Pedestrian Paths as an Indicator of Legibility Aspects of Omani Traditional Settlements

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Abstract. The interest for studying the Omani built heritage is not recent. However, the published research about the subject since the early 1970s, is limited in number and sporadic in topics and territories investigated. Moreover, there was no or little interest in examining this built heritage from the point of view of its urban design typologies. This paper is examining the urban form of these settlements and linking it with legibility aspects. Legibility and its influence on users of urban spaces have been significant for many theorists in urban studies. In their point of view, behaviour patterns of pedestrians are strongly influenced by legibility perception of the spatial patterns in urban spaces. The current research aims at studying the legibility aspects of traditional Omani residential settlements in an objective evaluation represented by numerical approach. Through a descriptive and analytical method, the results will link the influence of urban forms with legibility and behaviour patterns of pedestrians, which are deeply affected by the perception of body and mind. The paper explored paths’ forms influence on legibility perception of pedestrian in some of traditional settlements in Oman that have a strong urban identification. Five case studies representing traditional Omani settlements were chosen and analysed with an innovative quantitative approach capable of discovering, evaluating deficiencies, and suggesting solutions to develop local concepts for paths in any urban settlements. The findings disclose that the contest to adopt international approaches to solve local urban spaces has created pointless, despicable, and unused spaces, while adopting local patterns, features and solutions will enhance the legible image of local urban settlements.

1. Introduction

The impact of worldwide theories, unwise imitation of western urbanization and the domination of imported patterns on traditional and indigenous forms can be among the reasons for the loss of local identity and the collapse of spatial legibility in our cities. The paper argues that Omani traditional urban settlements have fulfilled the needs of their residence for an inclusive, legible and liveable built environment. Subsequently, introducing proactive guidelines for improving legibility aspects in contemporary urban communities based on values of Omani traditional urban settlements forms would enhance the cognitive map for their residents.

According to Lynch [1] paths are one of the most significant physical elements in any urban settlement, as they can be considered the lines that connect different places in any urban form. These forms used to have high qualities for pedestrians in the past, whilst today’s modern societies, due to pragmatism and materialistic inclinations, doesn’t pay much attention to pedestrians’ demands and instead, they focused on cars routes and automotive plans [2]. Legibility and its effect on urban spaces...
have been noteworthy for many theorists in urban studies in a way that from their view, behaviour patterns of pedestrians are severely affected by legibility perception of the body and their environment activity. One of these theorists is Kevin Lynch who by introducing the concept of the “Image of the City”, he identified the structural elements that define this “Image” and its legibility: nodes, edges, landmarks, paths, and districts [1]. On the other hand, in his book about responsive areas, and based on Lynch’s elements, E. Bentley [3] introduced guidelines to achieve legibility in urban spaces, including paths, as the main element. In “Citizen-oriented Urbanization”, Francis Tibbalds [4] believes that urban areas should have legibility feature and be easily comprehensible [5], [6]. He suggested that city landmarks along with paths can play an important role in this matter.

In the same perspective, Cullen referred to “serial vision” to draw attention to the importance of the image established while moving. In his book, “The Concise Townscape”, he stated that an entire image of a city or urban pattern is shaped by series of correlated spaces [8]. According to Cullen, mobile from one point to another in a path or a street affords “serial drawings” that could subsequently form a city shape. The buildings are the sole features in the city form. They can be evaluated as architectural components. However, they create volumes and they are perceived as “walls” of paths and spaces when they form groups.

Movement in urban context and its relationship with legibility aspects was a focal point for Cullen. According to him, “a city and its elements are perceived from the street level” [8] Likewise, Jane Jacobs considered the cities from the streets level. However, unlike Cullen and Lynch, she focused on the vitality and security issues in urban streets, besides the imaginary aspects of cities. For Jacobs, the image of the city can be summarized in its streets [9].

