Grading methodology of the pedestrian urban road environment

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Abstract: - The improvement of pedestrian safety, mobility and convenience is an important step for the promotion of sustainable mobility in urban areas. This study presents the grading process and walkability score of the pedestrian urban environment of six selected roads in the city of Volos, Greece. The roads were characterized as main, collector or local urban arterials, located inside or close to the center of the city. Four suitably trained auditors walked across the streets and using a questionnaire graded independently the pedestrian urban road environment features in each road segment and crosswalk. The auditors' team included three undergraduate students as the team members and a PhD candidate as the team leader. The questionnaire included 9 questions for the road segments and 6 questions for the crosswalks. The rating scale varied between 1 (awful) and 5 (very good) score. We calculated the average score of each question for the road segments and crosswalks across each street. Furthermore, we calculated the walkability score for each road segment and crosswalk and as an average the total walkability score of each street. The innovation of our study was that we graded separately the walkability features of each road segment and crosswalk, concluding to a total walkability score of a street as a synthesis of the auditors' grades.

Key-Words: - Walkability score, Pedestrian, Auditor, Road segment, Crosswalk, Sustainability

1 Introduction

Walking is a transport mode that demands physical effort from the pedestrians. The choice of walking or the selection of the route depends on the characteristics of the urban road environment. Walking is a sustainable transport mode which represents a new perception of urban culture into a more ecological footprint. The sustainable city favors the walking and bicycling. The design, development and operation of the urban road environment focus on human and not automobile scale.

Community authorities all over the world are constantly under pressure to provide their citizens a road environment suitable to walking. This study presents the findings of a walkability grading process in urban streets. The results of our study can help decision makers and engineers to plan and implement remedial actions that favor pedestrian needs and promote sustainable transportation in urban areas.

1.1 Urban road environment features related to walking

There are major benefits from the promotion of walking, both in urban and in regional level. Pedestrians do not consume fuel to reach their destination, pollute the air or produce noise. In urban areas the selection to walk depends on many factors. Shay et al (2003) propose two groups of factors that influence walking (ability and motivation) [1]. The "ability" factors include features of the urban environment that help pedestrians to walk with safety and convenience, which are:

- Distance of the route
- Value of time
- Transportation cost
- Weather protection
- Pedestrian infrastructure
- Traffic flow volume and speed

The "motivation" factors relate to personal or social characteristics. Only with the presence of the ability factors are the motivation factors operational in order to promote walking among citizens. Some of the most important motivation factors are the following:

- Transportation time
- Accessibility to destination
- Road safety
- Personal safety
- Attractiveness of the urban environment

Mackett (2001) concluded that the distance and the time to reach the destination are major factors to select walking [2]. Pedestrians walk slowly, resulting to a limited distance they are able to transport (1-2 km). Furthermore, the value of time is very important for workers with high salaries.

Easton and Smith (2003) concluded that many citizens are afraid to walk because they fear for their personal safety [3]. Many citizens, especially women, avoid walking during the night selecting another transportation mode or choosing not to transport. According to Bradshaw and Jones (2000), many parents consider that their children face danger not only for their road safety but also for their personal safety [4].

The influence of the urban road environment attractiveness is very difficult to be counted. Some studies conclude that an attractive urban road environment raises the level of walking [5]. Litter, graffiti and pavement maintenance are important features. The aspect of a low maintained urban road environment limits the desire to walk [6].

The providence of pedestrian infrastructure relates to walking and the selection of the route. The sidewalks and crosswalks should be located across the pedestrian desire line, otherwise pedestrian do not use them choosing a different route [7]. Pedestrians consume physical effort and usually choose the shortest route to reach their destination. Furthermore, the land use and the presence of destinations that raise the transportation demand influence the selection of the walking route.

1.2 The concept of walkability

Citizens desire to live in a city where they will be able to walk with safety and convenience. Cities that are suitable to walking (walkable city) have many benefits for their citizens, such as:

- A road network safe for pedestrians
- Better accessibility to destinations for all
- Selection of multiple transportation modes
- Better health for their citizens

The definition of walkability is not specific but can be explained as the suitability that the urban road environment offers to pedestrians. The walkability level differs among urban areas and cities. There are many differences related to economical, cultural and topographical factors. Pedestrians should be able to walk in the entire urban road network in order to reach their destinations. The basic features of a walkable urban road environment are the following:

- Accessibility
- Convenience
- Attractiveness
- Road safety
- Personal safety

The promotion of walkability can improve the quality of life in urban areas and raise the sustainability footprint of the city.

