EXPERIMENTAL INVESTIGATION ON PEDESTRIAN BEHAVIOUR WALK IN INUNDATION

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Experimental Investigation on Pedestrian Behaviour Walk in Inundation

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I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

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ABSTRACT

Walking velocity of pedestrians is governed by many influencing factors such as Body Mass Index of Pedestrian, behaviour of pedestrian and type of obstacle facing. Several approaches for determining the pedestrian walking velocity have been done by experiment in laboratory. Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices for Streets and Highways includes a walking velocity of 1.2 m/s with zero elderly pedestrian involved. Many research have study about how to evacuate from danger area to safe area by considering the maximum height of water and only on walking velocity at traffic signal not in water. However, so far not much study on the velocity of human while in water. Besides, this study relatively rare because there much lacking in evacuation process especially in Malaysia. Therefore, this study have two main objective is to determine empirical data of walking velocity of human during inundation for different Body Mass Index (BMI) and to simulate evacuation process during flood disaster. In this study, implementation of experiments under laboratory conditions with 8 pedestrian and extraction of trajectories by video analysis walking in water and without water. The data analysed for each task given with one directional flow of pedestrian with different level of water 0.08m, 0.43m and 0.9m. The result show that average walking velocity for female is lower than female and pedestrian who has normal Body Mass Index (BMI) will move faster in shallow water. Within three different level of water show that high Body Mass Index have been move faster in deep water because of balancing of buoyancy force. Therefore, the velocity of walking pedestrian slower when walking deeper in water. The differences is about 50 % from the normal walking velocity in straight line when walking in water in depth 0.9m. The results are of particular importance for the future evacuation process when flood occurs or emergency response plan.

ABSTRAK

Berjalan halaju pejalan kaki ditadbir oleh banyak faktor yang mempengaruhi seperti Body Mass Index pejalan kaki, tingkah laku dan jenis halangan yang dihadapi. Beberapa pendekatan untuk menentukan kelajuan berjalan pejalan kaki telah dilakukan oleh eksperimen di makmal. Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices for Streets and Highways meliputi kelajuan berjalan kaki iaitu 1.2 m / s dengan sifar pejalan kaki yang terlibat. Kebanyakan kajian hanya focus kepada berpindah dari kawasan bahaya ke kawasan selamat dengan mempertimbangkan ketinggian maksimum air. Hal ini kerana tidak banyak kajian terhadap halaju manusia semasa dalam air. Selain itu, kajian ini agak jarang berlaku kerana terdapat banyak kekurangan dalam proses pemindahan terutamanya di Malaysia. Oleh itu, kajian ini mempunyai dua tujuan utama untuk menentukan data empirikal kelajuan berjalan manusia semasa banjir untuk Indeks Jisim Badan (BMI) yang berbeza dan mensimulasikan proses pemindahan semasa bencana banjir. Dalam kajian ini, eksperimen di bawah keadaan makmal dengan 8 pejalan kaki dan pengekstrakan lintasan oleh analisis video yang berjalan di dalam air dan tanpa air. Data dianalisis untuk setiap tugas yang diberikan dengan satu arah aliran pejalan kaki dengan ketinggian air yang berbeza 0.08m, 0.43m dan 0.9m. Hasil kajian menunjukkan bahawa purata kelajuan berjalan untuk wanita adalah lebih rendah daripada wanita dan pejalan kaki yang mempunyai Body Mass Index (BMI) biasa akan bergerak lebih cepat di kedalaman air yang tinggi kerana mengimbangi daya keapungan. Oleh itu, halaju berjalan pejalan kaki lebih perlahan ketika berjalan lebih dalam di dalam air. Hasil kajian ini amat penting untuk proses pemindahan pada masa depan apabila banjir berlaku atau kecemasan.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background

Flood is a common natural disaster occur in Malaysia. It is an overflow of water that submerges land which is usually dry. Flood can be classified into two parts which are flash flood and monsoon floods. Based on the hydrological perspectives, the clear difference between these two disasters is the period taken by the river flow to recede to the normal level. Flash flood takes only some hours to return to the normal water level, while monsoon flood can last for months. Normally, inundation in Malaysia will occur at the end of the year which in November and monsoon season where the rate of rainfall exceeds the normal levels.

For the last few decades, Malaysia has experienced several major flood disasters and the occurrences of flood are getting more frequent in recent years especially in some states like Penang, Pahang, Johor, Terengganu and Kuching due to anthropogenic activities brought about by changes in land use and climate. According to New Strait Times article on 24 January 2018, Penang has experienced a recent flood incident in 15 September 2017, 5 November 2017 and 5 January 2018. It shows to have crippled more than 80% of the state included Penang International Airport (PIA) and displaced thousands of residents in low lying areas. Therefore, it caused several flights from PIA were reportedly delayed. Other than that, this disaster caused death, houses damaged, disruption of transportation, reduction of income and damage of furniture and other appliances.