2. The problem

Vague, impersonal and pointless urban spaces, resulting from mistaken paths design, are among the main defects that plague most of contemporary Middle Eastern cities. The present paper argues that legibility as an approach for paths design can help in creating a strong but simple pattern within a city and its neighborhoods. Such designs will enable residents and visitors to comprehend how an area is organized and how to make their way around it. This will allow them to construct correct personal cognitive maps which consolidates their perception of the sense of place [10]. It is also argued that, in this matter, there is a lot to learn from the traditional settlements and the physical patterns of their paths, nodes, open spaces, etc. To further explore these claims and provide important data needed for the development of adequate neighborhoods design guidelines, the present research built upon the works of Lynch works [1], [4], [11]–[13], and identified six indicators that represent the ability of paths in creating a legible and cognitive map of any urban settlement. These indicators were applied in the study of the main paths in five traditional Omani settlements (ar. Harat, sing. Hara): Misfat al-Abriyin, Harat al-Khabt, Harat Qasra, Harat Saija, Hujrat Msalam and Harat As-Saybani. These settlements were selected based on their heritage values as specified in the reports produced by the Ministry of Heritage and Tourism, that is: state of conservation, strong urban identity, social values, clarity of character and consistency of formation that shape the settlements through time [7], [14]–[20].

3. Aim and objectives

The aim of identifying all the characteristics of legible urban spaces of the traditional Omani settlements and their structural form/pattern is a huge aim that cannot be presented fully in this paper due to the publishing constraints. As such, the study chose one of the elements of urban form that has a significant effect on the legibility of any of urban settlements; that is “paths”. The study main aim is to proof that “local urban places need local urban laws”. The research objectives can be briefed into the next three points:

1. To analyze the design and formation of paths in five different traditional Omani settlements to identify the typology of pattern.
2. To quantitatively, evaluate the characteristics of those paths against well-known standards set by professional experts in the field of urban design and cities’ planning [1], [11], [21], [22].
3. **Compare the findings with the international norms to find out:**
   a. If the international norms match the local ones.
   b. If the local urban context should uniquely be treated based on its social, economic, and environmental aspects.

4. **Paper contribution**
   The paper has framed the research problems, paper contribution and the process used to tackle the challenges in three main perspectives as illustrated in Figure 1.

![Figure 1: Research Problems and paper contribution](image)

5. **Methodology**
   With a focus on paths as one of the five elements of *Kevin Lynch* in defining the image of the city, the study approaches the urban composition of traditional Omani settlements through four main phases of analysis: **a)** physical and cognitive data collection, through site visits, surveying, interviews, Analyzing maps, satellite images, and personal notes, **b)** characterization analyses through illustration methodology following the procedures of [21], [23], as well as the methodology of *John Peponis* [14], [24]. **c)** Numerical analysis to characterize the patterns. **d)** Finally, comparing the characterized patterns typology with international standards to identify local norms that are relevant to Omani social, cultural and environmental contexts. This methodology was implemented in the studied settlements following four main phases Figure 2:

![Figure 2: Methodology diagram and sequences](image)
In the first phase, the paper specifies the spatial composition of urban design elements based on the unique background of Oman traditional settlements with respect to literature of Lynch, Montgomery, Kelly et al and Tylor [1], [10]. Subsequently, the features of each element were analyzed, by using the collected data on the composition with a focus on paths. As urban design measures cannot be obtained, or computed, from secondary sources, but must be collected through field observation or interviews [10], the study used an extensive on-site data collection through architectural documentation direct observations, semi-structured interviews, and previous research initiated by the first author and a team of experts and students of Sultan Qaboos University between the years 2015 to 2017 [16]–[19].

In the second phase, the paper reviewed multidisciplinary perspectives on urban form to select the appropriate approach to tackle the research problem. The review assessment focused on issues of measurement and quantitative analysis. In their study, Song and Knaap [25] proved that urban amendment can be measured and showed how those measurements can help in analyzing the urban transformation over time. They focused on three sets of measurements: a) street network design, b) land-use intensity, and c) land-use pattern. By focusing on disparity in physical form, character, and space (nodes) analysis along the paths of the selected case studies, Song and Knaap followed the work of John Peponis [6], [14]. His studies examined the composition, formation, measurements and analysis of urban forms through a numerical quantitative approach that could be applied in the present research’s investigation about paths within urban settlements. Building on an extensive literature review, the study outlines six indicators to be assessed. Those indicators were tested efficient in many researches to be the main indicators to describe the features of any path [11]–[14], [21], [23]. Those indicators are: a) Accessibility b) Direct Visibility c) Path Elongation d) Path Widening e) turns and f) Path Length.