1.3 Pedestrian road safety

Pedestrian road safety is a key factor in a walkable city. Pedestrians need safe space to walk. They need continued sidewalks separated from traffic flow, with an adequate width and maintenance level, without presence of obstacles across their desire route. Ramps should be provided in street corners. Crosswalks should be located in intersections across the pedestrians' desire route. Traffic lights are necessary in streets with high volumes of traffic flow and speed. Pedestrians should have a clear view of incoming motorists in order to select a safe traffic gap to cross the street. Lack of street lighting raises problems for pedestrian road and personal safety during the night.

One of the most important factors that influence the pedestrian road safety is the driving behaviour of the motorists, such as:

- Do not give priority to pedestrians to cross the street, even in crosswalk sites [8]
- Drive with high speed in school areas or in sites with high pedestrian flow.
- Passing through neighbourhoods in order to avoid traffic jam in main urban arterials
- Drive when they have consumed alcohol or drugs
- They driving attention is distracted

The same important is the pedestrian walking behaviour, such as:

- They cross the street without paying attention to the incoming traffic
- They do not choose safe traffic gaps when they cross the street or jaywalking
- They usually cross the street outside of the designated crosswalk
- They violate the indications of the traffic signs and signals
- Their attention is distracted

In USA, according to the Traffic Safety Facts 2008 Data: Pedestrians, 4.378 pedestrians lost their life and 69.000 were injured in the year 2008 [9]. The most fatalities took place in urban areas (72%), in sites outside intersections (76%), during good weather condition (89%) and during the night (70%). The 70% of the pedestrian fatalities were men. Pedestrian age is related to the pedestrian road accident fatalities. The 18% of the fatalities were pedestrians over 65 years old and the 7% children under 15 years old. The time of the day and the day of the week are also related to the pedestrian road accident fatalities. The 38% of the pedestrian fatalities under 16 years old took place between 3pm and 7pm. About the half of the pedestrian fatalities took place during the weekend, due to the higher pedestrian traffic volumes that are usually noticed in this time period of the week.

In EU-14, according to the Traffic Safety Basic Facts 2007: Pedestrians, 3.683 pedestrians lost their life in road traffic accidents in the year 2005 [10]. In Greece, according to the Road Fatalities in EU: 2008, 248 pedestrians lost their life in the year 2008 [11]. The 81% of the pedestrian fatalities took place in urban areas. On the contrary, the pedestrian fatalities reported in urban areas were 72% in Netherlands and 63% in Sweden. The most dangerous urban sites for the pedestrian road safety were the intersections, where pedestrians conflict with other road users.

1.4 Walkability audit tools

The study in the field of the relationship between urban road environment features and pedestrian activity has evolved during the last years. Early research focused on compliance with supervised exercise programs in relation to proximity to facilities [12]. The next generation of the studies examined the impact of the community environment on leisure physical activity in various populations [13]. In the same time period, transportation and city planning researchers were studying the relationship of land-use patterns to walking for transportation, using both survey and GIS measures [14]. Recently, physical activity surveys have become more comprehensive, allowing assessment of walking for both recreational and transportation purposes [15], [16]. In order to understand better the impact of the urban environment characteristics on pedestrian activity, it was necessary to develop high-quality measures [17]. There are three categories of urban environment measures:

- Personal interview or self-administered questionnaires (surveys). These measures examine the extent to which individuals perceive access and barriers to various elements of recreation, land use and transportation environment.
- Systematic observation (audits), to quality objectively and unobtrusively attributes of the urban environment.
- Data from archival (existing) data sets layered and analyzed with GIS.

Audit tools allow systematic observation of the urban environment, including the presence and qualities of features hypothesized to affect pedestrian activity (e.g. street pattern, number and quality of public spaces, sidewalk quality). Many characteristics of the urban environment can be measured without direct observation, using existing data, such as GIS or aerial photos. Such “remote” methods may be less labour intensive and therefore less time consuming. Researchers, use audit tools to collect primary data on physical features that are not commonly incorporated into GIS databases (e.g. street trees, sidewalk width). Audit tools are also used to measure physical features that are better assessed through direct observation (e.g. architectural character, landscape maintenance). Not all audit tools are intended for research purposes. Some of them are developed to support local decision making. Such tools engage community members in collecting data that will be used to better understand the needs and opportunities for changing the pedestrian environment in their community. Tools designed for community use are less detailed than those designed for research purposes.

Audit tools typically require in-person observation for collecting data, as opposed to videotaping or other methods [18]. Researchers walk or drive through a neighbourhood, park or trail, systematic coding characteristics using definitions and a standardized form. For assessing features of the urban environment, street segment is a typical unit of observation. Road segments typically comprise two facing sides of one street block. The audit tool is usually a paper containing close-ended questions (e.g. check boxes, Likert scales) or open-ended questions or comments. Segments are typically sampled because it is not very easy to audit entire neighbourhoods. Sampling is either random or purposeful. Purposeful sampling ensures that rare but important features of the environment, such as parks or corner stores are included. Segments of trails and areas within parks can also be units of observation.