This inundation was unpredicted which need an effective flood evacuation to minimise the negative impact on surrounding community. Human factor such as age, weight, and height is one of the factors need to be considered to obtain effective evacuation plan.

1.2 Problem Statement

Disasters, natural or man-made such as hurricanes, floods and conflicts may come in unlimited diversities. According Abarquez (2004) flood is an event that causes serious disruption of the functioning of society, causing widespread human, material or environmental losses, which exceed the ability of the affected people to cope using their own resources. Hence, more frequent the flood occurs can leads to severe and tremendous damages to the people, economy and properties. Therefore, an effective evacuation has to designed to minimise the impact of disasters, emergency planning and preparedness measures.

According to Taylor and Freeman (2010), an evacuation is considered a way to prepare people when at risk from an impending hazard. Evacuation is important steps in disaster management. It can be classified into (1) small or large scale evacuation; (2) immediate or pre-warned evacuation; and (3) mandatory, recommended or voluntary evacuation. Evacuation steps included hazard detection, issuance of warning, preparation to evacuate, movement to identified shelters through a network (Stepanov and Smith, 2009).

For this specific study, in order to understand the evacuation process to plan for evacuation planning and an efficient way by through modelling and simulation. Penang International Airport (PIA) located on targeted flash flood area was chosen to conduct the simulation to mimic the realistic flood evacuation with less constraint. Figure 1.1 shows an overview of a recent flood at Penang International Airport.

Figure 1.1 : The overview of flood at Penang International Airport

According to T.Ishigaki (2008), the evacuation speeds depend on flow velocity and water depth by considering two parameters criteria which is momentum and specific force of flow. The maximum of momentum and specific force of flow criterion for safe evacuation. Meanwhile, Keiichi (2003) and T.Ishigaki (2005) done previous researches on effective inundation by focusing on dimensional evacuation shelter which allow more effective opening that more flood victim can be transferred. Both researches were both provides numerical data to designed effective evacuation.

However, the evacuation designed was lack of empirical data which considered of human factors. Human factors or human behaviours such as age, weight, and height need to be considered to design more realistic effective evacuation plan. Human factors were assumed to be affected walking speed. Walking speed is one of the factors need to validate the during evacuation process.

Based on this problem this study is to determine the empirically effect of water on pedestrian and the time taken of human to transfer from inundation area to evacuation area. The human speed while walking in water is difference than in the free flow because pressure in water is higher compared to the air. Research only in static movement of water without having any hitch such as garbage, muddy soil, water that moves contrary or fast, slippery soil or at night situation and bring a lots of thing. This study is very important to make sure the safety of human while move from one place to another place in water without consider the human behaviour and flood subway area.

1.3 Objectives

The objectives in this study are:

1. To determine empirical data of walking speed of human in inundation for different Body Mass Index (BMI).
2. To simulate evacuation process during flood disaster.

1.4 Scope of Work

Penang International Airport (PAI) was main reference for research area to conduct the evacuation simulation. This study divided into two parts which experimental work by construct the modelling and simulate the human speed in water at Hydraulic Laboratory in Civil Engineering Campus. In this part, people need to walk in hydrostatic water and at straight line. The result will be compared to get the differences to be used to validate the simulator before using the software.

The second part is modelling and simulation and it becomes the best choice of methodology to understand evacuation behaviour by its replication. The replication of an evacuation process via mathematical model can demonstrates the dynamics of the evacuation via simulation. This medium subsequently provides significant advantages that permit investigating the evacuation behaviour in an artificial way, which is often either not possible or too risky in the real world. The crucial traits in evacuees' behaviour could be reproduced and explained then.

1.5 Significant of Study

The empirical data from this research which egress time are expected to be useful database and tool for the design and dimensioning of future pedestrian facilities which involved in water or any disaster that needed to moving from risky area to safe area. The average human walking speed in water was produced based on empirical results obtained from the experiment simulation in water. To simulate evacuation process during flood disaster. In future, this study expected can be used in Malaysia if any disaster was happened or any activities that needs evacuation of people from one place to another safe place.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The study of pedestrian flow and evacuation behaviour in water is useful due to immediate applications in a safety assessment and management of emergency evacuation. In recent decade, Malaysia has experienced several major flood disasters and the occurrences of flood are getting more frequent in recent years especially in some states due to anthropogenic activities brought about by changes in land use and climate.

In these issues, the central problems are safety of flood victims and the evacuation process from a hazardous or risky area to safe areas is really need. A large of channel has been developed in the past to analyse and anticipate walking in water in different level of water. Before using a model of simulation to predict quantitative results like total evacuation time, it needs to be calibrate thoroughly and validated by using empirical data (Boltes et al, 2014; Zhang et al, 2011).

