Evacuation models of the future: Insights from an online survey on user's experiences and needs

Ronchi, Enrico; Kinsey, Michael

Published in:
Proceedings of the Advanced Research Workshop: "Evacuation and Human Behaviour in Emergency Situations"

2011

Evacuation models of the future: insights from an online survey of user's experiences and needs

Ronchi, E. [1]; Kinsey M.J. [2]
[1] Department of Roads and Transportation. Polytechnic University of Bari, Via Orabona 4, 70100 Bari (BA), Italy, enronc@poliba.it
[2] Fire Safety Engineering Group (FSEG), University of Greenwich, London SE10 9LS, UK, m.j.kinsey@greenwich.ac.uk

ABSTRACT

This paper presents a summary analysis of data regarding evacuation model user's experiences and needs obtained via an online survey. The survey was available in 6 languages: English, German, Chinese, Spanish, Italian and Russian. The different versions allowed the survey to be accessible to an international participant base. The survey was developed by the team at www.Evacmod.net; an evacuation modelling portal for the simulation of human behaviour during emergency situations. Participant responses to the survey in raw data format will be publicly available from the portal to allow model developers/users or any interested parties to analyse the data. In total 198 participants either fully or partially completed the survey. Participants came from some 36 different countries, from a wide range of different education and occupational backgrounds, and used models for a variety of different purposes. The survey consisted of 16 questions addressing issues including perception of importance of model features, usage/awareness of other models, knowledge of model validation/verification, training, and usage of multiple models. The presented analysis provides information for evacuation model developers of user characteristics and subsequent guidance for instructing future model development.

1 INTRODUCTION

The understanding of human behaviour in fire has received more research interest during latter half of the 20th century. In parallel, the development of fire safety building codes [1] has required engineers to demonstrate buildings conform to an increasing number of fire safety requirements. As part of this, analytical people flow calculations were traditionally adequate to demonstrate a structures evacuation capability. However, the development of ever unique and complex structures has meant it is not always possible to assess certain structures using such calculations [2]. This has fuelled the development and usage of computer based evacuation models to explore the potential influence of human factors during unique/complex emergency situations [3,4].

The use of computers to simulate emergency evacuations can be traced back to the 1970s [5]. Since then a number of evacuation models have been developed with a range of different features [6,7]. Indeed evacuation model capabilities [8,9], scrutiny [10,11] and validation [12,13] have been the focus of a large a number of research papers in the last two decades.

However, whilst evacuation models are increasing in complexity [14] as understanding of human behaviour in fire progresses, there is a lack of understanding regarding evacuation model user experiences and needs of such models.

To address the above issues and attempt to gain a better understanding of the current uses and desired needs of the evacuation modelling community, an online survey was developed. The survey was developed by the team at www.Evacmod.net; an evacuation modelling portal for the simulation of human behaviour during emergency situations. On the website, students, fire safety engineers, software engineers, behavioural scientists, researchers or any interested parties can communicate and share their knowledge and experience in this field. The use of a publicly accessible online survey was intended to reach as wide as international audience as possible coming from a broad variety of different backgrounds.

The first part of the paper presents a description of the survey and the reason why the questions have been selected. The methods of dissemination have been described in order to demonstrate that the sample population is representative of the general evacuation user modelling community. Participant demographic and characteristics are presented in the following section. These have been described in order to highlight how evacuation models are currently being utilised. Participants were required to provide information about their experiences and degree of knowledge of various aspects regarding evacuation models e.g. model validation, training, model awareness etc. Limitations of the survey have been described together with future possible improvements for data collection. Overall conclusions based on the analysis of participant responses are then presented. Such analysis is intended to assist future development of evacuation models.