Researchers have developed several audit tools in recent years. Some of the most important are the following:

- PEDS: Pedestrian Environmental Data Scan [19]
- SPACES: Systematic Pedestrian and Cycling Environmental Scan [20]
- I-M Inventory: Irvine Minnesota Inventory [21], [22]
- SLU Analytic Audit Tool [23]

Most audit instruments included one or more features of: land use (e.g. presence and type of housing, retail); streets and traffic (e.g. traffic volume, presence of traffic calming); sidewalks (e.g.

presence and continuity of sidewalks); bicycle facilities (e.g. presence of bike lanes); public space/amenities (e.g. presence of street furniture or benches); architecture or building characteristics (e.g. building height); parking/driveways (e.g. presence of parking garages); maintenance (e.g. presence of litter); and indicators related to safety (e.g. presence of graffiti).

In audit instruments, reliability is an important factor. Inter-observer reliability is the primary form of reliability assessed, although test-retest reliability is relevant for assessing stability of observed features. Audit tools that report reliability by item or by domain. Measures of physical disorder, tidiness or safety-related features tend to be less reliable, compared to measures such as land use and street characteristics.

In person observation is time consuming. Researchers must select sites, define and sample segments within sites, train and monitor observers, collect data and analyze them. Estimates of time required for data collection vary depending on the number of items observed and the type of urban environment (mixed use or residential). Audit tools have recently been developed using personal digital assistant (PDA) devices, such as Palm Pilots, or personal computers (PCs) for data collection. Tools that involve electronic data input save time for data entry. Among audit tools that use paper forms, some have one-page format, which may be easier to manipulate in field.

Relevant skills that are needed for observing the urban road environment include some knowledge of the content area, as well as the ability to carry out the technical methods of the observation. Typically, observers are undergraduate or graduate research assistants from various fields, who are trained to observe detailed features of the urban environment. Often recommended is the combination of classroom and field training. Because many terms and concepts are likely to be unfamiliar to observers, the manual and training must provide clear definitions. Observers should be well trained and inter-observer reliability should be high in order to ensure quality of measures of the study. So, the training process is a key factor for the succession of such instruments.

2 Methodology

The improvement of pedestrian safety, mobility and convenience is an important step for the promotion of sustainable mobility in urban areas. This study presents the grading process and walkability score of the pedestrian urban environment of six selected roads in the city of Volos, Greece.

2.1 Study area

The study area consisted of six urban roads located inside or close to the center of the city (Fig.1):

- Iasonos St (Main Arterial)
- Kartali St (Main Arterial)
- 28 October St (Collector Arterial)
- Gazi St (Collector Arterial)
- Korai St (Collector Arterial)
- Diakou St (Local Street)

