CALCULATION AND SIMULATION OF EVACUATION OFFICE SPACE

MARTIN SZÉNAY[1], *MARTIN LOPUŠNIAK*[2]

Abstract — *Slovak legislation obliges the design of the escape routes used for evacuation time calculation according to the standards which result have to 2012 verify strict requirements. At the same time the number of people which is necessary for calculation evacuation time is artificially increased beyond the normal capacity of the buildings. We use as a basis zones of office space. Used fire section is given in Slovak standards, as a prime example of determining the number of persons in the building. In order to obtain the necessary results, we used the method of calculation according to STN 92 0201-3 and methods of computer simulation software buildingExodus. We also use a combination of different input parameters, in particular the value of a unit capacity of an emergency lane and the speed of movement of person by Slovak and English law. Normative calculation in which we considered more than one combination of mobility, an escape route is shown as unsuited to the requirements for the maximum allowable time for evacuation.*

Keywords — *evacuation of the building; calculation of evacuation; simulation of evacuation*

INTRODUCTION

There are several ways to approach the design of escape routes. Proposal escape routes is solved according to the rules laid down in the standards and regulations of the Slovak Republic. In this case, the "input conditions" (capacity and speed of movement) and "boundary conditions" (number of people, length and width of the escape route) under which it is possible to determine the estimated time of evacuation. However in the fire engineering we have effective approaches, such as real experiments, calculations based on advanced approaches using real input data and not least the possibility of using simulation software. All these alternative approaches are making it possible approximate calculation to the real results. Currently we have available more than 50 simulation modeling software to modeling of evacuation of the building.

In the standard STN 92 0241 – Person/surface rate in buildings [1] are given standardized procedures by which it is possible to determine the number of persons on escape routes. Buildings used for people whose numbers during treatment usually does not exceed designed capacity. With an emergency, we must consider the fact that at the moment is in construction exceeded capacity.

The article deals with analysis of escape route from fire compartment offices, which is given as a prime example [1] (Example A.2, page 15 and 16). The analysis was aimed to determine the estimated time of evacuation, with consideration of different values "boundary conditions". These results were compared to the results obtained by the simulation tool buildingExodus, in which the user interface was modeled fire compartment designed, taking into account different scenarios during the evacuation.

1. PROBLEM STATEMENT

1.1 Description of the fire compartment

Fire compartment which is located on the third floor, includes one unprotected escape routes to protected escape route (Fig. 1). For the analysis, we considered an escape route with premises, which gives an example of the STN 92 0241: reception hall – 9 persons, receptions – one person, open-space offices – 46 persons and kitchen – 6 persons. The resulting number of persons considered in the calculation and simulation is 62. It is necessary to take into account the location of fixtures such as tables, chairs, shelves etc. [1].

1.2 Description of the simulation tool - buildingExodus (BEXO)

BEXO simulation software is designed to simulate the evacuation of large numbers of people in large buildings. Spatial and temporal proportions within BEXO are set two-dimensional geometric network and the simulation clock. Spatial grid maps the geometry of the building, the location of exits, internal partitions, obstacles etc. The space network maps the geometry of the building, the location of exits, internal partitions,

[1] Martin Szénay, Ing., Technická Univerzita v Košiciach Stavebná fakulta, martin.szenay@tuke.sk

[2] Martin Lopušniak, doc. Ing. PhD., Technická Univerzita v Košiciach Stavbená fakulta, martin.lopusniak@tuke.sk

obstacles etc. The network consists of nodes and links (Fig. 2). In BEXO node is a standard room with dimensions of 0.5 x 0.5 m and generally has eight connections with neighboring nodes to 45 °. Nodes can be assigned special properties. For example, the nodes that match the stairs, barriers or floor space footprint (some terrain features) are so assembled in three different classes. An important part of the program are virtual people. People can also assign different characters physical or psychological (gender, age, aggression, etc.). People can go from node to node along by linking individual nodes. The simulation will follow the trajectory of each individual, creating a way out of the building, or overcome the risk of fire, such as heat and toxic gases [2] [3].

