

## MEASUREMENT OF USER SATISFACTION IN VERTICAL PEDESTRIAN MOVEMENTS

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**Abstract.** *This research study examines the human relationship with the staircase, the vertical circulation tool, in terms of user satisfaction. In the literature, the lack of papers dealing with user satisfaction in detail within the scope of dimensional competence necessitates this study. The satisfaction values of the stair users and the variables affecting these values, and at the same time, the realisation of the satisfaction analysis of the existing national stairway standards constitute the main objective of the study. For this purpose, 400 user satisfaction surveys were conducted in two different application areas and analysed by Statistical Package for the Social Sciences software. According to the findings of the research, the stairs chosen in the application areas are designed in accordance with national stairway standards. Users expressed their dissatisfaction with normal-to-weak-weighted negative feedback on the variables of visual admiration, dimensional competence, safety and fatigue. Finally, the existence of the relationship between the variables affecting the user satisfaction is examined; recommendations based on user satisfaction for staircases design are offered.*

**Key words:** *Vertical Circulation, Stairs, User Satisfaction, Pedestrian Motion, National Stairway Standards*

### 1. INTRODUCTION

The relationship between human and structured environments, pedestrian movements and social behaviour are examined and expressed especially based on spatial perception [1]. According to Bacon, spaces and environments do not take on significance without time and movement; therefore, they are expected to encourage users activate and excite design elements [2]. The examination of urban space design studies reveals an aim to leave continuous and uninterrupted effects on people who move within the spaces [3].

The concept of pedestrian movement is also important in vertical circulation, which has existed since the beginning of human life. Vertical pedestrian movements are provided by simple staircase examples in primitive life. With today's architecture and technological

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facilities, these movements are provided by systems such as elevators, escalators and ramps. These elements, which provide vertical pedestrian movement with fixed or movable systems, are expected to create positive psychological effects, as well as physical features such as providing the shortest possible and least exhausting connection. Some studies evaluated this question in terms of design and cognition and examined it both in the spaces where the pedestrians move constantly and in the space scale [4]. In other words, these elements are expected to make human movement, especially wayfinding more efficient, which brings satisfaction to the pedestrian [5].

Human-vertical circulation relationships and developments in architecture necessitate user satisfaction in the creation of human-oriented design. However, this consideration is often neglected in architectural elements that are designed to satisfy the human being. Considering this situation, it is necessary to focus on user satisfaction in vertical circulation elements, which are used intensively in daily life. The literature review revealed that user satisfaction was emphasised in the studies on the pedestrian movements. However, a detailed study on user satisfaction in vertical circulation elements was not found.

Stairs have their own basic geometry and rules that depend on the physical characteristics of people. The structure of the stairs should be shaped according to the structure of the human body [6]. Staircases have been designed with consideration for these elements. Over time, the basis of the dimensional measures of the stairs have been preserved and only minor changes have been made for improvements.

Vitruvius stated the ideal dimensions with the temple stairs. According to this example, the riser height should be 23-25.5 cm and the tread widths should be 46-51cm or 1.5-2 step width. Later, different dimensions were determined for more comfortable movement on stairs [6]. While different riser heights and tread widths have been observed in different regions, the balance between these measurements unchanged. From this point of view, some international and national standards in current use are presented in Table 1 and Table 2.

Today, technological advances tend to improve the quality of life by making it easier. These developments have led people to settled and inactive lifestyles that cause health problems. In this context, many exercise behaviours that we perform in daily life are solutions to health problems.

The use of stairs constitutes an example of short, repetitive exercise behaviour. Stair-climbing behaviour, especially against gravity, is considered a strong physical exercise [14]. The importance of the use of stairs as a physical activity is emerging in consideration of the protective role of exercise for many diseases such as cardiovascular diseases, diabetes and cancer [15]. The United States Department of Health and Human Services proposed the increased use of staircases to be one of the 100 life-changing steps against obesity [16].