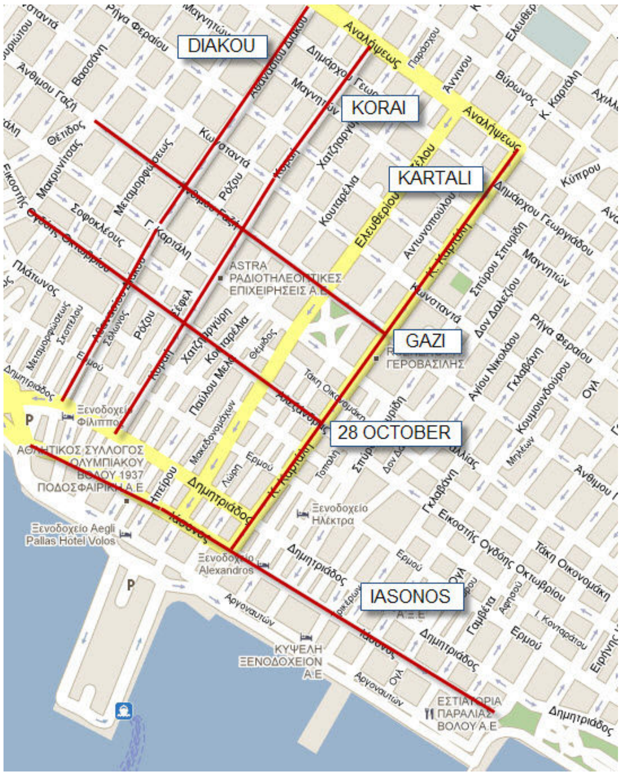

Fig. 1: Study Area

2.2 Street coding

The streets were separated into road segments and crosswalks with identification codes for each one. The street was separated into two sides: “Side A” and “Side B”. Iasonos St consisted of 16 road segments in Side A and 28 in Side B. 28 October St consisted of 15 road segments in Side A and 13 in Side B. Gazi St consisted of 10 road segments in both sides of the street. Kartali St consisted of 12 road segments in both sides of the street. Korai St consisted of 10 road segments in Side A and 11 in Side B. Finally, Diakou St consisted of 11 road segments in Side A and 13 in Side B. This difference was created from the length of each road segment and its identification. We kept the same codes for opposite road segments (e.g. 8A, 8B) but we put subcodes if subsegments were noticed (e.g.

1A, 1B1, 1B2), (Fig. 2). We named the crosswalks according to the nearby road segments codes. So, the crosswalk 1B2_2B1 was the crosswalk located between the road segments 1B2 and 2B1 (Fig.2).

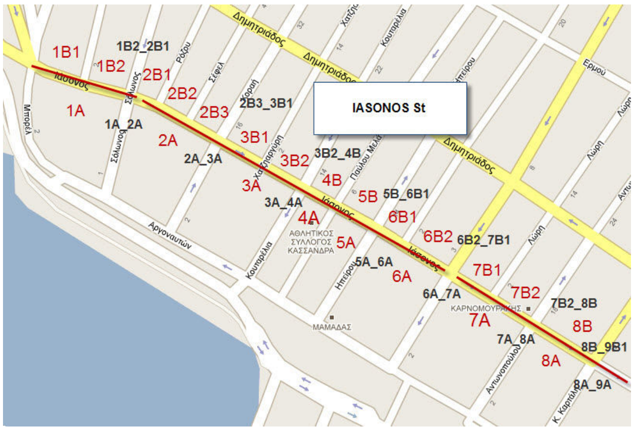

Fig. 2: Street coding

2.3 Selection and training of the auditors' team

The auditors' team included three undergraduate students as members of the team and a PhD candidate as the leader of the team. The training process was very important for the successfully implementation of the questionnaires. The team leader explained the target of the study and the details of the questionnaire to the team members. The duration of the first step of the training was no more than two hours. The second step of the training was a pilot implementation of the questionnaires in a typical road segment and a typical crosswalk in the study field. After the second step, the auditors' team solved all the possible problems and misunderstandings for the implementation of the study, during a debriefing conversation.

2.4 Data collection: Implementation of the questionnaires

The auditors walked across the streets and graded independently the walkability features in each road segment and crosswalk. They graded each side of the road separately. The rating scale was between 1 (awful) and 5 (very good), (Fig. 3). The questionnaire of the walkability features of the road segments consists of 9 questions (Table 1). In the 9th question the auditors graded the total walkability score of the road segment. The question No10 refers to the average grade of the questions No1-N8. The questionnaire of the walkability features of the crosswalks consists of 6 questions (Table 2). In the question No6 the auditors graded the total walkability score of the crosswalk. The question No7 refers to the average grade of the questions No1-No5.

Table 1: Questionnaire (road segments)

Walkability features (road segments)	
Questions	
1	Convenience of walking relating to the width of the sidewalk.
2	Obstacles on the sidewalk across the pedestrian desire line.
3	Maintenance level of the surface of the sidewalk.
4	Weather protection of the pedestrians across the sidewalk.
5	Street lighting level across the sidewalk.
6	Pedestrian personal security
7	Pedestrian road safety
8	Attractiveness of the urban environment
9	Walkability grade (auditor)
10	Average walkability grade (No1-No8)

Table 2: Questionnaire (crosswalks)

Walkability features (crosswalks)	
Questions	
1	Obstacles in the corner across the pedestrian desire line
2	Maintenance level of the surface of the corner.
3	Maintenance level of the surface of the crosswalk.
4	Street lighting level in the crosswalk area.
5	Pedestrian road safety.
6	Walkability grade (auditor)
7	Average walkability grade (No1-No5)

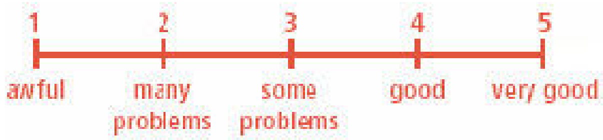

Fig. 3: Rating scale

The auditors answered the questionnaires during good weather and normal traffic flow conditions. The concept was to evaluate the urban road environment in normal conditions so that no other factor could influence our study. Furthermore, the auditors walked across the street during the night, in order to grade the visibility level across the sidewalks and crosswalks and the level of personal security.