In the third phase, the study builds upon the two previous ones to make the calculation and equations set by previous studies as mentioned above. Measures of urban design both objectively and subjectively were collected by members of our research team, through field-work and residents’ interviews. Objective assessment included various details of the built and natural environment thought to be associated with legibility. For example, common measures include the path’s width; elongation; heights and setbacks of buildings; the intersections; nodes along the main path; number of turns; etc. The semi-structured interviews were performed by using a snowball method to assess the residents’ satisfaction with their urban context. It included questions about legibility, safety, coherence, pedestrian friendliness, or attractiveness.

Finally, in the fourth phase, the study followed a comparative analysis in four main steps:
- Applying the approved equations that describes the features of the main path characteristics in every case study.
- Applying accumulative aggregation process capable of concluding a pattern inferred from all paths’ measures in all case studies.
- Define the pattern/common form (based on the previous aggregating process) that shapes the traditional Omani settlements on paths’ layouts level.
- Compare the pattern results with the international standards to conclude the research objectives.

6. Building legibility paths quantitative framework
This method connects the target paths according to their similarity and measurements, and groups them based on the indicators that describe paths’ characteristics. As a result, through the comparison of main paths in all case studies we could find out similar features, and their attributes. The spatial composition features of each path are represented by using a diagrammatic scheme. In the six case studies, paths’ widths and lengths were measured and their rankings (main, secondary, and marginal) were defined. Main features such as heights, nodes, special buildings, and landmarks were also recorded. Moreover, common measures included the path’s elongation, heights and setbacks of buildings, intersections, nodes along the main path, number of turns, etc. were verified graphically and mathematically. Additionally,
subjective assessment was also used to find out the legibility level and residents’ satisfaction in their urban context, based on their feedback about the questions of legibility aspects, safety, coherence, pedestrian friendliness, or attractiveness.

| Haret Al Khabt | Al-Hosn | Haret Qasra |
|----------------|--------|-------------|
| ![Haret Al Khabt](image1) | ![Al-Hosn](image2) | ![Haret Qasra](image3) |

| Haret Al-Msalamat | Hārat As-Saybanī | Haret Saja |
|-------------------|------------------|-----------|
| ![Haret Al-Msalamat](image4) | ![Hārat As-Saybanī](image5) | ![Haret Saja](image6) |

**Figure 3.** Paths recognition forming the settlements of the six selected case studies (source: authors and [7], [26])

7. Formulas
By reviewing a variety of quantitative models that have the ability to describe the urban context in an objective way, the model of cognitive frame building created by John Peponis [24] was the most appropriate for the study under discussion in this paper. It is focused on assessing urban spaces according to their perception. However, due to the complexity of Peponis’ model which takes into account two kinds of perceived urban environment; moving and static sceneries. It has been proven accurate, based on its quantitative indicators, additionally it is largely modified to assess urban environment, and to some extent, it covers our research main focus -paths- with some of its indicators. Please refer to appendix I for indicators description and formulas. According to Peponis, the four indicators of the cognitive frame model are:

- **Direct Visibility (DV):** It is written in the formula: \( DV(x) = (\Sigma n + 1) m^2 \), where \((\Sigma n)\) is the sum of all nodes visible from the node \((x)\), to which you can move in a straight way. The indicator essentially indicates the visible and directly reachable area.

- **Path Elongation (PE):** It is written in the formula \( PE(x) = \Sigma (l - l_o)/l_o \), where \((l)\) is the real the shortest path in several meters between \((x)\) and \((y)\), and \((l_o)\) is the straight path between \((x)\) and \((y)\), if path is not blocked. The indicator reveals the straightness of the path and its regularity form level based on the number and position of blocking buildings along it, which could turn the path from standard type to labyrinth type.
- **Turns (T)**: The average number of turns is calculated according to the formula $MT(x) = \Sigma t / (n - 1)$, where $(\Sigma t)$ is the sum of the turns moving from $(x)$ to all remaining vertices, $n$ the number of vertices. The indicator is slightly comparable with path elongation one, but in fact it concludes it and helps to comprehend more specifically person’s perception of distance. The point is that, corresponding to urban spatial composition, a person can sense the distance both in length units and turns [21]. The ability to consider both of them in one model is an advantage.