2 SURVEY DESCRIPTION

The survey was made available in six languages, English, German, Chinese, Spanish, Italian and Russian. The different versions allowed the survey to be accessible to an international participant base. The methods of dissemination have been various in order to achieve a relevant number of participants belonging to different areas of expertise that use different models. The dissemination of the survey has been conducted in collaboration with a range of model developers. In addition, several online forums have been used that are either dedicated or associated with using such models. These include newsletters, mailing lists, forums, and social networking sites. The call for participation to complete the online survey started in January 2011 and ended in June 2011 over a period of six months.

The survey consisted of 16 questions divided in to two sections and required approximately 15 minutes to complete. The first section (Background and Interests) required information about participants' characteristics and demographics. Information on participant nationality, academic background, position and working area were investigated. Questions regarding types of application, uses and years of experience with the models were included.

The second section (Needs and Experiences) addressed several issues including user perception of importance of model features, usage/awareness of other models, knowledge of model validation/verification, model training, and usage of multiple models.

2 PARTICIPANT CHARACTERISTICS AND DEMOGRAPHICS

In total 198 participants either fully or partially completed the survey. Almost all participants (94% (186)) stated their country of residence. Whilst participants came from some 36 different countries, approximately 40.4% of participants came from three countries including the UK (15.7%), Germany (14.6%) and U.S (10.1%) (see Figure 1).

