*Original Article*

# The Application of the Environmental Adaptation Concept to A Collector Road in KKU, Thailand

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## Abstract

A collector road in Khon Kaen University, Thailand, previously suffered from pedestrian accident risk, adverse traffic environmental impacts and amenity problems. Most vehicles commonly travel at high speeds and barely reduce their speeds and stop to permit safe and secure pedestrian crossing. The main objectives of this research are as follows: (i) to determine the pedestrian accident risk in an specific area along a collector road in front of the complex building in KKU and (ii) to evaluate the applications of environmental adaptation concept to manage the vehicle/pedestrian conflicts on such road. Traffic calming namely the Environmental Adaptation Method (EAM) concept was applied to manage the hazardous interactions between pedestrian crossings and vehicle movements. The activity profile was modified in correspondence with the adapted speed profile by changing various road physical and land use characteristics of the collector road. The performance evaluation of road physical and land use modifications of the collector road in the two occasions were conducted. However, the recent road modification illustrated relatively unsuccessful results in reducing the operating speed while traffic flows increased dramatically.


**Keywords:** Traffic Calming, Environmental Adaptation, Sharing the Main Streets, Collector Road

## Introduction

Khon Kaen University (KKU) is located in Khon Kaen city positioned in the middle of the northeastern region of Thailand. The campus covers around 900 hectares and has more than 60,000 residents including academia, students, staff members and others. KKU campus currently becomes the main access for local residents to connect with other parts of the city. The collector road in front of the complex building see (Figure1) is an important route in KKU and is used as the short cut between two national highways, located at the boundary of the campus. The conflicts between pedestrians and vehicular movements on the KKU collector road in front of the KKU complex building were pronounced and urgently needed to be resolved. To alleviate the pedestrian and vehicle interactions, the concepts of the Environmental Adaptation Method (EAM)[1] was applied in this area in two occasions.

The main objectives of this research are as follows: (i) to determine the pedestrian accident risk in an specific area along a collector road in front of the complex building in the KKU and (ii) to evaluate the applications of environmental adaptation concept to manage the vehicle/pedestrian conflicts on such road. This paper describes the following elements: (i) introduction and research objective; (ii) research methodology; (iii) the applications of the environmental adaptation concept; (iv) results analysis and (v) conclusions.

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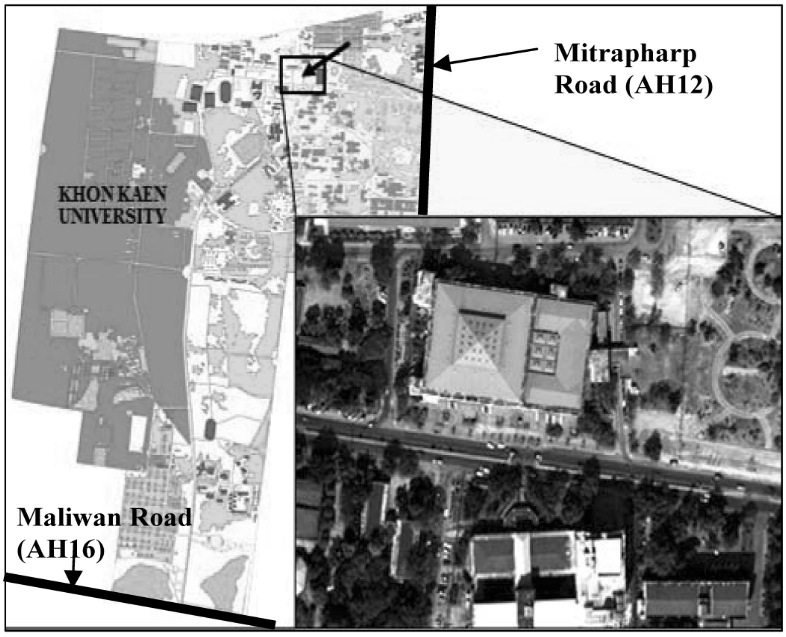