- **Path Length (PL)**: between the turns is calculated by the formula $PL(x) = \Sigma l / MT$, where $(\Sigma l)$ is the average length of straight sections passing through $(x)$, $(MT)$ is the average number of turns. Basically, the indicator reveals which mid-length axes crosses the network points. For example, the indicator will be significantly lower in Islamic cities, representing labyrinth type, slightly larger in the medieval cities of Western Europe and even larger in the traditional cities of Europe. (see historical paths’ forms in urban contexts of human settlements section)

- **Accessibility (Ac)**: which is the number of intersections with respect to the length of path and it is calculated by the given formula $Ac=(\Sigma i / L_{xy})X100$, where $(\Sigma i)$ is the sum of intersections and $(L_{xy})$ is the real shortest path in meters between $(x)$ and $(y)$.

- **Path Widening (PW)**: is the average percentage between paths widths to the height of boundaries edge (building heights alongside the path). It is calculated with the given formula $PW = AVG \Sigma (wn/hn)$, where $\Sigma (hn / wn)$ is the sum of all the individual measures’ values and $n$ the number of measurements utilized.

Before starting applying previous formulas on the selected paths, the international norms, developed after [6], [14], [23], [24] should be considered as per Table 1.

| INDICATORS  | INTERNATIONAL NORMS |
|-------------|----------------------|
| 1 Accessibility | 6 or more            |
| 2 Direct Visibility | 137 or more        |
| 3 Path Elongation | 20 or less          |
| 4 Path Widening | 67 or less           |
| 5 Turns       | 3 or less            |
| 6 Path Length  | 8 or more            |

The local results were acquired solely by applying the formulas on each main path in each Hara of the selected traditional settlements as illustrated in Hata! Başvuru kaynağı bulunamadı. The acquainted results and the way they were documented for each case study is represented in Table 2. The template is showing the results for each indicator numerically and in chart means with a main map of the dominating path and its intersections.

**8. Results and Discussions**

To apply the comparison between local and international norms of paths’ designs, the first step was to apply the equations in (Section 6.), on the dominant paths of the selected case studies. It was very important to develop a proactive template that is capable of comparing and identifying the matches and mismatches of equations results. The red code of results represents the mismatches while the green one represents the matches. To describe the center of a distribution for getting the pattern of paths in all case studies, the researchers first used $AVERAGE$ function first, which proofed not to be realistic as gave misleading values in some instances. Hence, the $MEDIAN$ function was used instead.
Table 2. All cases results related to international NORMS (author)

| Case Study | Description |
|------------|-------------|
| Case Study 1 | Harat As-Saybani |
| Case Study 2 | Harat Qasra |
| Case Study 3 | Harat Al-Khabt |
| Case Study 4 | Harat Saija |
| Case Study 5 | Harat Msalamat |
| Case Study 6 | Harat Misfat al Abriyin |

**Table:**

| VCI INDICATORS | Saybani | Abriyin | Qasra | Alkhabt | Masalmat | Saija | Results & Comparison |
|----------------|---------|--------|-------|---------|----------|-------|----------------------|
| 1 Accessibility | 2.13 | 1.52 | 3.64 | 5.55 | 4.58 | 3.57 | Int. NORMS            |
| 2 Direct Visibility | 16.75 | 18.00 | 56.75 | 60.75 | 1.88 | 12.70 | Not in the range of Int. NORMS |
| 3 Path Elongation | 48.42 | 41.94 | 60.19 | 47.92 | 6.49 | 1.38 | 20 or less           |
| 4 Path Widening | 135.00 | 176.00 | 140.00 | 116.67 | 167.00 | 150.00 | 67 or less            |
| 5 Turns | 1.11 | 1.25 | 1.20 | 1.14 | 1.33 | 1.20 | 3 or less             |
| 6 Path Length | 12.82 | 22.00 | 39.29 | 11.09 | 51.25 | 33.11 | 8 or more             |

Not in the range of international NORMS
Within the range of international NORMS
Accessibility Pattern

The indicator results for the case studies show mismatching on all results. The nearest indicator to the international norms that is (6 or more), scored in Harat Al- Khabt scoring (5.63). The accessibility indicator coded Accessibility (Ac) - by definition of study- “is the number of intersections along the path with respect of the length of path”. It is calculated with the formula “Ac= (Σi/Lxy) X100”- where (Σi) is the sum of intersections and (Lxy) is the real shortest path in meters between x (starting point of the path) and (y) (ending point of the path)”. The overall median number that represents the Pattern, which is (3.61), is less than the international norm (6 or more) Table 1. The Omani traditional settlements have their own unique that definitely have their effects on the pattern configuration, among the most important characteristics are: Environmental aspects, Social aspects, Defensive aspects.