2.2 Pedestrian Walking Behaviour

Movement of pedestrians is a fundamental part of a multi-mode and multi-level public's transportation system. In contrast to vehicular movements, pedestrians interact continuously with each other and their surrounding environment, changing their walking direction and speed frequently.

In particular, when pedestrian walking in water people were tend to move slowly compared in air due to gravity is much less important because buoyancy which tendency to float largely cancels it out. Therefore, the time duration need to cross the lane in water higher than in the air. This parameter was very important in process of evacuation from risky area to safer area when in inundation.

Many research studies have been carried out an experiment to investigate the evacuation process especially in subway condition such as Japanese. Harry Yeh,.(2015) have done a research of experimental studies on gender and age factors in tsunami casualties. These study is about the tsunami casualty model is developed with criteria based on whether a person can remain standing within tsunami flow. A simplified model of a human body is made using anthropometric data. This trend is consistent with some of the field observations. It is important to consider gender and ages factors when a coastal community plans for tsunami preparedness. This factor due to the development of the casualty model is based solely on physical mechanisms, the model results can be used to remove physical causes from field data, which then allows for further investigation of social and behavioural factors.

Based on these research, it shows that the human behaviour is very important to be considered. It will be covered by Body Mass Index(BMI) which according to weight and height of that person.

2.3 Walking Speed

Walking speed of pedestrian is crucial element for safety purpose and also effectiveness in designing the structure. Definitions of macroscopic variables relatively straightforward in unidirectional vehicular traffic flow. But it is more complicated to measure these variables in pedestrian traffic flow due to pedestrians' multi-dimensional movements. Generally, speed is define as the rate of motion expressed as distance per unit time (Highway capacity manual 2000). In terms of pedestrian, pedestrian speed is the average pedestrian walking speed, generally expressed in units of meters per second (Tom, 2014).

Pedestrian walk differently on different types of location. Walking speeds are governed not only by the area but also by the age and gender, land uses, temporal variations, cell phone usage, carrying baggage while walking and movement in groups. Another research on walking speed of pedestrian is by Rastogi et al.,(2012). This paper discusses development of adjustment factors for effective design of pedestrian facilities on the basis of pedestrian walking speeds on three types of facilities.

The study finds that males walk generally faster than female irrespective of facility than those of females. Under varying effects, the speeds of female pedestrians stabilize faster than male pedestrians. Younger adults show continuously changing behaviour with a change in the width of the facilities. The effect of grouping by age is more pronounced on older pedestrians. Higher group sizes cause high reduction in walking speeds irrespective of type of facility.

2.4 Summary

Many of researchers have carried out experimental, modelling, and mathematical analysis to investigate the pedestrian behaviour since pedestrian is complex, there were numerous studies on the pedestrian behaviour such as types of facilities, social effect and so on. However, study on the pedestrian flow in water is relatively rare. Thus, there is a need to have quantitative and qualitative validation on pedestrian walking speed.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the steps taken to determine the walking velocity of pedestrian in water. This research is fully based on experiment analysis data.

For this research, the study area is at Penang International Airport which having inundation problem if heavy rain is occur. This building consists many partition that need to investigate to do evacuation process. This research need the detail layout of location to simulate by using the simulator without do modelling.

In this study, the experiment have been done at Hydraulic Laboratory, USM Engineering Campus to get the average of walking velocity of pedestrian. For the experiment, channel sizing 1.5 m x 10.2 m was constructed in the laboratory and the result have been compared with simulator to do the validation.

In this study, some software was used to make this study success such as Corel Video Studio Pro, Autodesk Maya and CBS-DE. The result from the experiment which the velocity of walking pedestrian will be compare with the velocity in software and compare the result. This comparison to check whether the simulator can be used in simulation of evacuation process or not.

3.2 Experimental Work

Research activities have been divided into two parts which experiment work and modelling and numerical simulation.

3.2.1 Task

An experiment was held at Hydraulic Laboratory at School of Civil Engineering, Universiti Sains Malaysia for one day involving 8 pedestrians. This experiment involves six males and two females. The parameter that have been considered is three different water depth cases, based on gender and Body Mass Index (BMI) of pedestrian.

Table 3.1 : The level of water that was used in the channel.

Types	Height (m)
Ankle	0.08
Knee	0.43
Waist	0.90

Table 3.2 : Body Mass Index Range that was used

No	Classification	Body Mass Index (kg/m^2)
1	Underweight	Less than 18.5
2	Normal Weight	18.5 until 24.9
3	Overweight	25 until 29.9
4	Obese	30 and above

The experiment was divided into three parts which are :

Step 1

The participants was started with fill the form including name, weight, height, age, and gender. Pedestrians was wearing caps, either red or blue, to differentiate the gender, so that pedestrians can be seen without occlusion at any time.

