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The Development of a Physical Environment Assessment Form for Safety and Security in Transitional Space between Mass Transit Stations and Buildings

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Abstract

Mass transit systems are vital in addressing traffic congestion and promoting the economy in the city and surrounding spaces. The transitional space connecting mass transit stations and buildings holds significance as it improves accessibility and convenience, especially along transit routes, with a focus on those serviced by electric train lines. The primary objective of travel is to reach one's destination safely and efficiently. This research aims to investigate the criteria and develop assessment forms for assessing the physical environment for safety and security in transitional spaces between mass transit stations and buildings. This qualitative research studies and filters criteria from regulations, laws, and theories related to the physical environment for safety and security. First, developing an assessment designed for an initial trial in the specific area. Next, ensuring the tool's compliance through an expert evaluation. Subsequently, conducting a second trial within the area to identify and implement any necessary improvements, with a final validation carried out by an expert. Only after all necessary corrections have been made and verified will this assessment be utilized in subsequent evaluations. The research found that the central concept of the assessment model focuses on good visibility throughout the journey, the lack of obstacles that can cause danger, and the importance of safety equipment and personnel readiness. The assessment consists of two main factors, seven sub-factors, and 46 criteria, including (1) the physical environment factor for safety and security consisting of boundaries, entrances, and positioning of transitional spaces (12 items), blind corners and obstacles (10 items), lighting (2 items), signs and information (7 items), cleanliness and maintenance (3 items), (2) the security equipment and security guard factor, consisting of safety equipment (6 items), and security guard (6 items) in maintaining a secure environment.

Keywords**:** *Assessment form; Transitional Space; Physical Environment; Safety and Security*

1. Introduction

1.1 Background

Mass transit systems, especially electric train systems, are a crucial alternative for commuting amidst the current traffic congestion, which can significantly save time and increase comfort. Economically, they are a vital factor in stimulating economic growth, resulting in trade development along electric train routes and creating activities during the transition from travel to surrounding spaces. While the development of an electric train route holds the potential to alleviate traffic congestion and promote economic growth along its path, it is essential to acknowledge that such land development and economic activities may introduce new problems and exacerbate traffic issues without a comprehensive plan in place. One effective long-term solution to mitigate traffic congestion involves the designation of specific areas for private car use. This strategy is particularly valuable in densely populated zones with a significant traffic impact, especially at intersections and locations with ongoing construction projects, such as shopping malls and government infrastructure developments, which include electric train systems and airports. The establishment of seamless connectivity between mass transit systems and structures in these areas is of utmost importance. Presently, there are ongoing efforts to finalize guidelines for the establishment of standards for Traffic Impact Assessment (TIA), which will have implications for future projects

(Office of Transport and Traffic Policy and Planning, 2020). This concept underscores the likelihood of creating numerous connecting areas in the future.

The most important thing for all types of travel is to reach the destination safely. Therefore, throughout the journey, it must be a place that is safe for life, property and prevents crimes or dangers to users (Jeffres, Bracken, Jian, & Casey, 2009; Badiora, Wojuade, & Adeyemi, 2020). The need for safety in travel corresponds to Maslow's Hierarchy of Needs, which indicates that when physiological needs are adequately met, humans will want safety and security in life and property (Maslow, 1954; Newton, 2018). This transitional space serves as a transition point between mass transit systems and surrounding spaces, connecting public spaces, semi-public spaces, and private spaces of private buildings connected to public stations, while promoting economic development along the route.

However, even though there are economic developments along electric train routes, it may also lead to crime along these routes (Zhong, & Li, 2016; Bowes, & Ihlanfeldt, 2001). If the travel connection is not safe, commuters may be at risk of losing life and property (Guthrie, & Fan, 2016), creating feelings of insecurity anxiety in travel, which may affect the image of the service provider in the perception of commuters, causing them to switch to other means of travel., This negative potential outcome would hinder the solution to traffic congestion and the development of transportation systems as a whole. When referring to spaces with travel connections, it involves transitioning from one space to another.,. Entrances and exits in these spaces are considered the most dangerous, followed by stairs, escalators, and train platforms. Furthermore, the walkway connecting the station platform to the parking space may also be unsafe (Deniz, 2018). In the context of Thailand, particularly in the present economic hub, office buildings and shopping centers are expanding rapidly. This growth has highlighted the prevalence of areas with a high-risk level and a significant need for safety measures. As a result, there is a critical demand for security personnel and equipment, particularly in locations linked to main roads, electric trains, mass transit systems, and entry-exit points. This necessity arises from the substantial flow of incoming and outgoing traffic within these areas. (Muanhong, 2016; Samboonraung, 2010; Thongmar, 2015)

Additionally, a physical environment that has blind spots and travel obstacles, along with inadequate lighting, could potentially cause safety issues. Having good visibility throughout the route and reducing problems with dark corners where potential criminals can hide can create a safer travel environment. Commuters will feel secure, and fear of travel can be reduced (The National Crime Prevention Council (NCPC) of Singapore, 2003; Welsh, Mudge, & Farrington, 2009; Newton, 2018; Ceccato, Gaudelet, & Graf, 2022). However, despite having established regulations, laws, various theories related to the safety of transitional spaces and to address long-term traffic problems, we have initiated a Traffic Impact Assessment (TIA), which is currently in progress. Part of the legislation also requires the establishment of travel connectivity areas. Furthermore, when discussing travel behavior and human needs, it is crucial to consider the physical environment in these connecting areas. Adequate lighting, cleanliness, and effective security management, which includes CCTV installation and security personnel assisting users, can significantly improve user comfort and safety, resulting in better utilization. However, despite the existence of regulations and various laws governing safety in these travel connection areas, there is still a lack of detailed criteria concerning environmental characteristics and security management that align with Thailand's specific connectivity context.

Therefore, this research aims to study the criteria and develop tools for assessing the physical environment for safety and security in transitional spaces between mass transit stations and buildings. This tool is intended to be part of the assessment of transitional spaces, and the results from the space assessment may be used to improve and address safety issues related to the physical environment in transitional spaces, making travel safer in the future.