**Figure 1** A collector road adjacent to the complex building in Khon Kaen University

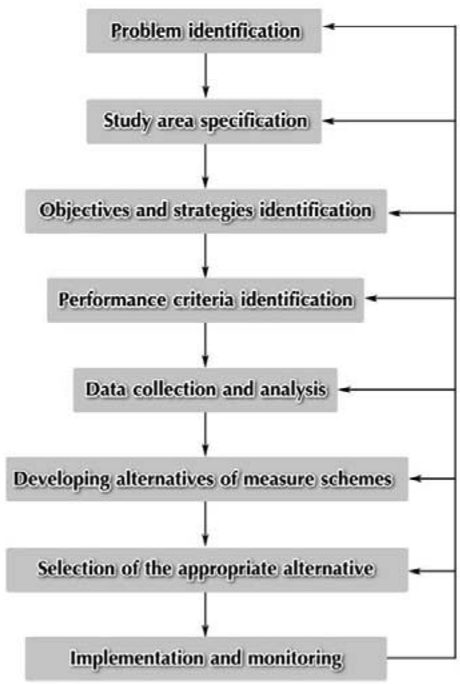



**Figure 2** Flow chart diagram of the application process of the EAM concept

## Materials and Methods

The interactions between pedestrian crossings and vehicle movements on a collector road in front of the KKU complex building were well recognized as pedestrian accident risk, traffic environmental impacts and amenity problems. EAM was consequently applied to resolve the problems. The following description will explain the important steps of the EAM application process to the KKU collector road[6] and (Figure 2) also shows flow chart diagram of the process. The EAM application processes are as follows: **(i) problem identification:** based on comprehensive field surveys and data collections of traffic and land use characteristics along a collector road in front of the KKU complex building has been suffered from pedestrian accident risk, traffic environmental impacts, amenity and esthetic and land scape problems;

**(ii) study area specification:** a collector road, a divided four-lane road with 1.5 meters median width and narrow footpath as shown in (Figure 1 and 3) in front of the complex building is functioning as the main street in KKU. In addition, the adjacent road network and surrounding land use on both sides of the road were also taken into account; **(iii) objectives and strategies identification:** the main objectives of this research is to improve road and land use physical characteristics to reduce conflicts between pedestrian maneuverings and vehicles movements (therefore pedestrian accident risk) and to improve the environmental and amenity quality; **(iv) performance criteria identification:** prior to conducting a detailed investigation of the project. The performance criteria must be identified and selected to assess and evaluate the outcome of proposed alternatives; **(v) data collection and analysis:** the collected data include physical road and land use characteristics of a collector road, adjacent road network and surrounding land use such as mid-block and intersection traffic volume, Origin and Destination (O-D) traffic data, operating speed, pedestrian crossing maneuvering and others; **(vi) developing alternatives of measure schemes:** alternatives will be developed in an integrated fashion. Therefore, different control, design and construction measures as suggested in[1] will be properly selected and incorporated as set of different alternatives to be proposed for implementation; **(vii) selection of the appropriate alternative:** the different alternative were proposed and compared in correspondence to the specified objectives. Then, the appropriate alternative was selected for actual implementation.

In this research, ESM, Song's model[2,3] and other methods were adopted to assess the pedestrian accident risk performance. In addition, the micro-simulation modeling approach was systematically adopted to assess the several performance outcomes of the existing and the proposed alternatives[4]; **(viii) implementation and monitoring:** the selected alternative was actually implemented. Based on the performances criteria, the comparisons of between the before implementation (existing) situation and the implemented (the first implementation) alternatives were systematically conducted. Subsequently, the second improvement was recently implemented. The details of the before-, the first- and the second-implementations and their determined performances were briefly summarized in section 5.

## The Application of the environmental adaptation concept

EAM developed by Professor Hans Westerman[1] is the method to modify the physical and land use characteristics of the roads in response to the needs of users by process of land use planning and transportation policy. It aims to provide safety, efficient traffic operation, amenity, and cost-effectiveness to all road users. EAM focuses on the management of the conflicts between vehicles movements and pedestrian activities along sub-arterial roads, collector roads and the likes. EAM must be conducted in an integrated approach involving modification of street function and/or activities along the road. This approach is related to the alteration of road and/or activity function, the design and management of road space and its corresponding traffic, and the design and management of the frontage landscape. The following process is the heart of the application of the EAM[1]: (i) gathering all pedestrian-oriented activities into a 'core zone' and directing all vehicle-oriented activities to a 'transition zone'; (ii) integrating all control measures to reduce traffic speed and/or minimize traffic volume in a core zone (to the target (the 85th percentile) speed of 25-35 km/h) and in a transition zone (to 40 km/h); and (iii) improving the quality of street and streetscape within study area by modifying the landscape, road space, and road frontage[1]. The key factors influencing the design and planning for the EAM are the changes in road function, vehicle speed, traffic flow, through traffic, heavy vehicles, frontage activities, pedestrian behaviors, road reserve width and so on. Design for EAM can be reflected in the selection of design, construction and control measures in the way that they are integrated to achieve the primary objectives[1]. EAM has been successfully applied and implemented in many projects in Australia[1,5,6].

