Development of Evacuation Plan Simulation in TUP Manila

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Abstract- The project aims to create a simulation of how evacuation is going to happen if there is a disaster occurring within the vicinity of TUP Manila. Modeling and Simulation is used for the evacuation plan to be developed. By using the simulation software AnyLogic, the simulation itself is successfully developed. This project will be helpful to students to have an awareness of what to do in times of evacuating from such disasters like fire and earthquakes. It can be also used by faculty and staff to guide every student in their safest site in times of disaster.

Keywords- Modeling, Simulation, Evacuation, Disaster, Plan, Fire, Earthquake

I. INTRODUCTION

Disasters are natural tragedies that touch all of humanity on Earth and have a variety of negative effects on human life. Although many natural disasters are unavoidable, their negative consequences for people can be reduced. It is critical to enhance public knowledge about disasters, whether they are caused by human actions or natural disasters. Disaster education is crucial in spreading this awareness [1]. Disaster preparedness is a national public health issue. Individuals and communities are increasingly at risk of being impacted by natural disasters, and this trend is anticipated to continue. If they have adequately prepared for a crisis, college students could play a key role in responding to and recovering from a big disaster [2].

According to Nolan, while disaster prevention is a top goal for safety experts at schools and colleges, having a well-developed evacuation plan that can be implemented at any time is also critical. Acts of terrorism, gas leaks, chemical spills, collapses, explosions, bomb threats, tornadoes, and even acts of violence must all be considered in the planning process. With libraries, theaters, classrooms, and offices, dormitories, swimming pools, water systems, restaurants, laboratories, and daycare centers, a college or university is like a little city—or a collection of small cities. Even primary and secondary schools may have a wide range of amenities [3]

II. BACKGROUND OF THE STUDY

Disaster risk is a broad word that refers to a set of laws, policies, and initiatives aimed at reducing disaster losses and building resilience by 'preventing new disaster risk, reducing existing disaster risk, and managing residual risk. The terms disaster risk reduction and disaster preparedness are used interchangeably in this subject to indicate issues that must be addressed before a certain danger or scenario has an impact on populations. They are closely connected and overlap, but their emphasis differs significantly.

The Philippines has ranked fourth after China in the list of the countries most affected by disasters in the past 20 years. About 149 million Filipinos were affected by natural disasters during the past two decades, representing an average of 7,796 per 100,000 population. Furthermore, in 2013, Super Typhoon Haiyan, which hit the country, killed at least 6,000 people [4].

Technological University of the Philippines - Manila like most institutions of higher education to engage in a method for detecting, assessing, managing, and monitoring risks. A Disaster Risk Management Plan's objective is to sketch out the framework of how risks are managed and to ensure the university (including the staff, faculties, students etc.) are aware of the procedures and lessen the casualties in case of disaster. The limitation of the development of this project is that the simulation would be in 2-dimensional space only since the devices of the developer were only limited in running 2d only and it will just include the student's way path only.

The goal of the researcher is to foster a risk-aware culture that allows the university to identify, measure, control, and assign responsibility for risk management while encouraging the accepting of reasonable opportunities. Risk management is the responsibility of all academics and staff who have a role in the university's operation and initiatives.

III. RELATED LITERATURE

The events that occur in people's living areas result in loss of life and property, are called disasters. Natural disasters, which have natural, human, The biological and extraterrestrial types are the most effective ones. Natural disasters are disasters that start in completely natural ways in which there is no intervention of human beings. They can continue for decades, in addition to those whose duration is only a few seconds, depending on the type, which may cause considerable damage, destruction for the living world, which disrupts normal life conditions, which may create psychological and sociological problems in social memory as well as the loss of life and property for societies [5].

According to Türksever, disasters are defined as calamities that affect all humanity on Earth and have a negative impact on human life in a variety of ways. Although many natural disasters cannot be avoided, their negative consequences for people can be mitigated. It is critical to raise public awareness about disasters, whether they are caused by human action or natural disasters [6]. Disaster education is critical in raising this awareness. According to Gonzales, earthquakes, volcanic eruptions, and floods are some of the natural calamities that occur every year, at any point and anywhere, causing threats to the livelihoods of every person, especially students and workers [7]. Natural disasters demolish schools and impair children's education every year, causing immense sadness in many countries. In addition to causing acute injury to children, there is emerging evidence that natural catastrophes can have a number of indirect long-term consequences [8].