1.2 Literature Review

The review of literature related to the development of a physical environment assessment form for safety and security in Transitional Space between Mass Transit Stations and Buildings is as follows:

Definition of the Transitional Space

In this research, the term 'transitional space' refers to the space that serves as a transition point for travel between mass transit systems and surrounding buildings. It acts as a passage between public, semi-public, and private spaces, facilitating passengers to conveniently connect between mass transit stations and surrounding

buildings, such as shopping malls, office buildings, and condominiums. Moreover, this space is also where access rights are checked, and access of commuters passing in and out is screened (Benn, & Gaus, 1983) between mass transit stations and surrounding buildings, ensuring security for commuters and building users.

Definition of Safety and Security in Transitional Space

'Dangers' can be divided into two categories: natural disasters, such as flooding and poor environmental conditions, and those caused directly by humans. Dangers from human acts are categorized into two types: unintentional or accidental, primarily due to negligence or lack of awareness, leading to accidents. These dangers are typically overt and unintended. The other type of danger involves intentional acts, where perpetrators usually intend to hide their actions, such as robbery, coercion, bombing, shootings, and theft of property.

Therefore, 'safety' refers to being free from all of these dangers. Safety from natural hazards and unintentional or accidental human acts refers to safety from accidents, disasters, and health hazards. While these types of dangers may not always be preventable, preparations can be made to avoid the occurrence of accidents and mitigate any potential impacts. On the other hand, safety from intentional human acts relates to the danger posed to the well-being and property of organizations and building users. This type of safety involves preventing or inhibiting malicious harm to life, peace, stability, and the property of organizations and related individuals or groups. This prevention of intentional dangers is referred to as 'security'. Regarding safety in public transportation, it involves the perception and feelings of risk associated with crime for passengers and related staff. Every passenger has the right to travel safely, free from all forms of danger (Ceccato, & Newton, 2015). It provides an example of a secure transitional space is shown in Figure 1.

Figure 1 An example of a transitional space that is characterized by a secure physical environment. It is an area that sees through fencing covering a predictable route provides visibility. (Sources: Adapted and modified from The National Crime Prevention Council (NCPC) of Singapore, 2003)

Laws, regulations, and theories related to the physical environment for safety and security.

For this research, the study involves laws, regulations, and theories related to the physical environment for safety and security as follows:

1. Laws and regulations related to the physical environment for safety and security.

There are specific laws and regulations to provide guidelines for the construction and maintenance of transitional spaces, emphasizing the basis of structure safety and utility. They facilitate public service users and increase passengers' access to mass transit systems. The study of laws and regulations in Thailand related to the physical environment for safety and security currently consists of 6 issues as follows: (1) Ministerial Regulation No. 4, B.E. 2542, issued under the Empowerment of Persons with Disabilities Act, B.E. 2534 (Royal Thai Government Gazette, 1999a), (2) Mass Rapid Transit Authority of Thailand Act, B.E. 2543 (Royal Thai Government Gazette, 2000), (3) Regulations of the Rehabilitation Committee for the Disabled-on Control of Standards for Equipment and Facilities Directly to People with Disabilities, B.E. 2544 (Royal Thai Government Gazette, 1999b), (4) Bangkok Ordinance on Building Control Act B.E. 2544 (Royal Thai Government Gazette, 2001), (5) Announcement of Bangkok Metropolis Re: Criteria for Permission and Compensation for Construction of Links Between Transportation Systems Bangkok Mass Extension with outside buildings. (Royal Thai Government Gazette, 2012), (6) Ministerial Regulation Prescribing the Facilities in the Building for Disabled and

Old Persons (No. 4) B.E. 2564 (Royal Thai Government Gazette, 2021). The timeline for issuing regulations and laws is shown in Figure 2.

From the review of these six sets of laws and regulations, it is evident that they can be divided into three phases: Phase 1 - Before construction/design, Phase 2 - During construction, and Phase 3 - During use. The main objective of these phases is to ensure safety and convenience of use, from the preparatory phase for construction to the operation phase. They prescribe the width and height of entrances and exits to the transitional space, and there must always be public access. It is also specified that nothing should obstruct normal use. However, a notable observation is that no clear definition of safe physical environment criteria exists. The only specification is that it should be safe for use (Panpet, & Upala, 2020).

In addition to the relevant laws and regulations in Thailand, we reviewed international laws and regulations related to the design of physical environments and the safety of transitional spaces between mass transit stations and buildings which are usually linked with building control laws. When comparing international laws with those in Thailand, particularly regarding objectives, building safety, health, fire prevention, environmental considerations, and more, it is noted that both sets of laws aim to ensure adequate structural integrity and strength of buildings to prevent catastrophic failure and danger to occupants throughout the lifetime of the building. This includes fire prevention and measures for when a fire occurs. The laws cover the period from construction to utilization, including building modifications. Specific regulations and laws in Thailand related to transitional spaces between mass transit stations and buildings also emphasize the safety of public access, environmental preservation, and urban orderliness (Cozens, & Love, 2015; Cozens, Love, & Davern, 2019; Newman, 1977). However, no explicit mention is made of safety in using these spaces.