The details of applications of EAM to the collector road in KKU are shown in (Table 3). In addition, it should be noted that the process of EAM of the main street in KKU campus was done with high level of public participation. Information of EAM and design was disseminated through open sources such as university's radio channel, web site, advertising boards and brochures. The main objective of the adaptation is to reduce accidental risk due to pedestrian-vehicle conflict as well as increase amenities of the campus especially in student service zone.

The results of pedestrian accident risk, pedestrian safety analysis, and field surveys indicated that there is high risk of an accident during pedestrian crossing maneuverings. The EAM concept therefore was applied to manage pedestrian safety problems. The activity profile (number pedestrians per hour per 100 m) is rearranged in accordance with the target speed profile by changing several road physical characteristics and landscape. Two actual improvements were completed as shown in (Figure 3). The summary of the details of road physical and land use characteristics during the before improvement period, the first improvement period and the second improvement period were also presented in (Table 1).

(a) Before Improvement (b) The First Improvement (c) The Second Improvement

**Figure 3** The road and land use physical characteristics of the study area during before and after applying the EA concept

**Table 1** The road physical characteristics during the before-, the first- and the second-improvements

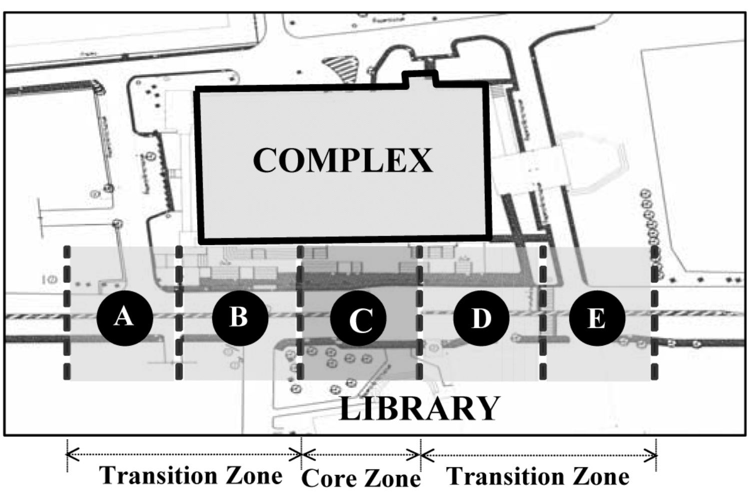
| Road physical and land use adaption | Before Improvement | The 1st Improvement | The 2nd Improvement |
|---|---|---|---|
| Core zone and transition zones | No Core zone and transition zone | Core zone 40 m. Transition zone 80 m. (on both sides) | The same as the 1st Improvement |
| Speed hump length at core zone | Level asphaltic concrete road surface without speed hump | Brick-paver speed hump is 40 m. long at the core zone. Speed hump side slopes are 7 percent and 15 cm. high. | In west-bound direction, two asphaltic-concrete speed hump of 82 m. and 15 m. long at core zone and transition zone, respectively. In east bound direction, one asphaltic concrete speed hump of 82 m. long at core zone. Speed-hump side slope are 7 percent and 10 cm. high. |
| The effective road width and the median and footpath width | Footpath width of 2.5 m. Road width of 9.0 m. in each direction the median width of 1.5 m. | Widening the median with from 1.5 m. to 2.0 m.; widening footpath width to at least 3.0 m. and reducing the road width to 6.0 m. in each direction. | The same as the 1st Improvement |
| Bus stop locations | In west bound direction, bus stop location is situated at the location prior the pedestrian crossing | Relocating the new bus stop location in the west bound direction. Beyond the speed hump location | The same as the 1st Improvement |
| Pedestrian crossing control at mid-block location | Raised median of 1.5 m. wide | Planting bush trees (Bougainvillea) along the median (transition zone), expect for the core zone. | The same as the 1st Improvement |
| Warning the driver and riders to reduce their running speeds | No warning | Installing rumble strips and changing the texture of road surface to brick pavement at the intersection prior to the improvement area | No rumble strips and the texture of road surface to asphaltic pavement at the intersection prior to the improvement area |

## Results

The road physical conditions, road networks, origin-destination data, traffic volumes, speeds, composition, pedestrian movements, jay walkers and jay runners were observed and collected during the before- and the first- and the second-improvement periods. Further analysis is solely concentrated on the vehicle/pedestrian interactions at the core zone (C) in the morning peak period.