Experimental studies have been performed to improve the behaviour of stairs and their frequent use in daily life. When the studies were examined, it was observed that users wanted to create behavioural changes through orientation signs, posters, images or texts on the strips. In these studies, visual stimulants were found to have positive effects on increasing the use of stairs [17]. Different commands and clues were frequently used on the stairs to increase stair-climbing behaviour [18]. In a similar study [19] that considered the demands of users, it was suggested the existence of elements such as easy access to the ladder area and aesthetic features improved the stairs and made them more attractive. In another study on university structure, an 8.2% increase in total staircase use was achieved through the aesthetic features of the stairs and visual orientation signs [20]. In another study [21], the use of stairs increased from 27.7% to 31.2% with visual footprint guidance and to 43.6% with the use of health messages. While modern social trends and technologies affect the quality of life, they create an inactive lifestyle with negative health results [22]. The

persuasive negative effects of technology will be reduced by the effect of technology and create a social impact by altering the attitudes and behaviours of people [23]. For this purpose, next to the escalator in Odenplan Metro station in Stockholm, a social staircase design with a musical staircase concept was applied. This design increased the use of stairs by 66%, which led to the development of different social behaviours of users [24].

**Table 1** Comparison of Dimensional Properties of International Stair Standards [7, 8, 9, 10].

	ADA Standards (Americans with Disabilities Act)	BS 5395- 1:2010 (British Standards)	BOCA (Building Officials Code Administrators)	DIN 18065 (Deutsches Institut für Normung)
Riser Height and Tread Widths (cm)	Riser Height: min. 10 cm. max. 18 cm. Tread Widths: min. 28 cm.	Tread Widths: 2R+T= 60 cm.	Riser Height: min. 10 cm. max. 18 cm. Tread Widths: min. 22.8 cm. Suggested Angle: 25 cm. min. 91cm.	Riser Height: min. 14 cm. max. 19 cm. Tread Widths: 2R+T= 59 cm.~ 65 cm. min. 26 cm. max. 37 cm. min. 80cm.
Stair Width (cm)	-	-	-	-
Landing Length (cm)	-	min. 85 cm.	-	-
Angle of Staircase (deg)	-	15° ~ 55° Suggested Angle 42°	-	-
Handrail Height (cm)	86.5 cm. ~ 96.5 cm.	min. 85 cm.	86 cm. ~ 96 cm.	80 cm. ~ 115 cm.
Headroom (cm)	-	min. 200 cm.	min. 203 cm.	min. 200 cm.

**Table 2** Comparison of Dimensional Properties of National (in Turkey) Stair Standards [11, 12, 13].

	Planned Areas Zoning Bylaws	İstanbul Municipality Zoning Bylaws	Ankara Municipality Zoning Bylaws
Riser Height and Tread Widths (cm)	Riser Height: Without elevator: max. 16 cm With elevator: max. 18 cm. Tread Widths: min. 28 cm.	Riser Height: in housing: max. 17 cm. in other structures: max. 16 cm. in outdoor stairs: max. 15 cm. Tread Widths: min. 27 cm. in housing: min. 27 cm. in other structures: min. 29 cm. in outdoor stairs: min. 32 cm.	Riser Height: Without elevator: max. 16 cm With elevator : max. 18 cm. Tread Widths: min. 28 cm. in housing: min. 28 cm. in other structures: min. 30 cm. in outdoor stairs: min. 35 cm.
Stair Width (cm)	in housing: min.120 cm. in other structures: min.150 cm.	in housing: min.120 cm. in other structures: min.150 cm.	in housing: min.120 cm. in other structures: min.150 cm.
Landing Length (cm)	in housing; min.120 cm. in other structures; min.150 cm.	in Housing; min.120 cm.	in Housing; min.120 cm.
Angle of Staircase (deg)	-	-	-
Handrail Height (cm)	number of steps >5; 90 cm	number of steps >5; 90 cm	number of steps >5; 90 cm
Headroom (cm)	-	-	min. 210 cm.

## 2. METHOD

In this part of the study, the relationship between the stairs and the user satisfaction of the vertical circulation elements was evaluated.