Step 2

Then, the pedestrian was walked without water within 10 meters that has been marked and the time was recorded by facilitator only within 8 meters to decline the initial and stopping time taken by pedestrian. This step have been repeated for three times to calculate the average.

Step 3

The same pedestrian have been walk in the channel with different level of water and repeat for three times for each level. At the same time, the scene have been recorded by Go Pro to do the analysis. The time will be recorded by the pedestrian and the facilitator to reduce error while press the stop watch. The channel of the research are constructed based on the layout shows in the Figure 3.1. Figure 3.2 shows that the video that was converted to the image sequence to do the tracking.

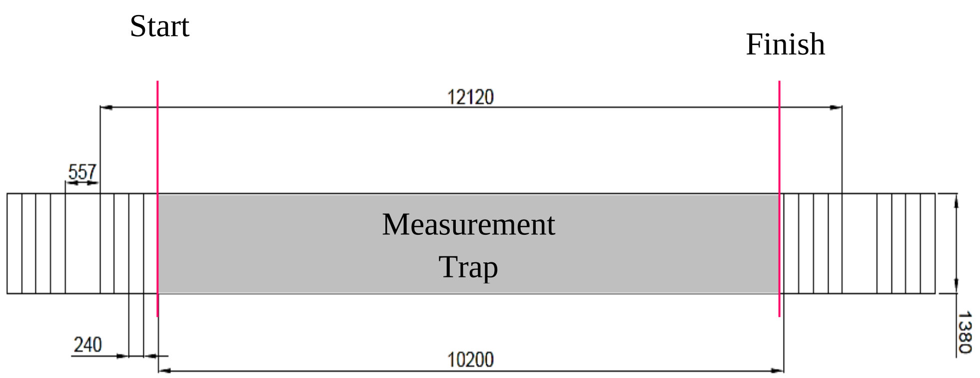

Figure 3.1 : The plan layout of the channel

Figure 3.2 : Image sequence shown the measurement trap for H=0.43

3.2.2 Video Data Gathering

A GoPro camera is used to record every pedestrian movement throughout the experiment session in the channel with different level of water. The video camera have been installed on the crane of the laboratory at 4.16 m height from the floor to cover whole region of the channel during the run of tasks as shown in Figure 3.3. To be precise, the video start to record starting from the pedestrian move from first stage of stair until the pedestrian step onto first stage of stair at another side. Since the experiment have been conducted with the presence of variables, there are about 72 recording videos with different level of water, body mass index of pedestrian and gender.

Figure 3.3 : The height of Go Pro Camera Set-Up hang on crane in the at Hydraulic Laboratory

3.2.3 Video data analysis

Video analysis will be performed in three stages: (i) conversion from video to image sequence; (ii) track of pedestrian trajectories; (iii) determination of average walking velocity, relationship between velocity and Body Mass Index (BMI).

Stage 1

Video image will be converted to image sequence in PNG format using Adobe After Effects CS4 with the frame rate of 25 fps ;

Stage 2

Image sequence is used to track the trajectories of every pedestrian in every frame. The trajectories of every pedestrian are recorded in terms of path coordinates and pedestrian-frame-based tracking method is used. The HBS tool (in-house developed tool) and Autodesk MAYA (MAYA) are utilized for this tracking. The tracking of path coordinates for each pedestrian is performed across consecutive frames in

MAYA. As the video is taken at 25 fps, the path coordinates of pedestrians are extracted for every 20 frames such that frame have an interval of 0.8 s. This sampling interval would ensure the tracking quality. Each pedestrian is tracked from the time he/she enters the first stage stairs of the channel until he/she touch of the contrary first stage stair of channel. The time he/she touch the first stage of stair is regarded as his/her first frame, and the point is marked on the head of the pedestrian. Afterwards, the frame is moved to the next 0.8 s (or 20 frames) and the same pedestrian in marked again at his/her head.

