Simulation of the Shopping Centre „Zona I „ Evacuation

RADOJE B. JEVTIĆ, Electrotechnical school “Nikola Tesla”, Niš

Previous annonucement
UDC: 355.244.2:519.876.5

One of the most important and the most complex tasks in human protection and human safety in objects is the projecting of the object evacuation. There are many factors that could effect on the opportune living of object such as object assignment, arrangement of rooms, arrangement of furniture, arrangement of exits, occupant speed and many other that human lives and material properties depend on. This is very important for objects with great number of humans, such as high residential objects, shopping centers, schools, hospitals etc. This paper has written to show the possible evacuation situations and calculate minimal time for evacuation in case of the shopping centre „Zona I“in Niš.

Key words: *Evacuation, Simulation, Shopping centre*

1. INTRODUCTION

The problem of the object evacuation presents one of the most important and most problematic tasks in object projection. It is very difficult to predict every possible situation that leads to safe and secure living of the object. The evacuation term is very complex, but, generally, it presents the safest, shortest and fastest way of moving for people, animals and material properties from endanger object or location to the secure place. The causes of evacuation could be different: fire, gas, bomb threat, earthquake, flood, civil disorders etc. Every of these causes demand proper strategy of object or location projecting that must be realized in order to increase of human and material properties safety. An example of the evacuation in case of flood is presented on figure 1.

Figure 1 - An example of evacuation in case of flood

Author’s address: Radoje Jevtić, Electrotechnical school “Nikola Tesla”, Niš, Aleksandra Medvedeva 18

Paper received: 10.04.2014.
Paper accepted: 24.04.2014.

Very often, it is not possible to realize the evacuation until the accident is complete, although the evacuation demands momentarily reaction. An example for that case is the earthquake. An example of evacuation in case of earthquake is presented on figure 2.

Figure 2 - An example of evacuation in case of earthquake

Very complex case in the evacuation problematic is evacuation of object with the great number of humans inside in case of fire. These objects could be buildings, schools, markets, shopping centers, hospitals, theaters and similar objects. The fire presents very unpredictable accident and could cause huge damage to human lives and material properties. This is the fact that significantly can complicate projecting and design of evacuation routes and, if they don’t realize correctly, directly harm safety of humans inside them.

Evacuation routes were projected as primary and secondary. Primary evacuation route is the most frequently, route for normal communication in object. For example, these routes could be stairs, hallways, corridors and other surfaces used for communication in object or in separate floor. They are with the different dimensions for every type of object. These routes are the routes that fire services used for, in case of fire. The secondary routes depend on objects purpose. These routes could involve windows, roofs etc. Both types of evacuation routes must satisfied many standard and no standard demands, according to the number of people, type and purpose of object, speed of people moving, necessary time of evacuation etc. The evacuation routes must be clearly visible at the evacuation plan. An example of evacuation plan with evacuation routes is presented on figure 3.

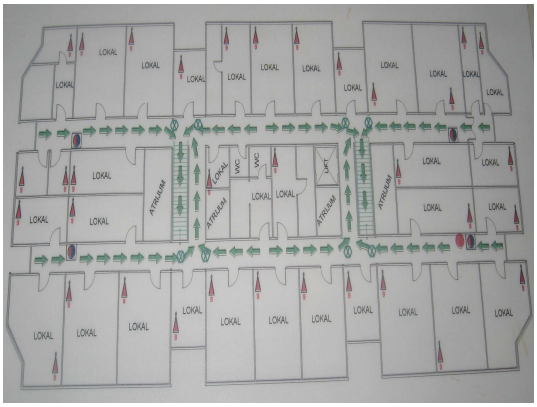

Figure 3 - An example of evacuation plan with the evacuation routes

One particularly interested aspect according to object or location evacuation is panic and stress affects to the occupants. It is known that calm occupants have bigger chances to leave the determinate object or location than occupants influenced by stress and panic. In panic and stress situations, occupants move faster but chaotic. That implies many unexpected situations in object or at location. Evacuation routes in object have its own maximal occupant flow. That is especially important for stairs, elevators, hallways, corridors etc. Very often case is, that in the state of panic and stress, occupants shrilly try to get out from the object or try to leave the location and cause tragedy. There were lots of similar cases with tragic epilogue. The occupant's behavior, knowledge and education, physical and psychic condition (occupant speed, panic and stress influence, moral and human qualities) should be studied in details. For example, the occupant's speeds in this paper were from 1,5 m/s to 4,5 m/s in steps of 1 m/s, which show situations with calm occupants and situations with occupants in panic. It is also important to note that panic state of occupants pretty much determinate than the state that implies fast moved occupants. An example of panic and stress situation in Moscow metro, caused by fire, is presented on figure 4.