3 Results

3.1 Walkability grade: Road segments

The four auditors graded the walkability features of the road segments answering the questions No1-No9 (Table 3). The standard deviation of their grading for each road segment can indicate the differences across the street (Table 4). The question No1 refers to the convenience of walking relating to the width of the sidewalk. The highest grade was noticed in Iasonos St (4.00) and Kartali St (4.31), where the sidewalk width was about 2-3m and the pedestrians could walk with convenience. The lowest grade was noticed in Diakou St (2.69), where the sidewalk width was about 1m, inadequate for the pedestrians. In the rest of the streets the grade was medium. So, we consider that in main urban arterials the sidewalk width was adequate for pedestrians comparing to collector and local streets.

The question No2 refers to the obstacles on the sidewalk across the pedestrian desire line. The highest grade was noticed in Kartali St (4.76), indicating that the street furniture was aligned across the sidewalks. The lowest grade was noticed in Korai St (3.65) and Diakou St (3.78), indicating that the street furniture and parked vehicles were hampering pedestrians to walk across their desire route.

The question No3 refers to the maintenance level of the surface of the sidewalk. There were major differences among the road segments and the streets. In Iasonos St (4.80) and Kartali St (4.61) the maintenance level was high. In 28th October St (3.14) and Gazi St (3.35) was medium and finally in Korai St (2.87) and Diakou St (2.68) was low. We consider that the maintenance of the sidewalks was focused in main urban arterials.

The question No4 refers to the weather protection (sun, rain) of the pedestrians across the sidewalk. Almost in all the streets the protection of the pedestrians was medium or low (<3.00). Only in Kartali St (3.38), we noticed that the pedestrian weather protection was medium due to the presence of trees. The building facades did not constantly protect the pedestrians across the desire route.

The question No5 refers to the street lighting level across the sidewalk of each road segment. The level of street lighting was high in Iasonos St (4.23), due to the presence of lighting poles and night life (bars, restaurants). In Kartali St (3.85) the level of the street lighting was lower, due to the presence of large trees that hamper the lighting poles and the lower level of night life. The level of the street lighting was medium in the rest of the streets (collectors and local), characterized from the absence of night life and residential land use.

The question No6 refers to the pedestrian personal security during the night. The level of street lighting, the land use, the pedestrian traffic flow and the presence of beggars or drunken people influences the pedestrians' personal security. All the auditors were men, so sex was not a factor that influenced the grading. The level of personal security was medium or high in all the streets. The highest grade as expected was noticed in Iasonos St (4.26) and Kartali St (4.33). The lowest grade was noticed in Diakou St (3.54), due to the lower level of street lighting and pedestrian traffic flow.

The question No7 refers to the pedestrian road safety across the sidewalks. The highest grade was noticed in Iasonos St (4.29) and Kartali St (4.64) due to the larger width of the sidewalks and the absence of obstacles across the pedestrian desire route. On the contrary, the lowest grade was noticed in Diakou St (2.90), because the pedestrians were forced to walk inside the street due to the lower width of the sidewalks and the presence of permanent or mobile obstacles across their desire route.

The question No8 refers to the attractiveness of the urban road environment. The basic features related to this question were the architecture of the buildings, the presence of litter or graffiti and the presence of trees. The highest grade was noticed in Iasonos St (3.75) and Kartali St (3.86) and the lowest in Korai St (2.73). The absence of trees, the presence of deserted buildings, litter and graffiti lowered the level of attractiveness. Furthermore, the architecture image of the buildings was not noticeable.

The question No9 refers to the total walkability grade the auditors consider in each road segment. In question No10 we counted the average grade of the questions No1-No8. The term of "walkability" is descriptive and we consider that is very difficult to put weight in each criterion. So the total walkability grade can be counted either from the auditors themselves or as average of the walkability features grades.

A survey in citizens walking across the street can offer a useful walkability grade. It cannot be implemented separately in each road segment because the sample will be inadequate. The survey should refer in a specific length of the street, because the participants will be biased from the walkability level of the previous road segments. On the contrary, an auditors' team can grade with reliability the walkability level of the microscale urban road environment.