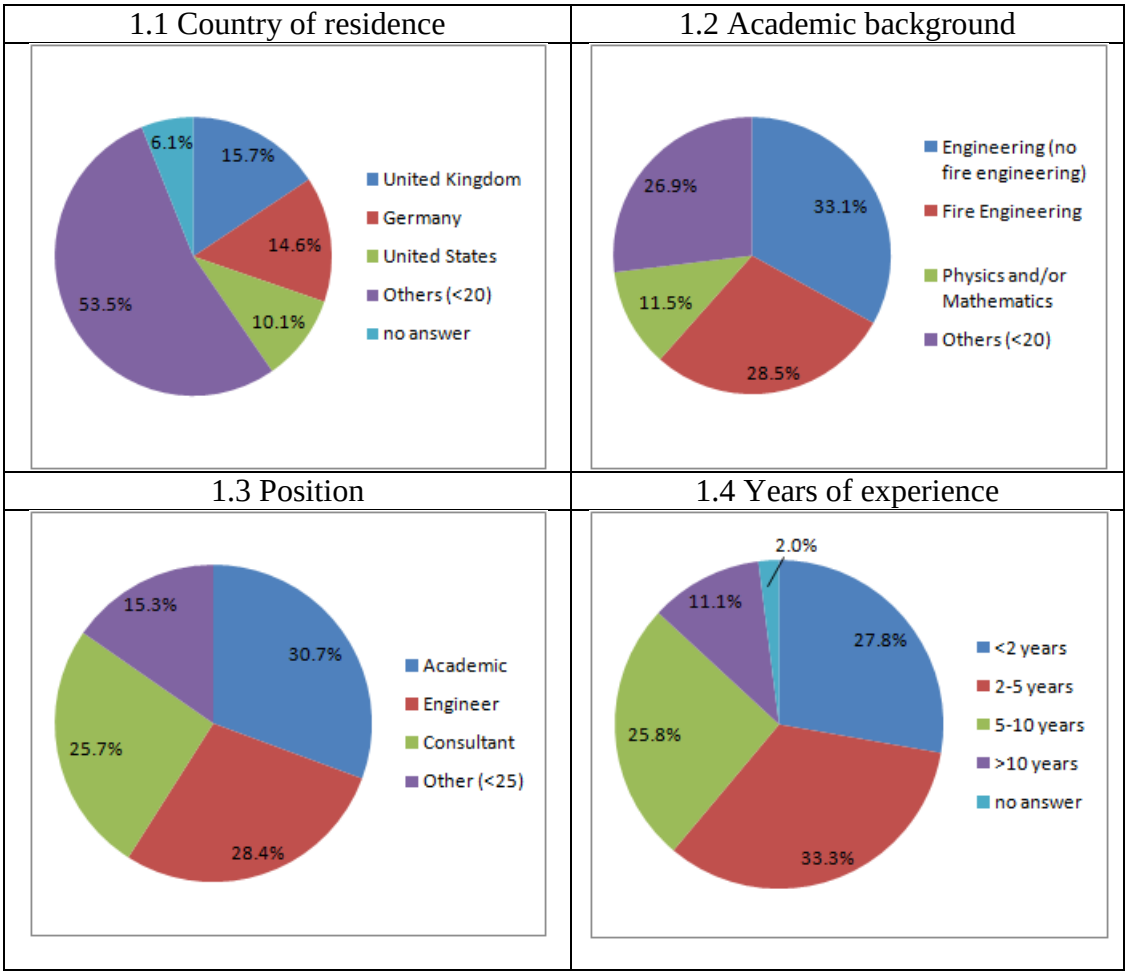

Figure 1: Country of residence (1.1), academic background (1.2), position (1.3 - both considering single and multiple backgrounds), and current working area (1.4) of the survey participants.

Focusing on the academic background of participants, 61.6% came from engineering backgrounds. The majority of participants stated that their current occupation was either in academia (30.7%) or engineering (28.4%) (see Figure 1). From Figure 1 it can also be seen that the majority of participants (61.1%) had less than 5 years experience using evacuation models.

Participants were asked to rate on a 5 point Likert scale the extent to which they use models in different contexts (5 = main context and 1= not at all). Almost two thirds of participants (64.0%) responded that they mainly used models within an evacuation context with just over a third (35.8%) using the models for research/testing (see Table 1).

Score	Evacuation (%)	Large-scale events (%)	Pedestrian planning in normal conditions (%)	Research /testing (%)
5 (main context)	64.0	19.1	16.6	35.8
4	13.2	19.7	14.2	16.5
3	10.2	18.5	15.4	13.6
2	6.1	20.2	14.2	15.3
1 (not at all)	6.6	22.5	39.6	18.8

Table 1: Proportion of responses that stated is of context for using models.

Participants were asked how frequently they used evacuation models. From Table 2 it can be seen that the majority of participants (64.6%) use evacuation models at least once a month. This decreases to approximately a third (33.8%) for participants that use evacuation models at least once a week.

Frequency	Proportion (%)
Less than once a year	6.1 [21]
At least once a year	93.9 [186]
At least once a month	64.6 [128]
At least once a week	33.8 [67]
Several days a week	17.7 [35]

Table 2: Frequency of use of evacuation models.

The data collected represents participants from a wide variety of different countries, backgrounds and experiences with different models. With such a diverse sample of participants it is hoped the general applicability of the results is increased.

3 RESULTS

Participants were presented with a list of factors related to evacuation models. They were asked to state how important they thought each factor was when selecting/using a model based on a 5 point Likert scale (5= very important and 1= not important). The overall frequency of participants that stated the level of importance for each factor can be seen in Figure 2 (N=167).

All scores were averaged for each factor then placed in order (the higher the value the more important the factor). A Wilcoxon Signed-Rank test was used to determine if any significant difference existed between factors so that each factor could be given an ordinal value of importance (see blue box values in Figure 2) relative to the other factors.