As a first step, field observations were made in the designated area. Dimensional properties of the stairs on the two selected application areas were determined and compared to national and international stairway standards. Surveys were conducted to measure user satisfaction and perform statistical analysis of the collected data. These questionnaires, with 11 Likert types and 2 multiple-choice questions, aim to determine the level, dimensional competence and safety of the stairs. Finally, the completed current survey data underwent regression and correlation analysis with the SPSS 19 programme. The data were examined for answers to the following hypotheses:

- There is a positive relationship between the dimensional properties of the stairs and the users' feeling of fatigue.
- There is not a relationship between the gender of the user and the safety of the stairs.
- There is a positive relationship between the dimensional properties of the stairs and the aesthetic-visual appreciation.
- There is a relationship between the aesthetic-visual appreciation of the stairs and the user's gender.

### 2.1. Case Study

Suleyman Demirel University's central campus was chosen for this field study. As a result of the preliminary observations, two vertical circulation areas with intensive use within the central campus of SDU boundaries and dimensional characteristics of the areas were determined.

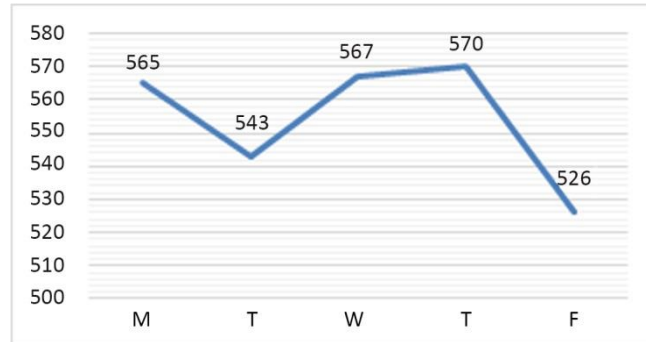
#### 2.1.1. West Campus- Application Area A

The selected area of application on the SDU West Campus is on an important pedestrian axis (Figure 1) and serves a large part of the West Campus (rectorate building, student affairs office and most engineering structures). The application area was observed for five days in April, 2017. Preliminary observations indicated that the lowest pedestrian intensity in the application area was between 14.30 and 15.30 and the maximum pedestrian intensity was between 16.30 and 17.30, as presented in Tables 3a and 3b.

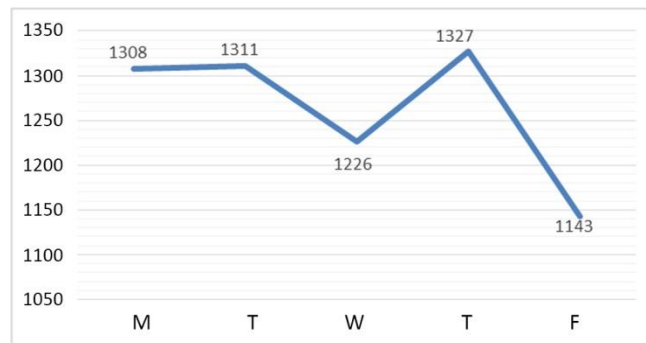


**Fig. 1** West Campus- Application Area A

**Table 3a** Application Area - A 14.30-15.30 Pedestrian Density Analysis



**Table 3b** Application Area - A 16.30-17.30 Pedestrian Density Analysis



The staircase in the application area consists of 50 steps. The stairway has the same size and 17 cm riser height in each step. Tread widths are 30 cm and 32 cm. The width of the stairs continues to be 5 m until the last eight steps, at which it decreases to 3 m. The staircase has 24 landings with an irregular distribution of 290-300 cm in width. Handrail heights are 75 cm.