It is said that a disaster is an unplanned event in which the needs of the affected community outnumber the available resources [8]. A disaster occurs somewhere in the world almost every day, but the scope, size, and context of these events vary greatly. Large-scale disasters with numerous casualties are uncommon. Certain widely publicized disasters, such as the September 11, 2001, terrorist attacks, Hurricanes Katrina and Sandy, and the Boston Marathon bombing, have focused people's attention on disaster planning and preparedness. Disasters are becoming more common, and the number of people affected is growing. This increased morbidity is due not only to the increased number of events, but also to population dynamics, location, and susceptibilities.

The Philippines is one of the world's most vulnerable countries to natural disasters and climate change. With over 7,000 islands and 36,000 kilometers of coastline, nearly everyone – 74 percent of the population – and everywhere – 80 percent of the land area – are vulnerable to disaster, with Manila considered to be at "extreme risk." [9].

The Philippines is one of the most vulnerable countries to natural disasters. The country's location makes it vulnerable to storms that cause flooding, mudslides, and typhoons. Furthermore, the presence of offshore trenches such as the Manila Trench makes the Philippines vulnerable to tsunamis. Unfortunately, this is not the end of the list. The Philippines is also located on the Ring of Fire, a path in the Pacific Ocean basin that is prone to earthquakes and active volcanoes.

The Philippines is made up of 7,107 islands, which makes infrastructure development difficult. Natural catastrophes also have a disproportionately negative impact on infrastructure in low-income areas. However, throughout the last decade, the Philippine government has made significant progress in improving infrastructure and making the country more disaster ready.

Infrastructure will account for approximately a quarter of the Philippine government's budget in 2020. By 2022, President Rodrigo Duterte wants to invest 6% of the country's GDP in infrastructure. His "Build, Build, Build" initiative has contributed significantly to the growth in money, which will be used to fund projects such as the Manila subway and other modes of transportation, as well as water and energy resources.

The Global Facility for Disaster Reduction and Recovery (GFDRR) has allocated $2.5 million for infrastructure projects in the Philippines. GFDRR is concerned with understanding and mitigating disaster risk, as well as strengthening governance and improving recovery, rehabilitation, and reconstruction. In the Philippines, GFDRR currently has three active projects. The first is the "Support for Sustainable, Inclusive, and Resilient Tourism Project," which is scheduled to be completed in June 2021. The second project, "Philippines Disaster Risk Financing," is set to finish in August 2020. Finally, the "Support for Earthquake-Resilient Greater Manila Program" is scheduled to be completed in September 2021 [10].

The preceding paragraphs interpreted that in terms of GDP, human development index, life expectancy, and infant mortality rate, the Philippines remains a third-world country. While the Philippines still faces numerous structural challenges, it has made significant progress during the last decade. The Philippines can reduce poverty and enhance livelihoods by equipping islands to deal with natural catastrophes and by assisting farmers [11].

Typhoons and storms, which account for 58% of all disasters in the country, as well as related flooding (25%), and landslides (6%), pose the greatest threats to the country. Storms outnumber all other natural disasters in terms of fatalities, people affected, and economic damage. Though less common than hydrometeorological disasters, earthquakes (5%), volcanic eruptions (5%), and drought (1%), can all have devastating effects. These disasters collectively kill over 1,000 people each year.

IV. SIMULATION MODELING METHODS

DES (Discrete Event Simulation)

Discrete Event Simulation a medium level of abstraction, discrete event simulation focuses on the processes in a system. Specific physical details, such as car geometry or train acceleration, are typically not represented. Discrete event simulation modeling is widely used in industries such as manufacturing, logistics, and healthcare. For example, if describing the behavior of each individual object is easier than attempting to create a global workflow, agent-based modeling may be the solution. System dynamics can also be used if you are interested in aggregate values rather than individual unit interaction [12].

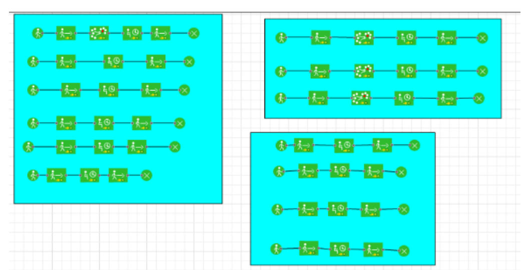

Fig 4.0 "DES Model"

Since Discrete Event Simulation focuses more on real-time processes in a system. It will be used in the development of the evacuation plan simulation. Time and state variables are two essential variables used to describe the characteristics of the simulation model. Discrete systems have the following components:

1. Entity: A component or object in the system that requires an explicit representation in the model.

2. Attribute: A characteristic of an entity. Some of the attributes of an entity can be state variables. An attribute that applies to one observation may not apply to another.
3. Global Variables: A set of variables that contains all the information needed (complete and minimal) to describe the system at any given time.
4. Source: Can be represented by the individual or group which will accept the entity for processing.
5. Suspend An activity of an entity with no exact period when it starts and ends.
6. Statistical calculations: Calculate the simulation performance output.
7. Event: An event that can change the state of the system.
8. Time: Variable that represents the total simulation time
9. Start and end: A state that begins or ends a simulation.

The flowchart below shows on how the process of evacuation will occur in each event.

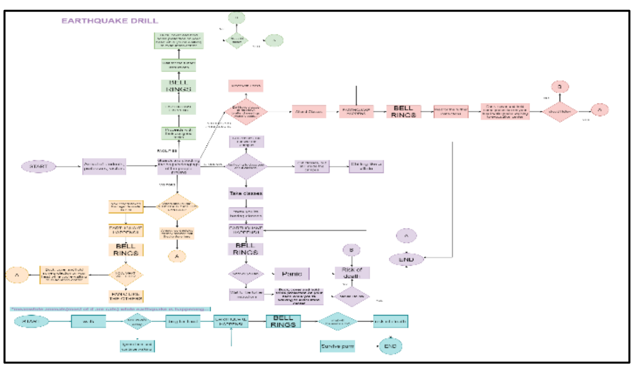

Fig 4.1 "Earthquake Flowchart"

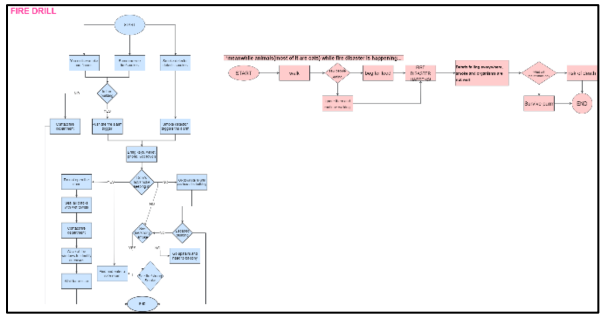

Fig 4.2 "Fire Drill Flowchart"

V. DATA SET

The Simulation Software that will be used is Anylogic. AnyLogic is a simulation software that uses 2D and 3D modeling to help businesses in transportation, manufacturing, rail logistics, mining, supply chain, healthcare, and other industries test and explore what-if scenarios. It includes built-in animation libraries for a variety of industries, including rail, pedestrian, road traffic, and material handling.

AnyLogic enables data analysts to build simulation models using a variety of modeling methodologies and languages, such as discrete events, agent-based, system dynamics, process flowcharts, state charts, and action charts. It enables employees to present visual models with graphical objects to visualize vehicles, employees, equipment, buildings, and other items in accordance with business requirements. Organizations can use the built-in GIS maps to search for and locate cities, streets, roads, hospitals, shops, and bus stops to generate simulation models. AnyLogic includes an

API that allows organizations to integrate the system with a variety of third-party solutions. Pre-designed simulations, such as monte carlo, sensitivity analysis, and parameter variation experiments, are also available on the platform [14]. MosimTech argued that AnyLogic is the ideal tool for simulations with a high number of iterations and complex requirements. Because it is multidimensional, it can complete several simulations faster than other tools, providing you with more insights faster.

According to the International Organization for Standardization (ISO), an international need to harmonize a system of communicating escape routes in buildings that do not rely on the use of words led to the development of a new code. ISO 23601:2020 – Safety identification – Escape and evacuation plan signs establish design principles for displayed escape plans that provide information on the fire safety, escape, evacuation, and rescue of a facility's occupants. Escape plans may be displayed as signs in workplaces and in public areas to help people orient themselves in relation to the planned escape route. They may also be used by fire, rescue, and medical teams, as well as by intervention forces in the case of a terrorist attack. Escape plans should complement the facility's safety exit guidance system [15].

ISO 23601 is based on the safety signs, color codes, and design requirements of ISO 7010:2003 – Graphical symbols, Safety colors and safety signs, and Safety signs. It establishes a common method of illustrating the position of the viewer in relation to designated escape routes leading to emergency exits and the location of fire safety and emergency equipment close to escape routes. The code covers design requirements, size of plan elements, content and representation, materials, installation and location, and inspection and revision of the escape plans. It establishes a common method of illustrating the position of the viewer in relation to designated escape routes leading to emergency exits and the location of fire safety and emergency equipment close to escape routes.