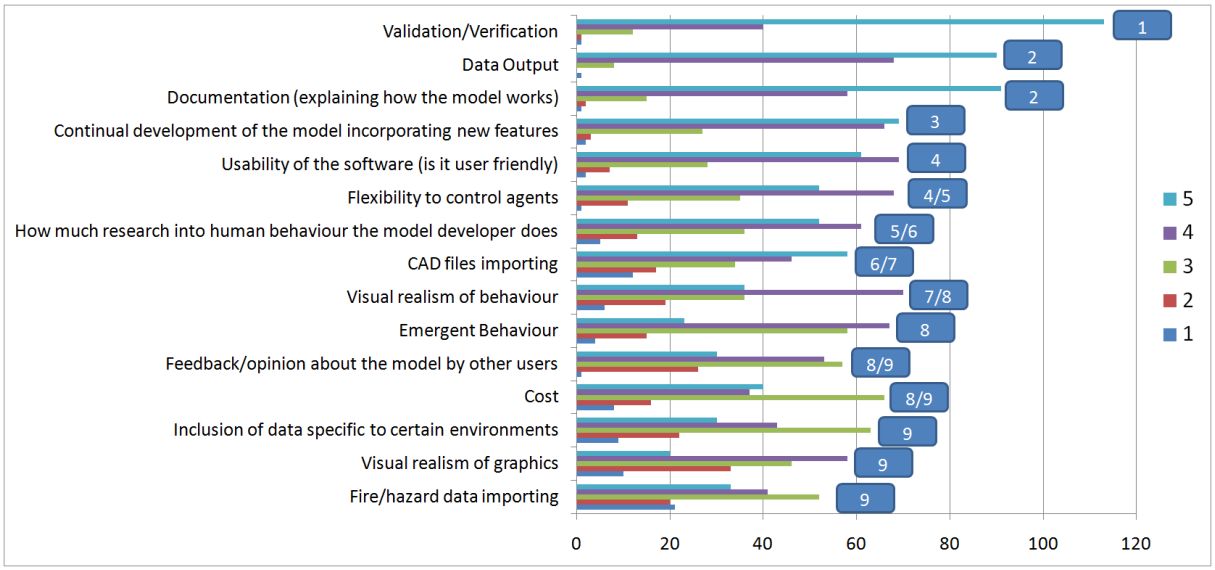

Figure 2: Frequency of participants that stated the level of importance for each factor when selecting/using a model (5= very important, 1= not important). Blue square value indicates overall relative order of importance e.g. 1= most important, 2= second most important etc.

Overall results show that participants considered validation/verification to be the most important factor when selecting/using a model, closely followed by documentation (explaining how model works) and data output options of the model. Such findings suggest that model users require assurances that a model produces accurate results. Demonstrating a model's predictive capabilities by comparing model results to data collected from actual evacuation/experimental/normal situations is of considerable importance to model users. Similarly, detailed documentation explaining how a model functions with the data used in the model contributes to reducing user uncertainty of how a model functions.

Participants were asked what models there were aware of (N=191). The majority had an awareness of EXODUS (66.5%), FDS+Evac (58.1%), and Simulex (57.6%), with just under half also being aware of STEPS (45.5%) and Pathfinder (40.8%). It is unclear whether model awareness is reflective of the success of a model's marketing, increased number of publications associated with a given model, increased age of a model, the method of survey dissemination favoring certain model users, or general popularity of a model. In addition to stating the models that participants were aware of, participants were also asked what model they mainly used (N=198). Over half of participants mainly used one of six models including Simulex (13.6%), FDS+Evac (12.6%), VISSIM (8.6%), STEPS (7.1%), Pathfinder (6.6%), and EXODUS (5.6%) (see Figure 3).

