



**THE APPLICATION OF SIMWALK SIMULATION
MODEL AND SILICONCOACH FOR PEDESTRIAN
MOVEMENT IN TRANSIT STATION: A CASE
STUDY OF MASJID JAMEK LRT STATION**

BY

ZULFADLY AZIZI BIN BOHARI

**A thesis submitted in fulfilment of the requirement for the
degree of Master of Science (Built Environment)**

**Kulliyyah of Architecture and Environmental Design
International Islamic University Malaysia**

AUGUST 2015

ABSTRACT

The expansion of a city, created by a dispersal of activities; driven by scarcity of land in central areas, this has necessitated the movement of urban dwellers. Some of these activities have required movements to be made as far as nearby cities over great distances using various transportation modes. Activities such as recreation, commuting and shopping occur frequently in public spaces such as stations, shopping malls and stadiums. Due to the numerous activities generated by pedestrians, this situation affects the fluidity of movement in enclosed spaces, especially during evacuation. Therefore, the application of simulation technology has become a powerful tool in controlling and managing crowds in public buildings. Masjid Jamek LRT Station is selected as a case study in order to demonstrate the movement of pedestrians in an enclosed public space. Five objectives have been formulated to bridge the gap in literature - to determine walking behaviours of the pedestrian, to assess wayfinding behaviours of users from the entrance to the exit points during ingress and egress, to identify the factors influencing the movement flow of citizens in public spaces, to validate the simulated model with actual movements of pedestrians in the station building and to suggest and recommend the possible shortest path route based on walking behaviours during crowding events or emergency situations. Aiming at accurately and effectively assessing the movement of thousands of people in public spaces, this exploratory research captures invaluable data of real time users' movements. Applying the methods of video capturing and manual pedestrian counting, the study employed Siliconcoach to identify the walking speed and demographic characteristics of the pedestrians. The findings reveal that the average walking speed of a Malaysian is 1.48m/s, taking into account factors such as users' characteristics, as well as their familiarity with the attributes of the environment. The simulation package, SimWalk, is then applied to develop a simulation of users' movement based on these findings. The developed model will allow a visualisation of the movement of each user as an animation. Recommendations are proposed based on the developed model to overcome the issues and problems related with the flow movement of users in public spaces. Hence, it is beneficial for stakeholders, especially in the built environment and computing disciplines, to plan and design public spaces ergonomically at the preliminary phase. It is hoped that the research will be beneficial in contributing towards the planning and designing of potentially crowding public spaces in the future.

خلاصة البحث

التوسع في المدينة التي يشكل من خلال انتشار الأنشطة وندرة الأراضي في المناطق قد استلزم حركة سكان الحضر. وبعض هذه الأنشطة التي تحتاج إلى الحركات ستكون بقدر المدن القريبة مع مسافة كبيرة باستخدام مختلف وسائل النقل. وقعت في كثير من الأحيان أنشطة مثل إعادة التكوين، والسفر، والتسوق في الأماكن العامة نحو مبنى محطة، ومجمعات التسوق، والملعب. وبسبب العديد من النشاطات الناتجة عن النشأة، يؤثر هذا الوضع على سيولة الحركة في الأماكن المغلقة وخاصة أثناء إخلاء. لذلك أصبح تطبيق تكنولوجيا المحاكاة أداة قوية في إدارة الحشود والسيطرة عليهم في المباني العامة. يتم اختيار محطة مسجد جامع السكك الحديدية كدراسة حالة لتوضيح حركة المشاة في الأماكن العامة المغلقة. قد وضعت خمسة أهداف لسد هذه الفجوة في الأدب، وهي تحديد سلوكيات المشي للمشاة، وتقييم سلوك المستخدمين من مدخل إلى نقطة الخروج أثناء الدخول والخروج، وتعرف على العوامل التي تؤثر على حركة تدفق المواطنين في الأماكن العامة، وتحقيق من صحة نموذج المحاكاة المتقدمة مع الحركة الفعلية للمشاة في مبنى محطة، واقتراح أقصر الطرقات الممكنة بناء على سلوك المشي أثناء مزاحمة أو حالة طوارئ. وبسبب يهدف هذا البحث إلى تقييم حركة الآلاف من الناس في الأماكن العامة بالدقيق والفعال، فإن البحث الاستطلاعي يكشف بيانات ثمينة عن حركات المستخدمين في الوقت الحقيقي. ولتطبيق أساليب أسر الفيديو والحساب اليدوي للمشاة، فإن البحث شغل سيليكونكوش لتحديد سرعة المشي ومميزة الديموغرافية للمشاة. فتكشف النتائج أن معدل سرعة المشي للماليزيين هو 1.48 متراً/ثانية مع مراعاة عوامل مثل خصائص المستخدمين؛ إلمامهم بسمات البيئة، فلذلك تم تطبيق حزمة المحاكاة سيم ولك لتطوير محاكاة حركة المستخدمين بناء على هذه النتائج. وسيفسح النموذج المتقدم مجالاً لتصور الحركة لكل مستخدم كرسوم متحرك. تقترح التوصيات بناء على النموذج المتقدم للتغلب على القضايا والمشكلات المتعلقة بحركة تدفق المستخدمين في الأماكن العامة. لذلك، فإنه من المفيد لأصحاب المصلحة وخاصة في البيئة المبنية ونظام الحاسوب أن يخططوا الأماكن العامة ويصممونها مريحاً في المرحلة الأولية. ومن المؤمل أن يكون البحث مفيداً في مساهمة نحو تخطيط وتصميم أماكن عامة قابلة للازدحام في المستقبل.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Built Environment)