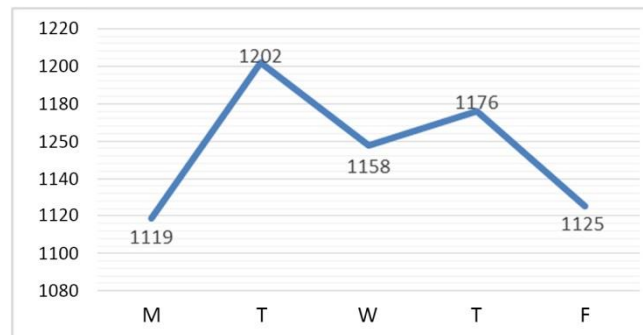
*2.1.2. East Campus- Application Area B*

The selected application area on the SDU East Campus is on a pedestrian axis with intensive use (Figure 2). This axis is a continuation of the bridge connecting the West Campus and the East Campus and serves a large part of the East Campus (library and central classrooms structure). The application area was observed for five days in April, 2017. Preliminary observations indicated that the lowest pedestrian intensity in the application area was between 10.30 and 11.30 and the maximum pedestrian intensity was between 08.30 and 09.30, as presented in Tables 4a and 4b.

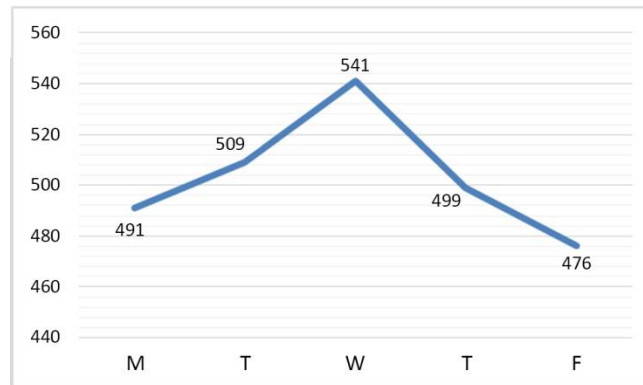


**Fig. 2** East Campus- Application Area B

**Table 4a** Application Area - B 08.30-09.30 Pedestrian Density Analysis



**Table 4b** Application Area – B 10.30-11.30 Pedestrian Density Analysis



The staircase in the application area consists of 56 steps. The riser height of stairs is 17 cm, with the exception of the last 17 steps, which are to 14 cm. Tread widths are 38 cm. The width of the stairs is 4 m. The staircase has 15 landings with an irregular distribution of 175-210 cm in width. Handrail heights are 75 cm.

## 2.2. User Satisfaction Survey

The vertical circulation satisfaction survey begins with questions about gender, age and education level in order to determine the demographic characteristics of the users. These questionnaires, with 11 Likert types and 2 multiple-choice questions, aim to determine the level, dimensional competence and safety of the stairs.

The survey was separately performed for the SDU West Campus application area A and the SDU East Campus application area B. Analysis studies were conducted for each application area.

### 2.2.1. West Campus- Application Area A

The vertical circulation satisfaction questionnaire was completed by 200 users. Of these participants, 193 volunteers were valid and seven volunteers were considered invalid. The sample group consisted of 90 men and 103 women. This group has an average age of 21.33 years. In addition, Cronbach's alpha value was determined as 0.819 as a result of a reliability analysis performed on the feedback surveys.

### 2.2.2. East Campus- Application Area B

The vertical circulation satisfaction questionnaire was completed by 200 users. Of these participants, 185 volunteers were valid and 15 volunteers were considered invalid. The sample group consisted of 91 men and 94 women. This group has an average age of 21.85 years. In addition, Cronbach's alpha value was determined as 0.833 as a result of a reliability analysis performed on the feedback surveys.

## 3. RESULTS

In this study, the factors affecting the satisfaction of the stairs were examined and analysed. In the first stage, national and international staircase standards were examined and property dimensions such as stair width, riser height and tread width were obtained.

- The maximum value of the riser height of the stair is approximately 18 cm depending on the area characteristics in compliance with national and international standards.
- The minimum value of the tread width is 28 cm by national standards; by contrast, different minimum values of the tread width are accepted by international standards.
- National standards set the minimum value of the stair width as 120 cm for residential buildings and 150 cm for other buildings; by contrast, the minimum value of the stair width is 91 cm by Boca Standards (1995) and 80 cm by DIN 18065 (2015).
- Handrail height is specified as 90 cm by national standards. International standards set handrail height between 85 cm and 96.5 cm.
- There is not enough data to compare the national and international standards for headroom, landing length and staircase angle.