As indicate in (Figure 4) in the before-improvement period at the core zone (C), the traffic flows (collected during 7:30 and 8:30 AM) in the east-bound, west-bound and combined both directions were 577, 610 and 1,187 passenger cars per hour, respectively, while in the first improvement period, the traffic volumes the east-bound, west-bound and combined both directions were 790, 812 and 1,602, respectively. In the second improvement period, the traffic volumes in the east-bound, west-bound and combined both directions were 833, 921 and 1,754, respectively. In the first and second improvement periods, the morning peak hourly (combined both directions) volumes were considerably greater than that in the before improvement period. This was possibly because during the first and the second improvement periods, the certain amount of through traffic attempted to avoid traffic congestion on the existing road network and use the collector road as the short-cut route.

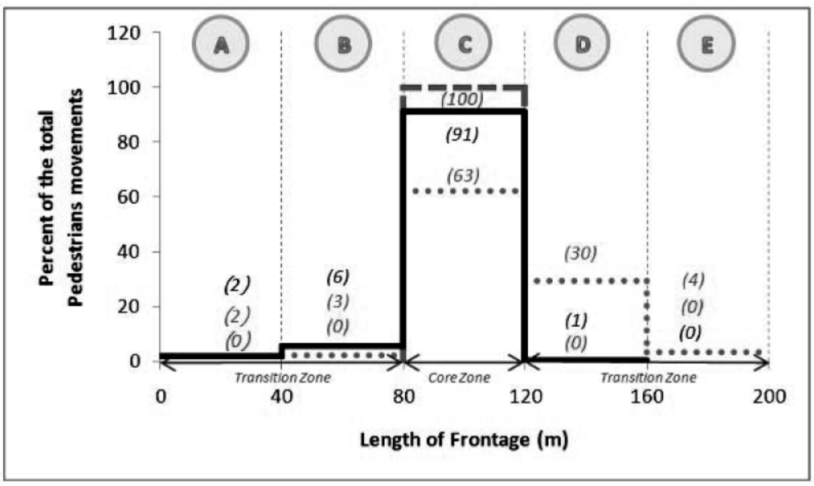
(Figure 5) illustrated the speed profile collected during 7:30 and 8:30 AM in the core zone (C) and the transition zones (A, B, D and E) during the before-, the first- and the second- improvement periods. In the before-improvement period, the 85$^{th}$ percentile speeds in the core zone were 54.8 km/h and 45.0 km/h in the east- and west-bound directions, respectively, while in the first-improvement period, the 85$^{th}$ percentile speeds in the core zone were reduce to 31.0 km/h and 30.6 km/h in the east- and west-bound directions, respectively. Interestingly, in the second-improvement period, the 85$^{th}$ percentile speeds in the core zone were become 43.0 km/h and 38.7 km/h in the east- and west-bound directions, respectively. It could be concluded that based on the 85$^{th}$ percentile speeds (in both directions) in the core zone, the first- and the second- improvements could potentially reduce traffic speeds dramatically. The results indicated that the installation of a speed hump (in the first-improvement period) can effectively reduce the hazardous speed (in the before- improvement period) to the safer target speed interval (25-35 km/h). McLean et al[7] implicitly noted that if a car hit a pedestrian at the impact speed of 50 km/h, the probability of survival is only 7%. However, if the impact speed is reduced to 31 km/h, the probability of survival is greatly raised to 99 %. However, the effectiveness of the improvement in the second-improvement period was lesser than that of the first-improvement period, because of the construction of speed humps during the two improvement periods were physically different in terms of the type of road surface and their physical characteristics (side slopes and heights).