Table 3: Average grade: walkability features (road segments)

Street	Iasonos	28 October	Gazi	Kartali	Korai	Diakou
No	Average (road segments)					
1	4.00	3.33	3.43	4.31	2.90	2.69
2	4.60	4.26	4.48	4.76	3.65	3.78
3	4.80	3.14	3.35	4.61	2.87	2.68
4	2.89	2.66	2.42	3.38	2.42	2.57
5	4.23	3.57	3.33	3.85	3.13	3.17
6	4.26	3.63	4.12	4.33	3.81	3.45
7	4.29	3.27	3.78	4.64	3.01	2.90
8	3.75	2.94	3.30	3.86	2.73	2.85
9	4.19	3.24	3.57	4.60	2.99	2.77
10	4.10	3.35	3.53	4.22	3.06	3.01

Table 4: Standard deviation grade: walkability features (road segments)

Street	Iasonos	28 October	Gazi	Kartali	Korai	Diakou
No	St. Dev. (road segments)					
1	0.65	0.49	0.90	0.51	0.70	0.86
2	0.34	0.18	0.57	0.21	0.53	0.55
3	0.34	0.77	1.01	0.31	0.47	0.88
4	0.69	0.58	1.15	0.57	0.56	0.57
5	0.34	0.26	0.63	0.49	0.90	0.93
6	0.45	0.51	0.23	0.00	0.23	0.85
7	0.62	0.58	0.68	0.49	0.63	1.00
8	0.28	0.48	0.63	0.06	0.51	0.67
9	0.54	0.55	0.84	0.38	0.43	0.74
10	0.46	0.48	0.72	0.33	0.57	0.79

In a high walkable road segment there is continues sidewalk with adequate width and absence of obstacles across the pedestrian desire route. The maintenance of the surface of the sidewalk is good without cracks and holes. Weather protection, cleanliness, trees and attractive building facades raises the walkability level of the street (Fig. 4). On the contrary, obstacles on the sidewalk, deserted buildings and litter lower the walkability score of the street (Fig. 5).

Fig. 4: High walkable road segment

Fig. 5: Low walkable road segment

The walkability grading profile of the road segments among the streets was almost the same for both auditors and the average grade of the questions No1-No8 (Fig. 6). The highest walkability score was noticed in main urban arterials: Iasonos (4.19) and Kartali (4.60). In collector streets the walkability score was medium: Gazi St (3.57), 28th October (3.24) and Korai St (2.99). The lowest walkability score was noticed in Diakou St (2.77) which is a local street. So, we concluded that the profile of the walkability score of the road segments across the streets relates to the vehicle or pedestrian traffic flow and the land use.

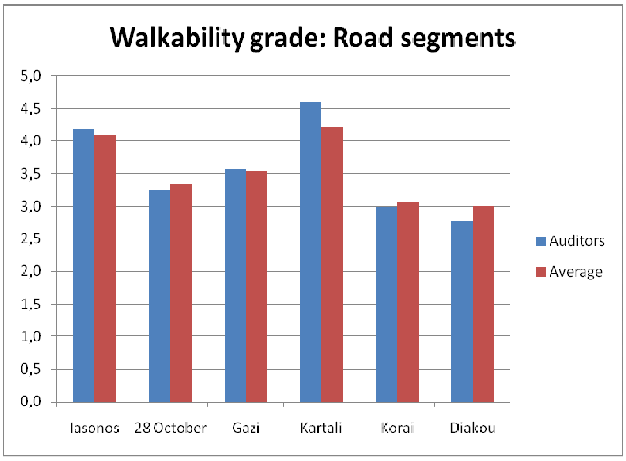

Fig. 6: Walkability grade (road segments)

3.2 Walkability grade: Crosswalks

The four auditors graded the walkability features of the crosswalks answering the questions No1-No5 (Table 5). The standard deviation of their grading for each crosswalk can indicate the differences across the street (Table 6). The question No1refers to the obstacles located in the corner of the sidewalk-crosswalk, across the pedestrian desire route. The highest grade was noticed in Iasonos St (4.38) and the lowest in Diakou St (3.33). The presence of ramps across the main arterials creates a clear space for the pedestrians where they can stand before crossing the street.

The question No2 refers to the maintenance level of the surface of the corner and the ramp. The highest grade was noticed in Iasonos St (4.33) and Kartali St (4.28). On the contrary, the lowest grade was noticed in Diakou St (3.09).

The question No3 refers to the maintenance level of the surface of the crosswalks. It refers not only to the presence of cracks or holes but also to the visibility level of designated crosswalks. The highest grade was noticed in Kartali St (4.24). In all the other streets the maintenance level was medium (3.2-3.6).

The question No4 refers to the street lighting level in the crosswalks. The grade was high almost in all streets. The lowest grade was noticed in Gazi St (3.63). In main arterials the street lighting poles and the building facades create a high level of lighting during the night. On the contrary, in collector and local streets, the lighting poles are mainly located in intersections where the most traffic accidents are noticed.

The question No5 refers to the pedestrian road safety in crosswalks (designated or not). The highest grade was noticed in Iasonos St (4.06) and Kartali St (4.39), where the pedestrians cross street with traffic calming measures and designated crosswalks with traffic lights. On the contrary, in collector and local streets the pedestrians cross typical urban roads without designated crosswalks. In these streets the motorists usually do not drive fast improving the road safety feeling of the pedestrians. The lowest grade was noticed in Korai St (3.77).