Figure 4 - An example of panic and stress situation in Moscow metro

The successful object evacuation and saving of human lives and material properties can be significantly improved with the usage of simulation programs, such as Pathfinder. Pathfinder is an agent based egress and human movement simulator. This program provides a graphical user interface for simulation design and execution as well as 2D and 3D visualization tools for results analysis. This and similar programs present inevitable and necessary tool in evacuation predicting, planning and projecting [1, 2].

2. SIMULATION MODEL

As always, the first step in the solving of the problem of this kind is to create the simulation model of the desire object, in this case, the shopping centre Zona I. Simulation model was created according to its real model, with its complete dimensions. Although this simulation model was created in Pathfinder, it was possible to create this model in some other program, such as Auto Cad or PyroSim and inserted it into Pathfinder program.

The shopping centre „Zona I" in Niš is an object with approximately 56 m X 20.5 m. It is located in Bulevar Nemanjića street, number 67. It was built with idea to provide all types of stuff so that there were no needs for living in the downtown. This shopping centre is one of three shopping centers that were built in the Bulevar Nemanjića street. They are located only few hundred meters between each other. There are lot rooms with different purpose in the object: shops, markets, bank, pharmacies, cafes etc. It has basement and two floors with four exits/inputs, two from the front and two from the back side of the object. The width of stairs was 1,28 m. The width of the exit/input doors was 1,82 m. There was a lift in

the object, but this lift was cargo lift and it was irrelevant according to the evacuation. The pictures of the shopping centre „Zona I” in Niš and its inside detail from the first floor are presented on figures 5 and 6 [3].

Figure 5 - Shopping centre „Zona I” in Niš

Figure 6 - Shopping centre „Zona I” in Niš, inside detail from the first floor

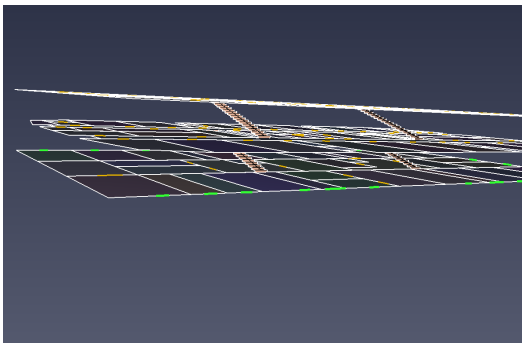

Figure 7 - Shopping centre „Zona I” in Niš – Pathfinder presentation

According to exposed facts and dimensions, the simulation model of shopping centre „Zona I” in Niš in Pathfinder was realized. The presentation of the shopping centre „Zona I” in Niš simulation model, in Pathfinder, is presented on figure 7. The Pathfinder presentation of the second floor (above view) of the shopping centre „Zona I” in Niš is presented in figure 8.

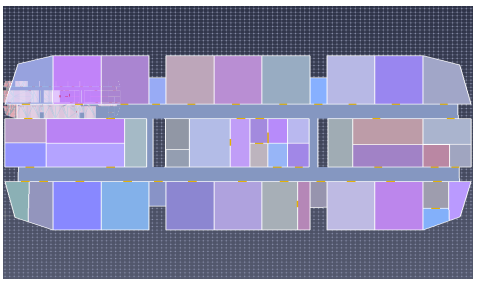

Figure 8 - Shopping centre „Zona I” in Niš, secound floor - above view Pathfinder presentation

The simulation of evacuation was realized for different occupant's speeds, with different occupant's number per floor. It was decided that the occupant number per floor is, in the first case, 80 occupants per floor; in the second case, 100 occupants per floor and in the third case, 150 occupants per floor. The scenario implied that all of four exits/inputs were available. The occupant's speeds were from 1,5 m/s to 4,5 m/s in steps of 1 m/s. The main reason for this assortment of speeds was in wish to simulate the situation of calm evacuation, without stress and panic, and to simulate situation with occupants in panic, where the stuck and chaos would be presented. The situations where the stuck is caused by panic and stresses (stairs for example) are very often and real [4, 8].