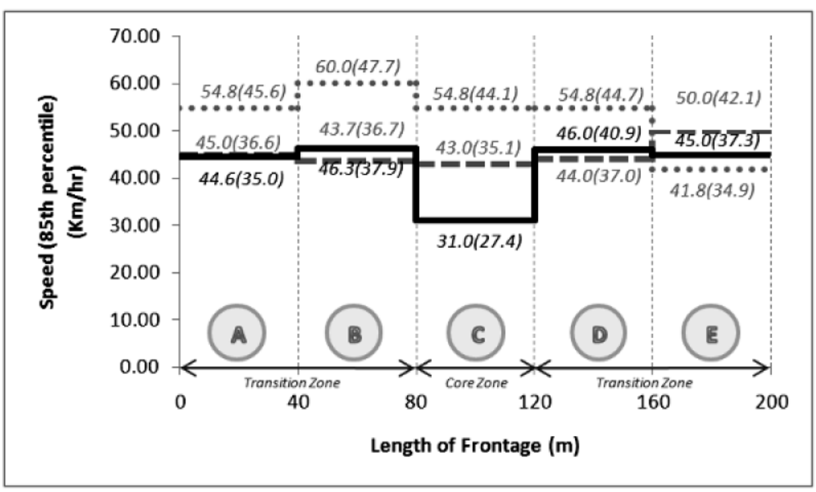

**Figuer 4** Five zones of pedestrian crossing data collection

(Figure 5) also illustrated that the pedestrian crossings maneuverings (activity profile) collected during 7:30 and 8:30 AM in the core zone (C) and the transition zones (A, B, D and E) during the before-, the first- and the second-improvement periods. These pedestrian crossings were classified into walking and running maneuvering. As shown in (Figure 7), the percentage of the pedestrian crossings in core zone (C) was increased from 63% (in the before- improvement period) to 91% and approximately 100% in the first- and the second-improvement periods, respectively. In the transition zone (D), the percentage of the pedestrian crossings was reduced from 30% (in the before-improvement period) to only 1% and 0% in the first- and the second-improvement periods, respectively. In other remaining zones, the percentages of the pedestrian crossings were very low and relatively unchanged during those periods. The results clearly show that the principal achievement of the applications of the EAM concept in gathering as many as pedestrian crossings in core zone (with lower target speeds) and minimizing such crossings in transition zone (with high traffic speeds).

*(a) East-bound direction*




***Activity profile***

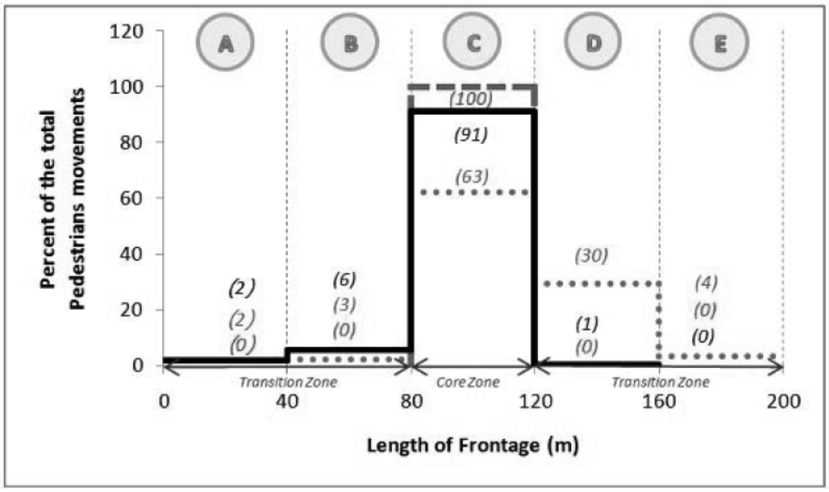



85th Percentile Speed (Average Speed)

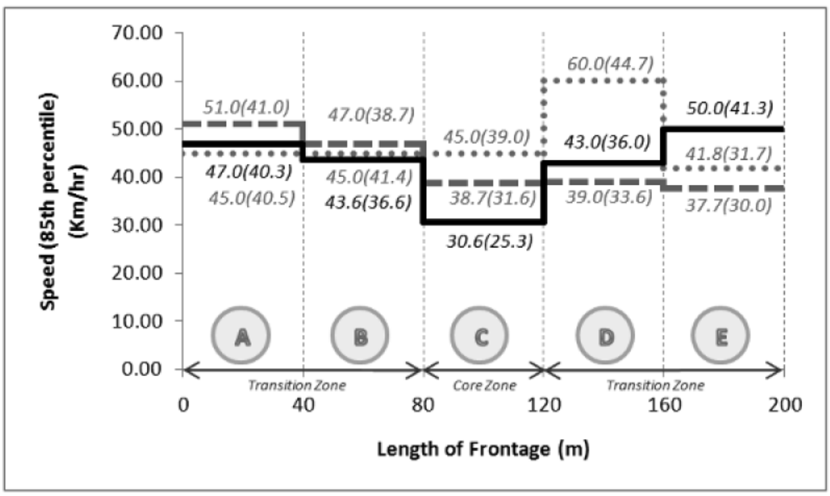
***Speed profile***

| | |
|---|---|
| ·········· | Before Improvement |
| ——— | 1st Improvement |
| — — — | 2nd Improvement |