Figure 4. Accessibility (Ac) - Number of intersections with respect of the length of path
Ac=(Σi/Lxy)X100

Direct Visibility Pattern

This indicator shows the visible and directly accessible area from a node. It is calculated by the formula DV(x) = (Σn + 1) m², where (Σn) is the sum of all nodes visible from the node (x), to which one can move in a straight way in m. length.

The direct visibility indicator in all case studies also scored significantly less than the international norms. The significant variation between the maximum-recorded results (in Harat Al Khabt) and the median number of all compared to the international norm also represents the same aspects listed previously.

Figure 5. Direct Visibility (DV)- The visible and directly accessible area. DV(x) = (Σn + 1) m²

Path Elongation

This indicator tells how much of a particular investigated structure departs from the road archetype and approaches to the labyrinth. It is calculated by the formula PE(x) = \( \Sigma \frac{I - I_0}{I_0} \), where (I) is the sum
of real shortest paths in meters between (x) and (y), and (I₀) is the straight path between (x) and (y), if space is not obstructed.

Three fundamental principles directed and formed paths in all cases. They are moral unity, social relations and ethical responsibility. Moral unity builds specific social and religious points of integration in the fabric of the Hara through the spatial organization of solids and voids that could not be achieved by lengthening paths. Social relations also directed paths in public, residential and domestic domains and led to specific kinds of cluster formations around concentrated areas of use. The paths that connected those clusters tended to have these segmented lines for privacy purposes.

Figure 6. Path Elongation (PE)- The indicator tells how much of a particular investigated structure departs from the road archetype and approaches to the labyrinth.

**Path Widening (PW)**

The indicator represents the average percentage between path width and the height of boundaries edge (building heights alongside the path). It is calculated by the formula PW = AVG ∑(wn/hn), where ∑(hn / wn) is the sum of all the individual measures’ values and n = number of measurements utilized.

As can be concluded from the indicators results (on individual cases or on median level of all results), the indicator results are far from the international norms that define this indicator with the figure of (67 or less). The international norms were derived from the westernized urban laws. The hot weather and the strong radiation of the sun in local environment of Oman forced the people to invent ways for protection. Compact design required paths to be narrower and the boundaries to be higher. This strategy preserved the paths from the sun radiation and adapted them to the local climate.

Figure 7. Path Widening (PW) - the average percentage between paths’ widths to the heights of boundaries’ edges (building heights alongside the path)

**Turns (T)**

The indicator is somewhat similar to the path elongation but it supplements it to understand more precisely the people’s perception of distance. A person can feel the distance in both length units and
turns. The average number of turns is calculated according to the formula $\text{MT} (x) = \frac{\Sigma t}{(n - 1)}$, where $(\Sigma t)$ is the sum of the turns moving from $(x)$ to all remaining vertices, $n$= the number of vertices.

The legibility and the recognition of distances are among the important attributes of Omani traditional settlements. When navigating, people tend to overestimate distances when routes contain more turns (route-angularity effect) (23). Path segments, the stretches of path between two turns such as seen in Harat As-Saybani and Misfat al-Abriyin, provide convenient segmentation for path recognition concept. Hence, the results came within the logical and international norms.

**Figure 8.** Turns (T) - The indicator is somewhat similar to the path elongation but accompaniments it and helps to understand more precisely person’s perception of distance. A person can feel the distance both in length units and turns.

$$\text{MT} (x) = \frac{\Sigma t}{(n - 1)}$$

Path Length (PL)

This indicator defines which mid-length axes crosses the network points. Length of the path between the turns is calculated by the formula $\text{PL}(x) = \frac{\Sigma l}{\text{MT}}$, where $(\Sigma l)$ is the average length of straight sections passing through $(x)$, $\text{MT}$= is the number of turns. The fact that all results of this indicator lied within the norms range proves that estimated distances between locations along the same segment are often shorter than locations on different segments (26) (27). This has been termed the route-segmentation effect (Montello, 1997) and is thought to increase efficiency by allowing people to break routes into subunits forming clusters. This is exactly what the Omani families and tribes used to have at that period based on social factors as explained previously in path elongation section.