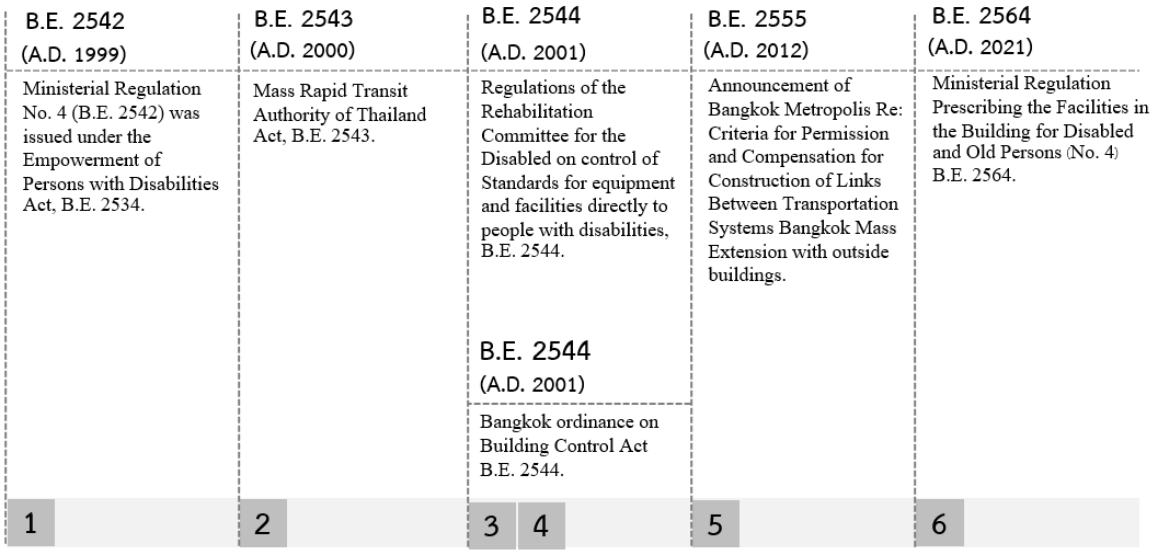

Figure 2 Timeline of laws and regulations related to the design of the physical environment for safety and security in transitional spaces between mass transit stations and buildings in Thailand.

2. Theories related to the physical environment for safety and security.

This research employs two conceptual theories, namely Facility Management in terms of Security Management and Crime Prevention Through Environmental Design (CPTED).

- Facility Management in terms of Security Management

Facility Management refers to the administrative process of managing, supervising, and maintaining a building to ensure its readiness and effectiveness. The goal is to maximize benefits for building users and owners, with the organization's activities and objectives at the core and the building as a tool to support the organization's work. This aims to improve efficiency and achieve organizational goals, acting as a key business tool for competition with neighboring buildings. It enhances an organization's potential and productivity, supporting short-term and long-term organizational needs. Therefore, the relationship between the building, the organization,

humans, and the building's efficiency are crucial in the organization's business operations. The focus is on providing services to people within the building (People), work processes (Process), and physical spaces (Place) to ensure integrated operations towards achieving organizational goals. The physical system (Facility) comprises two components: (1) Physical Resources and (2) Operations or Facility Services (Alexander, 1993; BIFM, 2003; Julasai, & Chotipanich, 2004; Nutt, 2004).

Security management is a part of building operations/services, providing security to building users. This refers to managing operations to ensure the safety and protection of building users' well-being, life, and property from individuals or groups with malicious intent. The security system comprises three components: (1) Physical Components: These include fences around the space, walls, and doors of the building's entrances and exits, as well as internal walls within the building. (2) Security Operations: These refer to organizing security personnel to maintain order and security within the space, to inspect the premises, and respond to incidents. (3) Security Technology: This refers to equipment installed on the premises, such as CCTV, access control systems, traffic control systems, dangerous object detection systems, alert systems, etc. (Chotipanich, 2010). This is shown in Figure 3.

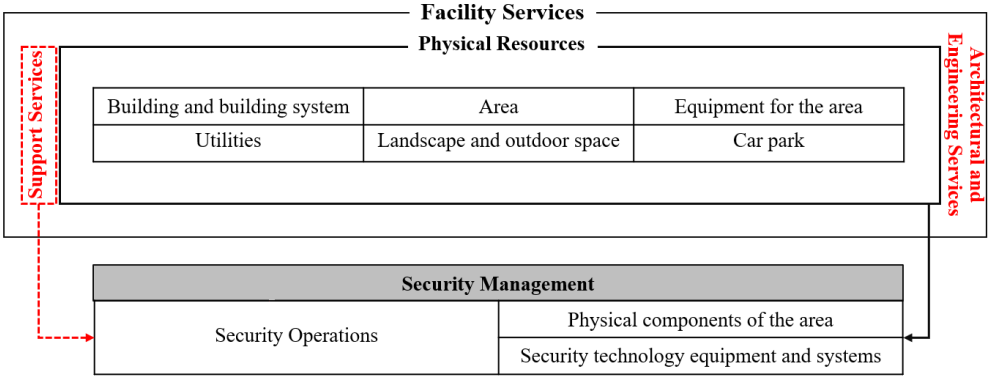

Figure 3 The components of Facility terms of building and physical resource management and security management.

- Crime Prevention Through Environment Design: CPTED

Crime Prevention Through Environment Design (CPTED) is a crime prevention theory through law enforcement and the relationship between crime and community conditions. The basic principle is appropriately and effectively designing the environment to reduce crime rates and residents' fear. In its initial stage, CPTED primarily focused on ensuring environmental safety through proper lighting, beautification, and habitability, which were considered secondary benefits. Later, in its second phase, CPTED expanded to include the use of spaces to accommodate activities, increase safety for people, and maintain well-lit spaces. Currently, in its third phase, CPTED has been expanded to diversify the activities within the space, providing more fun and diverse experiences and responding to the needs of the community and surrounding spaces (Mihinjac, & Saville, 2019).

The guidelines of CPTED are related to the physical design of the space, emphasizing the relationship between the purpose of the space's use, the management of people's behavior, and the physical environment. These can be new designs or improvements to existing spaces for better efficiency (Randall, 2008). The aim is to segregate, limit, and manage access to public, semi-public, and private spaces, which are considered one way to ensure safety. A well-designed space, according to CPTED, can prevent potential crimes and is composed of essential principles such as zoning, natural surveillance, strict access control, supporting legal activities, location management, and image management (Cozens, & Love, 2015; Cozens et al., 2019; Newman, 1977). Security measures in the perspective of CPTED include (1) physical measures focusing on hardware and technology such as access control systems, locks, alarms, closed-circuit television (CCTV), and metal detectors, (2) organizational or individual level measures that use personnel as the basis for security, defining groups responsible and authorized for security, such as patrol lines, security officers, etc., and (3) natural measures that focus on using natural zoning for security by dividing spaces into zones with different safety levels (Randall, 2008).