3. SIMULATION AND SIMULATON RESULTS

The simulation results mean minimal time need that all of the occupants inside the object live the object, for all three different number of occupants per floor. At the first case, the complete number of occupants was 240, in the second case, the complete number of occupants was 300 and n the third case, the complete number of occupants was 450. An examples of the simulation for the case with 100 occupants per floor, randomly positioned, at 15,4 seconds and 59,4 seconds are presented on figures 9 and 10. The simulation results for 80 occupants per floor, 100 occupants per floor and 150 occupants per floor are presented on figures 11, 12 and 13. All of the occupants were randomly positioned.

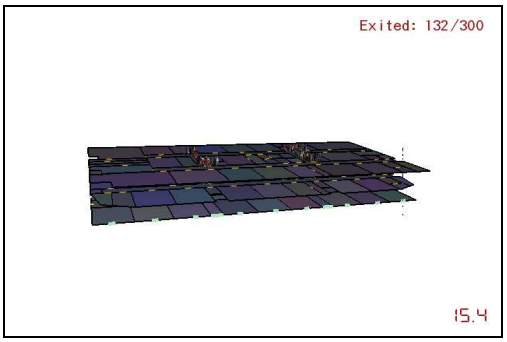

Figure 9 - An example of the simulation for the case with 100 occupants per floor at 15,4 seconds from the start of the simulation

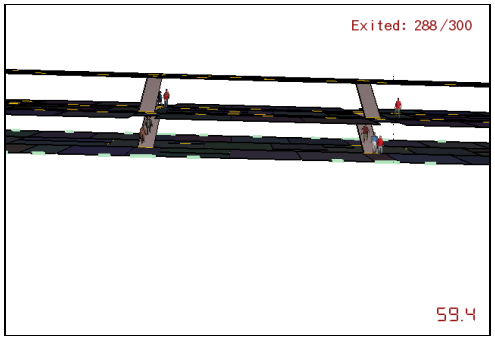

Figure 10 - An example of the simulation for the case with 100 occupants per floor at 59,4 seconds from the start of the simulation

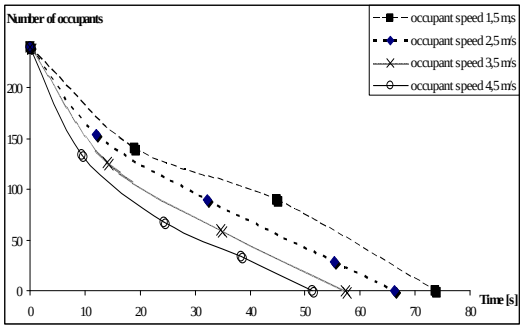

Figure 11 - Simulation results for 80 occupants per floor

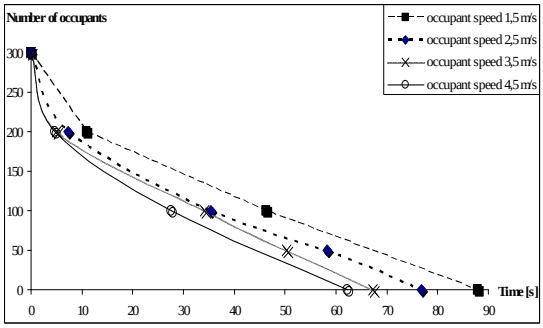

Figure 12 - Simulation results for 100 occupants per floor

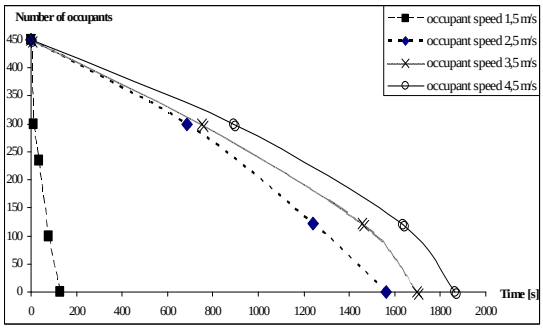

Figure 13 - Simulation results for 150 occupants per floor

4. ANALYSE OF THE RESULTS

Simulation results that were presented on figures 10, 11 and 12 showed the time need for the shopping center evacuation. For the first and the second scenario, where the 80 and 100 occupants per floor were positioned, no matter on occupants speed, the minimal times need for object evacuations were from 50 to 100 seconds. But, for the third scenario, where the 150 occupants per floor were positioned, the minimal times for occupants speeds from 2,5 m/s to 4,5 m/s were from 1560 to almost 1900 seconds, which was pointed to the stuck situation. As it was shown, it takes a lot of time to resolve the stuck situation. It is very important to note that these situations could be very unpredictable according to time need for resolve and consequences that could arise. But, according to the data in the last years, the shopping center „Zona I”, for the most of the time, was half empty, which was considered mostly the people which worked in its shops, which is appropriate to the first or the second scenario. Of course, it is important to know and to predict the possible situations with more occupants in the object.