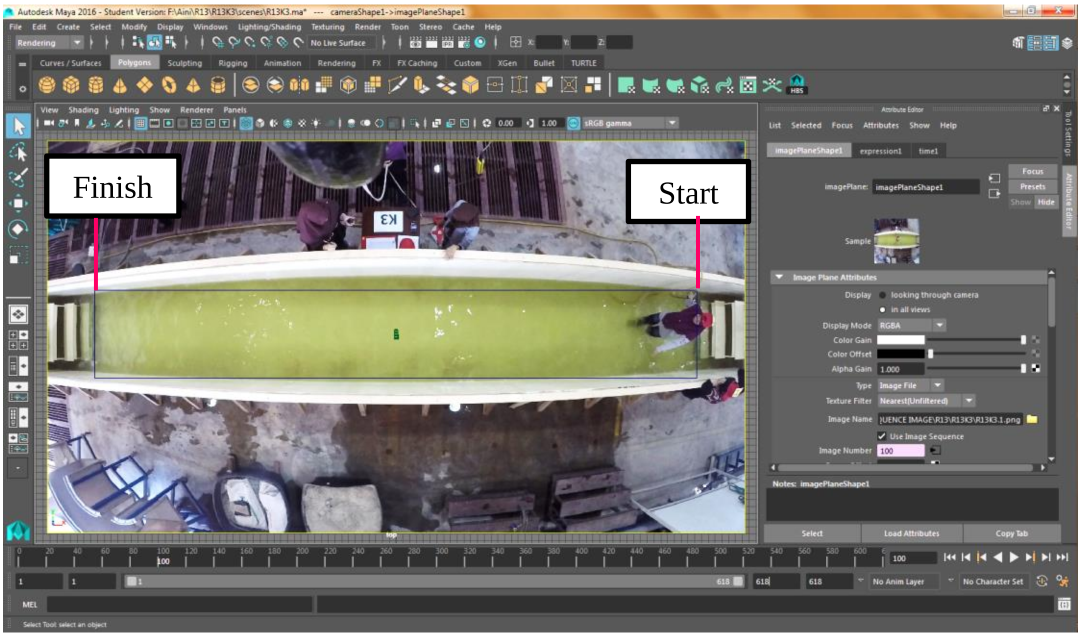

Figure 3.4 : The tracking of path coordinates for pedestrian is performed across consecutive frames in MAYA.

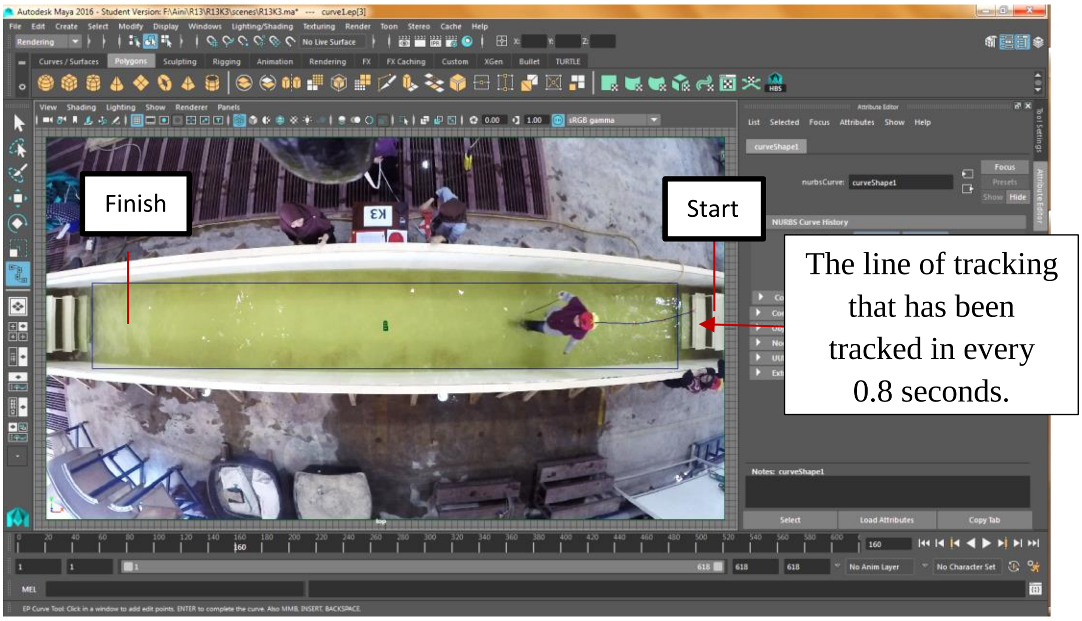

Figure 3.5 : The tracking of path coordinates for pedestrian is performed across consecutive frames in MAYA.

The process is continual until the pedestrian touch of the contrary first stage stair of channel. After one pedestrian is tracked, the next pedestrian is searched over time and tracked. The process is repeated until all pedestrians in the stack of images are tracked.

a. Stage 3

From the path coordinates, the average walking velocity of each pedestrian can be determined using conventional definition of velocity. Pedestrian vector velocity on the 2D-plane is given by:

$$\mathbf{v}(\mathrm{t}) = [v_x, v_y] \approx \left[\frac{\Delta \mathrm{x}}{\Delta t}, \frac{\Delta \mathrm{y}}{\Delta t} \right]$$

From the obtained results, the typical forms of fundamental diagrams at measurement trap, back and front, for unidirectional flows will be produced.