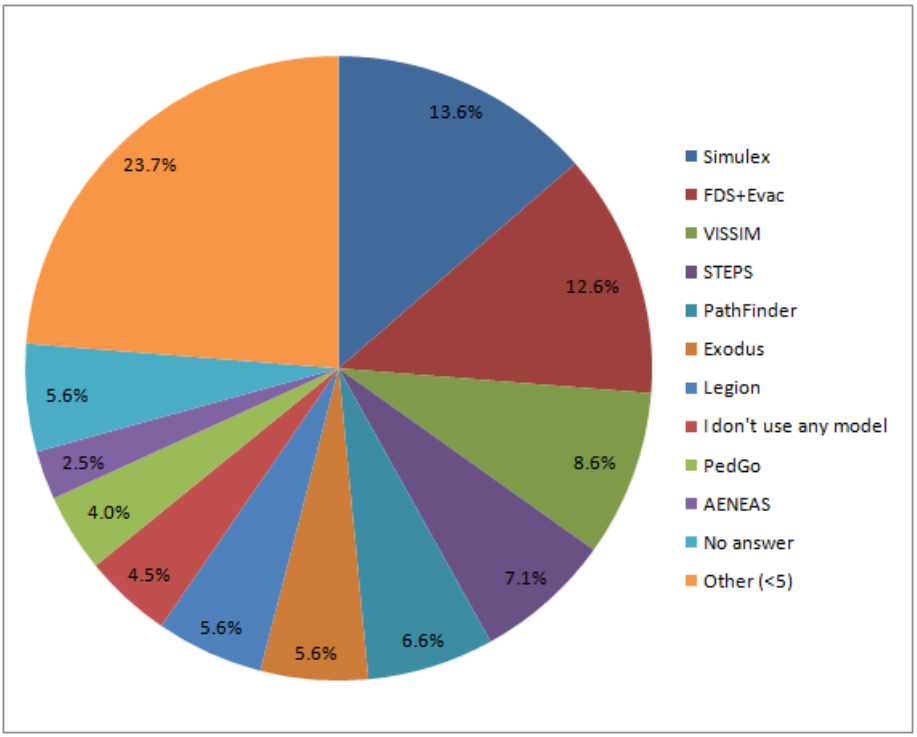

Figure 3: Proportion of participants that mainly use a given model.

Focusing on the top 7 models according to frequency of participants (i.e. ≥10 participants), user responses were separated for the question asking how important different factors were when selecting/using a model (N=170). The scores were averaged for each factor for each model then placed in order. The higher the average score the more important users of a certain model thought a given factor was (see Table 3). It should be highlighted that such results reflect participant perception rather than a models actual success of addressing each factor.

The results highlight that participants believe each model addresses each factor to a different extent. The results also suggest factors that specific model developers might consider advantageous for future model development.

It should be kept in mind that such factors may not have been considered by participants when selecting/using their current model. In such incidences, participants may adopt 'confirmation bias' behavior where they state higher importance of certain factors that they know their model addresses i.e. justifying their selection. A similar issue may have occurred with model developers themselves completing the survey. Potential issues like these should be considered when interpreting the results.

	Ordinal Rank (1= more important, 7=less important)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Cost	FDS+Evac	Legion	Exodus	STEPS	Pathfinder	VISSIM	Simulex
Validation/Verification	FDS+Evac	Legion	STEPS	Pathfinder	Exodus	Simulex	VISSIM
Usability of the software (is it user friendly)	Exodus	Pathfinder	STEPS	Simulex	FDS+Evac	Legion	VISSIM
Emergent Behaviour	Exodus	FDS+Evac	Pathfinder	Simulex	Legion	VISSIM	STEPS
Fire/hazard data importing	FDS+Evac	Exodus	Pathfinder	Simulex	STEPS	Legion	VISSIM
CAD files importing	STEPS	Legion	Pathfinder	Exodus	Simulex	FDS+Evac	VISSIM
Inclusion of data specific to certain environments	Legion	VISSIM	Simulex	Exodus	Pathfinder	FDS+Evac	STEPS
Visual realism of behaviour	Legion	STEPS	Pathfinder	VISSIM	Exodus	FDS+Evac	Simulex
Visual realism of graphics	Legion	Pathfinder	STEPS	VISSIM	Simulex	Exodus	FDS+Evac
Flexibility to control agents	STEPS	Exodus	Legion	VISSIM	Simulex	Pathfinder	FDS+Evac
Documentation (explaining how the model works)	STEPS	FDS+Evac	Pathfinder	Exodus	Legion	Simulex	VISSIM
How much research into human behaviour the model developer does	Exodus	Legion	FDS+Evac	VISSIM	Pathfinder	STEPS	Simulex
Data Output	STEPS	Legion	Exodus	Simulex	FDS+Evac	Pathfinder	VISSIM
Feedback/opinion about the model by other users	Legion	FDS+Evac	Simulex	Pathfinder	VISSIM	STEPS	Exodus
Continual development of the model incorporating new features	Legion	FDS+Evac	Pathfinder	Simulex	VISSIM	STEPS	Exodus

