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People flow modelling in building design

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Cohesive and safe social interactions that involve crowd gatherings require well designed and properly managed public spaces. In spite of the latest technologies and guidelines used to ensure adequate space design, congestions and fatal accidents are frequently experienced in public buildings around the world. Improving safety in public spaces can be achieved by taking into consideration circulation patterns and crowd management.

Brocklehurst et al (2005) and Pauls (1983) indicated that those building design parameters which affect crowd circulation and management are: route/entrance type, dimension of stair risers and treads, handrail height and spacing, number of stairs, and the width of corridors and doors. A careful consideration of people flow within circulation areas during the design process is important to check the adequacy of the above parameters in providing a safe environment for users.

This paper presents two case studies where modelling is used to assess the flow of users within circulation areas to identify the likelihood of congestions and then recommend ways of improving the design to avoid such shortfalls. SMART Move was used for the modelling, this is a network-based software which helps to obtain a detailed analysis and design optimisation of people's movement in a space. This model consists of Nodes and Links where nodes represent the origin of people's movements and links are the paths connecting the nodes (Sharma et al, 2009).

A new five- block extension catering for six chapters (Chapters 2-5 and Chapter 7), with 240 students in each chapter, is being added to the existing school of Sir Robert Woodard Academy, part of the West Sussex Academies. The research focused on evaluating the efficiency of the school's space design to handle the flow of pupils at peak hours to ensure the safety of the students.

Using those design parameters that affect pupil circulation inside the school the morning arrival time of pupils was modeled using the SMART Move software. This established that significant queues built up on the stairways used by Chapters 4 and 5 in building block F (Figure 2), and also in front of the doors to the assembly halls of Chapters 3 and 4 which were located on the first and ground floors respectively. Hence the design parameters of the stairs and entrance doors of the assembly halls of Chapters 3 and 4 had to be adjusted to ensure the safety of the students. Based on the analysis of the modelling results, design changes were recommended for the stairs and the assembly hall door width as well as the number of doors used for the different chapters.

Cairo Expo City is a project funded by the government of Egypt as a major attraction for North Africa and the Middle East. The project is being designed by the architect Zaha Hadid and is in its concept stage. The project consists of an Exhibition Centre, a Convention Centre, a multi-storey car park, and hotel towers. The Exhibition Centre consists of five halls, with a total floor area of 100,064m2. Hall 5, designed to be separate from the Exhibition Centre, will be developed in Phase 2. It is adjacent to the Convention Centre and is connected to the 4 Exhibition Halls by an underground pedestrian walkway. The Convention Centre is located on the eastern side of the site occupying a total floor area of 31,000 m2. The multi-storey car park is connected to the Exhibition Centre by a monorail which forms the spine of the Exhibition Centre. The monorail is expected to be one of the best features of the project with a capacity of 2250 persons per hour.

It is proposed that the Metro will be functioning at the start of the Cairo Expo City project. The Metro is proposed to arrive at the northern side of the site. The arrival and departure profile to Cairo Expo City for the public, as planned by the Cairo transport organisation in charge is as follows: 25% of visitors will arrive by Metro, 17% by bus, 6% by taxi, 25% using shared taxi, 18% using car and the rest 8% by other modes of transport.

Using the main circulation design elements such as corridors, stairs, and escalators, as design parameters, the departure of visitors from the facility was modelled in detail. This was because the hall would then be populated with the maximum number of occupants and hence all the above design elements would be used to maximum capacity.

The modelling identified major queues and bottlenecks in a number of points around the building such as entrance gates, some of the corridors, staircases, escalators, and exits. The recommendations for design changes therefore included widening corridors, substituting some staircases with ramps, increasing the number of escalators. Using these changes, the building was remodelled showing a considerable reduction in the queues sizes.

The research demonstrated that in spite of designing circulation spaces according to design standards, congestions and queuing can be common problems that affect users. This highlights the need for and importance of computer modelling to investigate and improve those design parameters that can affect the safety and comfort of users. A simulation approach to model people movement using computing technologies was used in this work to investigate the safety of users during the design process. Elements of building design such doors, corridors, stairs which impact on people circulation can be analysed in detail to improve designs. Using modelling software, buildings can be evaluated at full capacity to highlight areas of congestion and overcrowding. Accordingly, the design parameters used in the design can be altered or additions can be made. The work also shows that using computer modelling to simulate real world scenarios can help in better understanding people movement patterns and hence inform building design.

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