In conclusion, CPTED has been developed by emphasizing the limitation and segregation of entrances/exits and natural defense lines combined with good maintenance, proximity to and friendliness with the surrounding community, emphasizing participation and a sense of ownership of the place among the community.

However, installing security equipment in the space can increase safety, liveliness, beauty, and the feeling of naturalness which also create a sense of safety. Notably, the level of wayfinding capability in the users' space can influence their sense of safety. Good design promotes the natural use of the space and reduces the need for additional equipment and technology. (The National Crime Prevention Council (NCPC) of Singapore, 2003)

Concerning CPTED in the context of transit spaces, it is still comprised of the principles of CPTED, just like any other space. From the collection of strategic approaches and practical applications according to the design principles of crime prevention through environmental design, the main points for projects such as pathways, underground tunnels, overpasses, or connective spaces include territorial reinforcement of personal and public spaces, access control, maintenance and management, and natural surveillance (American Public Transportation Association, 2010; Cozens, & Love, 2015; Ministry of Justice: New Zealand, 2005; The Queensland Government, 2021).

Crime prevention through environmental design in transit-connective spaces emphasizes the prevention, rectification, and setting of guidelines so that these spaces have no hidden, obstructive, or impedimental points in transit. Spaces that are covered, blocked, and hard to escape from can lead to fear and a sense of danger. Solving these problems by reducing fear can increase the feeling of safety (Jack *et al*., 1993), focusing on natural elements to ensure safe space usage and preventing the opportunity for criminals to commit a crime. Furthermore, it also reduces the chance of committing a crime by emphasizing the natural usage of the space safely. An open environment and good visibility are essential to creating safety. Perceived safety includes various factors such as personal characteristics, social characteristics, time and place related to lighting, amenities, information systems, mobile phones, coverage, location, open environment, and surveillance (Sundling, & Ceccato, 2022); this is shown in Figure 4.

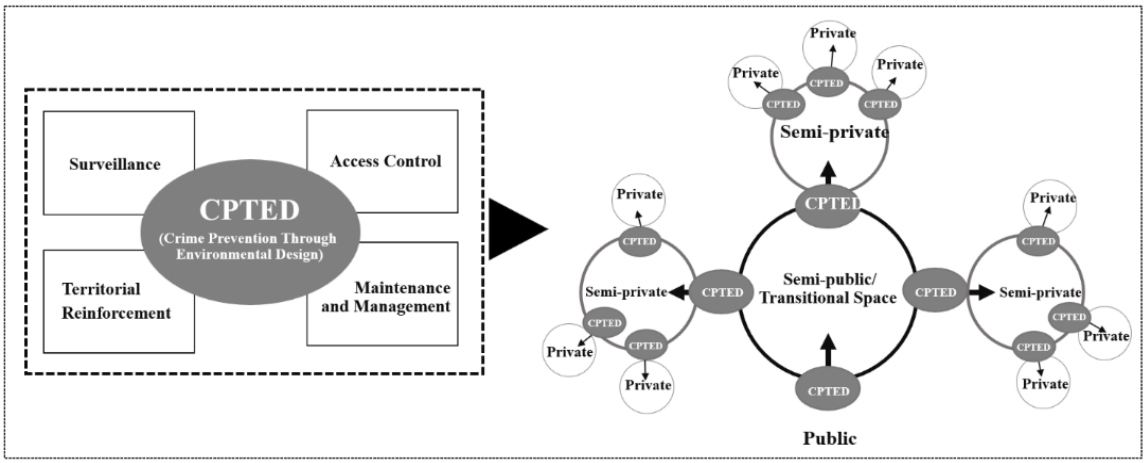

Figure 4 Crime Prevention Through Environment Design (CPTED) involves access to public, semi-public, and private spaces in transit areas (Sources: Adapted and modified from Cozens, & Love, 2015)

- Concepts of forms and methods for evaluating physical environment characteristics for safety.

After reviewing the literature on the main concept of Crime Prevention Through Environmental Design (CPTED), it is evident that there is a method for evaluating physical environment characteristics for safety. Specifically, most of these methods are presented in the form of manuals, categorized by building type, each containing a description of the assessment's purpose. These manuals list the safe physical environment characteristics for a given building type, allowing for an assessment to determine whether the space meets the specified safety physical environment criteria. Consequently, these manuals serve as documents providing guidelines for designing and managing the physical environment with safety and crime prevention in mind. However, it is worth noting that there is currently no assessment form available for evaluating the physical environment. The development of such an assessment tool would be invaluable for assisting administrative and area management agencies in evaluating their local conditions, ultimately leading to more efficient area management practices. (American Public Transportation Association, 2010; Cozens, & Love, 2015; Ministry of Justice: New Zealand, 2005; The Queensland Government, 2021).

2. Objectives

The research aims to achieve the following objectives:

1) Investigate the criteria relevant to assessing the safety and security of the physical environment in transitional spaces between mass transit stations and buildings.

2) Select the most pertinent criteria for creating a physical environment assessment form to ensure safety and security in these transitional spaces.

3) Develop an assessment form that can be utilized to evaluate the physical environment's safety and security in the transitional areas between mass transit stations and buildings.

3. Materials and Methods

This research was a qualitative study, and the methodology consisted of the following five steps:

Step 1: A literature review and related research were conducted concerning transit between mass transit stations and buildings, public spaces, laws, regulations, and theories related to the physical environment for safety and security, and security management in transitional spaces between mass transit stations and buildings.

Step 2: Criteria relevant to the physical environment for safety and security were screened from the information gathered in Step 1 using content analysis.

Step 3: A tool for assessing the physical environment for safety and security in transitional spaces between mass transit stations and buildings was developed based on the criteria identified in Step 2. This assessment tool was then pilot tested in the first research space to filter the most suitable criteria for real-world conditions.

Step 4: The index of Item Objective Congruence (IOC), which was the physical environment assessment form for safety and security in transitional spaces between mass transit stations and buildings, was verified by three experts who were designers, academics, teachers, or practitioners related to the management of physical resources and security management. After the experts checked the consistency of the research tool, their suggestions were used to make adjustments. The revised tool was then pilot tested in real space for a second time and further refined.