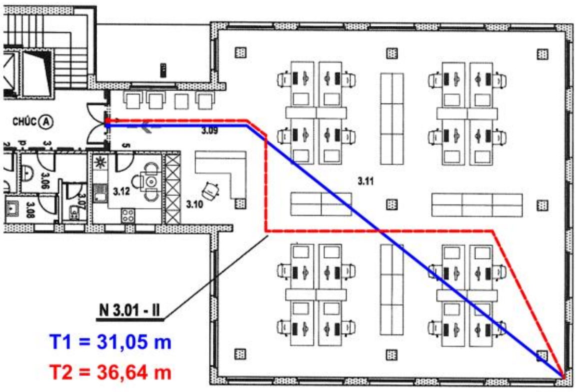

Fig. 1.: Schematic of fire compartment

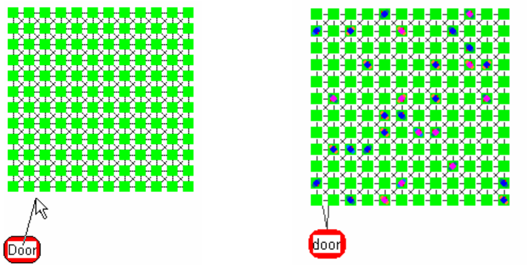

Fig. 2.: Space network and add people to model

2. CALCULATION METHOD AND SIMULATION

STN 92 0201-3 provides for an evaluation parameter - Estimated time of evacuation of people t_u [min], which represents the time required to evacuate all persons from the fire compartment or construction [4]. For the calculation according to use "input conditions" for the movement of people by flat (v_u = 30 m·min^{-1}; K_u = 40 person·min^{-1}) [5]. "Boundary conditions" will be resolved as follows:

T1 – the length of the escape route without considering the deployment fixtures (31.05 meters); **T2** – the length of the escape route with considering deployment fixtures (36.64 meters); **E1** – in the fire compartment are all people capable of independent movement (E = 62, s = 1); **E2** – in the fire compartment are 90% of people capable of independent movement and 10% of persons with reduced mobility (E_1 = 56; s_1 = 1 – E_2 = 6; s_2 = 3); **E3** – in the fire compartment are 85% of persons capable of independent movement and 15% of persons with reduced mobility (E_1 = 53; s_1 = 1 – E_2 = 9, s_2 = 3).

In the simulation software will consider various scenarios during the evacuation, and different values of the conditions affecting the movement of persons:

Geometry (G) – Capacity of escape lane by STN is 1.2 person·m^{-1}·s^{-1} for internal double doors width 1.8 m pointing to CHÚC A. From the kitchen area lead more interior door width of 0.8 m: **G1** – the unit capacity of the escape lane K_u = 1,33 person·m^{-1}·s^{-1} according to the English standard; **G2** – Using the boundary nodes at reduced speed to v = 0,45 m·s^{-1}; **G3** and **G5** – the unit capacity of the escape lane K_u = 1,2 person·m^{-1}·s^{-1} for level – crossing over the door depicting three nodes = 3 emergency lanes (**G3**), 2 units = 2 emergency lanes (**G4**) and 1 node = 1 escape lane (**G5**); **G6** – a person must overcome obstacles to the degree of difficulty 5 (hindering the smooth escape after escape route); **G7** – Other obstacles to the spatial distribution of the escape route with the degree of difficulty 5; **G8** – Encapsulation of internal doors for evacuation (jam, the problem with the opening of a second wing ...) and then opening up after a few seconds.

Population (P) – People are women and men aged 20-60 years randomly assigned to physical parameters: **P1** – People are randomly placed in individual rooms; **P2** – cast a standard number of people in various areas by STN 92 0241.

Behavior of persons (B): **B1** – people are randomly assigned parameters as a function mobility of 1 to 5, Patience 1-5, enterprise 1 to 10; **B2** – person must overcome obstacles to the degree of difficulty 5 located on escape routes – only persons with agility equal to or greater than 5 can overcome the obstacles, others with less than 5 agility they need to evade or change the direction of escape; **B3** – Increasing the parameters of patience evacuees; **B4** – Increasing entrepreneurship parameters evacuees; **B5** – Terms of reference for some evacuees – people begin to run immediately to the east but to pack their belongings or return from a forgotten matter, which increases total evacuation time; **B6** – Using the block - some people are aware of evacuation rather than others. People who are on the escape route and know about the dangers of fire, have a longer response time and blocking the escape route to others whose response time is shorter and accumulate in them;

B7 – Using the block and Social gene - people who do not know about evacuation and block escape routes to the east is to learn about it from people with the same index of social gene and escape with them regardless of their response time was longer (3 people located near the very back: reaction time = 30 s, Social gene = 10; 3 persons located in the alley between the office desks and furniture, and 3 people at the reception escape routes: reaction time = 60 s, Social gene = 10; Other people randomly scattered in the zone: reaction time = 0s, Social gene = 0).