The question No6 refers to the total walkability grade the auditors consider in each crosswalk. In question No7 we counted the average grade of the questions No1-No5.

Table 5: Average grade: walkability features (crosswalks)

Street	Iasonos	28 October	Gazi	Kartali	Korai	Diakou
No	Average (crosswalks)					
1	4.38	3.68	3.94	4.18	3.47	3.33
2	4.33	3.28	3.62	4.28	3.38	3.09
3	3.61	3.29	3.46	4.24	3.53	3.27
4	4.27	4.19	3.63	4.06	4.17	3.93
5	4.06	4.01	3.80	4.39	3.77	3.85
6	4.18	3.55	3.59	4.26	3.46	3.47
7	4.13	3.69	3.69	4.23	3.66	3.49

Table 6: Standard deviation grade: walkability features (crosswalks)

Street	Iasonos	28 October	Gazi	Kartali	Korai	Diakou
No	St. Dev. (crosswalks)					
1	0.57	0.47	0.74	0.59	0.73	0.81
2	0.47	0.75	0.66	0.58	0.87	1.23
3	0.89	0.93	0.50	0.67	0.73	0.93
4	0.39	0.82	0.69	0.80	0.40	0.60
5	0.50	0.70	0.48	0.56	0.65	0.57
6	0.64	0.81	0.59	0.62	0.85	1.01
7	0.56	0.73	0.61	0.64	0.68	0.83

In a high walkable crosswalk there is a deginated crosswalk, with absence of obstacles in the corners and good maintenance of the pavement (Fig. 7). If the vehicle traffic flow and speed are high, a traffic light should be operating in order the pedestrians to cross the street with safety because there is a lack of safe traffic gaps.

Lower walkability score of a crosswalk could be noticed due to the lack of maintenance on the pavement surface (Fig. 8). The grading process after rain could help identifying there problems.

Fig. 7: High walkable crosswalk

Fig. 8: Low walkable crosswalk

The walkability grading profile of the crosswalks among the street was almost the same for both auditors and the average grade of the questions No1-No5 (Fig. 9). The highest walkability score was noticed in main urban arterials: Iasonos (4.13) and Kartali (4.23). In the other streets (collector arterials, local streets) the walkability score was medium: Gazi St (3.59), 28th October (3.55) Korai St (3.46) and Diakou St (3.47). So, we concluded that the profile of the walkability score of the crosswalks across the streets relates to the type of the crossing streets and the vehicle traffic flow and speed.

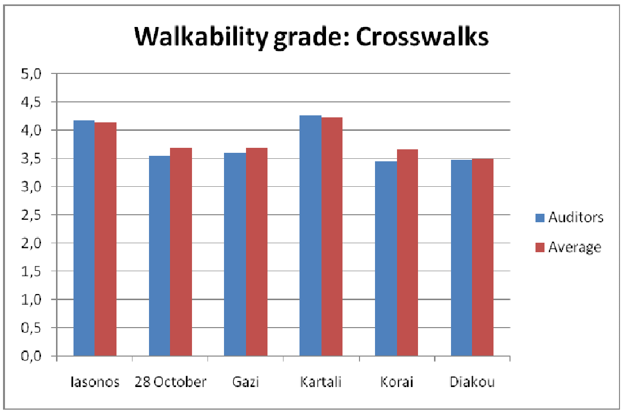

Fig. 9: Walkability grade (crosswalks)

4 Conclusions

This study evaluated the walkability score of the pedestrian urban road environment across selected streets in the city of Volos, Greece. The main conclusion of our study was the following:

- The sidewalk width was adequate for pedestrians to walk with convenience in main arterials.
- The street furniture was aligned on sidewalks across main arterials.
- Street furniture and illegally parked vehicles were obstacles across the pedestrian desire route, mainly noticed in collector and local streets.
- Ramps provide a clear space for pedestrians to stand before crossing the street.
- The maintenance level of the surface of the sidewalks was higher in main arterials and lower in collector and local streets.
- The maintenance level of the surface of the crosswalks and corners was higher in main arterials and lower in collector and local streets.
- The weather protection level of the pedestrians was medium across all the streets.
- The street lighting level was higher in main arterials and lower in collector and local streets, mainly noticed in intersections.
- The personal security level was good or medium in all streets.
- The pedestrian road safety relates to their ability to walk in the sidewalks and not across the street.
- The pedestrian road safety in intersections relates to the presence of designated crosswalks or traffic lights.
- The attractiveness of the urban road environment was higher in main arterials.