Step 5: The physical environment assessment form for safety and security in transitional spaces between mass transit stations and buildings from Step 4 was sent to experts to check for correctness based on their suggestions. Once there were no further edits or suggestions, this assessment form was used in subsequent research.

The research framework is shown in Figure 5, while examples of research areas where tools are being pilot tested are displayed in Figure 6.

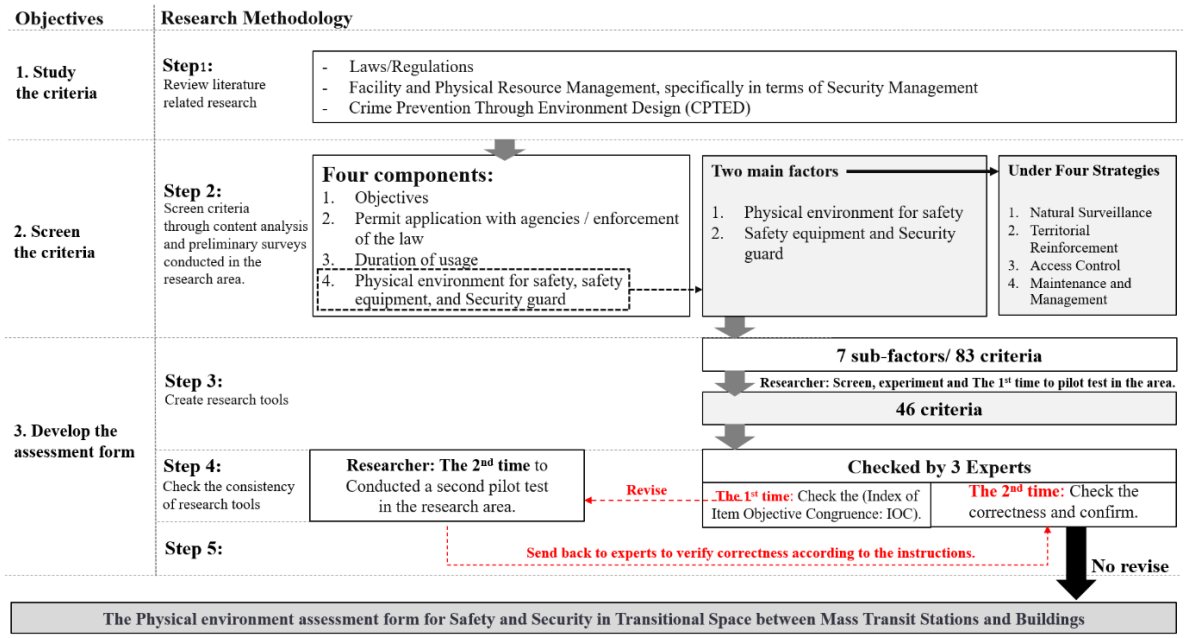

Figure 5 The research framework

Figure 6 CEN-Siam Station is an example of a research area where tools are being pilot tested.

The research results were as follows:

4. Results and Discussion

4.1 Studying the criteria for assessing the physical environment for safety and security in transitional spaces between mass transit stations and buildings.

From the review of criteria related to the physical environment for safety and security in transitional spaces between mass transit stations and buildings, we identified three distinct parts: (1) Six sets of laws and regulations, (2) Facility Management focusing on Security Management, and (3) Crime Prevention Through Environment Design (CPTED). These main criteria could be further summarized into four main components.

Component 1: The objectives, laws, regulations, and theories associated with the physical environment for safety and security in Transitional Spaces between Mass Transit Stations and Buildings all aim for safety but have some differences. Regulations and laws are designed to ensure the structural integrity of buildings, fire prevention and suppression, and good hygiene when using buildings. On the other hand, Security Management focuses on ensuring the safety of life and property when the facilities are in use, relying on the preparedness of security plans, equipment, and security personnel. This is security in terms of management. This aligns with the objectives of Crime Prevention Through Environment Design (CPTED), which also emphasizes the preparedness of equipment and security personnel, but additionally focuses on the characteristics of an environment with good visibility throughout the travel route to prevent and reduce risks to the life and property of space users.

Component 2 : The submission of permits to authorities and enforcement of laws. Laws and regulations require obtaining permission before construction and have direct legal enforcement consequences for damages resulting from structural failure. Meanwhile, Security Management and Crime Prevention Through Environment Design (CPTED) do not require permission but are crucial aspects that ensure the safety of the building's users and enhance the organization's productivity. Although these do not have direct legal consequences, they can have legal implications if any danger to life and property occurs when using the building.

Component 3 : The time frames for use, laws, regulations, and theories related to the physical environment for safety and security are divided into 3 phases: Phase 1 is pre-construction/design, Phase 2 is during construction, and Phase 3 is building usage. Regulations and laws are related to Phase 1, pre-construction/design, and Phase 2, construction, with the primary objective being the structural safety of the building. In Phase 3, they relate to the safety of the building from the danger of structural collapse and fire prevention throughout the usage of the building, however it does not provide specific detail on how security is managed. Security Management and Crime Prevention Through Environment Design (CPTED) are relevant to Phase 3, aiming to ensure safe space usage is free from threats to life and property. However, Security Management focuses to Define the scope of work during building usage, ensuring users' safety and convenience when using the building. CPTED focuses to Define the physical environment regarding good visibility along the walking path, including determining the necessary equipment and security personnel.

Component 4: Factors related to the physical environment for safety and security, equipment, and personnel. Component 4 encompasses considerations pertaining to the physical environment, safety, security, equipment, and personnel. Within this component, several factors related to safety and security within the physical environment are addressed. These factors include aspects such as boundary definition, entrance design, positioning of transitional spaces, identification and mitigation of blind spots and pathway obstructions, lighting, signage, and compliance with relevant laws and regulations. In more detail, Component 4 involves specifying structural characteristics that ensure sturdiness and safety to prevent collapses. It also defines the required height for convenient access by fire trucks in case of emergencies. Notably, it stipulates that transitional space

entrances/exits must have a minimum width of 2 meters, with the height matching the floor height of the ticket office within the system. These measures are all aimed at enhancing safety, preventing accidents and disasters, and maintaining high standards of hygiene (Safety).