3.3 Modelling and Numerical Simulation

Modelling and numerical simulation was the second part of research which involving some software to do the simulation. To make this part success, several information is needed such as site layout including size of place, average velocity of human and detail of level of water at the site.

3.3.1 Site survey

a) General information of the Penang Airport have been obtained from Authority.

b) Site observation was conducted to obtain building' occupants population distribution and demographic information (age and gender), buildings furniture and obstacles, and wall boundaries to identify the safe level to evacuate.

c) Level from datum in a building was identified in terms of numbers and location.

d) The above data are used for modelling the computational domain and initializing the calculation.

3.3.2 Simulate hypothetical evacuation scenarios by Autodesk® MAYA® 2010

Autodesk® MAYA® 2010 (MAYA) software is one of the world's most widely used software and powerful 3D movie and visual effects software. It can run on Windows, Linux and Mac OS X operating system. The software is composed of a comprehensive visual workflow toolkit that is used for modelling, movie and rendering visual effects. The processes of creating in MAYA CG works are in 3D space by modelling and arranging objects in a scene, setting colours and textures for objects, positioning lights and rendering objects.

Alongside its visual workflow, MAYA is equipped with a cross-platform scripting language, called Maya Embedded Language (MEL). MEL is used to automate many tasks within MAYA, as well as certain tasks that are not available from the GUI. Using MEL, own scripts can be created, which can save time and labor and extend the capabilities of MAYA.

By employing MAYA as visual effects software, CBS-DE is designed to be integrated with MAYA environment. This integration provides an effective tool of crowd behavior simulator with two different parts, a mathematical model part and a visualization part. To enhance the capabilities of the simulator, a self-developed MEL script plug-in, named Human Behavior Simulator (HBS) tool, adds a specific feature to the simulator.