We propose the classification of the streets according to their walkability score in three levels (high, medium, low) with positive (+) or negative (-) perspectives.

- Iasonos St: High (+)
- Kartali St: High (+)
- Gazi St: Medium (+)
- 28th October St: Medium (-)
- Korai St: Low (+)
- Diakou St: Low (-)

References:

[1] Shay, E., Spoon, S., and Khattak, A., Walkable environments and walking activity, *Final Report for Seed Grant Submitted to Southern Transportation Center*, University of Tennessee, 2003

[2] Mackett, R.L., Policies to attract drivers out of their cars for short trips, *Transport Policy*, 8, 2001, pp. 295-306

[3] Easton, H., and Smith, F., , *Getting there: Reducing crime on public transport*, 2003

[4] Bradshaw, R., and Jones, P., *The family and the school run: what would make a difference*? Scoping report June 2000 for the AA Foundation

[5] Gehl, J., *Keynote speech*, WALK21 Conference Proceedings, 1999

[6] Smith, G.R., *Area-based initiatives: The rationale and options for area targeting*, CASE paper 25, London, 1999

[7] Sharples, J.M., and Fletcher, J.P., *Pedestrian perceptions of road crossing facilities*, Scottish Executive Central Research Unit: Edinburgh, 2000

[8] Eliou, N., and Galanis, A., Pedestrians and drivers' behaviour in street crossings with flashing green beacon, *Proceedings of the European Transport Conference 2009*

[9] *Traffic Safety Facts 2008 Data: Pedestrians*, NHTSA National Center for Statistics and Analysis

[10] *Traffic Safety Basic Facts 2007: Pedestrians*, European Road Safety Observatory

[11] *Road fatalities in EU: 2008*, European Commission/ Directorate General Mobility and Transport

[12] Dishman, R., Compliance/ adherence in health-related exercise, *Health Psychology*, 1, 1982, pp. 237-267

[13] Sallis, J.F., Hovell, M.F., and Hofstetter, C.R., Predictors of adoption and maintenance of vigorous physical activity in men and women, *Preventive Medicine*, 21, 1992, pp. 237-251

[14] Handy, S.L., Boarnet, M.G., Ewing, R., and Killingsworth, R.E., How the built environment affects physical activity: views from urban planning, *American Journal of Preventive Medicine*, 23, 2002, pp. 64-73

[15] Saelens, B.E., Sallis, J.F., and Frank, L.D., Environmental correlates of walking and cycling: findings from the transportation urban design and planning literatures, *Annals of Behavioral Medicine*, 25, 2003, pp. 80-91

[16] Hoehner, C.M., Ramirez, L.K.B., Elliott, M.B., Handy, S.L., and Brownson, R.C., Perceived and objective environmental measures and physical activity among urban adults, *American Journal of Preventive Medicine*, 28, 2005, pp.105-116

[17] Sallis, J.F., Owen, N., and Fotheringham, M.J., Behavioral epidemiology: a systematic framework to classify phases of research on health promotion and disease prevention, *Annals of Behavioral Medicine*, 22, 2000, pp. 294-298

[18] Ewing, R., Handy, S., Brownson, R., Clemente, O., and Winston, E., Identifying and measuring urban design qualities related to walkability, *Journal of Physical Activity and Health*, 3, 2006, pp. 223-240

[19] Clifton, K.J., Livi Smith, A.D., and Rodriguez, D, The development and testing of an audit for the pedestrian environment, *Landscape and Urban Planning*, 80, 2007, pp. 95-110

[20] Pikora, T.J., Bull, F.C.L., Jamrozik, K., Knuiman, M., Giles-Corti, B., and Donovan, R.J., Developing a reliable audit instrument to measure the physical environment for physical activity, *American Journal of Preventive Medicine*, 23, 2002, pp. 187-194

[21] Boarnet, M.G., Day, K., Alfonso, M., Forsyth, A., and Oakes, M., The Irvine-Minnesota inventory to measure built environments, Development, *American Journal of Preventive Medicine*, 30, (2006a), pp. 144-152

[22] Boarnet, M.G., Day, K., Alfonso, M., Forsyth, A., and Oakes, M., The Irvine-Minnesota inventory to measure built environments, Reliability Tests, American *Journal of Preventive Medicine*, 30, (2006b), pp. 153-159

[23] Brownson, R.C., Hoehner, C.M., Brennan, L.K., Cook, R.A., Elliot, M.B., and McMullen, K.M., Reliability of two instruments for auditing the environment for physical activity, *Journal of Physical Activity and Health*, 1, 2004, pp. 189-207