In contrast, Security Management places a strong emphasis on various aspects, such as providing security personnel, establishing methods for job performance, conducting inspections to assess job performance, and ensuring the availability of security equipment and personnel. This approach shares similarities with Crime Prevention Through Environmental Design (CPTED) in its dedication to enhancing security. Security Management directs its attention to high-risk areas, particularly focusing on the entrance-exit zones and the boundaries that separate the building's transitional areas from other zones. This involves a concerted effort to maintain clarity and appropriate positioning of the connection area, which is ideally situated in front of the building and within the same area as the activity zone. Additionally, CPTED adds criteria for the physical environment with good visibility throughout the travel route. This is shown in Table 1.

Table 1 Components of the concept related to the physical environment for safety and security in Transitional Space between Mass Transit Stations and Buildings.

Components	Physical Environment / Security Management		
	Laws / Regulations	**Security Management**	**CPTED**
1. Objectives	For safety and security involving the structural integrity of the building, the excellent health of the building's users, fire prevention measures, and the provision of standard facilities for people with disabilities or frailties and the elderly.	Supporting organizations and maximizing the utility of physical resources helps ensure the safety of life and property for users in the building (Security).	For safety and security from crime by utilizing the principles of crime prevention through environmental design.
2. Permit application with agency / Law enforcement			
Application for permission	Permission must be obtained in the pre-construction phase.	No permission is required.	
Law enforcement	There are direct legal consequences for damages resulting from structural failure.	There are no direct legal implications.	
3. Duration of usage			
Phase 1: Before construction/design	Define safe building structure characteristics.	-	-
Phase 2: During construction	Control and inspection during construction	-	-
Phase 3: During use	Specify that it must be safe from dangers of unstable structure.	Define the scope of work during building usage.	Define the physical environment regarding good visibility along the walking path.
4. Factors related to the physical environment for safety and security, equipment, and personnel.			
4.1 Factors related to the physical environment for safety and security.			
Boundary, entrance, and positioning of transitional space	The width of the transitional space entrance/exit must be at least 2 meters, and the height must be equal to the ticket office's floor height in the system and sufficient for a fire truck to enter and exit quickly.	There must be a security management plan for the entrance/exit and transitional space between the building and other spaces.	Establish clear boundaries for transitional spaces, which should be located at the front of the building and near or within the same activity space.

Components	Physical Environment / Security Management		
	Laws / Regulations	**Security Management**	**CPTED**
Blind spots and obstructions in the path	The space for going up and down should be unobstructed for everyday usage.	-	The pathway should provide a clear line of sight.
Lighting	-	Establish a method for maintaining the lighting system.	Provide adequate lighting to identify faces from a distance of at least 10 meters.
Signs and information	-	-	Ensure clarity and visibility of both information and location from various viewing distances.
4.2 Factors related to security equipment and security guard.			
Security equipment	-	There must be control over entrances and exits and screening access to the transitional space, with security equipment.	
Security guard	-		

4.2 Screening of criteria and development of a physical environment assessment form for safety and security in Transitional Spaces between Mass Transit Stations and Buildings.

From the laws, regulations, and theories related to the physical environment for safety and security in Transitional Spaces between Mass Transit Stations and Buildings, four elements can be analyzed, namely objectives, permissions/licenses/legal enforcement, usage duration, and factors related to physical environment for safety and security, security equipment, and security personnel. For this study, the fourth element was analyzed for criteria to develop a physical environment assessment form for safety and security in Transitional Spaces between Mass Transit Stations and Buildings under the principle of Crime Prevention Through Environment Design (CPTED) with four strategies: Natural Surveillance, Territorial Reinforcement, Access Control, and Maintenance and Management.

After analyzing safety-related criteria in the transitional space using content analysis, it was found that they can be divided into two main factors, seven sub-factors and 83 criteria. After pilot testing these criteria in a pilot study within the research space, 46 suitable criteria were identified, divided as follows:

Main-factor 1: Factors related to physical environment for safety and security, comprised of 5 sub-factors: boundaries, entrances, and positioning of transitional spaces; obstructed and obstructing travel points; light; signs and information; cleanliness and maintenance, divided into 34 criteria. Main-factor 2: Factors related to security equipment and personnel, comprised of 2 sub-factors: security equipment and security personnel, divided into 12 criteria.

After conducting a pilot test on the assessment form by evaluating the transitional space, which is the research space, for the first time, three experts checked the form for research tool congruence (Index of Item Objective Congruence: IOC). The IOC value for each item and the entire form had to be ≥ 0.5. After inspection, the overall IOC value for the entire form was 0.95. The IOC value for the 46 items ranged from 0.67 – 1. Therefore, it can be concluded that the survey form is congruent with the research objectives and can be used to survey the transitional spaces.

The experts' result of the research tool congruence check (Index of Item Objective Congruence: IOC) is shown in Table 2.

Table 2 Results of Index of Item Objective Congruence (IOC) for the safety assessment form for the physical environment in Transitional Space between Mass Transit Stations and Buildings.

Factors	No. of questions	IOC index by item
Main-factor 1: Factors related to the physical environment for safety and security		
Sub-factor 1: Boundaries, entrances, and positioning of connecting spaces	12	0.92
Sub-factor 2: Blind spots and travel obstructions	10	0.93
Sub-factor 3: Lighting	2	0.84
Sub-factor 4: Signs and information	7	0.95
Sub-factor 5: Cleanliness and maintenance	3	1
Main-factor 2: Factors related to security equipment and security guard		
Sub-factor 6: Security equipment	6	1
Sub-factor 7: Security guard	6	1
IOC in full	**46**	**0.95**

Further recommendations for improving the tool include qualitative criteria and adding more detailed descriptions which could provide more precise insights. If measurable numerical indicators could be specified for quantitative criteria, it would make the survey more precise and explicit.