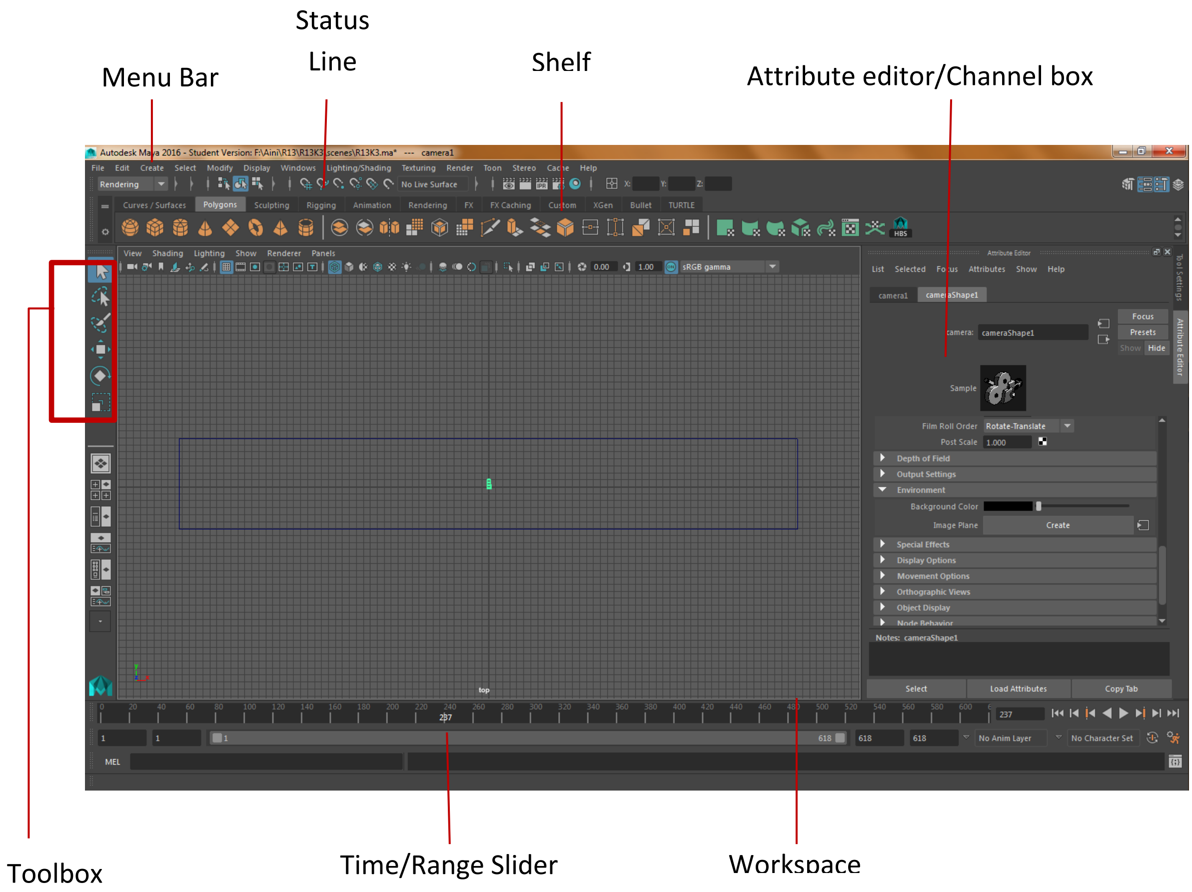

Figure 3.6 : MAYA user interface

For a quick basic MAYA environment, Figure 3.6 shows MAYA user interface (UI) which is the initial MAYA screen that MAYA users see and operate within MAYA. The UI comprises the menus, icons, scene views, windows and panels. In the middle of the interface is the workspace where most of the focus will be to create and manipulate the 3D objects and scenes. By default, the workspace displays in a perspective panel (named *persp*). To the right of the panel is the Attribute editor/ Channel box. This box is where most of the attributes of the selected object is displayed and edited. By pressing Ctrl+A, a switching between the Attributes editor and the Channel box occurs.

Through this research, in conjunction with more workings of 3D modelling and movie with MAYA, references were made to the book authored by Dariush Derakhshani (2011), Introduction to Autodesk® MAYA® 2016 and also the book published by Autodesk®, Inc. (2010), Getting Started Autodesk® MAYA® 2011.

3.3.3 Modelling the computational domain

Modelling is usually the first step in creating CG. In this subchapter, the summary was made based on standard modelling techniques used in creating the computational domain of the LIA and 3D objects. The details of creating the computational domain are beyond the scope of this chapter. Other than that, the HBS tool is also employed in creating the computational domain. The details application of HBS tool can be referred in Appendix A.

In MAYA there are three types of modelling methods available: polygons, NURBS and subdivision surfaces. All three requires a process that begins with deciding how best to achieve the design, and it is common to mix modelling methods in a scene. Each method has particular characteristics and benefits. In this modelling works, only the polygon method is utilized.

Polygon method is a network of three-or-more sided flat surfaces called *faces* that get connected together to create a *poly mesh* (Getting Started Autodesk® MAYA®, 2011). Polygon meshes are comprised of vertices, faces and edges as shown in **Figure 3.7**. Polygonal method has a wide range of applications and is the preferred method for many 3D applications. It can be rendered quickly, delivering increased velocity and interactive performance.

In conjunction with creating the computational domain of the PIA, modelling a polygon mesh from a 2D reference image was imposed. Hence, the 2D images of the PIA were imported into MAYA as a reference image for constructing the computational domain and 3D models. Thereafter, modeling a polygon mesh from a reference image was conducted by using some of the polygon modeling tools by:

1. Working with components of a polygon mesh (faces, edges, and vertices)
2. Selecting faces, edges and vertices polygon meshes
3. Scaling and extruding faces on polygon meshes
4. Splitting vertices and subdividing polygon faces
5. Combining separate meshes into one meshes
6. Adding faces to an existing mesh
7. Using snap to grid

The product of the modeling was still in 2D models. As such, to build 3D models, the same procedures as above were applied together with the texturing and rendering processes. In MAYA, texturing is a process of modifying the appearance of the 3D models and rendering is a process of creating bitmap images of the model based on various shading, lighting and camera attributes.

Afterwards, the population distribution, boundaries, persons' attributes and domain's characteristics of the PIA are initialized on the domain and are imposed by using HBS tool.

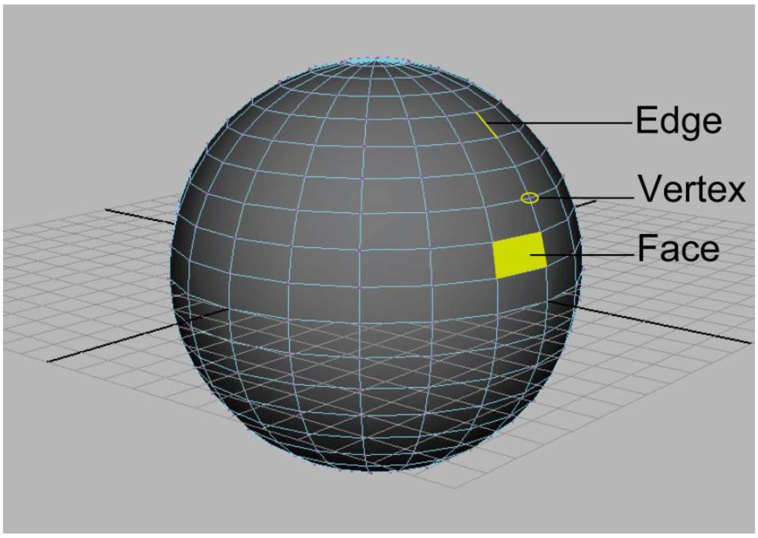

Figure 3.7 : A polygonal sphere and its component

3.3.4 Computational domain and the HBS tool

The area covers approximately 109,242 m^2 with two main buildings: the airport (the PIA). Since the investigation is related to the flood evacuation process, an area with a height more than 5.0 m is considered as an adequate level for evacuation area. This level is predicted from the previous history of tsunami height that hit Malaysia in December 2004. From the survey conducted, two locations of evacuation areas are identified; the first location is located on the Level 1 of the PIA (at the corridor).