The properties of the two different staircases were evaluated according to the above-mentioned standards. The evaluation results are as follows:

- Riser heights are 17 cm in application area A, whereas riser heights are 14-17 cm in application area B. These values are compatible with national stairway standards.
- Tread widths are 30-32 cm in application area A, whereas tread widths are 38 cm in application area B. These values are partially compatible with national stair standards.

- Stair widths are 5 m in application area A, whereas stair widths are 4m in application area B. These values are compatible with national stairway standards.
- The handrail heights, measuring at 75 cm in both application areas, are compatible with national stairway standards.

### 3.1. Application Area A Survey Results

- The stairs were deemed visually and aesthetically poor by 37.8% of participants.
- The majority of participants found the adequacy of the dimensional properties of the stairs fair (31.6%) or poor (42.5%).
- The riser heights were described as fair by 40.9% and satisfactory by 29.5% of participants.
- Participants characterised the tread widths as dimensionally wide (40.4%) and fair (26.4%).
- The stair widths were described as dimensionally wide by 49.2% of participants.
- Most participants rated the safety of the stairs as fair (38.3%) or good (satisfactory) (33.2%).
- Feelings of fatigue after completing between 11 and 20 steps during stair ascent and descent were reported by 25.9% of participants. Feelings of fatigue were reported by 67.3% of participants at the ascent midpoint.

According to the above-mentioned survey values, it is observed that user satisfaction with the staircase is insufficient. In addition, it is thought that the variability of the dimensional properties between steps of the staircase contributes to user dissatisfaction.

### 3.2. Correlation Analysis for Application Area A

The correlation value between the gender of the user and the aesthetic and visual appreciation of the stairs was determined as 0.099 (Table 5). This value indicates that there is an extremely weak relationship or no relationship between the two variables.

**Table 5** The relationship between of gender- aesthetics and visual appreciation

		gender	appreciation
	Pearson Correlation	1	,099
gender	Sig. (2-tailed)		,170
	N	193	193

The correlation value between the dimensional properties of the stairs and user fatigue was determined as 0.690 (Table 6). This value indicates that there is a positive and high degree of relationship between the two variables.

**Table 6** The relationship between of dimensional properties of stair and user fatigue

		dimensional properties	user fatigue
	Pearson Correlation	1	,690
dimensional properties	Sig. (2-tailed)		,000
	N	193	193



The correlation value between the gender of the user and the safety of the stairs was determined as 0.038 (Table 7). This value indicates that there is an extremely weak relationship or no relationship between the two variables.

**Table 7** The relationship between of the gender of the user and safety of the stairs

		gender	safety of the stairs
gender	Pearson Correlation	1	,038
	Sig. (2-tailed)		,602
	N	193	193

The correlation value between the dimensional properties of the stairs and the aesthetic and visual appreciation of the stairs was determined as 0.539 (Table 8). This value indicates that there is an extremely weak relationship or no relationship between the two variables.

**Table 8** The relationship between of dimensional properties of stair and the aesthetic and visual appreciation of the stair

		Dimensional Properties of Stair	appreciation
Dimensional Properties of Stair	Pearson Correlation	1	,539
	Sig. (2-tailed)		,000
	N	193	193

### 3.3. Application Area B Survey Results

- The stairs were deemed visually and aesthetically poor by 37.8% of participants same as area A.
- The majority of participants found the adequacy of the dimensional properties of the stairs fair ( 49.7%) or poor (28.1%).
- The riser heights were described as fair by 44.9% and satisfactory by 28.1% of participants.
- Participants characterised the tread widths as dimensionally wide (42.2%) and fair (35.1%).
- The stair widths were described as dimensionally wide by 37.8% of participants.
- Most participants rated the safety of the stairs as fair (37.8%) or well (satisfactory) (31.9%).
- Feelings of fatigue were reported by 27.0% of participants after completing between 11 and 20 steps during stair ascent and descent. Feelings of fatigue were reported by 70.0% of participants at the ascent midpoint.