Table 3: Ordinal rank of importance for each factor stated by users of each model

Participants were requested to state their level of knowledge regarding validation/verification of the model that they mainly use (N=196). Only 6.1% of participants stated that they had no knowledge of model validation/verification. This means that 93.9% of model users have some knowledge of validation/verification of their model. Indeed 80.1% stated that they had either read literature regarding model validation/verification or both read literature and compared the model with modelled/actual data.

Only 10.6% of participants stated they have an agreement with a model developer for using only one model. This highlights that most model developers actually have a choice of which model to use and are not contractually obliged to use a single model. Such agreements provide financial benefit to model developers. However, restricting user model choice is considered to have an ultimate negative impact on the field by prohibiting the use of other model's that may better suit a user's needs.

Just over a third (33.7%) of participants stated that they have previously used a different model to the one they currently use. This indicates that most model users have not used more than one model. Though the reasons for this behavior are uncertain, such findings suggest either increased model loyalty, increased model familiarity, lack of awareness of other models, or contractual agreement to use a model.

5 LIMITATIONS

The survey has a number of limitations that should be noted. These include:

Dissemination by model developers. As previously mentioned, a small number of model developers have assisted with dissemination of the survey by sending the survey to their users. However, a number of model developers did not respond to the invitation to take part in the survey. This could mean that users of certain models, and their subsequent experiences and needs, are underrepresented in the survey results. Future data collection should perhaps look to address this issue with more collaboration with model developers.

Publicly availability. The survey was publicly accessible. Consequently it was prone to participants perusing through the survey without completing any questions. Another issue was the potential for abuse in the survey (e.g. people completing the survey with malicious intent). Each participant's computer IP address and time stamp were recorded in order to minimise the potential of malicious intent, thus influencing the final analysis. If an IP address occurred multiple times, such responses were analysed to ascertain whether or not the answers provided appeared malicious. Despite this only a single participant response was identified as being malicious.

Likert scale. The use of a Likert scale allows participants to state a finite level of difference between the importance of given factors (i.e. a limited variance). Future data collection could address this by using continuous numerical scale with no bounds to more accurately represent any difference between levels of importance between factors.

Such survey limitations should be considered when interpreting or applying the results in any context. Indeed further investigations should look to address such issues.

6 CONCLUSIONS

This paper has presented an analysis of data from an online survey in order to gain an understanding of evacuation model users' experiences and needs.

Results have shown that model users consider validation/verification to be the most important factor when selecting/using a model. This is highlighted by 93.9% of participants having some knowledge of validation/verification regarding the model they mainly use. This factor is closely followed in the importance scale by model data output options and documentation explaining how a model works. It is suggested that the results highlight the increased complexity of evacuation models and the subsequent assurances required regarding the accuracy of model results.

It is clear that model users require assurances regarding the predictive capabilities and how they are implemented within a model. The authors suggest that this can achieved through greater transparency with regards to algorithms, assumptions, and data incorporated into evacuation models.

The majority of participants only use evacuation models at least once a month. Such infrequent usage suggests the ease of use and familiarity with a model is an important factor. This is highlighted by the usability of software being ranked 4th in terms of importance when selection/using a model. Addressing such factors would decrease the time required to perform evacuation analysis and therefore would likely have cost saving benefits.

Results also suggest that many model users are unaware of other models and subsequently their capabilities. This lack of awareness inhibits informed model selection. To help address this issue the team at www.Evacmod.net has developed a Model Directory in collaboration with Erica Kuligowski at NIST based on a review of evacuation models [2]. This project allows model developers to provide up to date information about models on the site themselves. This provides a central resource for existing and potential future model users to find out more information about each model. Indeed the team at www.Evacmod.net would like to urge any model developers that are not already taking part to join the project.