On the other hand, the HBS tool is specially designed to enhance the capability of the simulator in specifying person's attributes and domain's characteristics. It is a scripting language which is embedded into MAYA acts as a plug-in component that adds a specific feature to the simulator. The details application of the HBS tool is elucidated in the Appendix A of this thesis.

3.3.5 Average walking velocity of persons in a group

In this subchapter, the procedure of video data-gathering and determination of the average walking velocity are described in detail. Figure 3.9 shows phases in this work. The first phase is procedures of video data-gathering in which divided into three parts, (1) conversion from video images into image sequence; (2) tracking path coordinates of pedestrians; and (3) transformation of coordinates and trimming data into pedestrian trap. Meanwhile, in the second phase, the average velocity of pedestrians walking in a group is determined.

Video processing is considered as a prominent tool to collect pedestrian data since the cost of a video is relatively cheap and the technologies of video processing is growing very rapidly. Furthermore, video had been traditionally used to collect macroscopic pedestrian data.

3.3.6 Conversion from video to image sequences

To collect data on pedestrians walk in groups, the video film recordings are performed by a video static camera in the field with a perspective view setting. Ideally, the camera should be set with a top view. However, due to site constraints, the camera has to be set with a perspective view to the real-world plane. Hence, an affine coordinate's transformation method is used to transform the image coordinates to the real-world coordinates for subsequent analyses.

The video film obtained is then converted to the image sequence by using a software named Adobe After Effect CS4 (the AE). To make use of the AE, a composition that holds the media like videos, images or audio needs to be created. Hence, the media needs to be imported into the AE. To do so, from the File menu in the AE interface, the Import item is selected and File item is clicked (refer to **Figure 3.10(a)**. The Import File window will pop-up immediately and the video film to be converted is selected from where it is saved and then the Open tap is clicked (as in **Figure 3.10(b).** In the project window, it can be seen the video film imported (refer to **Figure 3.10(c).** By default, the rate at which an imaging device produces unique sequential images called frames is 25 frames-per-second (fps). This is important information for subsequent analysis.

Afterwards, the video film is dragged to the Render Queue box at the bottom of the AE workspace. Then, to convert the film to the image sequence, at the Output Module, the 'Lossless' is selected. As shown in **Figure 3.10(d)** the Output Module Settings window will pop-up. The format of the output file converted is set from Video for Windows to PNG Sequence and the OK tap was selected. Later, the Render tap in the Render Queue box is clicked and for a few hours, the video film will be converted to the image sequence in PNG format.

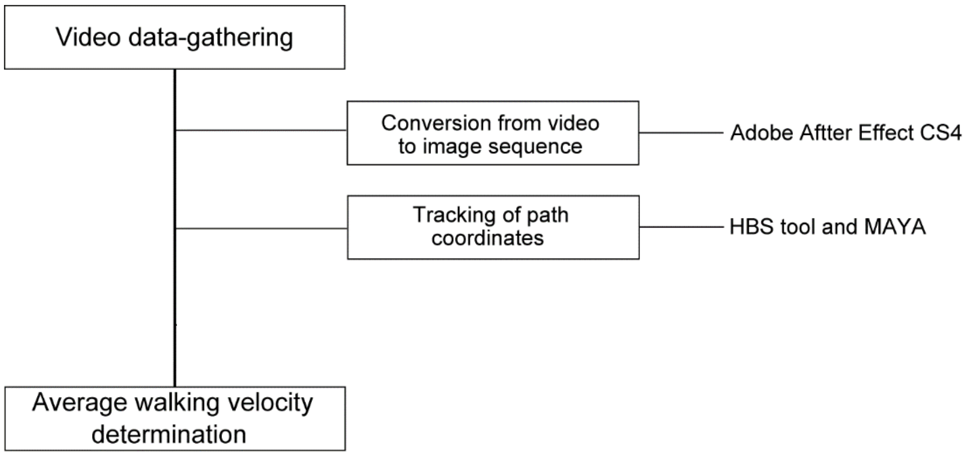

Figure 3.8 : The procedure of video data-gathering and determination of the average walking velocity