*(b) West-bound direction*




***Activity profile***




85th Percentile Speed (Average Speed)

***Speed profile***

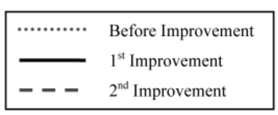



**Figure 5** Activity profiles and speed profiles by traffic directions during the before-, the first, and the second-improvement periods

The comparative evaluation in various performance aspects (during the before-improvement, the first-improvement and the second-improvement periods) was summarized in (Table 2). The percentage of jay runners in core zone was slightly reduced from 28.0 % in the before-improvement period) to 25.6 % and 24.0% (in the first- and the second-improvement periods, respectively. The rating score of the Environmental Sensitivity (ES) index for pedestrian safety[8] was improved from *'high'* (in the before-improvement period) to *'medium'* (in both the first- and the second-improvement periods). Based on the Song et al's model [2,3], pedestrian accident risk for both the before-improvement and the first- and the second-improvement periods is calculated as 2.18 x $10^{-5}$ (high risk) and 1.51 x $10^{-5}$ (medium risk) and 2.04x$10^{-5}$ (high risk), respectively. It should also be noted that even though the traffic volumes in the first- and the second-improvement periods considerably increased, the pedestrian accident risk is safer than that in the before-improvement period. This is because the vehicular speed is reduced dramatically according to the installation of a speed hump and time required to cross the shorter effective walked distance of approximately 10.0 m. (post) compared to 16. 5 m. (pre) for pedestrians was decreased dramatically. However, it is important to note that based on the calculated pedestrian accident risk, the pedestrian safety during the second-improvement period performed lesser degree of success compared to the first-improvement period. Based on the extensive people interviews, the perceived safety, esthetics, and landscaping aspects were significantly improved.

**Table 2** The comparative evaluation of various performance aspects

| Objective | Performance Indicators | Level of achievement of the project | | | |
|---|---|---|---|---|---|
| | | Before Improv. | 1st Improv. | 2nd Improv. | Remarks |
| Reduction in conflicts between pedestrians and vehicles | -Traffic volume in core zone (veh/h) | 1,187 | 1,602 | 1,754 | Average in both directions. |
| | -Vehicle speed (85th percentile in core zone (km/hr) | 50 | 31 | 42.1 | Average in both directions. |
| | -Pedestrian crossings in core zone (ped./h/100 m) | 625 | 696 | 695 | Average in both directions. |
| | -Jay runners in core zone (%) | 28.0 | 25.6 | 24.0 | Average in both directions. |
| | -ES for pedestrian safety | High | Medium | Medium | Based on ESM concept |
| | -Pedestrian accident risk | $2.18 \times 10^{-5}$ | $1.51 \times 10^{-5}$ | $2.04 \times 10^{-5}$ | Based on Song's model |
| Improvement in quality of the environment | -Footpath width (m) | 2.0 | 3.5 | 3.5 | |
| | -Median width (m) | 1.5 | 2.0 | 2.0 | |
| | -Effective Crossing distance (m) | 18.0 | 12.0 | 12.0 | |

## Conclusions

The conflicts between pedestrians and vehicle movements on a collector road in front of the KKU complex building were mostly recognized as problematic and required the suitable traffic-calming scheme to alleviate the problem. According to the ESM method, the pedestrian accident risk in that area was critical. The EAM was consequently applied to the case study area. Based on the field surveys, the applications of the EAM could potentially and effectively mitigate the traffic accident risk, maintain the environmental and amenity quality and enhance the acceptability of the affected stakeholders in terms of esthetics and landscaping. This concept can also be applied to other similar situations. The improved collector road performed well in reducing the vehicle and pedestrian conflicts. The EAM is an effective measure to manage potential pedestrian-vehicle accident risk on a collector road. The recent road modification (in the second-improvement period) showed lesser degree of success in calming the traffic speed while traffic volumes and pedestrian crossings increased dramatically.

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