Ahmed Hamdy Elsharkawi, “Evacuation Safety and Local Crowd Density in Arenas”

IMFSE Master’s Thesis,

Lund University Spring 2024.

Popular Science Summary

Arenas and other sports grounds host thousands of people during events, presenting challenges in terms of evacuation safety management, particularly during emergencies such as fires. While existing safety regulations typically focus on global density metrics, there is a growing recognition of the importance of assessing local densities in evacuation planning.

The aim of the thesis is to define simple methodology to identify local densities in key three- dimensional arena spaces where merging flows occur during emergency evacuations. As effective crowd management requires consideration not only of the global density but also of the local density using a simple method for estimation. The thesis will also verify the applicability of adopting evacuation modeling for high local density scenarios in arenas.

This study has reviewed existing research and theories, highlighting the importance of considering local densities in evacuation planning. Traditional approaches often rely on global density, overlooking the intricacies of crowd behavior in critical areas of arenas. By developing a simple method for measuring local density in 3D, the overall safety of the evacuation process is improved.

The simple control volume method is applied on a small-scale test. The local densities and the flows are obtained. Those results from the real-world data are compared to the modeling results for the same layout of the test. The modeling results showed relatively lower values compared to the real-world result particularly in terms of flow and density at the merging points of stairs and gates. The modeled outflow from the stairs was lower than observed in reality, affecting both stair density and evacuation time. Additionally, the reduced outflow from the stairs resulted in lower inflow at the gates, decreasing gate density compared to real-world data.

The main findings showed that while a straightforward method using control volumes provides useful insights, current evacuation models struggle to accurately estimate density due to their 2D nature and simplified assumptions about crowd behavior. To address this, the thesis emphasizes the need for advanced 3D simulations that account for non- rigid body dynamics. This could lead to more dependable evacuation models, improving safety measures in arenas during emergencies.