.....
Syahriah Bachok
Supervisor

.....
Mariana Mohamed Osman
Co-Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Built Environment)

.....
Norzailawati Mohd Noor
Internal Examiner

.....
Hassim Mat
External Examiner

This thesis was submitted to the Department of Urban and Regional Planning and is accepted as a fulfilment of the requirement for the degree of Master of Science (Built Environment)

.....
Norzailawati Mohd Noor
Head, Department of Urban and
Regional Planning

This thesis was submitted to the Kulliyyah of Architecture and Environmental Design and is accepted as a fulfilment of the requirement for the degree of Master of Science (Built Environment)

.....
Alias Abdullah
Dean, Kulliyyah of Architecture
and Environmental Design

DECLARATION

I hereby declare that this thesis is the result of my own investigation, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Zulfadly Azizi bin Bohari

Signature.....

Date

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

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ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful. Alhamdulillah. First and foremost, I would like to thank ALLAH SWT whom with His willing giving me the health, strength, and opportunity to complete this thesis. I would like to express my gratitude to my supervisor, Dr. Syahriah Bachok and my co-supervisor, Dr. Mariana Mohamed Osman for their guidance and support throughout the journey in finishing the research. They have been wonderful teachers, role models, and counselors of mine for the past three years.

Most importantly, I would like to thank my family members for their encouragement and love. Special thanks go to my parents, Mr. Bohari Junaidi and Mrs. Hashimah Rashid who always allowed me to choose my path, supported me along the way and helped me up when I faltered, and also my siblings (Syukri Afifi, Izyan Syafinaz, Norhazwan Arif and Asraf Mubarak), my aunt (Jaliah Junaidi) and my special nephew (Iman). There is no better support system to get through this thesis without their love.

My deepest thanks go to Nuraihan and all my colleagues in MSBE (Aswad, Aida, Zakiah, Nurul Izzati, Adiba, Aqila, Tuminah, Alyani, Farah, Shazwani Shahrir, Syazwani Rosli, Azza, Aisyah, and Ainaa) for their assistance and encouragement during my time at IIUM. Without their moral support, guidance, laughter, and love I would have never gotten to this point. And last but not least, thanks to Prasarana Malaysia Berhad for their assistance, advice and resources rendered during undertakings of this research. Thanks to the lecturers and staff of KAED, all my friends, and those people who I have not mentioned here for aiding me through this study.

Thank you for all the guidance, support, and love. Allah SWT can repay all your kindness.

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LIST OF ABBREVIATIONS

2D	2- Dimensional
3D	3- Dimensional
AMG	Ampang Line
CAD	Computer-aided Design
ID	Identification
KLJ	Kelana Jaya Line
LRT	Light Rail Transit
LOS	Level of Services
PMB	Prasarana Malaysia Berhad
SPAD	Suruhanjaya Pengangkutan Awam Darat
STAR	Sistem Transit Aliran Ringan

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

This research deals with an assessment of the pedestrian simulation model application as a modern crowd management tool while moving in a transit station. It focuses on pedestrians' movement and their characteristics within the concourse area of the station building. This research also includes an assessment of evacuation movement of the crowd in the case of an emergency situation. Additionally, in applying the simulation model, various processes related with model estimation, model calibration, model validation and sensitivity analyses are also discussed.