Both existing and potentially new model users can use the presented analysis for assessing criteria that should be considered when selecting/using an evacuation model. In addition, the analysis provides model developers with a general insight of users' needs and experiences for a variety of different model users. It is hoped this in turn provides guidance for the focus of future model development. To facilitate such aims, participant responses have been made publicly available on www.Evacmod.net (see http://www.evacmod.net/?q=node/2574) for third party analysis.

Future analysis of the survey results should perhaps seek to segregate the data according to participant specific factors. Of particular interest may be segregation according to the main models participant use, years of experience, and context of model usage.

ACKNOWLEDGMENTS

The authors thank the model developers and other individuals that have contributed to the dissemination, including Hubert Klüpfel, Andrey Skochilov, Tobias Kretz, and Steve Gwynne. Furthermore we would like to thank all the survey participants.

REFERENCES

1. Di Nenno, P., SFPE Handbook of Fire Protection Engineering 3rd edition, 2008, National Fire Protection Association, Quincy, Massachusetts.

2. Kuligowski, E. D., Peacock, R. D., Hoskins, B.L., A Review of Building Evacuation Models 2nd edition, 2010, NIST, Fire Research Division, Technical Note 1680.
3. Thompson, P. A. & Marchant, E. W., A computer model for the evacuation of large building populations. *Fire Safety Journal*, 24, 1995, pp 131-48.
4. Gwynne, S., Galea, E.R., Lawrence, P.J. , Filippidis, L. Modelling occupant interaction with fire conditions using the buildingEXODUS evacuation model, *Fire Safety Journal*, 36, 2001, pp. 327-357.
5. Bazjanac, V., Simulation of elevator performance in high-rise buildings under conditions of emergency , *Human Response to Tall Buildings*, 1977, pp- 316-328.
6. Santos, G., Benigno Aguirre E., A Critical Review of Emergency Evacuation Simulation Models, Proceedings of the NIST Workshop on Building Occupant Movement during Fire Emergencies, 2004.
7. Gwynne, S., Galea, E.R., Lawrence P.J., Owen, M., and Filippidis, L., A Review of the Methodologies used in the Computer Simulation of Evacuation from the Built Environment. *Building and Environment*, 34, 1999, pp. 741-749.
8. Lord, J., Meacham, B., Moore, A., Fahy, R., Proulx, G., Guide for evaluating the predictive capabilities of computer egress models, 2005, NIST Report GCR 06-886.
9. Castle, C. J. E., Guidelines for Assessing Pedestrian Evacuation Software Applications, 2007, Centre for Advanced Spatial Analysis University College London. Paper 115.
10. Ronchi, E., Alvear, D. Berloco, N., Capote, J. Colonna, P., Cuesta, A.: Human Behaviour in Road Tunnel Fires: Comparison between Egress Models (FDS+Evac, STEPS, Pathfinder), Proceedings of Interflam2010, 2010, pp. 837-848 Nottingham, UK.
11. Tavares R. M., Evacuation processes versus evacuation models: “Quo Vadimus?”, *Fire Technology*, 2008, No. 45 pp. 419-430.
12. Frantzich, H., Nilsson, D. and Eriksson, O., Evaluation and validation of evacuation programs, 2008, Lund: Dept of Fire Safety Eng. and Systems Safety, Lund University, Report 3143.
13. Galea, E. R.: A General Approach To Validating Evacuation Models with an Application to EXODUS, *Journal of Fire Science*, 1998, No. 16 pp. 414-436,.
14. Kuligowski, E. D.; Gwynne, S. M. V.: What a User Should Know When Selecting an Evacuation Model, *Fire Protection Engineering*, No. 3, pp. 30-40.