According to these results, it is possible to locate potential evacuation routes which could be very useful in some situation of evacuation [9].

5. CONCLUSION

This way of analyzing of evacuation times and evacuation routes is very appropriate because it gives good presentation how available evacuation routes could be used for different accidents (fire, earthquake etc) that could happen. It is also possible to locate new evacuation routes that could be used in accident (lower floors exits, lower windows etc). Testing these factors for different occupant’s speeds and behaviors gives good real presentation of potential evacuation scenario in object and great advantages in projecting and installing of complete protection systems, such as, for example, fire protection system. There are many new approaches and algorithms about evacuation and behavior under some accident that are constantly improving, witch cognition significantly increase the evacuation safety level [10-14].

REFERENCES

[1] Blagojević, M.: Alarm systems, Faculty of occupational safety, Niš, 2011.

[2] Jevtić, B. R, Blagojević, Đ. M.: Simulation of the school object evacuation, Tehnika elektrotehnika , Vol 2, pp. 365-370, ISSN 0040-2176, Beograd, Serbia, 2013.

[3] Thunderhead, Pathfinder Exmple Guide, 2012

[4] Helbing, D., Farkas, I., Viscsek T.: Simulating dinammical features of escape panic, Nature, Vol. 40, pp. 487-490, 2000.

[5] Tabares, R. M.: Evacuation Process Versus Evacuation Models: Quo Vadimus?, Fire Technology 45, pp. 419-430, 2009.

[6] Hasofere, A. M., Beck, V. R., Bennetts I. D.: Risk Analysis in Building Fire Safety Engineering, Elsevier, 2007.

[7] Thorton, C., O'Konski, R. and Hardeman, B.: Introducing: An Agent-Based Egress Simulator, Proceedings of the Fourth International Symposium on Human Behaviour in Fire, pp. 567-572. UK, 2009.

[8] Jevtić, B. R, Ničković, T.J.: Simulation of residential object evacuation, 57th ETRAN CONFERENCE, Zlatibor, ISNB 978-86-80509-68-6, Serbia, 2013.

[9] Jevtić, B. R.: The importance of fire simulation in fire prediction, Tehnika Elektrotehnika, Vol 1., pp. 153-158, ISSN 0040-2176, Beograd, Serbia, 2014.

[10] www.iafss.org/publications/fss

[11] www.nfpa.org/...buildings/faqs-about-building-e.

[12] www.stonybrook.edu/asaforms/.../EHSD0091.pd

[13] Kuligowski, E. D.: Modeling Human Behavior During Building Fires, NIST National Institute of Standards and Technology, NIST Technical Note 1619, USA, 2008.

[14] Galea, R. E.: The Developement and Validation of a Rail Car Evacuation Model, Proceedings of the 13th International Fire Science & Engineering Conference INTERFLAM 2013, Interscience, pp.1013-1034, 2013.

REZIME

SIMULACIJA EVAKUACIJE TRŽNOG CENTRA „ZONA I“

Jedan od najvažnijih i najkompleksnijih zadataka vezanih za zaštitu i bezbednost ljudi u objektima je projektovanje evakuacije objekta. Postoji mnogo različitih faktora koji mogu uticati na pravovremeno napustanje objekta kao što su namena objekta, raspored prostorija, raspored nameštaja, raspored izlaza, brzina ljudi koji napuštaju objekat i mnogi drugi koji mogu uticati na ljudske živote i materijalna dobra. Ovo je posebno važno za objekte sa velikim brojem ljudi u njima, kao što su stambeni objekti,trgovački centri, škole, bolnice itd. Ovaj rad je napisan da pokaže moguće situacije prilikom evakuacije i da izračuna minimalno vreme koje je potrebno za evakuaciju u slučaju tržnog centra „Zona I“ u Nišu.

Ključne reči: *evakuacija, simulacija, tržni centar*