The developers also used the data that is gathered from TUP Manila which shows the number of students and personnel within the university. It can be seen here in the figure the total number of each student per department and other personnel inside the school.

	1st year	2nd year	3rd year	4th year	5th year	CPPT	Total
COE	1038	1215	1269	797	94		4413
COS	447	597	693	235	0		1972
CLA	398	237	402	122	0		1159
CAFA	498	425	700	312	2		1937
CIEw/CPPT	373	235	717	131	0	13	1469
CIT	1685	1192	1874	1068	0		5819
							16769

Fig 5.0 "Number of Students per College"

	Morning	Night	Reliever	total
Guards	18	10	4	32
	Female	Male		total
Janitor	6	24		30

Fig 5.1 "Number of Staffs"

Only a total of 820 Students and 150 Staff/Faculty were included in the simulation assuming that not all the people were present at that certain time of the simulation. The number of faculty was not also included since the data that the developers requested from TUP have not been given yet.

The data also includes the Model of TUP's buildings and facilities to serve as a guide for the simulation. The following data is taken with the permission of Ar. Elpidio T. Balais Jr.

VI. RESULTS

The result of the simulation is very successful. The table below shows the building exit time and Evacuation exit time. The amount of time it takes for each building on a TUP campus to evacuate, the minimum time is from the college of engineering, which takes only 1 minute and 13 seconds to evacuate and go to TUP ground, and the maximum time is from the college of the industrial building. The students will remain on the TUP campus for 5 minutes before being evacuated. The quickest evacuation exit is from gate 2, which takes only 6 minutes and 9 seconds, while exit 1 takes the longest, taking 8 minutes and 14 seconds.

College	Students per College	Bldg. exit time	TUP ground standby time	Evacuation exit time	
COE	4413	1 min 13 sec	5 minutes	Exit 1	8 min 14 sec
COS	1972	2 min 38 sec			
CLA	1159	2 min 38 sec		Exit 2	6 min 9 sec
CAFA	1937	2 min 21 sec			
CIE/CPPT	1482	2 min 21 sec		Exit 3	7 min 11 sec
CIT	5819	5 min 37 sec			
Total Students: 16,482		**Min. exit time:** 1 min 13 sec **Max. exit time:** 5 min 37 sec		**Max. Evacuation time:** 8 min 14 sec	

Fig 6.0 "Simulation Analysis"

In this table shows, the amount of evacuation time of each building inside a TUP campus, the minimum time is from the college of engineering, which is just 1 min 13 sec. to evacuate and go to TUP ground, and the maximum building exit time is from the college of the industrial building. The students will wait 5 minutes before evacuating from the TUP campus. The minimum evacuation exit time is from gate 2, which takes just 6 mins and 9 sec to evacuate, while exit 1 is the maximum, taking 8 mins and 14 sec to evacuate.

Figure 6.1 Exit time of students in every building

This is the Exit building's graph. There will be a difference in the exit times of each building

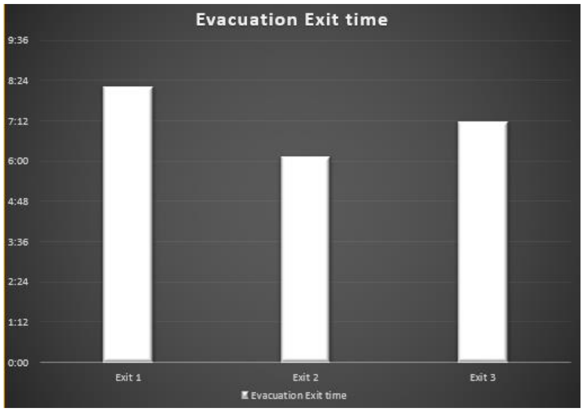

Figure 6.2 Exit time from gate 1 to 3

The graph represents the maximum time required to exit time from the TUP ground going to three exit gates.

VII. CONCLUSION

It can be concluded that the entire evacuation in TUP as measured by the developers takes about 31 minutes and 6 seconds. The arrival of each person in the university to the open field in case of disaster takes about 7 minutes and 14 seconds. The simulation shows that an evacuation plan that includes the safeness of each person is possible in times of disaster in the university.

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