5. Conclusion

The development of the Physical Environment Assessment Form for Safety and Security in Transitional Space between Mass Transit Stations and Buildings can significantly enhance the safety of the travel connection from mass transit stations to the end destinations for commuters. The criteria for evaluating the physical environment for safety and security in these transitional spaces in this study are derived from laws, regulations, and theories related to the physical environment, facility management, security management, and Crime Prevention Through Environment Design (CPTED). The study identified four key components: (1) Purpose, (2) Usage duration, (3) Permit applications and law enforcement, (4) Physical environment factors, safety equipment, and safeguards.

This research utilized the fourth component to develop the Physical Environment Assessment Form for Safety and Security in Transitional Space between Mass Transit Stations and Buildings. From the analysis, the critical points were categorized, validated by experts, and tested in natural environments. As a result, a tool for assessing the physical environment for safety and security in transitional spaces was developed, focusing on creating safe physical environments and preventing crime in connecting spaces with minimal reliance on systems and technology. The fundamental key principle is maintaining good visibility throughout the travel route. In conclusion, this research yielded the Physical Environment Assessment Form for Safety and Security in Transitional Space between Mass Transit Stations and Buildings, which comprises two main factors, seven sub-factors, and 46 criteria.

Main Factor 1: Physical Environment Factors for Safety and Security - 34 criteria in total, consisting of: Sub-factor 1.1: Boundaries, entrances, and placement of transitional spaces - there should be a clear distinction between the mass transit stations and buildings, with activities serving as natural surveillance. There are 12 criteria for this sub-factor, Sub- factor 1.2: Blind corners and obstacles to movement - the design should avoid blind corners and ensure good visibility throughout the pedestrian routes. This sub-factor has ten criteria, Sub- factor 1.3: Lighting - the pathway should be clearly lit, adequately illuminated, and natural outdoor light should be used to enhance natural surveillance. This sub-factor has two criteria. Sub-factor 1.4 includes seven criteria: Signs and Information - they should be clear, visible, easy to read, and display necessary information for navigation, such as walking routes, location identification, alternative routes, operating hours, current location, and emergency procedures and equipment. Sub-factor 1.5 has three criteria: Cleanliness and Maintenance - materials used should be durable and easy to maintain. Regular cleaning and maintenance are necessary to foster a sense of ownership and safety in the space.

Main Factor 2: Safety and Security Equipment and Security Guard - 12 criteria in total, consisting of: Sub-factor 2.1: Security Equipment - In this sub-factor, all criteria focus on identifying security devices, with an emphasis placed on equipment for access control. This includes screening access to connected areas, such as CCTV cameras, access control systems, and hazardous object detection equipment. Sub- factor 2.2: Security Guard -

all criteria in 2.2 sub-factor give importance to controlling access and filtering access to the transitional space by security personnel to minimize unauthorized access.

A physical environment assessment form is used to survey the transitional space for safety and security between the mass transit station and the building which two main factors, seven sub-factors, and 46 criteria mentioned above will be evaluated. The assessment results are given as "yes" or "no". "Yes" means the physical environment in the transitional space complies with the set criteria, while "no" means the space does not meet the set criteria. The survey includes definitions of physical characteristics to clarify various terms, such as: "Understand" which refers to knowing the subject, understanding the meaning, and understanding what others want to communicate, "Remember" means keeping something in mind, "Adequate" refers to having as much as needed, enabling further action from what is available, "Clean" means being free from undesirable stains and dirt in the space. If present, they should not exceed 30% of the space, "Obstruct" refers to obstructing or being a barrier to using the space, and "Hide" refers to no blind corners where suspicious objects can be placed or where someone can hide or obstruct, that may cause harm to pedestrians.

Details of the physical environment assessment form for safety and security in the transitional space between mass transit stations and buildings are shown in Table 3.

Table 3 Physical environment assessment form for safety and security in Transitional Space between Mass Transit Stations and Buildings

Main-factor	Sub-factor	Item	Criteria	Assessment Result
Main-factor 1: Physical Environment Factors for Safety and Security	Sub-factor 1.1: Boundaries, entrances, and placement of transitional space	1	Accessibility and visibility of the transitional space from the street and its adjacency to general pedestrian spaces.	Yes/No
		2	The transitional space's role as an activity space.	Yes/No
		3	If the transitional space serves as an activity space, it should be at the front of the building.	Yes/No
		4	Presence of a waiting space in the transitional space aids in travel connections.	Yes/No
		5	If a waiting space for travel connections is present, it should be adjacent to or within the activity space and located at the front of the building.	Yes/No
		6	The boundary between the mass transit station space and the building is clearly defined and easily observable.	Yes/No
		7	The entrance to the transitional space is easily identifiable.	Yes/No
		8	There are restrictions on accessing the upper part of the transitional space from the public space below at all times.	Yes/No
		9	There are restrictions on accessing the upper part of the transitional space from the public space below during certain times (e.g., during operating hours of the space, etc.).	Yes/No
		10	There is unrestricted access to public spaces at all permitted times without obstructing everyday use.	Yes/No
		11	The height of the transitional space is greater than or equal to the height of the ticket sales floor of the system or the height of the entrance/exits via the Sky Walk and is high enough to allow convenient access for a fire truck.	Yes/No
		12	The width of the transitional space is at least 2 meters.	Yes/No
	Sub-factor 1.2: Blind corners and obstacles to movement	13	There is good visibility along the straight walking path (if there are branches, consider visibility along the straight path only).	Yes/No
		14	There is good visibility all around the transitional space.	Yes/No
		15	There are no fences, railings, or barriers along the walkway.	Yes/No
		16	If fences, railings, or barriers along the walkway, they should be transparent and provide clear visibility at a height of 1.50 meters.	Yes/No
		17	There are no enclosed or hidden spaces.	Yes/No
		18	If there is a concealed or hidden space, mirrors must be installed in that concealed space to allow passersby to see around the space.	Yes/No