Reaction time (R): **R1** – 0 to 30 seconds is randomly assigned person without distinction of sex; **R2** – All persons have the same response time for fire and subsequent evacuation of 0 seconds.

Motion parameters (M): **M1** – The speed of movement is a setting by English standards. Speed after flat v = 1,33 m·s^{-1}. Mobility index is 1; **M2** – The speed of the evacuees, according by STN. The speed of the evacuees along escape routes, is v_u = 0,5 m·s^{-1} by flat. Walking speed of the peripheral nodes is reduced to 90% at v_u = 0,45 m·s^{-1}, to overcome the speed skipping over the obstacles located in the escape route is reduced to 80% at v_u = 0,40 m·s^{-1}. Mobility index is 1; **M3** – Reduction in capacity for 50% of the evacuees with mobility index of 0.7, the other evacuees without a handicap index have mobility 1; **M4** – Reducing the capacity of all evacuees from fire compartment with an index of mobility 0.7.

3. RESULTS

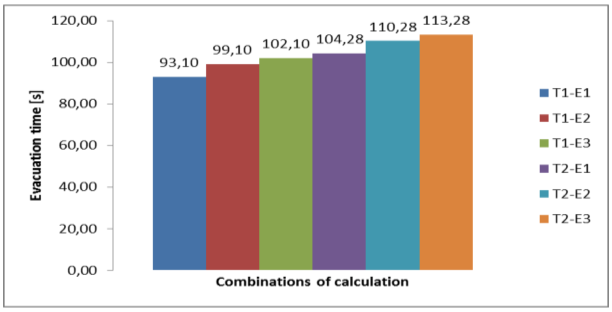

Fig. 3.: Times evacuation calculation by standards

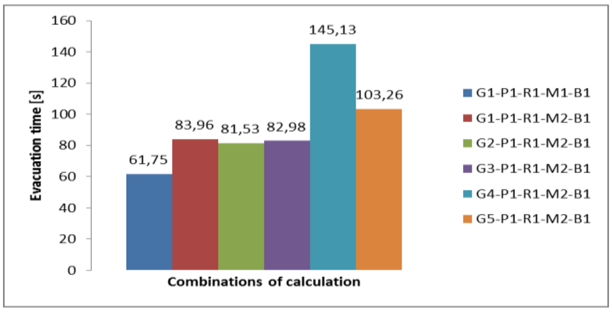

Fig. 4.: Times of evacuation according to changes in unit capacity of the escape lane internal emergency door

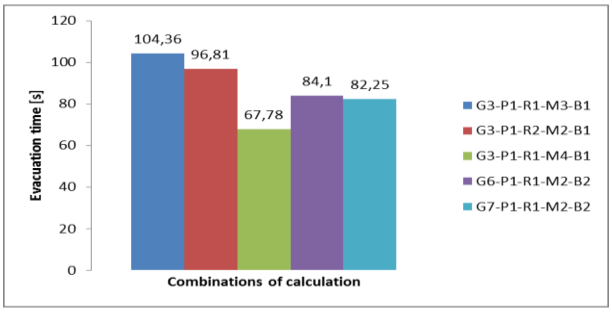

Fig. 5.: Times of evacuation depending on barriers to evacuation

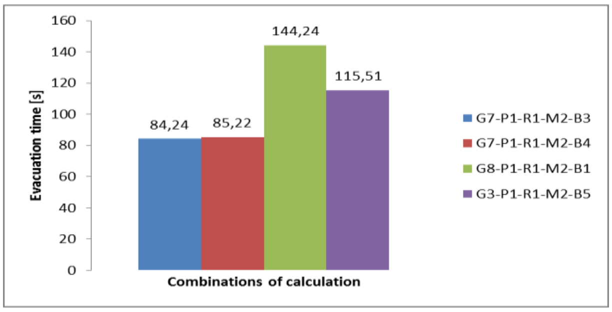

Fig. 6.: Times of evacuation depending on the conduct of persons during evacuation