As an introductory part of the study, this chapter will set the framework for a general understanding of the research. This will include an introduction to the research and the requirements of the study. The chapter also defines the goal and objectives of the research and the methods applied to this research. This chapter finally defines the scope and limitations of the study in order to ensure an exquisite orientation of the research based on a clearly defined research methodology and an organised structure towards the whole research.

1.2 RESEARCH BACKGROUND

The intent of this study is to assess the movement of passengers in an interchange station with the aid of simulation software. Simulation is a significant tool in producing, sustaining and optimising the schedules of transportation systems (Mohammad and Ting, 2010). Some of the elements that need to be taken into account

in assessing pedestrian movement in an interchange station area includes the location of the facilities provided, traffic management, as well as evacuation procedures (Banos et al., 2007; Cao et al., 2014).

The study was conducted in one of the major transit interchanges located in the heart of Kuala Lumpur's city centre, which was the Masjid Jamek LRT Station. Situated at the centre of Kuala Lumpur, the Masjid Jamek LRT Station is surrounded by major land uses such as commercial and retail, offices and businesses. Data provided by the transit operators revealed that the busiest stations include the main interchanges such as Masjid Jamek and KL Sentral (SPAD, 2011). Masjid Jamek LRT Station was gradually upgraded from a singular station to an interchange station with numerous improvements in order to address the convenience, safety and security of the users while moving within the station's interior.

In an urban centre, thousands of people are moving every day and generating trips. Via either motorised or non-motorised transportation modes, trips are generated by people to accomplish their activities. However, a thriving economy increases car ownership, which creates traffic congestion in Kuala Lumpur (SPAD, 2011; Abdul Aziz & Mohd Amin, 2012). Thus, the Malaysian government has worked to overcome this problem by introducing a three-line metro system, consisting of the STAR, PUTRA, and KL Monorail systems. The current daily ridership on the urban rail network stands at over 464,000 passengers per day with the Kelana Jaya and Ampang LRT services having the highest passenger loads (SPAD, 2011). The purpose of these transportation modes is to provide an efficient alternative to the present restrictions faced when travelling by road.

Transportation nodes such as interchanges, terminals and stations usually have a substantial number of people movement. Usually, commutes at transportation nodes

involve more than one mode of public transport. As the number of people on the move increases from time to time, the design of transportation nodes is aimed with the intention to cater for the demand of public transport users. Globally, transportation nodes require much consideration towards the needs, ergonomics and behaviours of prospective passengers and public transport users while in the planning stage.

Several issues regarding pedestrian movement at interchange stations have been identified for this research. The issues of security, convenience, facility utilisation, space structure and equipment layout of the station are crucial and need to be addressed (Schmid, 2010). To address these mentioned issues, the application of simulation software can be a useful tool in analysing the movement of passengers. Moreover, simulation technology will benefit the stakeholder in dealing with the evacuation process during cases of emergency (Okazaki & Matsushita, 1993; Bierlaire et al., 2003; Cao et al. 2014).

1.3 PROBLEM STATEMENTS

Four major problems are identified in this research. In general, all these problems relate to the development of interchange stations in Malaysia.

1.3.1 Difficulties in Controlling and Managing Crowd Movement in the Building due to Inefficient Layout

The developing world has seen the mushrooming of complex architectural and urban spaces. Scant concern has been paid by designers to the relation between space and human behaviours (Okazaki & Matsushita, 1993). Buildings can have different layouts and different systems of egress to match their original occupancy needs. Even though various egress designs can be code compliant, people will still behave

differently during emergency evacuations (Tzu-Sheng Shen, 2003; Wang et al., 2014). The interior space layout therefore plays an important role in influencing crowd movement.