### 3.4. Correlation Analysis for Application Area B

The correlation value between the gender of the user and the aesthetic and visual appreciation of the stairs was determined as 0.035 (Table 9). This value indicates that there is an extremely weak relationship or no relationship between the two variables.

**Table 9** The relationship between of gender- aesthetics and visual appreciation

		gender	appreciation
gender	Pearson Correlation	1	,035
	Sig. (2-tailed)		,220
	N	185	185

The correlation value between the dimensional properties of the stairs and user fatigue was determined as 0.623 (Table 10). This value indicates that there is a positive and high degree of relationship between the two variables.

**Table 10** The relationship between of dimensional properties of stair and user fatigue

		dimensional properties	user fatigue
dimensional properties	Pearson Correlation	1	,623
	Sig. (2-tailed)		,000
	N	185	185

The correlation value between the gender of the user and the safety of the stairs was determined as 0,019 (Table 11). This value indicates that there is an extremely weak relationship or no relationship between the two variables.

**Table 11** The relationship between of the gender of the user and safety of the stairs

		gender	safety of the stairs
gender	Pearson Correlation	1	,019
	Sig. (2-tailed)		,794
	N	185	185

The correlation value between the dimensional properties of the stairs and the aesthetic and visual appreciation of the stairs was determined as 0.558 (Table 12). This value indicates that there is an extremely weak relationship or no relationship between the two variables.

**Table 12** The relationship between of dimensional properties of stair and the aesthetic and visual appreciation of the stair

		Dimensional Properties of Stair	appreciation
Dimensional Properties of Stair	Pearson Correlation	1	,558
	Sig. (2-tailed)		,000
	N	185	185

#### 4. CONCLUSIONS AND RECOMMENDATIONS

People prefer to use escalators and elevators to stairs as vertical circulation tools. Stair-climbing is exhausting and requires effort. Current studies to increase the use of stairs have been insufficient in increasing usage preference and lasting user satisfaction due to the lack of examination of the dimensional deficiencies that cause fatigue.

Based on the effects of the dimensional properties of the stairs on user satisfaction, the dimensional standards determined by the different societies were examined. These standards, which should be determined depending on the anthropometric dimensions of people, generally have close values. It is a universal problem for societies with anthropometric differences to use similar stair standards. Therefore, a field study was conducted considering Turkish stair standards. Although the selected areas are in line with the Turkish stair standards, they are inadequate in terms of user satisfaction. Their dimensional inadequacies have been specifically mentioned by the users. This indicates that the existing Turkish stairway standards do not comply with the national anthropometric structure and that similar results may arise on different country standards.

The study findings result in the following recommendations:

- Attempt to increase stair user satisfaction by focusing on dimensional competence rather than visual and aesthetic aspects, contrary to studies in the literature.
- Discuss and improve existing stairway standards by examining the anthropometric dimensions of societies within the scope of dimensional competence.
- Perform the necessary dimensional improvements to ensure user satisfaction on existing stairways.

These recommendations are the basis for future work. These changes will remove the tiring, frightening and unhealthy aspects of vertical pedestrian movement for users. Making the use of stairs exciting and safe will permanently increase their use.

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#### APPENDIX - 1 USER SATISFACTION SURVEY

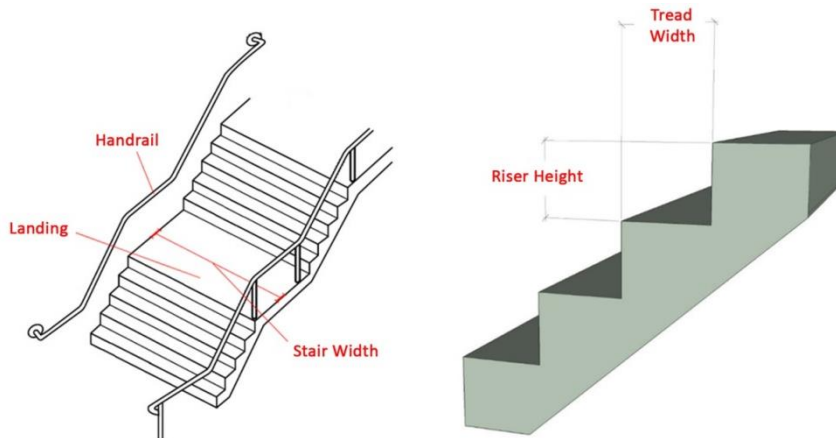
Gender: Female

Male

Age:

Level of Education / Occupation:

#### Sample stairs and definitions



Please answer the following questions related to the staircase of the campus where you live and are using approximately everyday. (1\*2\*3\*4\*5)

1. Please evaluate of the design of stair aesthetically.

Very poor ① Poor ② Fair ③ Good ④ Excellent ⑤

2. Please evaluate of the functionality and comfort of stair.

Very poor ① Poor ② Fair ③ Good ④ Excellent ⑤

3. Please evaluate of the dimensional competence of stair.

Very poor ① Poor ② Fair ③ Good ④ Excellent ⑤

4. Please evaluate of the riser height of stair. (Low: very poor, high: excellent)

Very poor ① Poor ② Fair ③ Good ④ Excellent ⑤

5. Please evaluate of the tread width of stair. (Narrow: very poor, wide: excellent)

Very poor ① Poor ② Fair ③ Good ④ Excellent ⑤

6. Please evaluate of the stair width. (Narrow: very poor, wide: excellent)

Very poor ① Poor ② Fair ③ Good ④ Excellent ⑤

7. Please evaluate safety of the stair.

Very poor ① Poor ② Fair ③ Good ④ Excellent ⑤

8. If you do not think the stairs safe, please state your opinion on the reason.

- Stair has many slope
- Stair has different riser heights and tread widths
- The stair does not have enough lighting
- The stair does not have enough handrail heights
- Other reasons.....

9. Please evaluate visual liking of the stair.

Very poor ① Poor ② Fair ③ Good ④ Excellent ⑤

10. If you don't like the stair visually, please give your opinion on the solutions.

- Different railing designs can be selected.
- Landscaping can be differentiated.
- Different stair designs can be selected.
- Another opinion.....

11. Which vertical circulation tool do you prefer instead of stair?

Elevator  Escalator  Ramp  Another .....

12. Are you tired of ascent - descent?

Yes  No

13. Which steps are you getting tired at?

- 0-10
- 11-20
- 21-30
- 31-40
- 41-50

## **MERENJE ZADOVOLJSTVA KORISNIKA VERTIKALNIM KOMUNIKACIJAMA ZA PEŠAKE**

*Ovo istraživanje ispituje odnos ljudi i stepeništa, koje je instrument za vertikalnu komunikaciju, u smislu zadovoljstva korisnika. U literaturi je malo radova koji se detaljno bave zadovoljstvom korisnika pravilnim dimenzionisanjem, što je bilo povod za ovu studiju. Vrednosti zadovoljstva korisnika stepeništa i promenljive koje utiču na ove vrednosti, i sa druge strane analiza zadovoljstva korisnika postojećim nacionalnim standardima za stepeništa čine glavni cilj ove studije. U tom cilju je anketirano 400 korisnika u dva rejonu i ankete su analizirane korišćenjem Statističkog paketa softvera Društvenih nauka. Prema nalazima istraživanja, odabrane stepenice u datim rejonima su projektovane u skladu sa nacionalnim standardima za stepenište. Korisnici su izrazili svoje nezadovoljstvo i dali normalno do slabo ponderisanu negativnu povratnu informaciju o promenljivima kao što su vizuelno dopadanje, pravilno dimenzionisanje, bezbednost i zamor. Konačno, ispituje se postojanje odnosa između promenljivih koje utiču na zadovoljstvo korisnika; daju se preporuke zasnovane na zadovoljstvu korisnika stepeništima.*

*Ključne reči: vertikalna komunikacija, stepenište, zadovoljstvo korisnika, kretanje pešaka, nacionalni standardi za stepeništa*