EMERGENCY EVACUATION OF SUBWAY STATIONS DURING A DISASTER, STUDY CASE: "STATION 5 OF TURO"

Saeed ALIGHADR
M.Sc. Department of Civil Engineering, Azarbaijan Shahid Madani University, Tabriz, Iran
Alighadr.saeed@gmail.com

Abdolhossein FALLAHI
Assistant Professor, Department of Civil Engineering, Azarbaijan Shahid Madani University, Tabriz, Iran
fallahi@azaruniv.edu

Keywords: Emergency Evacuation, Evacuation Simulation, Distinct Element Method, Subway Station, People Density

Safety is a primary consideration in any building, especially where large number of people come together such as in subway stations. There are many risk factors which can cause casualties such as earthquake, fire, etc. One of the important considerations in an emergency situation is evacuation of people. To evaluate the evacuation of a place, an effective way is simulation. In this paper as a study case, we simulate the evacuation behavior of Station 5 of Tabriz Urban Railroad Organization (TURO) by using Distinct Element Method (DEM).

In DEM, analysis can compute the position of each element (person) step by step by solving the equation of motion. DEM can calculate the interaction force between the element and the environment and between the elements themselves. The governing equations of motions are:

$$m_i \ddot{x}_i(t) = f_i^{\,x}(t) \qquad (1)$$

$$m_i \ddot{y}_i(t) = f_i^{\,y}(t) \qquad (2)$$

in which m_i is mass of i-th element, and $f^{\,x}$ and $f^{\,y}$ are various forces including driving force acting on the element in x and y directions, respectively (Kiyono et al., 1998).

There are different ways to present elements such as circular (Kiyono et al., 2000), elliptic (Kiyono et al., 2004), and three overlapping circles elements (Langston et al., 2006).

The program used for this research has been first used by Kiyono which was further improved by his students later on. It is a time step tracking simulation model, which follows the route and rotation of each element, in order to determine the direction and position of each entity, in each time step. The program simulates movement and decision making by means of adding the psychological forces to the physical forces. Algorithm that can consider avoidance, overtaking, and pass between elements naturally, is used. The position of each element can be calculated sequentially by solving above equations step by step.

Evacuation simulations are done for 5 different cases regarding number of people at platform and concourse levels which is depicted in table 1.

Table 1. Number of people of considered cases

Case	1	2	3	4	5
Platform	100	200	300	400	400
Concourse	100	100	100	100	200

Evacution time for platform level is calculated to be 75, 140, 324, 438 and 438 sec and for concourse level 110, 190, 370, 477 and 477 sec for cases 1 to 5, respectively.

As results show by increasing the number of people from 100 (Case1) to 400 (Cases 4 and 5), evacuation time becomes 5.8 times for platform level. In concourse level not only the number of people in the level itself but also the number of people of platform level evacuated through the concourse level is effective in evacuation time. For example comparing Case1 to Case5, evacuation time becomes 4.3 times.

To control density of people near exits and gates, 6 and 5 control zones are considered in platform and concourse levels, respectively. Maximum calculated densities (by person/m^2) for different considered cases are shown at Table 2.

Table 2. Maximum densities of considered control zones (person/m^2)

Case	1	2	3	4	5
Platform level	1.64	1.94	4.18	4.32	4.32
Concourse level	1.41	2.83	4.05	4.39	4.5

As results show by increasing the number of people from 100 (Case1) to 400 (Cases 4 and 5), maximum density becomes 2.6 times for platform level and for concourse level comparing Case1 to Case5, maximum density increases by nearly 216 percent.

Considering results of simulations discussed above, we can conclude that number of people has great influence in evacuation time and maximum density of people so it is essential that before construction of public buildings such as subway stations, evacuation simulations considering maximum expected number of people in order to meet safety requirements should be done.

REFERENCES

Kiyono J, Miura F and Yagi H (1998) Simulation of Evacuation Behavior During a Disaster by Using Distinct Element Method, *Proceeding of Civil Engineering Conference,* 591/I-43: 365-378, (In Japanese with English Abstract)

Kiyono J, Toki K and Miura F (2000) Simulation of Evacuation Behavior from an Underground Passageway During an Earthquake, *12WCEE,* Paper No.1800, Auckland, New Zealand

Kiyono J and Mori N (2004) Simulation of Emergency Evacuation Behavior during a Disaster by Use of Elliptic Distinct Elements, *13WCEE,* Paper No.134, Vancouver, Canada

Langston P, Masling R and Asmar BN (2006) Crowd Dynamics Discrete Element Multi-Circle Model, *Safety Science,* 44: 395-417