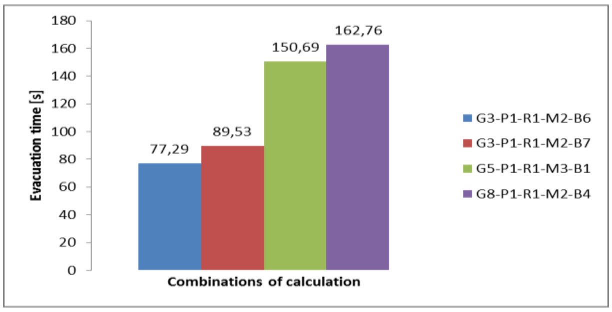

Fig. 7.: Times of evacuation depending on changes in the conditions of evacuation and their impact

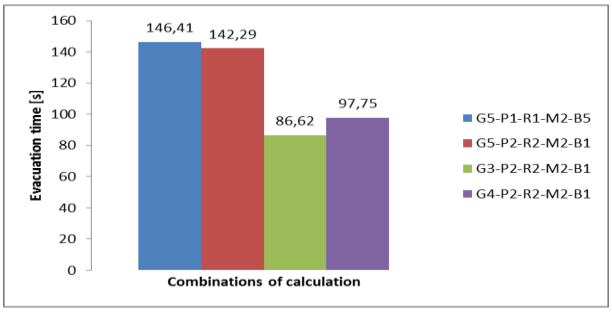

Fig. 8.: Comparison of unit capacity of the escape lane in internal doors

4. DISCUSSION

In the fire compartment we can consider allowed time to the evacuation of 78 seconds. In calculating the time for evacuation of the standard it can be seen that none of the combination does not meet the maximum allowable time for evacuation. It is also not possible to consider the number of people in immobile for more than 10%, since the present example, for evacuating only one direction. Potential difficulties with unsatisfactory results may appear low levels of capacity of emergency lanes, speed of movement and the high number of persons in the zone.

In order to simulate the evacuation it was found the greatest threat to internal exit door. Leaf doors during working hours is normally open only one wing.

Leaf doors during working hours is normally open only one wing. In the event of an evacuation, people as a result of attacks typically not open the other door leaf, or when you open could cause problems (door jam). And it is the greatest times were observed when both door wings unopened door. The door leaf has a width of 800 mm (1.5 of an emergency lane) and the person needs to pass at least one emergency lane (550 mm). In open door leaf width 1600 mm (3 escape lanes) can pass through the door three people at once. Closure of one door wing resulted in a delay time of the evacuation of more than 70%. For combinations of proceedings or persons with reduced mobility, one escape lane through the exit door, the resulting times even more. The actual conduct of a person also has a significant impact on evacuation time. Fire emergency, the people could not decide which things can work out at the speed of collapse and which to leave, thereby extending the time by more than 36%. The shortest evacuation time was made with the setup of motion parameters by English standards (61.75 seconds). When setting the movement speed and width of the escape lanes to STN results in the shortest time with a reaction time of 0 seconds for all randomly placed people (67.78 seconds). In locating persons according to STN 92 0241 was the evacuation time (86.62 seconds).

Itself a prime example of the STN 92 0241 is the assessment of the evacuation time to comply. The problem is the large number of people in the zone, low levels of capacity and speed of movement of the escape lane. Evacuation simulation shows the problem of using the exit door. It is arguable whether normative calculation methods and its excess capacity occupancy buildings by persons should undergo treatment, complications arise because the design of escape routes where it is not always possible to meet stringent requirements.

CONCLUSION

Article evacuation times were determined from the zone which is given as a prime example of STN 92 0241. In standardized calculation of the value of one or did not comply with the allowable time for evacuation. When we used progressive methods of calculation, the value of the capacity of emergency lanes and the speed of movement of the English standards, the results demonstrate the value which results in a problem with the exit door - the longest period of 163 seconds. Only three combinations and the results of the simulation program meet the requirements of Slovak legislation - the shortest time: 62 seconds.

ACKNOWLEDGEMENTS

This work was supported by grant project 1/0835/14 “Experimental research of physical properties of fragments and construction details of the building envelope in non-stationary heat and humidity conditions.”

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