Main-factor	Sub-factor	Item	Criteria	Assessment Result
		19	There are no turning points that exceed a 60-degree angle.	Yes/No
		20	If a turning point exceeds a 60-degree angle, a full-length mirror must be installed at that turning point to allow pedestrians to see around the corner.	Yes/No
		21	If a turning point exceeds a 60-degree angle, and a full-length mirror is not installed at that turning point, the turning point space must always be clear and visible.	Yes/No
		22	There are no physical obstacles, such as poles and sharp corners, that could potentially cause harm.	Yes/No
	Sub-factor 1.3: Lighting	23	Natural or artificial light allows for face recognition from a distance of 10 meters (able to see the details of the face clearly).	
		24	There is a consistent level of lighting along the route (i.e., there are no alternating dark or bright spots along the route that would hinder visibility).	Yes/No
	Sub-factor 1.4: Signs and Information	25	There are clear directional signs when approaching the connecting space.	Yes/No
		26	There is a pedestrian path that is separated from other paths with fewer people.	Yes/No
		27	Suppose there is a pedestrian path separated from other paths with fewer people. In that case, signs must indicate the position and path leading to other paths, or there are clear and sufficient choices in different paths.	Yes/No
		28	There are signs displaying necessary travel information, such as walking paths, location identification, alternative routes, operating hours, standing positions, methods, and various equipment in case of emergencies, within a visible range.	Yes/No
		29	Directional signs in suitable positions can be seen from a distance of 15 meters or more.	Yes/No
		30	The connecting space is transitioning into a private space.	Yes/No
		31	If the connecting space is transitioning into a private space, there must be clear signs or "no trespassing" signs.	Yes/No
	Sub-factor 1.5: Cleanliness and Maintenance	32	The space is kept clean and well-maintained. If there is any debris, it should not cover more than 30% of the space.	Yes/No
		33	Furniture is used along the road, entrance, or central space.	Yes/No
		34	Suppose the furniture is used along the road, entrance, or central space. In that case, it must be made from materials resistant to damage, and the furniture must be securely fastened or removed from the connecting space after operating hours.	Yes/No
		Mass transit station (origin)		
		35	There is screening and monitoring at the entrances and exits of the mass transit station using safety and security equipment such as CCTV cameras.	Yes/No
		36	There is screening and monitoring at the entrances and exits of the mass transit station using safety and security equipment such as Access Control and hazardous object detection equipment.	Yes/No

Main-factor	Sub-factor	Item	Criteria	Assessment Result
Main-factor 2: Security Equipment and Security Guard	Sub-factor 2.1: Security equipment.	**Transitional space**		
		37	There is screening and monitoring at the entrances and exits of the connection space using safety and security equipment such as CCTV cameras.	Yes/No
		38	There is screening and monitoring at the entrances and exits of the connection space using safety and security equipment such as Access Control and hazardous object detection equipment.	Yes/No
		The building or mass transit station (destination)		
		39	There is screening and monitoring at the entrances and exits of the building or mass transit station (destination) using safety and security equipment such as CCTV cameras.	Yes/No
		40	There is screening and monitoring at the entrances and exits of the building or mass transit station (destination) using safety and security equipment such as Access Control and hazardous object detection equipment.	Yes/No
	Sub-factor 2.2: Security guard	**Mass transit station (origin)**		
		41	There is proactive screening and monitoring at the entrances and exits of the mass transit station by dedicated security guards stationed at checkpoints.	Yes/No
		42	There is proactive screening and monitoring at the entrances and exits of the mass transit station by patrolling security guards.	Yes/No
		Transitional space		
		43	There is proactive screening and monitoring at the entrances and exits of the connecting space by dedicated security guards stationed at checkpoints.	Yes/No
		44	There is proactive screening and monitoring at the entrances and exits of the connecting space by patrolling security guards.	Yes/No
		The building or mass transit station (destination)		
		45	There is proactive screening and monitoring at the entrances and exits of the building or mass transit station (destination) by dedicated security guards stationed at checkpoints.	Yes/No
		46	There is proactive screening and monitoring at the entrances and exits of the building or mass transit station (destination) by patrolling security guards.	Yes/No

These survey results yielded quality information allowing us to proceed with the study, nonetheless, there are some additional suggestions for the "Physical Environment Assessment Form for Safety and Security in Transitional Space between Mass Transit Stations and Buildings":

This assessment form is designed for those involved in constructing and maintaining safety in transitional spaces between mass transit stations and buildings, requiring specific knowledge, understanding, and relevant experience in the physical environment, architecture, engineering, or related fields. Therefore, the form is specialized and may not be suitable for the public. However, if the language and content are adapted, or if additional illustrations are included for easier understanding, the public can widely use it.

In addition, this assessment form evaluates transitional spaces that have already been constructed and opened for use, focusing on identifying and addressing safety issues in the physical environment. However, if the principles of this assessment can be applied from the beginning of the construction process, it would complement the concepts of Facility Management and Crime Prevention Through Environment Design (CPTED). This approach could proactively mitigate potential safety issues from the start.

However, there are significant limitations when applying the findings derived from this evaluation in the early stages of design and construction. This limitation arises because this approach offers safety recommendations but lacks legal enforcement mechanisms. This distinguishes it from building control laws, which prioritize ensuring the structural integrity and security of buildings. These laws include regulations

governing building inspections, which mainly focus on structural stability. It is important to note that this approach does not address safety concerns related to the preservation of human life and property or areas vulnerable to human influence. Additionally, when evaluating the effectiveness of the survey from an investment perspective, building owners may inadvertently overlook its importance if they fail to prioritize it or perceive it as merely a financial obligation. This oversight could lead to a failure to establish a vital safety compliance framework in accordance with the specific guidelines outlined in this research.

This assessment focuses on evaluating the characteristics of the physical environment in relation to security management and its connection to crime prevention. To achieve this goal, it is essential to develop an assessment model capable of identifying potential threats to life and property. The findings from this evaluation will be instrumental in improving overall safety measures. Additionally, it is crucial to address security concerns related to Thailand's variable climate due to its distinct seasons. This variability plays a significant role in creating a more comprehensive safety plan, especially in areas where travel connections are exposed to the elements. Climate change further compounds this vulnerability. To bolster our understanding and preparedness, further research should include in-depth studies on assessment models pertaining to climate and environmental safety. This research should also explore the use of suitable materials that can mitigate these challenges and consider a variety of locations for additional connected areas.

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