**Figure 9.** Path Length (PL) - The indicator tells which mid-length axes crosses the network points.

$$\text{PL} (x) = \frac{\Sigma l}{\text{MT}}$$

9. Concluding Remarks

The overall goal of this study was to highlight the relationship between legibility aspects and urban forms of Omani traditional settlements. The study went deeper into the discovery of another important question that is if the international norms of urban forms were able to achieve legibility aspects for local
communities in Oman. The legibility aspects were first stated and analyzed through their concepts and the way of achieving them through the use of urban forms or patterns. More specifically, it was question to know “What kind of urban forms that can achieve these aspects? What are the standards or norms to be applied?”. Dealing with all urban forms’ elements was a huge task that cannot be conducted within the scope of this paper. Therefore, the research focused on the “paths” as one of Kevin Lynch’s elements of urban forms that participates in shaping the whole image of the city and its comprehension. The study analyzed data gathered from direct observations, interviews, Architectural documentation. To set the international norms and their characterization, the study came up with norms through illustration methodology and the one applied by John Peponis. Designing a proactive template that has the ability to compare and show the matches between international norms and real data recorded was a crucial contribution of the present research.

Finally, the study concludes on very important notes that should be considered when planning and design new community settlements in Oman or in regions with similar socio-cultural and climatic contexts. Those notes can be briefed as follows: 1) Legibility aspects are connected to urban forms by many means 2) International urban norms are not fixed values or numbers and cannot be applied to any urban settlements around the world without considering social, environmental and the unique status of the designated community living in this settlement3) The study proofed that local values of paths in the selected case studies deviate from international norms 4) The study explained these variations and why they happened.

Undoubtedly, further research and development of this model is needed. More urban elements need to be investigated to enrich the model and provide a holistic picture of the urban configuration and its perception by the residents. However, the investigation presented in this paper allows, at least to state that the urban form legibility, in essence, helps to comprehend the spatiality of urban settlements, the consistencies of the interactions between its social contents and the specificity of its spatial network.

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## Appendix I: Paths indicators related to legibility concept

| Indicators | Description | Formula | Illustration |
|------------|-------------|---------|--------------|
| **Accessibility (Ac)** | Number of intersections along the path | $Ac = \Sigma / L_{xy}$ | ![Accessibility Diagram](image1) |
| | where $\Sigma$ is the sum of intersections and $L_{xy}$ is the real shortest path in meters between x and y. | | |
| **Direct Visibility (DV)** | The indicator basically shows the visible and directly accessible area. | $DV(x) = (\Sigma n + 1)$ m² | ![Direct Visibility Diagram](image2) |
| | where $\Sigma n$ is the sum of all nodes visible from the node x, to which you can move in a straight way in m length. | | |
| **Path Elongation (PE)** | The indicator tells how much of a particular investigated structure departs from the road archetype and approaches to the labyrinth. | $PE(x) = \Sigma (1 - 10)/10$ | ![Path Elongation Diagram](image3) |
| | where $l$ is the real shortest path in meters between x and y, and $l_0$ is the straight path between x and y, if space is not obstructed. | | |
| **Path Widening (PW)** | the average percentage between path wide to the height of boundaries edge (building heights alongside the path). | $PW = AVG \Sigma (\text{w} / h_n)$ | ![Path Widening Diagram](image4) |
| | where $\Sigma \text{w} / h_n$ is the sum of all the individual measures' values and $n$= number of measurements utilized | | |
| **Turns (T)** | The indicator is somewhat similar to the path elongation but accompanies it and helps to understand more precisely person’s perception of distance. a person can feel the distance both in length units and turns. | $MT(x) = \Sigma / (n - 1)$ | ![Turns Diagram](image5) |
| | where $\Sigma$ is the sum of the turns moving from x to all remaining vertices, $n$ is the number of vertices. | | |
| **Path Length (PL)** | In essence, the indicator tells which mid-length axes crosses the network points. | $PLT(x) = \Sigma / MT$ | ![Path Length Diagram](image6) |
| | where $\Sigma$ – the average length of straight sections passing through x, MT is the number of turns. | | |