Walking facilities such as stairs, escalators, elevators, walkways and ticket gates influence the speed of pedestrian movement (Lee et al., 2005 and Daamen et al., 2005). Shaha et al. (2013) studied pedestrian flow characteristics such as speed, flow and density on the different width of staircases in a railway station. It was found that there is a relationship between pedestrian flow and speed, where flow influenced speed especially when the pedestrian flow is more than the rate of 10 p/min/m (Shaha et al., 2013). According to the Interchange and Integration Plan by SPAD (2013), the problem of ineffective and inefficient public transport modes was caused by improper physical buildings and ticketing constraints. In addition, interchange stations such as the Dang Wangi/Bukit Nanas station, Bank Negara/Bandaraya station and Kuala Lumpur/Pasar Seni station have bad pedestrian connectivity despite the location of these stations being close to each other SPAD (2013).

Meanwhile, with reference to the integration improvements of Masjid Jamek LRT Station, the upgrading of the interchange encompasses some changes to the interior space in order to facilitate passenger movement. These improvements have been done to optimise transfer activity, such as raising the floor level of the existing Concourse 1 of Ampang Line Station, relocating a part of the ticketing counter of Ampang Line Station and providing new ticket gates. An effective public transportation system gives a good impression to users (SM Sabri & Mohd Zakwan, 2012). The improvements in the interchange station are aimed towards promoting the development of public transportation usage amongst users.

Prior to the improvement of Masjid Jamek LRT Station, the station's interior was complex in terms of its design, and this may have led to confusion for users, particularly for first timers. Users faced difficulty in deciding their choice of route in the interchange station. Since Masjid Jamek LRT Station was changed into a multi-purpose facility, the route choice for users, especially first timers, turned out to be more complex (SM Sabri & Mohd Zakwan, 2012). Further, during times of emergency, this complex design may affect the evacuation process, where evacuees would tend to walk faster at the outdoor spaces as compared to indoor (Lam & Cheung, 2000).

The above-mentioned studies discussed how pedestrian movement reacted with pedestrian facilities. However, in the analysis, no research exists on the impacts of alterations to the station's interior. Thereby, a large concern of this research was to determine the influence of the alteration of physical facilities towards pedestrian flow and speed in the interchange station of Masjid Jamek.

1.3.2 Provision of Multiple Doors in the Station Leads to Confusion in Wayfinding

The source of problems in decision-making during pedestrians' wayfinding is the spatial characteristics of the station building. The provision of multiple doors for ingress and egress in the building has led to confusion among pedestrians to move, especially during emergency situations. Confusion occurs during wayfinding because of improper planning, poor signage, multiple accesses, variation of pedestrians' behaviour and inappropriate location of infrastructure in the station (Raubal, 2000; Hajibabai et al., 2007; Wen and Shen, 2011).

The pedestrian simulation model has been widely used to simulate pedestrians' wayfinding movement by taking into account spatial characteristics and pedestrians' behaviour while moving within an interior space, especially during an evacuation (Raubal, 2000; Hajibabai et al., 2007; Wen and Shen, 2011; Ronchi and Nilsson, 2012; Tong and Cheng, 2013). Generally, the simulation model takes into account the physical features of the building, number of doors and size of doors, whereas the pedestrian behaviour comprises of walking speed, pedestrian attributes and crowd motion (Ronchi and Nilsson, 2012; Tong and Cheng, 2013).

Pedestrians are normally confused with entrance and exit doors while they are moving in unfamiliar environments. Hence, the simulation model develops a set of algorithms for the selection of exits and entrances for the pedestrian during an evacuation scenario (Hostikka et al., 2007; Ronchi and Nilsson, 2012; Tong and Cheng, 2013). Therefore, it is crucial to analyse information from the simulation model, particularly data on the existing building station, in order to evaluate the effectiveness of pedestrian wayfinding (Raubal, 2000; Bierlaire et al., 2003; Wen and Shen, 2011).

1.3.3 Limited Research on Pedestrian Movement Study in Enclosed Public Spaces in Malaysia

Most pedestrian facilities have been designed based on literature, studies, technologies and specifications from developed countries. Ergonomic and geometric designs of seats, benches, handrails, staircases, flooring, escalator, exits and entrances points and other pedestrian facilities should be designed to accommodate different physical and physiological measurements of the Malaysian public. Most people, however, identify interchanges station as dangerous, dirty and unfriendly places (Monigl et al. 2010).