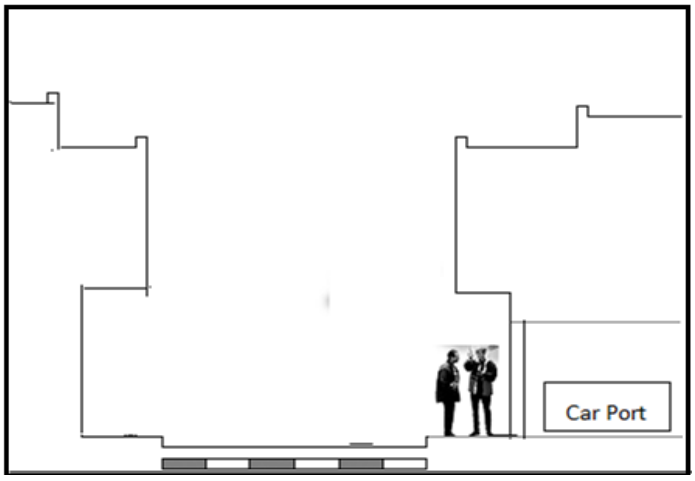

Figure (6): Proposed street section

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